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PhD THESIS

on

The effectiveness of web-based versus face-to-face personalised nutrition in Kuwait (The EatWellQ8 study)

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DECLARATION OF AUTHORSHIP

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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ABSTRACT

Background: Personalised nutrition (PN) aims to improve dietary intake and the health of individuals and to minimise the risk of chronic disease.

Aims: To develop and validate a web-based food frequency questionnaire (FFQ) suitable for Kuwait. This was incorporated into a PN app (eNutri), to investigate the efficacy of web-based PN compared to identical face-to-face PN and online population advice (EatWellQ8 study). A UK version of the eNutri app was previously used to assess the diet of UK adults (EatWellUK study) and baseline dietary data from these studies were compared.

Methods: Free-living adults were recruited from Kuwait for validation of the EatwellQ8 FFQ (n=99) which was compared with a 4 day-weighed food record (WFR) and a paper-form FFQ (PFFQ). To assess the effectiveness of delivering online PN advice using the eNutri app in Kuwait, participants (n=320) were randomised to web-based PN, face-to-face PN or generalised advice control groups for 12-weeks. Diet quality was assessed using a modified Alternative Healthy Eating Index (m-AHEI) at 0 and 12 weeks. Effects on the m-AHEI components, foods and nutrients were analysed using generalised linear models (GLM), as were comparisons between baseline data from the EatWellQ8 and EatWellUK studies.

Results: The EatWellQ8 FFQ was reproducible and had moderate agreement with the PFFQ and a 4-day WFR for measuring energy and nutrient intakes. After 12 weeks of the EatWellQ8 study (n=100), m-AHEI scores increased significantly in both PN intervention groups (face-to-face PN 19%, web-based 12%) compared to controls (4%) (P<0.01). BMI (-0.5 kg/m_2) reductions were only significant in the face-to-face PN (P<0.01). Compared to baseline data from EatWellQ8 (n=208), EatWellUK (n=309) participants' overall m-AHEI score was significantly higher (P<0.01).

Conclusion: Kuwaiti diets were less healthy than the UK. PN is more effective at improving dietary change than population-based advice in Kuwait. Future work should focus on delivery of PN advice in larger, longer-term trials including more heterogenous populations.

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Table of Contents

List of Tables

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

List of Figures

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

ABBREVIATIONS

AHEI	Alternate Healthy Eating Index
BMI	Body mass index
CVD	Cardiovascular disease
DDI	Dasman Diabetes Institute
DM	Diabetes Mellitus
DQS	Diet-Quality Scores
EPIC	European Prospective Investigation of Cancer
FFQ	Food Frequency Questionnaire
Food4Me	Food4Me trial
F&V	Fruits & vegetables
FA	Fatty Acid
GLM	General Linear Model
HEI	Healthy Eating Index
LOA	Limits of agreement
m-AHEI	Modified Alternative Healthy Eating Index
MUFA	Monounsaturated fatty acids
NCDs	Non-communicable diseases
NDNS	National Diet and Nutrition Survey
NNSSK	National Nutrition Survey of the State of Kuwait
NLS	Nutrition for a Lifetime System
PA	Physical activity
PAL	Physical activity level

PFFQ	Paper based food frequency questionnaire
PN	Personalised nutrition
PUFA	Polyunsaturated fatty acids
RCT	Randomised control trial
RD	Registered dietitian
SACN	Scientific Advisory Committee on Nutrition
SCC	Spearman correlation coefficients
SFA	Saturated fatty acids
TE	Total Energy
UK	United Kingdom
US	United States
WBV	Whole Body Vibration
WC	Waist Circumference
WHO	World Health Organisation
WFR	Weighed food record

PUBLICATIONS:

1. Franco RZ, Alawadhi B, Fallaize R *et al.* (2017) A Web-Based Graphical Food Frequency Assessment System: Design, Development and Usability Metrics. *JMIR human factors* **4**.

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CHAPTER 1 Introduction to the Thesis

1.1 Introduction

Identifying effective strategies for long-term dietary change is crucial to reduce the development of non-communicable diseases (NCDs) worldwide. Strategies to motivate individuals to change their nutritional habits is one of the most significant challenges in nutrition interventions. Recent work suggests that personalisation of nutrition interventions is more effective than general nutrition guidance as the advice is perceived as more personally relevant (1; 2).

The present chapter will: (i) discuss the relevance of Diet-Quality scores and their association to NCDs (ii) outline the needs to improve adherence to healthy eating in the Gulf region in relation to NCDs (iii) describe the role of personalised nutrition (PN) in changing eating behaviour and the methods used to deliver PN (iv) explore the use of applications to assist in the assessment of diet and delivery of PN advice. To conclude, the chapter will outline the research aims and objectives.

1.2 The association between Diet-Quality scores and non-communicable diseases

According to the World Health Organisation (WHO), NCDs remain the leading cause of global premature mortality, are the cause of 70% of all annual deaths and accountable for more than 40% of all premature deaths (<70 years of age) (3; 4). Similarly, in the Middle East, greater than 60% of annual deaths were due to NCDs (5). NCDs usually develop over a long time period and are non-infectious, examples include cancers, chronic lung disease, cardiovascular disease (CVD) and type 2 diabetes mellitus (DM) (6). The key behavioural risk factors that have been associated with the development of NCDs include; improper diets, sedentary lifestyles, tobacco and alcohol use (7). Such factors lead to the progression of physical conditions including type 2 DM, high blood pressure and obesity and eventually chronic disease(7; 8). Dietary lifestyles that are relatively high in sodium, red meats, saturated fatty acids (SFA) and low in monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), fruit, vegetables and wholegrains may increase the development of CVD and certain cancers (3). Therefore, the adoption of a dietary lifestyle that encompasses several healthy dietary patterns may be a more appropriate indicator for the

development of NCDs including CVD (9). Interest in using diet scores as conclusive measures of diet quality has risen in the past few decades and have been associated with risk of CVD and type 2 DM (9; 10). Diet-Quality scores (DQS) usually comprise of dietary/nutrient components including oily fish, fruits and vegetables (F&V) in which higher intakes indicate healthier diets and foods or nutrients such as SFA, sodium and red meat which lower intakes correlate with healthier diets (9; 11). The United States (US) have adopted the Healthy Eating Index (HEI) score which was found to be inversely correlated to high body mass index (BMI) levels and high blood pressure in men and was based of the US Food Guide Pyramid and the 2010 US Dietary Guidelines for Americans (12). Moreover, the US have further developed the Alternate Healthy Eating Index (AHEI) which was based on foods and nutrients predictors of disease and the Dietary Approaches to Stop Hypertension (DASH) score was found to be associated with lower risk for chronic disease development including CVD, DM, some cancers and all-cause mortality (13). In Europe, the Dutch Healthy Diet Index, based on the Dutch Guidelines for Healthy Eating 2006 was found to be associated with omega 3 fatty acid (FA) intakes and the PREDIMED Mediterranean Diet Score was found to have an inverse correlation with waist circumference (WC), BMI and waist-to-height ratio (14; 15). The MedDietScore that was also based on the Mediterranean diet was also found to be associated with a lower risk for the development of coronary heart disease (16). Although several DQS have been developed worldwide, it has been indicated that most revolve around US dietary guidelines and Mediterranean dietary regimens (9) and none have focused on the assessment of dietary intakes in the Arabian Gulf countries.

1.3 The rise of obesity and non-communicable diseases in the Arabian Gulf countries

The availability of energy dense, nutrient poor, relatively low-cost food is one of the key contributors to the rise in the development of obesity and NCDs (17; 18). In the Gulf region, urbanization and rapid economic growth since the 1970s has also led to a rapid increase in obesity (19). Although urbanization has promoted economic growth and higher living standards in the Gulf region, it is reported to have increased the prevalence of NCDs and NCD related risk factors (20). Urbanization has caused a shift in both the dietary intakes and lifestyle of populations, as they begin to incorporate a more “Westernised” diet and lifestyle that are usually high in fat and sugars, low in fibre and fresh F&V (21). Urbanisation may have also led to an overall sedentary lifestyle due

to increased use of cars and decreased levels of physical activity (PA) sport and regular exercise that have been associated with cheaper and easier access to travel and migrant working support to carry out many daily life activities (22). However, in the context of the Gulf countries, it has additionally unmasked this population's previously unrealized higher genetic propensity for these conditions (21). For example, when individuals of Middle Eastern descent living in Sweden were compared with the native national population, they were found to be two to three times more susceptible to type 2 DM (23). These genetic predispositions to obesity coupled with an obesogenic environment in the Gulf countries suggest the significance of incorporating tailored dietary approaches that may include genotype, phenotype or based on diet and lifestyle (2; 24).

WHO has estimated that CVD accounts for 71% of annual deaths in Kuwait (3). Kuwait is also within the top 3% of countries worldwide with the highest incidences of type 2 DM (25). Several methods to tackle the rise and development of NCDs in the Gulf countries have taken place, the goal being mainly to raise nutrition and lifestyle awareness at a national level. The Sultanate of Oman has adopted Health Vision 2050, an inter-sectoral partnership involving all departments of government in a programme to combat the emergence of obesity, type 2 DM and CVD (26). Similarly, Kuwait has responded to the obesity crisis by implementing the Kuwait National Programme for Healthy Living in 2013 (27). In addition to public awareness campaigns, Kuwait set up a national committee for the prevention of obesity, which aims to introduce healthy food into school canteens, educate pupils about nutrition and encourage sport (27). The Ministry of Health of the UAE formed a committee to develop a national strategy for reducing childhood obesity and DM by 2021 (28). Qatar also set up a national committee for nutrition and PA in 2011 that developed a 5-year plan (2011–2016) to reduce obesity and overweight by 1%, increase PA by 1%, increase fruit consumption by 10% and increase public awareness of nutrition and PA by 5% per year (29). The Kingdom of Bahrain has developed an "economic vision 2030", which stipulates a national policy framework of laws, directives and regulations to improve food and drink labelling, encourage healthy foods, completely stop the use of hydrogenated cooking oil and control of advertising and marketing of unhealthy foods and reduce sedentary lifestyle in adults by 10% to reduce obesity levels (30). The local and public initiatives for weight loss and adoption of healthier lifestyles in the Gulf countries are encouraging, yet more rigorous efforts by each Gulf country are needed to combat the rise of NCDs (21). A common misconception of public health programs is the assumption that presenting

facts based on clinical and epidemiological research to individuals is enough to promote desired health behaviours or that one health message can fit all types of audiences or set of circumstances (31). It has been proposed that a more personalised approach to dietary intervention strategies may be the key to tackling the prevention of NCDs.

1.4 Personalised nutrition and dietary improvement

It is becoming increasingly recognised that personalising information or tailoring messages for an individual can be more effective than presenting generic information in terms of engaging individuals, building their self-efficacy and improving health behaviours (32; 33). PN or dietary advice that is tailored towards an individual's specific nutritional needs is not a novel concept. Individuals distinguished by age or by a particular physiological status, for example, infants or pregnant women, have different dietary needs. Moreover, patients with allergies or chronic diseases, such as DM, hypertension or liver disease, require special diets. It follows that nutritional recommendations for the general population need further differentiation for specific subgroups. The aim of PN is to improve the overall dietary intake and health of the individual and may therefore utilise dietary intake, genotype, phenotype, and any additional individualised data to deliver more tailored nutritional advice (34). Personalisation in nutrition may also revolve around the individuals very personal and direct intentions based on elements such as likes and dislikes, needs, and current nutritional goals or health concerns. It was previously suggested that compared to generalised information, tailored information is more likely to be read, remembered and viewed as personally relevant (35). Moreover, it enables individualised feedback, commands greater attention, is processed more intensively, contains less redundant information, and is perceived more positively by health consumers (35; 36).

It is still unknown whether the method used to deliver the personalised advice may be a critical factor in ensuring successful dietary change. Currently, the two main methods utilised to deliver personalised dietary advice are via face-to-face consultations and online approaches (37). Results of face-to-face tailored dietary interventions have led to positive outcomes across a variety of responses, such as improving dietary outcomes, including increasing the intakes of F&V (38) and reducing intakes of fat (39). Furthermore, significant weight loss was achieved in personalised face-to-face dietary interventions to improve the overall dietary intakes of participants and increase physical activity

levels (PAL) (40). However, the feasibility of these face-to-face dietary consultations on a large scale to stimulate changes in diet and PA and help reduce the rising prevalence of obesity is limited. Face-to-face advice can be costly, may not be accessible to everyone, lacks anonymity and may also lead to participants loss of interest due to attendance associated burden (41; 42). Over the last two decades, increased focus has been given to web-based interventions that aim to improve the diet and lifestyle of individuals (43). Compared with tailored face-to-face advice, web-based tailored nutrition is more cost-effective and allows individuals to receive the dietary intervention required at home and therefore away from the usual clinical setting (44). According to the results of a meta-analysis that examined the effectiveness of online tailored nutrition interventions on the intakes of F&V, personalised dietary interventions were more effective at increasing the consumption of F&V compared to non-tailored web-based advice (45). Results of the meta-analysis also suggest that web-based tailored dietary advice is effective at improving F&V intakes in longer term (>40 weeks) trials compared to controls that received standardised advice (45). For weight, findings from a recent systematic review suggest that web-based weight-loss and weight maintenance interventions were found to be more effective than standardised controls that received usual care in the form of minimal in-person visits with a health practitioner or printed nutrition leaflets (46). However, results of the aforementioned review also reported mixed finding when comparing the web interventions to non-web-based nutrition interventions (usual care based on non-personalised advice) (46). These results suggest that personalised web-based nutrition interventions may be used as an alternative method to in-person dietary consultations to improve dietary intake of individuals. Given this information, research exploring the effectiveness of web-based PN advice that is given in an individualised setting is needed.

1.5 The use of applications to assist in assessing and delivering tailored dietary advice

Increased social media and Internet use comes hand in hand with increased technological advances around the world. To date, the world has seen a massive increase in Internet use of 1,052% since 2000, and it has been estimated that 94.8% of the UK population are Internet users (47). The Middle East has also experienced an increase in Internet use, and according to the latest statistics, 57.8% of the total population is using the Internet (47). In addition, the use of technology for promoting dietary change is a rapidly growing field of study. Interest in eHealth which is defined as the collective use of information technology and electronic communication in areas

relating to health, has risen concurrently with increased global internet usage (48; 49). Similarly, with increased global use of mobile devices, interest in mHealth which specifically focuses on using mobile communications and portable devices to deliver health advice has risen (50). eHealth aims to use web-based technologies in the form of applications and smartphones to improve the health of individuals (49). Results of a review that assessed the effectiveness of commercial dietary apps has indicated that none of the apps available to the public were capable of delivering PN advice and all used a food diary as a tool for dietary collection (51). For a dietary app to be valid it needs to include a reliable dietary assessment, collection and delivery system. Traditionally, the main methods used to collect dietary data used paper and pen formats that used either retrospective data collection methods such as 24-hour recalls and food frequency questionnaires (FFQ) or prospective methods of diet report in the form of a food diary (52). Compared to food diaries that require the entry of around three days of weighed food records, it has been suggested that in epidemiological trials, FFQs are less time consuming, easier to administer and give an overview of the subjects' diet over a longer time period (53). Nutrition apps allow for the digitalisation of dietary collection and assessment methods and according to data from a trial across three countries (New Zealand, Australia and the UK), nutrition apps are used by the majority of dietitians as sources for information and monitoring of clients (54). Such data emphasises the cumulative use of nutrition apps amongst nutrition professionals and individuals. Furthermore, the demand for more personalised health approaches has risen by consumers which has led to increased demands for novel technologies that provide effective tailored dietary assessment advice (49). Several trials have suggested that the use of tailored nutrition technologies may result in improved dietary changes and enhance intakes of selected nutrients and food groups, yet the strength of the outcome may vary and is influenced by factors such as type of feedback provided (2; 55; 56).

1.6 Aims and outline of the thesis

The current thesis was conducted to evaluate the effectiveness of delivering web-based PN compared to face-to-face PN in Kuwait. Initially, a novel automated, mobile responsive PN app (eNutri) was developed that was able to generate tailored feedback reports based on the top 3 dietary concerns of individuals, as well as individualised PA advice. To assess diet quality, a modified version of the Alternate Healthy Eating Index (m-AHEI) was used (13).

To ensure accurate assessment of dietary intake in the eNutri app, this thesis also aimed to develop and validate a novel web-based FFQ (EatWellQ8 FFQ) suitable for a Kuwaiti population. The EatWellQ8 FFQ was based on the validated Food4Me FFQ [57] and the well-validated European Prospective Investigation of Cancer (EPIC)-Norfolk FFQ (version CAMB/PQ/6/1205) [58] and a paper-form FFQ for Kuwait [59]. The FFQ validation study aims to ensure that the novel online FFQ can produce comparable results to the paper version of the current Kuwaiti FFQ and a 4-day weighed food record.

The EatWellQ8 FFQ was incorporated into the eNutri app, and used in the EatWellQ8 trial to investigate the efficacy of web-based PN advice compared to identical face-to-face PN advice and online population advice in Kuwait. The EatWellQ8 study was a 3-month, three-arm, randomized control trial which was designed to mimic a real-life web-based PN site (http://EatWellQ8.org) and a face-to-face PN service. The study aimed to answer the research question: "does web-based PN encourage individuals to follow a healthier diet and lifestyle when compared to face-to-face PN?". To address this question, participants in the study were randomised to one of the following study arms: (i) face-to-face PN on diet and PA group, (ii) web-based PN on diet and PA group or (iii) web-based non-personalised diet and PA control group. The primary outcome of the study was change in m-AHEI overall score and individual m-AHEI components between baseline and 12 weeks. The secondary outcomes included change in energy intakes, targeted nutrient intakes, PA and anthropometrics between baseline and 12 weeks which included obesity related measures (e.g. BMI).

The present thesis also aimed to compare the dietary intake of adults in Kuwait compared to the UK using baseline data from the EatWellQ8 trial and the EatWellUK trial which has also incorporated the eNutri system for the delivery of PN advice in a UK population. Similar to the EatWellQ8 trial, EatWellUK aimed to assess the delivery of online PN advice compared to generalised dietary advice in UK free-living adults.

It is hypothesised that:

- the online EatWellQ8 FFQ will be a useful dietary assessment tool for the collection of dietary intakes in Kuwait.
- the diet of Kuwaiti populations will be of a lower nutritional quality compared to UK populations.

- the delivery of web-based PN advice will result in comparable improvements in dietary change and weight loss as face-to-face PN recommendations in comparison to generalised nutrition advice delivered online in adults living in Kuwait.

1.7 Aims and outline of the thesis chapters:

Chapter 2: The objective of this chapter is to review current literature for the effectiveness of delivering web-based dietary and weight-loss advice and assess the effectiveness of online nutrition advice compared with face-to-face in adults.
It is hypothesised that web-based dietary advice is as effective at promoting healthy dietary changes compared to face-to-face nutritional advice.

Chapter 3: This chapter examines the accuracy of assessing dietary intake using an online FFQ developed to be used in the EatWellQ8 study. This chapter aims to validate the EatWellQ8 FFQ against a semi-quantitative paper-form of a FFQ and the gold standard 4-day weighed food record and to assess its reproducibility using test-retest methodology.
It is hypothesised that the EatWellQ8 FFQ will be a valid and accurate dietary tool for the assessment of energy, nutrient and dietary intake in Kuwait.

Chapter 4: This chapter aims to investigate the effectiveness of delivering PN web-based dietary advice compared to face-to-face PN advice using the web-based EatWellQ8 app in the EatWellQ8 trial.
It is hypothesised that web-based PN is as effective as face-to-face communication of identical PN advice and more effective than web-based general dietary recommendations in Kuwait.

Chapter 5: This chapter aims to describe and compare the baseline dietary data and characteristics of adults in Kuwait compared to UK adults using data collected from the EatWellQ8 FFQ and the EatWellUK FFQ and compare the dietary outcomes from both trials to current UK dietary recommendations.
It is hypothesised that compared to the UK population, the dietary intakes of adults living in Kuwait is higher in energy from fat, sugar, and salt and have, therefore, a lower overall nutritional quality compared to the UK diet.

Chapter 6: This chapter will discuss the results of the studies included in the thesis which relate to web-based PN, delivery and its overall effectiveness. Future research suggestions will also be addressed.

1.8 References

1. Griffiths F, Lindenmeyer A, Powell J et al. (2006) Why are health care interventions delivered over the internet? A systematic review of the published literature. JMIR 8(2), p.e10.

2. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2016) Effect of personalized nutrition on health-related behaviour change: evidence from the Food4me European randomized controlled trial. Int J Epidemiol 46, 578-588.

3. World Health Organization (2018) Noncommunicable diseases country profiles 2018. Geneva: World Health Organization Licence: CC BY-NC-SA 3.0 IGO, 223.

4. World Health Organization (2018) Preparing for the third meeting of the UN high-level meeting on NCDs and strengthening the role and contribution of the private sector: roundtable of selected CEOs and high-level executives of multinationals and independent global experts on NCDs: discussion paper:No. WHO/NMH/ADGO/18.97. World Health Organization.

5. Musaiger AO (2011) Overweight and obesity in eastern mediterranean region: prevalence and possible causes. J Obes 2011, 1-17.

6. Marmot M (2018) Diet, cancer, and NCD prevention. Lancet Oncol 19, 863-864.

7. Marmot M, Bell R (2019) Social determinants and non-communicable diseases: time for integrated action. BMJ 364, l251.

8. World Health Organization (2017) Noncommunicable diseases: progress monitor 2017.

9. Fallaize R, Livingstone K, Celis-Morales C et al. (2018) Association between diet-quality scores, adiposity, total cholesterol and markers of nutritional status in European adults: findings from the Food4Me study. Nutrients, 10, 49.

10. Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol 13, 3-9.

11. Lassale C, Gunter MJ, Romaguera D et al. (2016) Diet quality scores and prediction of all-cause, cardiovascular and cancer mortality in a pan-European cohort study. PLoS One 11, e0159025.

12. Guenther PM, Casavale KO, Reedy J et al. (2013) Update of the healthy eating index: HEI-2010. J Acad Nutr Diet 113, 569-580.

13. Chiuve SE, Fung TT, Rimm EB et al. (2012) Alternative Dietary Indices Both Strongly Predict Risk of Chronic Disease. J Nutr 142, 1009-1018.

14. Martínez-González MA, García-Arellano A, Toledo E et al. (2012) A 14-item Mediterranean diet assessment tool and obesity indexes among high-risk subjects: the PREDIMED trial. PlosOne 7, e43134.

15. van Lee L, Geelen A, van Huysduynen EJCH et al. (2012) The Dutch Healthy Diet index (DHD-index): an instrument to measure adherence to the Dutch Guidelines for a Healthy Diet. Nutr J 11(1), 49.

16. Panagiotakos DB, Pitsavos C, Arvaniti F et al. (2007) Adherence to the Mediterranean food pattern predicts the prevalence of hypertension, hypercholesterolemia, diabetes and obesity, among healthy adults; the accuracy of the MedDietScore. Prev Med 44, 335-340.

17. Swinburn BA, Sacks G, Hall KD et al. (2011) The global obesity pandemic: shaped by global drivers and local environments. Lancet 378, 804-814.

18. Crino M, Sacks G, Vandevijvere S et al. (2015) The influence on population weight gain and obesity of the macronutrient composition and energy density of the food supply. Curr Obes Rep 4, 1-10.

19. Alharthi FS, Alrahimi JS, Alotaibi AA et al. (2017) Prevalence of Undiagnosed Cardiovascular Risk Factors in Adults Aged 20-40: A Cross-Sectional Study in 2016 in Jeddah, Saudi Arabia. Cardiol Res 8, 111.

20. Allender S, Foster C, Hutchinson L et al. (2008) Quantification of urbanization in relation to chronic diseases in developing countries: a systematic review. J Urban Health 85, 938-951.

21. Ahmad MS, Ashrafian H, Alsaleh M et al. (2015) Role of metabolic phenotyping in understanding obesity and related conditions in Gulf Co-operation Council countries. Clin Obes 5, 302-311.

22. Monda KL, Gordon-Larsen P, Stevens J et al. (2007) China's transition: the effect of rapid urbanization on adult occupational physical activity. Soc Sci Med 64, 858-870.

23. Ahlqvist E, Ahluwalia TS, Groop L (2011) Genetics of type 2 diabetes. Clin Chem 57, 241-254.

24. Alzaman N, Ali A (2016) Obesity and diabetes mellitus in the Arab world. J Taibah Univ Med Sci 11, 301-309.

25. Atlas ID (2012) International Diabetes Federation (2012). ISBN 2930229853, 7.

26. Kumanyika S, Libman K, Garcia A (2013) Strategic action to combat the obesity epidemic. WISH 2013.

27. Behbehani K (2014) Kuwait National Programme for Healthy Living: first 5-year plan (2013-2017). Med Princ Pract 23, 32-42.

28. Thawani S (2014) United Arab Emirates journey towards excellence. ASQ, 1-10.

29. National Health Strategy (2014) National Health Strategy 2011-2016: Caring for the future. Supreme Council of Health, 1-61.

30. KINGDOM OF BAHRAIN MINISTRY OF HEALTH (2014) HEALTH IMPROVEMENT STRATEGY (2018 - 2015). https://wwwmohgovbh/Content/Files/Health_Improvement_Strategy(2015-2018)pdf, 1-50.

31. Sutton SM, Balch GI, Lefebvre RC (1995) Strategic questions for consumer-based health communications. Public Health Rep 110, 725.

32. Smeets T, Brug J, de Vries H (2006) Effects of tailoring health messages on physical activity. Health Educ Res 23, 402-413.

33. Kreuter MW, Wray RJ (2003) Tailored and targeted health communication: strategies for enhancing information relevance. Am J Health Behav 27, S227-S232.

34. Ordovas JM, Ferguson LR, Tai ES et al. (2018) Personalised nutrition and health. BMJ 361, k2173.

35. Brug J, Campbell M, van Assema P (1999) The application and impact of computer-generated personalized nutrition education: a review of the literature. Patient Educ Couns 36, 145-156.

36. Brug J, Oenema A, Campbell M (2003) Past, present, and future of computer-tailored nutrition education. Am J Clin Nutr 77, 1028S-1034S.

37. Fallaize R, Macready AL, Butler LT et al. (2015) The perceived impact of the National Health Service on personalised nutrition service delivery among the UK public. Br J Nutr 113, 1271-1279.

38. Maskarinec G, Chan CLY, Meng L et al. (1999) Exploring the Feasibility and Effects of a High-Fruit and -Vegetable Diet in Healthy Women. Cancer Epidemiol Biomarkers Prevent 8, 919-924.

39. Baron JA, Gleason R, Crowe B et al. (1990) Preliminary trial of the effect of general practice based nutritional advice. Br J Gen Pract 40, 137-141.

40. Brandt CJ, Brandt V, Pedersen M et al. (2014) Long-term effect of interactive online dietician weight loss advice in general practice (LIVA) protocol for a randomized controlled trial. Int J Family Med 2014, 1-6.

41. Harvey-Berino J, Pintauro S, Buzzell P et al. (2002) Does using the Internet facilitate the maintenance of weight loss? Int J Obes Rel Metab Dis: J I Assoc Stud Obes 26, 1254-1260.

42. Saperstein S, Atkinson N, Gold RJOr (2007) The impact of Internet use for weight loss. Obes Rev 8, 459-465.

43. Oenema A, Tan F, Brug J (2005) Short-term efficacy of a web-based computer-tailored nutrition intervention: Main Effects and Mediators. Ann Behav Med 29, 54-63.

44. Sherwood NE, Morton N, Jeffery RW et al. (1998) Consumer Preferences in Format and Type of Community-based Weight Control Programs. Am J Health Prom 13, 12-18.

45. Celis-Morales C, Abraham S, Keenan P et al. (2015) Effect of web-based tailored lifestyle interventions on fruit and vegetable consumption in adults: A systematic review and meta-analysis of randomised controlled trials. Proc Nutr Soc 74, (OCE1).

46. Sorgente A, Pietrabissa G, Manzoni GM et al. (2017) Web-based interventions for weight loss or weight loss maintenance in overweight and obese people: a systematic review of systematic reviews. JMIR 19, e229.

47. Miniwatts Marketing Group (2018) World Internet Users Statistics and 2018 World Population Stats. https://www.internetworldstats.com/stats.htm (accessed Nov 12 2018

48. Orlikoff JE, Totten MK (2000) Trustee workbook 4. Information, E-health, and the board: the brave new world of governance, Part 2. Trustee: J Hosp Govern Boards 53, 4p-4p.

49. Oosterveen E, Tzelepis F, Ashton L et al. (2017) A systematic review of eHealth behavioral interventions targeting smoking, nutrition, alcohol, physical activity and/or obesity for young adults. Prev Med 99, 197-206.

50. Akter S, Ray P (2010) mHealth-an ultimate platform to serve the unserved. Yearb Med Inform 19, 94-100.

51. Franco RZ, Fallaize R, Lovegrove JA et al. (2016) Popular nutrition-related mobile apps: a feature assessment. JMIR mHealth uHealth 4(3), e85.

52. Biro G, Hulshof K, Ovesen L et al. (2002) Selection of methodology to assess food intake. Eur J Clin Nutr 56, S25-32.

53. Margetts BM, Cade JE, Osmond C (1989) Comparison of a food frequency questionnaire with a diet record. Int J Epidemiol 18, 868-873.

54. Chen J, Lieffers J, Bauman A et al. (2017) The use of smartphone health apps and other mobile h ealth (mHealth) technologies in dietetic practice: a three country study. J Hum Nutr Diet 30, 439-452.

55. Kristal AR, Kolar AS, Fisher JL et al. (2014) Evaluation of web-based, self-administered, graphical food frequency questionnaire. J Acad Nutr Diet 114, 613-621.

56. Stumbo PJ (2013) New technology in dietary assessment: a review of digital methods in improving food record accuracy. Proc Nutr Soc 72, 70-76.

57. Fallaize R, Forster H, Macready AL et al. (2014) Online dietary intake estimation: Reproducibility and validity of the Food4Me food frequency questionnaire against a 4-day weighed food record. JMIR 16, e190.

58. Bohlscheid-Thomas S, Hoting I, Boeing H et al. (1997) Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the German part of the EPIC project. European Prospective Investigation into Cancer and Nutrition. Int J Epidemiol 26, S59.

59. Dehghan M, Al-Hamad N, McMillan CR et al. (2009) Comparison of a semi-quantitative food frequency questionnaire with 24-hour dietary recalls to assess dietary intake of adult Kuwaitis. SMJ 30, 159-161.

CHAPTER 2 A review of web-based and face-to-face dietary and weight loss interventions in adults

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2.1 Abstract

Prevention strategies for non-communicable diseases (NCDs) are a global priority as it has been estimated that NCDs will account for around 73% of worldwide mortality by the year 2020. The adoption of diets that are low in saturated fat, free sugars and higher in unsaturated fats, red and processed meats, wholegrains, fruit and vegetables have been shown to reduce the risk of NCDs. With increasing internet use, several nutrition interventions are now being conducted online as well as face-to-face, however it is unclear which delivery method is most effective. Interest in delivering web-based dietary and weight-loss advice has been rising, as internet delivery may be less costly. This review aims to assess the effectiveness of web-based and/or face-to-face dietary interventions, targeting specific dietary changes or weight loss on associated outcomes. In total, 48 peer-reviewed randomised controlled trials were identified and included following a literature review. The majority of face-to-face nutrition counselling interventions were successful at facilitating dietary change and weight loss, especially when combined with physical activity guidance. Web-based nutrition interventions results suggest that tailored web-based nutrition interventions may be successful at inducing short-term weight-loss and dietary change compared to standardised dietary interventions. Results of 6 trials that compared face-to-face with web-based nutrition interventions were inconsistent. Further controlled comparative studies and cost-benefit analysis are needed to assess whether web-based methods can be used as effectively as face-to-face interventions for consistent dietary change.

Key words: Face-to-Face nutrition, Personalised, Personalised nutrition, Web-based, Weight-loss, Dietary change

2.2 Introduction

According to the World Health Organization (WHO), minimal physical activity (PA), obesity and poor dietary habits are major risk factors for non-communicable diseases (NCDs), which include cardiovascular diseases (CVD), type 2 diabetes mellitus (DM) and several cancers (1). NCDs were responsible for around 89% of annual deaths in the UK and are the main cause of more than 2 million deaths annually in the European Union (1) . Similar findings are reported in the Middle East with greater than 60 % of annual deaths due to NCDs (2). The prevalence of obesity in the Middle East ranks among the highest in the world with approximately 80% of adults being reported as either overweight or obese (2).

A key global priority is prevention strategies for NCDs as they have been estimated to account for around 73% of worldwide mortality by 2020 (3). Given that obesity is a major risk factor for NCDs, the adoption of a healthy lifestyle that includes a balanced diet and increased PA is essential to reduce the risk of NCDs (4). Weight-loss strategies that are important for obesity reduction, can be achieved via several interventions such as diet and/or exercise (5). Furthermore, positive changes in both PA and diet may prevent an estimated 80 % of CVD and cerebrovascular disease (3).

Several studies have shown that the adoption of a diet that is relatively high in polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), potassium, fruit, vegetables; or moderately low in fat, saturated fatty acids (SFA), sodium and dietary cholesterol may reduce the development of certain cancers and CVD (6; 7; 8; 9). Despite public health campaigns, the public are still not adopting this type of eating pattern, therefore additional counsel and intervention methods are necessary. Dietary advice can be delivered in several ways via group or individual settings, over the phone, by text message, face-to-face with a dietitian/ nutritionist (in person or via video call) or online and can therefore be given verbally and or in written form. Dietary information is typically provided by registered dietitians (RD) or nutritionists in a nutritional counselling session or groups which involves the counsellor providing the client(s) with dietary advice that is tailored to the individuals' dietary needs whilst also facilitating behaviour change.

Following novel technological advances, methods of assessing dietary intakes and delivering dietary advice are replacing or supplementing obsolete written methods with

computerised, web-based and mobile methods (10; 11). Currently, most strategies used to either prevent or reduce obesity and CVD are based on standard public health recommendations and are therefore targeted at a population rather than personal level. For example, based on public overconsumption of salt and salt rich products, public health messages aim to decrease consumption of salt as a protective method against stroke and other CVDs (12). Nevertheless, more effective prevention strategies are necessary as NCDs continue to increase in number world-wide (3; 4; 13).

Personalised nutrition (PN) or nutrition that is tailored towards an individual's or specific groups' specific dietary requirements has been identified as an important component of effective dietary intervention (14; 15; 16). Recent work has focused on tailoring nutrition education based on physiological status or age, e.g. lactating mothers or infants (17), or diseases such as hypertension and type 2 DM (18; 19). PN may be more effective than general nutrition information as the advice is perceived as more personally relevant (20). A review by Contento and colleagues found that dietary change was successful when it was delivered in small-groups and/ or individual settings and that consumers tend to have a preference towards face-to-face nutrition that target behaviour change (21). In addition, face-to-face education has been shown to be effective in improving PA levels (22). However, face-to-face nutrition can be expensive, time consuming and may not be accessible to everyone (23). Interest in web-based health education messages has increased, as they are both cost-effective and accessible to the public. The use of web-responsive applications, websites or emails provide an alternative method to face-to-face nutrition counselling that can reach a larger population. Web-based PN may allow patients to receive the dietary intervention required at home and therefore away from the usual clinical setting (24). Recently, several studies have focused on tailoring online nutrition information in order to increase consumer awareness of nutrition and health (25; 26; 27). In a 2010 randomised clinical trial (RCT) that evaluated the effectiveness of tailored online interventions to improve fruits and vegetables (F&V) intakes of individuals across the United States, the authors found that tailored interventions were significantly more successful at increasing F&V intakes compared to non-tailored online interventions (25). More recently, the pan-European Food4Me study, which evaluated the efficacy of different levels of web-based PN compared with standard population-based dietary advice, also found that PN improved dietary intake significantly more than non-personalised advice (28). However, individuals worldwide are still consuming high saturated fat, high salt diets that are lacking in F&V (13). Given the differences in cost and reach between face-

to-face and web-based nutrition, it is useful to evaluate which method is more effective. Few trials have directly assessed the effectiveness of web-based nutrition compared with face-to-face nutrition. The purpose of this review is to assess evidence for the effectiveness of web-based and face-to-face dietary interventions on weight-loss and maintenance and dietary change.

2.3 Methods

This review focuses on weight-loss and dietary change trials delivered in person/face-to-face or via the web in adult populations. An extensive literature search was undertaken in PUBMED, Google Scholar and MEDLINE to identify the effect of communicating dietary advice (to change dietary habits) in face-to-face and web-based settings. Terms used in the searches were *face-to-face nutrition, nutrition interviews, weight-loss, dietary advice, web-based nutrition interventions, Online, one-to-one nutrition counselling, Online face-to-face nutrition, Online one-to-one nutrition, Internet nutrition advice, obesity, dietary changes and personalised nutrition*. All terms were paired for outcome measures (weight-loss and/or dietary change). Only articles that were written or translated into English were included in the search.

2.3.1 Study Selection

A total of 152 peer-reviewed and accepted manuscripts (from 1990-2017) reporting on RCT were identified, including one hand-searched manuscript, and 49 were included in the review after screening (see figure 2.1). Only randomised control trials (RCT) that reported original data on the effect of communicating dietary advice in a face-to-face setting and web-based nutrition interventions were included. Studies were excluded if the design trial was not a RCT, if the main focus of the trial was not dietary change or weight-loss and if non-diet related methods of weight-loss were used. Face-to-face nutrition interventions included studies that utilised either individualised (one-to-one) settings or nutrition advice delivered in group settings. The focus of this paper was on weight-loss and dietary change for the healthy and overweight/obese population, therefore, studies were excluded in people with eating disorders, pregnant women and if the goal of the intervention was for treatment of a specific medical condition, with the exception of disorders with asymptomatic risk factors such as hypertension, hypercholesterolemia or impaired glucose tolerance.

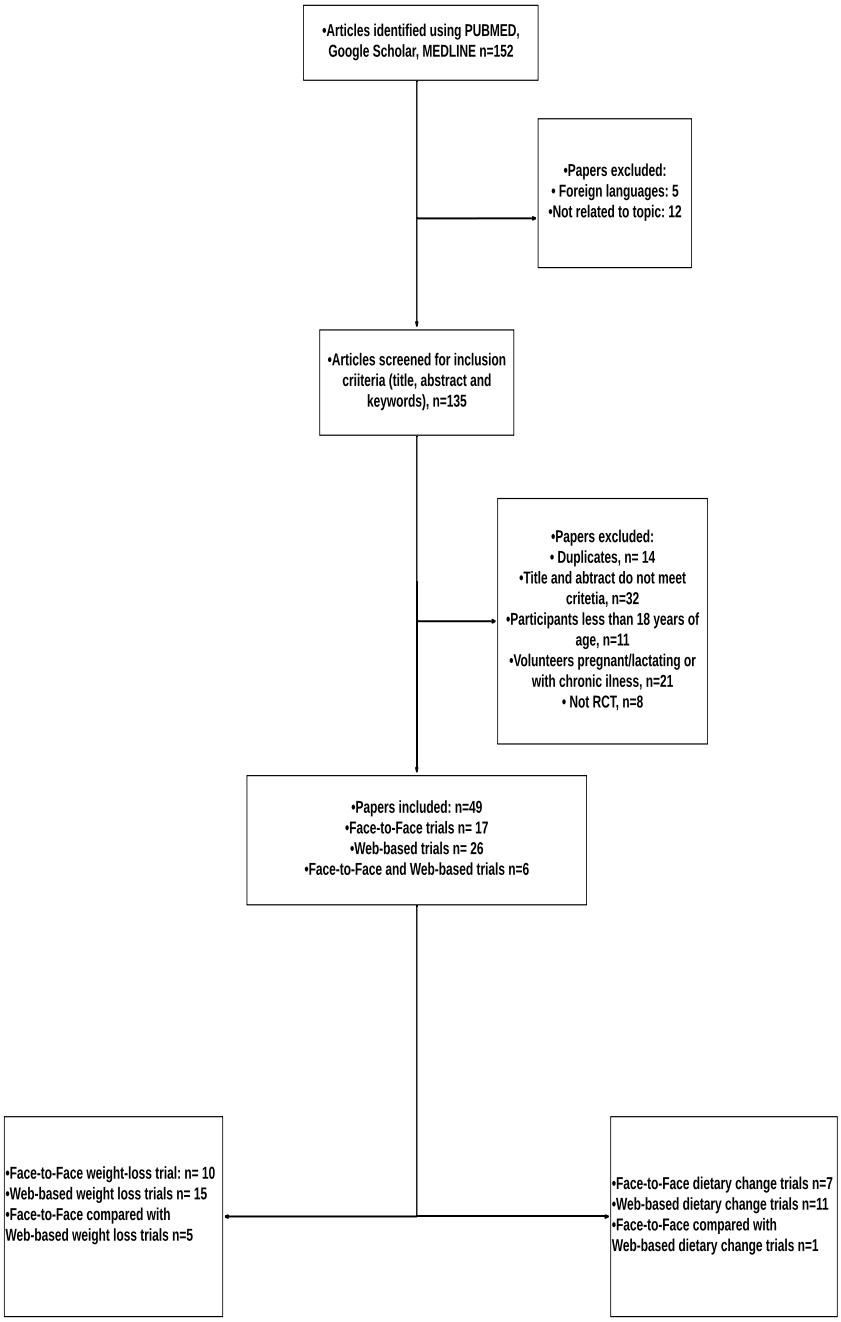

Figure 2. 1**.** Flow chart of the search process

2.4 Results

Of the 49 articles identified (Tables 2.1-2.4), thirty RCT focused on weight-loss (face-to-face, n=10; web-based, n=15; face-to-face vs. web-based, n=5) and nineteen RCT focused on dietary change (face-to-face, n=7; web-based, n=11; face-to-face vs. web-based, n=1).

2.4.1 Weight-loss interventions

2.4.2 Face-to-Face weight-loss interventions

In total, 10 face-to-face trials focusing on weight loss were identified (9 long term: >6 months, 1 short-term: 3-months) (table 2.1). Face-to-face interventions that used a combined approach (e.g. diet and exercise) appeared more effective than those that focused on diet alone, although not all resulted in significant weight-loss (29; 30; 31; 32; 33). Frequency and timing of weight loss consultations with RD/ a trained specialist appeared to impact directly on the success of weight loss programmes (34; 35; 36; 37; 38).

Significant weight-loss was achieved in 3 trials (2 long-term, 1 short-term) that assessed the effectiveness of diet and exercise on obese adults (29; 31; 32). Vissers et al. assessed the effectiveness of calorie restriction and exercise based on whole body vibration (WBV) on obese adults. A group of 79 participants were randomised into either: a diet only group, combined diet and exercise group, diet and WBV group or a control group. With the exception of the control group, weight decreased significantly in all three intervention groups at month 12 (diet only group -4.3kg diet and exercise group -6.6kg, diet and WBV group -2.9kg. In addition, participants in the exercise group and the combined diet and WBV group were able to maintain a weight-loss of 5% at 12 months (29). Research by Villareal et al. compared the effectiveness of a diet only intervention compared to diet and exercise in 107 obese adults aged 65 or older. Participants were randomly allocated to either: a diet group, exercise group, combined diet and exercise or a control group which received general nutrition information from practitioners during monthly follow-up sessions for a 12-month period. Participants in the diet only group and the diet and exercise group achieved significant weight-loss compared to baseline values (diet only group -9.7kg, diet and exercise group -8.6kg). The exercise only and control groups did not achieve significant weight change (31). A 3-month trial by Ross et al. on 52 obese men that compared the efficacy of diet only

weight-loss to diet and exercise weight-loss had similar findings. Volunteers were assigned to four groups; diet group, exercise with diet group, exercise group and control group. Body weight decreased significantly (-7.5kg) in both diet and exercise and diet groups but did not change in the exercise and control groups (32).

Results of 2 long term weight-loss plans followed by weight maintenance interventions suggest that face-to-face diet interventions are successful at weight-loss but not at weight-maintenance (30; 33). Subjects were randomised to either a diet, hybrid (diet + exercise), exercise only or a wait-list control group (30). Following the weight-loss period, non-significant differences were found between the groups, although greater weight-loss was achieved in the combined exercise and diet groups. All groups regained weight at the end of the trial, and greater weight gain was found in the diet only groups. Groups that included exercise were better able to maintain the weight loss (30; 33).

Results of 3 long-term trials have shown that continuous face-to-face dietary counselling increases the success of weight-loss maintenance (35; 36; 38). Research by Hakala et al. compared the efficacy of PN weight-loss compared to group sessions on 60 obese subjects in a 5 year follow up trial. Participants were randomly assigned to a PN group that received weight loss counselling with a RD followed by follow-up with a physician for two years or to group counselling for two years. Results of the trial has shown rapid weight-loss in group counselling but a more continuous effect was seen in the PN weight loss group (38). A 24-month trial by Yeh et al. showed that one-to-one dietary counselling with a RD was more effective than a skill-based intervention on achieving and maintaining weight-loss in a group of 80 overweight/obese women. The skill-based intervention group received RD guided visits to a supermarket and received 2 hours of PN advice with a RD and the controls received dietary counselling sessions. Although both groups lost significant weight compared to baseline, the one-to-one dietary counselling group lost more weight and both groups were able to maintain weight-loss at 24 months follow up (35). Similarly, a two year trial on 65 obese/overweight men by Heshka et al. has shown that weight-loss was significantly greater in the commercial group (-4.3kg) compared to the self-help group (-1.3kg) at 1 a 1 year follow up (36). The trial aimed to examine the effectiveness of a self-help intervention that received two consultations with a RD at baseline and week 12 to a commercial intervention that received vouchers to weight-loss programs such as weight watchers and weekly group meetings with a trained specialist.

Two long-term trials looked at the effectiveness of group based weight-loss sessions on obese individuals found comparable results (34; 37). An 18-month long trial evaluated the effectiveness of a low-fat Mediterranean diet to a low-fat standard weight-loss diet on 101 overweight participants. All subjects attended 1 weekly group sessions with a RD. The Mediterranean diet group lost significantly more weight (-4.1kg) at the end of the trial compared to the low-fat diet group (+2.9kg) (34). A possible reason for this weight gain in the low-fat diet group may be due to the diet being more restrictive when compared to the Mediterranean that offered a wider variety of food choices. A 12-month trial by Silva et al. evaluated the effectiveness of self-determination theory on PA and weight control in 239 obese/overweight women that were randomised to an intervention group which received 30 group sessions with a practitioner on PA and nutrition related topics that were self-motivated. The control group participants received 29 group standard health care sessions. At 12-months intervention group participants lost significantly more weight (-5.6kg) compared to controls (-1.5kg) (37).

2.4.3 Web-based weight loss interventions

Results of 15 reviewed articles (11 long-term: >6-months and 4 short term: 12-14 weeks) that assessed the effectiveness of web-based weight-loss interventions are summarised in Table 2.2. PN web-based interventions that assessed the effectiveness of a PN program to a generalised weight-loss site found that personalisation in web-based weight-loss programs is more effective than generalised weight loss information (39; 40; 41; 42; 43; 44). Non-significant differences in weight-loss were found in the trials that compared web-based weight-loss programs to paper-based weight loss tools (45; 46).

Gold et al. compared the effectiveness of using VTrim to eDiets.com. A total of 124 participants were randomly assigned to a 12 months VTrim intervention or eDiets.com control groups. Subjects in the VTrim group received a 6-month PN web-based weight loss program followed by a 6-month on-line weight maintenance program. Participants in the eDiets group received calorie-controlled diets based on PN preferences. At 6 months, significantly more weight-loss was reported amongst participants in the VTrim intervention group (-8.3kg) than the eDiets.com group (-4.1kg) and more of the VTrim participants were able to maintain a 5 % weight-loss at 12-months (39). Comparable results were found in a 6-month trial by Tate et al. that assessed the effectiveness of a web-based behaviour intervention to a general internet weight loss education in overweight subjects (n=91). All participants were given internet weight-loss resources

but only the web-based group were required to submit their weekly food journals to a therapist and received weekly PN feedback reports. Results of the study showed that web-based behaviour participants lost significantly more weight (-4.0kg) than general internet education participants (-1.7kg) at 12-weeks (*P*=0.05). Groups maintained weight-loss between 3 and 6 months (42). A 12-week trial by Collins et al. on 309 obese adults assessed the efficacy of an enhanced web-based weight-loss program to a basic internet website and a control group. Subjects in the enhanced group received PN reports and feedback, the basic group received access to a standard weight-loss site whilst the controls did not receive any intervention. Both groups lost significant weight compared to controls at the end of the trial (43).

Results of three 6-month long trials indicated that the utilisation of a web-based program results in significant weight-loss (40; 41; 44). Ashwell et al. examined the effectiveness of an online weight-loss program to a generalised online weight-loss program, whereby overweight and obese volunteers (n=180) were randomised to either the intervention group which offered PN diet plans to the participants or to the control group that were given access to a general weight-loss site. Results of the trial indicated that there was a significant reduction in weight from baseline in the intervention group participants (-2.5kg) compared to control group (-1.3kg) (*P*=0.013) (40). Research by Rothert et al. assessed the effectiveness of a PN web-based weight-loss program (Balance) to an online general weight loss program. A total of 2862 overweight/obese volunteers participated in the 6-month trial and were randomised to the intervention groups. Balance group participants received online PN plans and follow up emails to reinforce dietary and PA habits. The control group received online general nutrition information. Results of the study indicated significant weight-loss in the Balance group participants compared to the online general information group (41). A 6-month pilot study compared the efficacy of a web-based weight management program with/without the provision of a smart scale. Obese/overweight participants (n=92) were randomised to the intervention group that received a smart scale and access to a Weight-Watchers site or to a control group that were provided access to Weight-Watchers site. The intervention group also received weekly PN feedback emails and were asked to weigh and provide their weight frequently. Results of the trial has shown that both groups lost significant weight and results did not differ between groups (44).

Comparable results were achieved by 5 trials that compared PN web-based interventions to controls that received no intervention (47; 48; 49; 50; 51). A 14-week trial by Naimark et al assessed the effectiveness of a web-based app (eBalance) at enhancing the diet and lifestyle of individuals. A total of 85 volunteers were randomised into the eBalance group or the control group. All participants were required to attend a face-to-face seminar about the benefits of following a healthy lifestyle and diet. eBalance were given access to the app where they were given the flexibility to choose their own diet and lifestyle goals and were encouraged to log in as much as desired. The intervention group also received feedback about their diet and goals. At 14-week follow-up, eBalance participants lost significantly more weight compared to controls (47). A 12-week trial compared the efficacy of a web-based weight-loss trial with frequent log in to controls that received no intervention in 100 overweight/obese volunteers. Web-based group lost significantly more weight at the end of the trial compared to controls (50). Similarly, the 14-week Work Place Power study, assessed the effectiveness of a weight-loss website on 110 overweight/obese men that were randomised to either the intervention or a control group. The intervention group was asked to enter weight weekly and to submit online food and exercise diaries. Controls received no intervention. Intervention group lost significantly more weight (-4.0kg) at the end of the trial compared to controls (+0.3kg) (P<0.001) (49). A 6-month trial has shown that automated web-based feedback produces similar results to human e-mail counselling feedback compared to controls that received no intervention (51). Significant weight-loss was also achieved in the longest-term (38-weeks) trial by Balk-Moller et al., which assessed the effectiveness of a web-based program to promote weight-loss and a healthy lifestyle. A total of 269 participants were randomised to the SOSU life intervention group or to a control group. SOSU life intervention participants received PN feedback via email and text messages about diet and health. Control group participants received no intervention. At week 38, intervention group lost significantly more weight, compared to the control group (48).

Findings of 2 trials that assessed web-based weight-loss to paper resources resulted in weight-loss, but the differences in weight change between the web-based and paper resource groups were non-significant (45; 46). However, Blomfield et al. did show a significance difference in weight-loss in the web-based intervention compared to control group and to baseline values at 6-months (45). These results were similar to the findings of a 6-month study that compared a PN web-based weight-loss intervention to phone counselling and to controls that received a self-help paper resource (52).

Intervention groups lost comparable weight when compared to controls (P<0.001) (52). Results of a 12-month trial has shown that a paper resource (LEARN) resulted in significantly more weight-loss when compared to a web-based program (53) . However, the this may be due to the small sample size (n=47) which may have lowered the power of the trial.

2.4.4 Comparison of web-based with face-to-face intervention for weight-loss

Inconsistent results were found in 5 trials (2 long-term: >6 months and 3 short-term: 12-weeks) that compared face-to-face with web-based weight loss interventions (54; 55; 56; 57; 58). Results of three 12-week long trials indicated no difference between face-to-face and web-based interventions (54; 55; 58) and a 6-month trial indicated face-to-face to be better than a web-based intervention (56). A 12-week weight-loss trial by Bennett et al. in obese/hypertensive subjects (n=101) found that a PN web-based weight-loss plan was no more effective than usual care controls. The PN web-based group received access to a website and were encouraged to login frequently and the usual care participants received the standard care offered at the outpatient practice from health care practitioners. Weight-loss achieved in the two groups was not statistically different (55). A 12-week trial by Chambliss et al. assessed the efficacy of a web-based program with PN feedback from a health educator to a web-based program with automated feedback. In total, 120 overweight participants were randomised to the intervention groups or to a control that received no intervention. Significant weight-loss was found in both intervention groups compared to controls at the end of the trial (54). Similar findings were found in a short-term study by McDoniel et al. (58). In total, 111 participants were randomised to a web-based + PN counselling group or to a usual care group that received PN counselling. Results of the trial indicated significant weight change in the intervention group compared to baseline values, however, non-significant differences were found between the groups (58). Research by Harvey-Berino et al. assessed whether the effectiveness of a web-based behavioural weight-loss program is improved with the addition of face-to-face sessions in a 6-month long trial. A total of 481 participants were randomised to an Internet, face-to-face group or a combined intervention group. The combined intervention group received access to the internet site and met once a month in a group session. Weight-loss in the face-to-face group was significantly higher than internet and combined groups. In addition, the percentage of participants in the face-to-face group that achieved a 7% weight loss was significantly higher than Internet and combined intervention groups (56).

Results of the REFIT 6-month trial indicated that a combined face-to-face and web-based intervention was more effective than a 'Wait-list' control group. 107 male participants were randomised to the REFIT intervention group or a wait-list control group. REFIT participants received two 1-hour face-to-face group sessions with a public health trainee, which was followed by weekly interactive online contact for the first three months, followed by monthly online contact. Wait-list participants were asked to attend one face-to-face group session and received a feedback report but no treatment was provided. It was found that weight-loss was significantly higher in the REFIT group at 6 months compared to controls (P<0.001) (57).

2.4.5 Dietary change results

2.4.6 Face-to-face interventions and dietary change

Results of 6 long-term (>6 months) face-to-face trials (Table 2.3) that assessed the effectiveness of face-to-face dietary counselling on dietary change demonstrated that face-to-face dietary counselling may be effective at improving dietary intake. Only 1 long-term trial compared face-to-face dietary change to a computer based program showed that face-to-face was more effective at improving dietary change (59) (Table 2.3).

Results of 3 long-term trials indicated significant dietary change in face-to-face interventions compared to control groups. A 6-month trial that examined the impact of a lifestyle-modification intervention on 348 volunteers has shown that participants in the intervention group that received 40 hours of diet and lifestyle group sessions with an RD had significantly improved nearly all nutrition and PA variables with the exception of servings from whole grains and protein calories compared to baseline levels. Intervention participants also lost significant weight compared to baseline weight and compared to controls that received no intervention (60). A 12-month intervention trial by Baron et al. examined the effectiveness of a PN vs group nutrition intervention that aimed at reducing blood lipid levels. A total of 368 subjects were randomly allocated to either a dietary intervention group or a control group. Participants in the intervention group were given dietary advice by a Registered Nurse either in a face-to-face PN setting or in a group setting. Results of the trial indicated that the diet group participants reported increased intakes of fibre, PUFA and decreased intake of

SFA, whilst minimal changes were reported in the control group. Differences between groups were statistically significant (61). Results of a trial by Maskarinec et al. have shown that face-to face dietary counselling may enhance dietary F&V intake. A group of 29 women were chosen for the 6-month trial and were randomly allocated to either an intervention group or a control group. Participants in the intervention group received PN counselling sessions to increase F&V intakes. General dietary recommendations were provided to the control group participants. Intervention group participants increased their F&V intake at the end of the trial compared to control participants (P<0.001) (62).

Results of 2 long-term trials that focused on lowering dietary fat intakes resulted in non-significant results. A 12-month trial by Roderick et al. assessed the effectiveness of face-to-face dietary advice to generalised health information on dietary intake and weight. A total of 956 participants were randomly assigned to either a face-to-face dietary advice intervention or a usual care intervention. At the end of the trial, intervention group had lower intakes of SFA and dietary fat and lower mean serum cholesterol compared to controls, however these improvements were not statistically significant between the groups (63). Similarly, an 18-month trial by Coates et al. compared the effectiveness of low-fat diets among 208 postmenopausal women that were randomly assigned to a low-fat intervention group or a control group. Participants in the intervention group were required to attend group sessions with a nutritionist. At 6 months, the intervention group participants decreased their percentage of daily dietary fat intake but this change was non-significant. In addition, intakes of F&V were increased but no change was seen for wholegrain foods and similar results were seen at 12 and 18 months of the trial which may indicate self-reported bias by participants (64). Results of a 12-month trial that compared individualised behavioural nutrition counselling to controls that received brief nutrition counselling at improving F&V intakes in 271 low-income adults has indicated significantly increased F&V intakes in the individualised group (65). However, all F&V intake was based on self-report and participants received only two dietary consultations during the whole trial period (at baseline and week-2) that were restricted to 15 minutes which may have impacted trial outcomes (65).

2.4.7 Web-based interventions and dietary change

Results of 11 trials (6 long term >6-months, 5 short term, 3-16 weeks) that assessed the effectiveness of web-based interventions to improve dietary change were consistent, indicating that web-based programs induce positive dietary changes (Table 2.4). Significant improvements in dietary fat intake were found in 9 web-based trials that compared Internet dietary interventions with a control treatment group (66; 67; 68; 69; 70; 71; 72; 73; 74).

Two trials that examined the effectiveness of the Nutrition for a Lifetime System (NLS) web-based program, found comparable results (68; 73). The first 6 month trial by Anderson et al. compared the impact of a web-based intervention on the food choices made by supermarket shoppers (68). Participants (n=277) were randomly assigned to either a web-based intervention group that received the NLS web-based program or a no-treatment control group. At 6-months, participants in the intervention group decreased their fat intake from baseline and significantly increased their intakes of F&V and fibre (68). Similar findings were achieved in a trial by Winett et al. that examined the effectiveness of the NLS. Participants (n=127) were randomly assigned to either the NLS or a control group for 10-weeks and were asked to complete the NLS computer program at baseline. Participants in the NLS group significantly reduced their fat intake and increased their intakes of fibre, F&V compared to control group participants (P<0.001) (73) .

Results of the Food4Me 7 country 6-month long trial have suggested that web-based PN regardless of the level of personalisation is more effective at enhancing dietary change compared to controls that received standardised dietary advice (74). Participants (n=1269) were randomised to PN dietary advice, PN dietary advice + phenotype, PN dietary advice + phenotype + genotype or to a generalised dietary advice control group. At 6 months, participants in the PN groups had significantly lower intakes of red and processed meat (8.5%), salt (6.3%), daily energy intakes (4.4%) and significantly improved their overall Healthy Eating Index (HEI) (2.6%) scores compared to participants in the control group P<0.05 (74).

Results of 3 long-term web-based dietary change trials indicated that PN web-based interventions can result in significant dietary change when compared to controls (25; 66; 67). Results of a 12-month long trial on 2540 volunteers that compared two PN web-

based interventions; PN intervention, PN +motivational e-mail counselling intervention to a non-tailored intervention control group, indicated that the PN intervention with motivational counselling resulted in significantly greater F&V intakes (2.8 servings/day) when compared to controls (2 servings/day) (*P*=0.05). All groups increased F&V intakes significantly at the end of the trial compared to baseline values (25). A 6-month dietary intervention study by Delichatsios et al. examined the effectiveness of a web-based PN program that aimed at improving several aspects of diet quality. Adults (n=298) were randomised to either the intervention group that received weekly sessions with a computer automated voice program or the control group that received web-based PA information. At 6 months, intervention group participants increased intakes of fruit and fibre and significantly decreased daily SFA compared to controls (67). A 6-month trial by Vandelanotte et al. that compared a PN web-based dietary change intervention to a wait-list control produced similar results. Participants (n=771) were randomly assigned to four groups; the first group received PA and fat intake information at baseline, second group received PA information at baseline and fat intake information at 3 months, group 3 received at baseline the fat intake information and PA information at 3 months or a group 4 wait-list control group. All intervention groups significantly increased their PA scores, and reduced fat intakes when compared to control group participants (66) .

Results of 5 short-term web-based dietary change trials indicated significant differences between intervention and control groups (69; 70; 71; 72; 75). A 12-week trial by Brug et al. examined the effectiveness of a PN web-based intervention on total fat and F&V intakes. Participants (n=347) were randomised to the tailored intervention group, that received online feedback based on their dietary intakes, or a non-tailored control group that received generalised nutrition related information. Participants in the tailored group significantly decreased their fat score by 9% compared to baseline levels and to the control group (*P*<0.01). However, fruit consumption in the tailored group remained similar to baseline (69). A 12-week trial by Irvine et al. evaluated the effectiveness of a PN interactive computer-based program on the dietary intake of individuals. Participants (n=517) were randomised to either an intervention or control group. After 1 month, the intervention group significantly reduced their fat intake and increased their F&V intakes compared to controls. Furthermore, the intervention group maintained these dietary changes after a 60-day follow up (70). An 8-week-long trial assessed the efficacy of web-based dietary change programs to improve the dietary intake of 481 low-income women. Subjects were allocated to a web-based group, web-

based + phone-calls with researcher group or a non-diet related control group. Results of the trial indicated F&V intakes increased in both groups compared to controls which reached borderline significance (*P*=0.05) (75). Research by Oenema et al. studied the effectiveness of a short-term computer tailored nutrition intervention that aimed at improving dietary awareness. A total of 782 subjects were randomly assigned to a PN intervention group or a general nutrition control group or a control group that did not receive any information for a 3-week period. The intervention group significantly increased their awareness of the benefits of consuming a diet high in F&V and low in fat compared to the control groups (71). Comparable results were found in a 4-month trial by Stevens et al. that examined the effectiveness of a web-based intervention to improve dietary intake compared to controls. A total of 616 women were randomised to either the intervention group that received access to a web-based PN program in addition to two counselling sessions or a control that received non-diet related information. At the end of the trial, intervention group significantly increased F&V intake and decreased fat intake compared to controls (*P*<0.001) (72).

2.4.8 Face-to-face compared with web-based dietary intervention

A 6-month pilot study by Carpenter et al. examined how effective a group delivered cognitive and behavioural intervention is on dietary change. A total of 98 volunteers were randomised to a weekly meeting group, a correspondent group or a control group. Weekly meeting group met with a counsellor once/week for the first 16 weeks and bi weekly for the remaining 8 weeks. Correspondent group received weekly emails and had access to a general website about dietary change. The control group also received access to the site. At the end of the trial, the weekly meeting group had significantly increased their modified healthy index score compared to correspondent (*P*=0.04) and control groups (*P*= 0.02) (59).

2.5 Discussion

The interventions reviewed were difficult to compare as they varied considerably in sample size, duration, study design and contact with participants. Results of the face-to-face nutrition intervention trials indicated that frequent face-to-face nutrition counselling was effective at achieving and maintaining weight-loss in both individualised and group face-to-face sessions. Weight-loss was also achieved and sustained in face-to-face trials that had a combined approach of both counselling and exercise programs in which significantly greater weight-loss was achieved in the hybrid groups compared to the diet only or exercise only groups (29; 30; 31). A potential reason for this is that participants were motivated to comply with a diet regimen only under the supervision of a counsellor whilst exercise may have acted as a self-motivating behaviour for some participants (76). This supports the findings in a systemic review by Avenell et al. which reported that a combination of diet and behaviour therapy and exercise was associated with long-term weight-loss for up to 36 months (77). Results of the systematic review have also shown that a hybrid approach of diet and exercise in long-term trials resulted in significant long-term weight-loss of up to 18 months compared to diet only interventions (77). Results of the present review have also shown that face-to-face dietary counselling was found to be more effective at inducing targeted dietary change compared to controls especially when the intervention was individualised. These results are in line with a recent systematic review of 26 RCT by Mitchell et al. that assessed the effectiveness of individualised dietary consultations in primary health care, out of which 18 trials have demonstrated significant improvements in either anthropometrical outcomes (including weight change) and dietary change including increased fibre, calcium, improvements in salt and fat intakes compared to comparator groups (78). However, a number of limitations were found in the reviewed face-to-face trials which included small sample size for a long-term trial (29; 31; 33), low number of participants in each group which may have underpowered the study (32), control group received no intervention during trial period (30), low adherence rates and high attrition rates (29; 32; 33).

Results of the trials that assessed the efficacy of web-based weight-loss suggested that web-based weight-loss programs were effective at reducing weight especially during the first few weeks (12-16 weeks) but were not as effective at maintaining weight-loss longer-term(39; 40; 41; 42; 47; 51; 54). When face-to-face interventions were compared with web-based interventions, inconsistent results were found (54; 55; 56; 57; 58).

Outcomes from a recent systematic review of 20 systematic weight-loss or weight maintenance reviews by Sorgente et al. have suggested otherwise (79). Results from the systematic review have shown that web-based weight maintenance trials were more effective at weight-loss in comparison to web-based control groups but less effective than non web-based (face-to-face) interventions (79). However, limitations of the systematic review by Sorgente et al. included an overlap of articles in the systematic reviews and that the majority of reviews focused on weight-loss and not on weight maintenance, which may have compromised the efficacy of the results (79). Moreover, similar to previous reviews that compared web-based PN advice to commercial web-based weight-loss programs and to controls that received minimal or no advice, tailored/enhanced web-based programs were found to be more effective at reducing weight (79; 80; 81; 82). According to a systematic review and meta-analysis of 12 web-based weight-loss interventions that provided PN feedback, the addition of PN weight-loss feedback may further enhance the effectiveness of internet delivered behaviour change technique (80). When it came to the delivery of web-based dietary advice, results of the reviewed trials have suggested that enhanced web-based dietary advice is more effective at improving dietary change, especially consumption of F&V compared to generalised controls. This finding was supported further in a systematic review and meta-analysis of 13 RCT by Celis-Morales et al. that assessed the effectiveness of web-based dietary interventions at enhancing F&V intakes (83). Results of the systematic review have suggested that tailored web-based nutrition interventions were more effective at improving F&V intakes compared to non-tailored interventions (83). Findings from the reviewed trials also suggested that frequency of login was correlated with weight-loss, as weight regain occurred with decreased usage of the web-based programs (39; 40; 42; 47; 53; 57). Similarly, results from two systemic reviews by Sherrington et al (80) and Neve et al (84) and a trial by Vandelanotte et al. on PA which reported better outcomes when participants visited the web-based program more than 5 times (85). However, a problem with web-based interventions is high self-reported bias which is due to reliance on self-reported weight (80). In addition, most of the web-based weight-loss trials reported high attrition rates, previously reported to be common in web-based weight loss interventions (47).

A number of limitations of the present review should be acknowledged. First, there were differences in the trial designs and a few studies lacked a description of what the control group received during the intervention. Moreover, during the review process, it was difficult to determine whether the trials were conducted over the web (using a

computer) or delivered on a computer based application as there was no clear definitions used. The lack of detailed descriptions of the type of face-to-face dietary counselling provided e.g. consultation with a health practitioner was a limitation as well as minimal information about the type of usual care provided to control group participants in several trials. It was also difficult to compare the overall effect between the trials as they differed in design. In addition, the male: female ratio was not equal as most studies were carried out in women, calling for future trials to target men. As all of the included trials were diet related and therefore based on self-report, this may question the validity of the dietary intake information provided and outcome measures.

Findings from the present review have suggested that personalisation may enhance weight-loss and dietary change in both web-based and face-to-face interventions. However, most of the reviewed articles were short-term, therefore future reviews should focus on assessing long-term articles. In addition, most of the previous reviews focused on web-based weight-loss and only one has examined dietary change (83) signifying the need for more reviews that specifically target web-based dietary change. Moreover, limited work has focused on comparing the delivery of face-to-face and web-based dietary interventions, and more comparative trials are needed to demonstrate the strengths and weaknesses of each strategy. Face-to-face trials that targeted dietary change and/or weight-loss in specific population groups were successful at achieving weight-loss and/or dietary change; however, face-to-face consultation is costly and is not generally available to the public (31; 37; 64). There still remains insufficient evidence to suggest that web-based nutrition interventions are as effective as face-to-face interventions, therefore, further controlled comparative studies and cost-benefit analysis are needed.

2.6 Conclusion

Findings from web-based nutrition interventions and their impact on weight-loss and dietary change suggest that tailored/enhanced web-based nutrition interventions may be successful at inducing short-term weight-loss and dietary change compared to standardised dietary interventions. Face-to-face nutrition interventions were successful at enhancing both weight-loss and dietary change.

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Table 2. 1 Face-to-face weight-loss randomised controlled trials

Author	Participant number (n) and study characteristics	Outcome(s)	Study findings
Skender et al.1996(30)	n =127 (Diet; n=42, Exercise; n=43, Combined; n=42, C; n=38) 1-year trial with a 1-year follow-up period examining the effectiveness of three weight-loss interventions; Diet only, Diet and Exercise, Exercise only.	Weight-loss (Kg): diet group lost -6.8 vs -8.9 in combined group and -2.9 in exercise group	At 1-year follow-up, non-significant reduction in weight across all intervention groups compared to baseline values (*P*=0.09). Weight loss data not available for C group.
Silva et al. 2010(37)	n= 239 (I group; n=123, C; n=118) 1-year trial to assess the impact of a weight management intervention based on self-determination theory, body weight and PA	Weight-loss (Kg): I group lost -5.6 compared to -1.5 kg in the C group	At 1-year follow-up, significant reduction in weight was found between the I group and the C group P<0.001
Vissers et al. 2010(29)	n =79 (Diet; n=20, Combined; n=20, WBV; n = 18, C; n=21) 12–month trial assessing the effectiveness of calorie restriction and whole-body vibration (WBV) on obese adults.	Weight-loss (Kg): diet group lost -4.3 vs -6.6 in combined group and -9.9 in WBV group	At 12-month follow-up, weight significantly decreased in all intervention groups compared to baseline weight. Diet group P=0.009, Combined group P<0.004 and WBV group P<0.001. No change in weight observed for C group.
Yeh et al. 2003(35)	n=80 (Skill based Intervention (SBI); n=40, Diet/control group; n=40) 24 months trial assessing the efficacy of a skill-based intervention to office-based nutrition counselling	Weight-loss (Kg): At 6 mo., SBI group lost -4.0 compared to -1.7 in Diet group. At 24 months SBI lost -1.1 and Diet group lost -0.59.	At 6 months both SBI and Diet groups had statistically significant decreases in weight compared to their baseline levels P<0.05. Both SBI and Diet groups maintained weight losses at 24 months but the differences were not statistically significant.

McManus et al. 2001(34)	n=101 (Mediterranean diet group; n=51, Low fat diet group; n=50) 18-month trial to assess a diet moderate in fat based on the Mediterranean diet compared to a low-fat diet on weight-loss	Weight-loss (Kg): At 18 mo., Mediterranean diet group lost -4.1 and Low-fat group gained 2.9. WC (cm); decreased by -6.9 vs -2.6 in Diet group	After 18 months, Mediterranean diet group lost significantly more weight than the low-fat group and significantly their WC P<0.001 between the groups.
Heshka et al. 2003(36)	n=423 (Self-help group; n=212, commercial (Control) group; n=211) 24-month trial to compare weight-loss and health benefits through a self-help weight-loss vs a commercial program.	Weight-loss (Kg): At 12 months, Commercial group lost -4.3 vs -1.3 in Self-help group. At 24 months, Commercial group lost -2.9 vs -0.2 in Self-help group. WC (cm); at 12-months; Commercial group decreased by -4.9 vs -1.9 and at 24 months.; -2.6 vs -0.2	At 12 months, Commercial group participants lost significantly weight compared to self-help group P<0.001 and lost significantly more weight at 2-months P<0.001. WC also decreased significantly in the commercial group compared to self-help group at 12 months. P<0.005 and P<0.02
Villareal et al. 2011(31)	n =107(Diet; n= 26, Combined; n=26, Exercise; n=28, C; n=27) 12-month trial comparing the effectiveness of a weight-loss only intervention compared to weight and exercise in obese adults aged 65 or older	Weight-loss (Kg): Diet group lost -9.7 vs Combined -8.6, Exercise -1.8 and Control -0.9	At 12-month follow up, significant weight-loss was achieved in the diet only and the combined groups P<0.001 compared to the exercise group and C group
Kukkonen-Harjula et al. 2005(33)	n=90 (Walking group; n= 30, Resistance group; n=30, C group; n=30) 31-month trial to assess the efficacy of a weight maintenance program with or without exercise on obese men	Weight-loss (Kg): At 2 mo.: mean weight-loss in all 3 groups was -14.2 and -4.8 at 31 months.	No significant differences were found between groups at 2 mo. and at 31 months. after the addition of PA compared to the C group

Ross et al. 2000(32)	n=52 (diet + weight-loss; n=14, Exercise + weight-loss; n=16, Exercise group; n=16, C group; n= 8) 3-month trial to assess the effectiveness of a diet-induced weight-loss to an exercise induced weight loss on obese men	Weight-loss (Kg): Exercise+ weight-loss and Diet+ weight loss groups lowered by -7.5 vs no change in weight in exercise and C group. Fat loss (Kg): Exercise + weight-loss group lost -6.1 vs -4.8 in Diet+weight loss group	At 3-months, Body weight decreased by 8% in both Exercise + weight loss and Diet+ weight loss groups and did not change in the exercise without weight loss and C groups P<0.01. Significant fat loss was found in both weight loss groups (P < 0.001), but greater fat loss was found in the exercise+ weight-loss group compared to diet+ weight loss group (P < 0.03).
Hakala et al. 1993(38)	n=60 (PN group; n= 30), Group counselling; n=30) 5-year trial to assess the efficacy of PN counselling to group counselling to treat obesity	Weight-loss (Kg): at 3 mo.; PN group lost -25.4 vs -32.6 Group counselling, at 12 months.; PN group lost -38.1 vs -41.9 in Group counselling; at 24 mo. PN lost -26 vs -21 in Group counselling and at 5 years; PN group lost -16.3vs -15 in Group counselling	Group counselling led to rapid weight loss but a more sustained weight loss was found in the PN group, results were non-significant from baseline values.

N= Total number of participants, I1= Intervention 1, I2= Intervention 2, I3= Intervention 3, C= Control, WC=Waist Circumference, PA = Physical Activity, SBI = Skill Based Intervention, PN= Personalised Nutrition, WBV= Whole Body Vibration

Table 2. 2 Web-based weight loss randomised controlled trials

Author	Number (n) and study characteristics	Outcome(s)	Study findings
Gold et al. 2007 (39)	n=124 (VTrim n = 62, eDiets.com n=62) 12-month trial comparing the effectiveness of using VTrim; a structured behavioural weight loss website to eDiets.com; a commercial weight loss website	Weight-loss (Kg): VTrim lost -8.3 vs eDiet -4.1 at 6 months; at 12 months -7.8 vs -3.4	At 6-months VTrim group lost significantly more weight than the eDiets group; *P* = 0.004) and more of VTrim participants were able to maintain a 5 % weight loss at month 12 (*P* = 0.02)
Blomfield et al. 2014(45)	n=159 (I; n = 53, PR; n=54, C; n=52) 6-month trial assessing improvements in dietary intakes in obese/overweight males by utilising either an online program or paper resources compared to controls	Weight-loss (Kg): I group lost -5.8 vs -4.4 PR group vs -0.6 C group	Significant weight loss in the I group and PR group was achieved P<0.001. Minimal change was found in the C group.
Womble et al. 2004(53)	n=47 (eDiet=23, LEARN=24) 12-months RCT assessing the effectiveness of an online weight loss resource (eDiet) to a weight loss manual (LEARN)	Weight-loss (Kg): LEARN group lost -4.0 vs eDiet -1.1	Paper resource tool (LEARN) resulted in significantly more weight loss when compared to eDiet group p<0.05
McDoniel et al. 2010(58)	n=111 (SMART; n= 55, UC; n= 56) 12-week trial assessing the effectiveness of an online weight loss program (SMART) on obese adults in	Weight-loss (Kg): SMART group lost -3.5 vs -3.7 in UC	Significant reductions in weight were found in SMART and UC group (P≤0.05).

	comparison to usual care that received a paper resource		
Ashwell et al. 2014[40]	n=180 (I; n=90, C; n=90) 6-month trial examining the effectiveness of an online weight loss program that includes breakfast cereals to a generalised online weight loss program	Weight-loss (Kg): I group lost -2.5 vs -1.3 in C group	significant reduction in weight from baseline in the I group participants compared to C group P=0.013
McConnon et al. 2007[46]	n=221 (I; n= 111, C; n= 110) 12-months trial comparing the effectiveness and cost-effectiveness of a web-based weight loss program (I) to a usual care program (C) that received a paper resource on overweight volunteers	Weight-loss (Kg): I group lost -1.3 vs -1.9 C group	No significant differences between groups in weight loss was found
Chambliss et al. 2011[54]	n=120 (PN feedback group; n=45, Web-based feedback group; n=45, C group; n=30) 12-week trial to assess the efficacy of a web-based program with automated feedback or with PN feedback from a counsellor	Weight-loss (Kg): Web-based feedback group lost -2.5 kg vs -2.7 PN feedback vs 0.3 C group. WC (cm): Web-based group lost -2.84 vs -3.44 PN feedback group vs -0.55 C group	Web-based and PN feedback groups lost significantly more weight compared to control group at 12-weeks P<0.05. Web-based and PN feedback group participants decreased WC significantly compared to C group P<0.01
Kraschnewski et al. 2011[50]	n=100 (web-based; n=5-, C; n=50) 12-week trial to evaluate the efficacy of a web-based weight-loss intervention for adults	Weight loss (Kg): Web-based lost -1.4 vs weight gain of 0.6 in C group.	Web-based weight group significantly more weight compared to C group P<0.01

Rothert et al. 2006(41)	n=2862 (I; n=1475, C; n=1387) 6-month trial assessing the effectiveness of a personalised web-based weight loss program (Balance) to an online general weight loss program	Weight loss (Kg): I group lost -2.8 vs -1.1 C group	Results of the study indicated significant weight loss in the I group participants compared to the C group p = 0.0007
Crane et al. 2015(57)	n= 107 (REFIT =53, C= 54) 6-month trial assessing the effectiveness of a multicomponent web-based weight loss program (REFIT) to a wait-list control.	Weight loss (Kg): REFIT lost -5.3 vs -0.6 C group.	weight loss was significantly higher in the REFIT group at 6 months compared to C group p<0.001
Tate et al. 2006(51)	n=192 (C; n=67; Web-based feedback; n=61; or human e-mail counselling; n=64) 6-month trial assessing the efficacy of web-based feed-back to human email counselling	Weight loss (Kg): At 3 months, Web-based feedback lost -5.3 vs -6.1 human e-mail counselling vs -2.8 C group. At 6 months, Web-based group lost -4.9 vs -7.3 in human e-mail counselling vs -2.6 in C group	Web-based feedback group and Human e-mail counselling lost significantly more weight compared to C group at 3 months. (Web-based P=0.005 and Human E-mail P<0.001) and at 6 months P<0.001.
Tate et al.2001(42)	n=91 (Web-based enhanced; n=32, General group; n=33 6-month trial assessing the efficacy of a web-based behaviour intervention to a general internet weight loss education	Weight loss (Kg): at 3 months, Web-based lost -4.0 vs -1.7 in General group, at 6 months, Web-based lost -4.1 vs -1.6 in General web group. WC (cm); at 3 mo. Web-based reduced by -6.7 vs -3 in General group and at 6 mo.; Web-based reduced by -6.4 vs -3.1 in General group	Significant weight loss was achieved in the Web-based group compared to the General group at 3 and 6 months P<0.05 and have reduced WC significantly compared to General group at 3 P<0.001 and at 6 P<0.006 months

Naimark et al. 2015(47)	n=85 (eBalance; n=56, C; n=29) 14-week trial assessing the effectiveness of a web-based app (eBalance) at enhancing the diet and lifestyle of individuals.	Weight loss (Kg): eBalance lost -0.144 vs -0.128 in C group	At 14-week follow-up, eBalance group lost significantly more weight compared to the C group (p=0.03)
Morgan et al. (49)	n=110 (I= 65, C= 45) 14-week trial assessing the effectiveness of a work place weight-loss program.	Weight-loss (Kg): I group lost -4.0 vs +0.3 in the C group	At 14-weeks, I group participants lost significantly more weight than C group participants P<0.001
Collins et al 2010(43)	n=309 (Basic; n=99, Enhanced; n=106, C; n= 104) 12-week trial assessing the efficacy of an enhanced website to a basic website on weight loss	Weight loss (Kg): Enhanced lost -3 vs -2.1 in Basic vs 0.4 weight gain in C group. WC (cm): Enhanced lost -3.2 vs -2 in Basic vs -0.5 C group	Enhanced and basic group lost significantly more weight compared to C group at 12-week P<0.001 and reduced their WC significantly compared to C P<0.001
Thomas et al. 2017(44)	n=92 (web-based with scale; n=46, web-based without scale; n=46) 6-month pilot trial to evaluate the efficacy of a web-based commercial weight loss program with/with using a smart scale on weight loss and self-monitoring.	Weight loss (Kg): at 3 months web-based with scale lost -5.1 vs. 4.0 in web-based without scale. At 6 months, web-based with scale lost -5.3 vs. -3.9 in web-based without scale	Both groups lost comparable weight at 3 months and at 6 months. A significantly higher proportion of web-based with scale participants lost >5% of initial body weight at 3 months p=0.033 but not at 6 months.
Van Wier et al. 2009(52)	n=1386 (web-based; n=464, phone counselling; n=462, C group; n=460) 6-month trial to assess the efficacy of web-based with email counselling to phone counselling on weight-loss	Weight loss (Kg): -2.7 in phone counselling vs -2.1in web-based vs -1 in C group. WC (cm); phone counselling decreased by -4 vs -3.3 in web-based vs -2 in C group	Compared with C group body weight reduced significantly in phone counselling P<0.001 and web-based P<0.045 groups. Phone group resulted in greater weight loss and reduced WC compared to web-based group but this change was non-significant

Balk-Moller et al. 2017(48)	n=269 (I=152, C=117) 38-week trial assessing the effectiveness of a web-based program to promote weight loss and a healthy lifestyle.	Weight loss (Kg): intervention group lost -1.01 vs -0.03 in the C group	At week 38, web-based group lost significantly more weight, compared to the C group p=0.03
Harvey-Berino et al. 2010(56)	n=481(Web-based ; n= 161, face-to-face; n=158, Combined; n=162) 6-months trial assessing if the effectiveness of a web-based behavioural weight loss program is improved with the addition of face-to-face sessions	Weight loss (Kg): Face-to-face -8.0 vs -5.5 web-based vs. -6.0 combined group	At 6 months weight loss in the face-to-face group was significantly higher than web-based group and combined group P<0.05.
Bennett et al. 2010(55)	n=101 (Web-based; n=51, Usual care; n=50) 12-week trial evaluating the effectiveness of a web-based weight loss intervention among obese hypertensive adults	Weight loss (Kg): Web-based group lost -2.28 compared to a weight gain of 0.28 in usual care group	Greater weight loss at 3 months was found among web-based group compared to usual care group

N= Total number of participants, I = Intervention group, C= Control or usual care group, PR= paper resource group, UC= Usual Care, PN=Personalised Nutrition, WC= Waist Circumference, CM= Centimeter, RCT= Randomised Control Trial

Table 2. 3 Face-to-Face dietary change randomised controlled trials

Author	Number (n) and study characteristics	Outcome(s)	Study findings
Coates et al. 1999(64)	n=2207 (I; n=1324, C; n=883) 18-month trial comparing the effectiveness of low fat diets among postmenopausal women from several ethnic origins	Fat (%): I group decreased by 13.3% vs 2.3% in C group at 6 months and by -14.17% vs -2.54% at 18 months.; F/V: Consumption increased by 0.5 serving/d in I group vs 0.05 serving/d in C group at 6 months and by 0.8 serving/d and 0.1 serving/d in C group at 18 months	I group decreased percentage daily dietary fat intake and increased F+V intakes compared to baseline levels, but this change was non-significant. No change was seen for wholegrain foods.
Aldana et al. 2005(60)	n=348 (Diet; n=174, C; n=174) 6-month trial to determine the impact of a lifestyle-modification intervention receiving counselling compared to controls with no intervention	Fat (%): Diet lowered by 8.2% vs increase of 1% in C group. F/V: Diet group F increased by 0.9 serving/d vs no change in C group and increased V vs 1.4 serving/d vs 0.1 in C group. Wholegrains: Diet increased by 0.7 serving/d vs decrease of 0.5 serving/d in C group. PA (Steps/week); Diet increased by 12,372 steps/week vs 5661 steps/week in C group	At 6 months, Diet group participants experienced significant improvements in all nutrition and PA variables except calories from protein and whole-grain servings P<0.001.
Maskarinec et al. 1999(62)	n=29 (I; n= 13, C; n = 16) 6-month trial examining the effectiveness of increasing fruit and vegetable intakes among healthy women via personalised dietary sessions and group activities.	F/V: Mean consumption increased in the I group by 5.1 serving/d at 3 months vs 0.9 serving/d mean consumption in C group . at 6 months, F/V consumption in I group decreased to 7.4 serving/d	Increased average F + V consumption in the I group at 3 and 6 months whereas minimal differences in intakes were found in the C group (p<0.001)
Steptoe et al. 2003(65)	n=271 (Behavioural counselling; n=136, Basic counselling; n=135) 12-month trial comparing brief nutrition counselling to behavioural dietary counselling	F/V: Increased by 1.5 in Behavioural counselling vs 0.9 in Basic counselling. (5-a-day % increase) increased by 42% in Behavioural counselling vs 27% in Basic counselling group.	Increased F+V intake in the Behavioural counselling group compared to the Basic counselling group at 12-months P<0.021. % 5-a-day was also significantly higher in the Behavioural group compared to the Basic group P<0.019

Roderick et al. 1997(63)	n=956 (I; n =473, C; n=483) 12-month trial assessing the effectiveness of face-to-face dietary advice to generalised health information on serum cholesterol levels, diet and weight	Serum cholesterol: I group decreased serum cholesterol by 0.20 mmol/ compared to C group. F/V: I group increased consumption by F 0.76 serving/week, V 0.33 serving/week vs 0.28 F serving/week and -0.25 serving/week in C group. Fat (%): I group decreased by -2.4% vs C group by -0.9%. Weight loss (Kg): I group -0.1 vs 0.44 in C group	I group had lower mean serum cholesterol compared to C group. I group participants reduced their weight and intakes of dietary fat and saturated fat, this difference was not statistically significant
Carpenter et al. 2004(59)	n=98 (Weekly Meeting (WM) group; n=30, Correspondent; n=33, C; n=35) 14-week trial to assess the efficacy of group behavioural counselling via weekly meetings or correspondence to improve diet quality	Modified Healthy Eating Index: WM increased fruit score by 2.2 vs it was lowered by 0.18 in correspondence and lowered by 0.54 in C groups. WM increased Fat score by 2 vs 0.81 in correspondence and 0.39 in C group.	WM group significantly improved scores compared to correspondence P=0.04 and C group P=0.002
Baron et al. 1990(61)	n=368 (I; n= 187, C; n= 181) 12-month trial. examining the effectiveness of a dietary intervention that aimed at reducing blood lipid levels	Fibre (%): At 12 months, I group reported to have increased daily % fibre by 52% male participants and 42% in female participants vs 1% increase in males and 3% in reported fibre intakes in C group. Fat (%): I group males decreased fat % by 55% and females by 38% vs 5% decrease in C group male participants and 0% fat change in females. PUFA (%): 22% in I group male participants and 30% in females vs 1% increase in C group participants	I group reported increased intakes of fibre, PUFA and decreased use of saturated fat, minimal changes were reported in the C group. Differences between groups was statistically significant P<0.001.

N= Total number of participants, I= Intervention, C= Control, F+V= Fruits and Vegetables, F/V= Fruits or Vegetables, F= Fruit, V= Vegetables, PUFA= Polyunsaturated Fatty Acids, WM= Weekly Meeting, PA= Physical Activity

Table 2. 4 Web-based dietary change randomised controlled trials

Author	Number (n) and study characteristics	Outcome(s)	Study findings
Delichatsios et al. 2001(67)	n=298 (I; n=148, C ;n=150) 6-month trial comparing the effectiveness a web-based dietary program that aimed at improving the overall health of individuals	F/V: Consumption of fruit increased in the I group by 1.1 serving/day compared to C group. No difference for vegetables. Fibre: increased by 4.0 g/d in I group compared to C group.	I group significantly increased their fruit from baseline levels compared to C group P<0.05.
Anderson et al. 2001(68)	n=277 (I; n= 129, C; n=148) 6-month trial comparing the impact of a web-based intervention on the food choices made by supermarket shoppers	Fat (%): Decreased by 9% in I group vs increased by 2% in C group. F/V (%): consumption increased by 20 in I group vs 2.8% decrease in C group. Fibre (%) 20 % in I group vs 4% decrease in C group.	I group decreased their fat intake by p<0.05 and increased their serving sizes from F & V and increased their total fibre intake by 19 % P<0.01. C group increased their total fat intake and had slightly lower fibre intake
Stevens et al. 2002(72)	n=616 (I; n=308, C; n=308) 4-month trial to assess the efficacy of a web-based counselling intervention to minimise risk of diet-related cancers	Fat (%): I group lowered Fat by 2.84 vs C group increased by 0.48. F/V: I group increased by 0.54 serving/d vs lowered by 0.51 serving/d in C group.	At 4-months, I group had significantly increased F/V servings/day P<0.001 and decreased daily fat % intake significantly compared to C group P<0.009
Celis-Morales et al.2016(74)	n=1269 (PN; n=312, PN+phenotype; n=324, PN+phenotype+genotype; n=321, C; n=312) 6-month trial to examine the effectiveness of PN advice on dietary change in comparison to “one size fits all” advice	Red and processed meat intake decreased by 8.5%, salt intake decreased by 6.3%, energy intake decreased by 4.4% in all three PN intervention groups compared to C group. HEI increased by 2.7% in PN intervention groups compared to C group.	At 6-months, PN intervention groups improved intakes of red and processed meats, salt, had lower energy intakes and increased HEI significantly compared to C group P<0.05.

Brug et al. 1996(69)	n=507 (I; n =178, C; n=169) 6-week trial examining the effect of online personalised nutrition information on fat intake and fruit and vegetable intakes	F/V: Minimal increase in I group in F intake by 0.008 serving/d and V by 0.04 serving/d and C group decreased F intake by 0.04 serving/d and increased V by 0.06 serving/d. Fat: fat points/d decreased by 2.1 in I group compared to 0.8 in C group	Minimal increase in F&V consumption was found in the I group from baseline levels. Fat intake decreased significantly in the I groups P<0.001 and C group P<0.05 compared to baseline.
Block et al. 2004(75)	n=481 (I with Phone calls; n=162, I without Phone calls; n=160, C group; n=159) 8-week trial to assess whether an interactive CD-ROM can enhance the diet of low-income women.	F/V: I with Phone calls increased by 1.32 serving/d vs I without Phone calls by 1.20 serving/d vs 0.71 serving/d in C group	After Two months, both intervention groups significantly increased F/V consumption compared to C group (P<0.016 I with phone calls group , P<0.052 I without Phone calls group)
Alexander et al. 2010(25)	n=2540 (I1; n=848, I2; n=845, C; n=847) 12-months trial to assess F&V intake by comparing online tailored to non-tailored dietary interventions	F/V: I1 increased by 2 servings/d vs I2 increased by 2.8 servings/d vs C increased by 2 servings/d	Average F&V servings increased by more than 2 servings across all study arms (P<.001). Greatest increase in I2 compared to C group at 12 months (P=0.05)
Irvine et al. 2004(70)	n=517 (I; n= 260, C; n= 257) 2-month trial comparing the effectiveness of an interactive computer - based program on the dietary intake of individuals	Fat, F/V: I group decreased fat score by 0.5 SD and increased F&V intake by 0.93 SD compared to baseline levels vs a 0.41 SD decrease in fat score and 0.88 increase in F&V intake in C group	After 1 month, the I group reduced their fat intake compared to the C group P<0.001. I group significantly increased F&V consumption compared to controls P<0.001. I group maintained these dietary changes after a 60 day-follow up
Oenema et al. 2005(71)	n=782 (I; n= 261, G; n=260, C; n=261) Three-week trial examining effectiveness of a short-term computer tailored nutrition intervention that aimed at	Fat (points): I group decreased by 0.6 vs 0.8 in G vs 0.4 in C group. F/V: V intake Increased by 0.1 serving/d in I group vs	I group significantly increased their awareness of the benefits of consuming a diet high in fruits and vegetables P<0.05 and low in fat compared to G and C group

	decreasing saturated fat intakes and increasing fruit and vegetable intakes and to raise personal dietary awareness	lowered by 0.1/serving/d in GI vs lowered by 0.1 serving/d in C group	
Vandelanotte et al. 2005(66)	n = 771 (Simultaneous group 1;n=189 , Sequential group 2 ;n= 180,Sequential group 3;n=204 , C;n=194) 6-month trial comparing the effectiveness of a computer-individualised intervention on dietary fat intake and physical activity	Fat (%): I1 decreased by 11.5% ,I2 + I3 groups by 8.6% compared to 2.1% in C group . PA: increased by 61 min/week in I1 and by 93 min/week in I2+I3 and by 45 min/week in C group	I1, I2 and I3 groups significantly increased their PA scores P < 0.001, and reduced fat intakes P < 0.001 when compared to C group participants
Winett et al. 1997(73)	n =141 (I;n= 54, C;n=51) 10-week trial examining the effectiveness of a computer-based program “The Nutrition for a Lifetime System” (NLS) that aimed at helping shoppers at supermarkets to decrease intakes of fat and increase intakes of fruits, vegetables and fibre	F/V, Fat, Fibre: F/V I group increased F/V intake by 0.29 serving/1000Kcal compared to -0.12 serving/1000Kcal in C group. Fat (%): I group decrease by 3.2% compared to 0.7% increase in C group. Fibre: I group increased by 1.24 g/1000Kcal compared to decrease of 0.61 g/1000Kcal in C group.	I group significantly reduced their fat intake and increased their intakes of fibre, F & V compared to C group participants p<0.001

N= Total number of participants, I= intervention, C= Control, I1= Intervention 1, I2= Intervention 2, I3= Intervention 3, G= General nutrition information, F+V= Fruits and Vegetables, F/V= Fruits or Vegetables, F= Fruits, V= Vegetables, SD= Standard Deviation, PA= Physical Activity, HEI= Health Eating Index, NLS= The Nutrition For a Lifetime System

2.8 References

1. World Health Organization (2018) Noncommunicable diseases country profiles 2018

. Geneva: World Health Organization Licence: CC BY-NC-SA 3.0 IGO, 223.

2. Musaiger AO (2011) Overweight and obesity in eastern mediterranean region: prevalence and possible causes. J Obes 2011, 1-17.

3. World Health Organization (2010) Action plan for the prevention of avoidable blindness and visual impairment, 2009-2013: World Health Organization.

4. Nichols M, Townsend N, Scarborough P et al. (2013) Cardiovascular disease in Europe: epidemiological update. Eur Heart J 34, 3028-3034.

5. Veronese N, Facchini S, Stubbs B et al. (2017) Weight loss is associated with improvements in cognitive function among overweight and obese people: A systematic review and meta-analysis. Neurosci Biobehav Rev 72, 87-94.

6. de la Hunty A (1995) The COMA report on nutritional aspects of cardiovascular disease: the scientific evidence. Br Food J 97, 30-32.

7. Department of Health UK (2004) Choosing Health: Making Healthier Choices Easier: London: Her Majesty's Stationery Office.

8. US Department of Health Human Services (2005) Dietary guidelines for Americans, 2005, vol. https://health.gov/dietaryguidelines/dga2005/document/pdf/dga2005.pdf.

9. World Health Organization J, Consultation FE (2003) Diet, nutrition and the prevention of chronic diseases. World Health Organ Tech Rep Ser 916.

10. Thompson FE, Subar AF, Loria CM et al. (2010) Need for technological innovation in dietary assessment. J Am Diet Assoc 110, 48-51.

11. Stumbo PJ (2013) New technology in dietary assessment: a review of digital methods in improving food record accuracy. Proc Nutr Soc 72, 70-76.

12. Montagnese C, Santarpia L, Buonifacio M et al. (2015) European food-based dietary guidelines: A comparison and update. Nutrition 31(7-8), pp.908-915.

13. World Health Organization (2009) Global health risks: mortality and burden of disease attributable to selected major risks: World Health Organization.

14. Adamson AJ, Mathers JC (2004) Effecting dietary change. Proc Nutr Soc 63, 537-547.

15. Kreuter MW, Strecher VJ (1996) Do tailored behavior change messages enhance the effectiveness of health risk appraisal? Results from a randomized trial. Health Educ Res 11, 97-105.

16. Strecher VJ, Kreuter M, Den Boer D-J et al. (1994) The effects of computer-tailored smoking cessation messages in family practice settings. J Fam Pract 39, 262-270.

17. Nikièma L, Huybregts L, Martin-Prevel Y et al. (2017) Effectiveness of facility-based personalized maternal nutrition counseling in improving child growth and morbidity up to 18 months: A cluster-randomized controlled trial in rural Burkina Faso. PLoS One 12, e0177839.

18. Appel LJ, Brands MW, Daniels SR et al. (2006) Dietary approaches to prevent and treat hypertension a scientific statement from the American Heart Association. Hypertension 47, 296-308.

19. Dyson P, Kelly T, Deakin T et al. (2011) Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. Diabetic Med 28, 1282-1288.

20. Griffiths F, Lindenmeyer A, Powell J et al. (2006) Why are health care interventions delivered over the internet? A systematic review of the published literature. JMIR 8(2), p.e10.

21. Contento I, Balch GI, Bronner YL et al. (1995) The effectiveness of nutrition education and implications for nutrition education policy, programs, and research: a review of research. J Nutr Educ 27(6) 277-418.

22. Conn VS, Hafdahl AR, Mehr DR (2011) Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. Am J Public Health 101, 751-758.

23. Marshall AL, Leslie ER, Bauman AE et al. (2003) Print versus website physical activity programs: a randomized trial. Am J Prev Med 25, 88-94.

24. Sherwood NE, Morton N, Jeffery RW et al. (1998) Consumer Preferences in Format and Type of Community-based Weight Control Programs. Am J Health Prom 13, 12-18.

25. Alexander GL, McClure JB, Calvi JH et al. (2010) A randomized clinical trial evaluating online interventions to improve fruit and vegetable consumption. Am J Public Health 100, 319.

26. Noah SA, Abdullah SN, Shahar S et al. (2004) DietPal: a Web-based dietary menu-generating and management system. JMIR 6(1), p.e4.

27. Livingstone KM, Celis-Morales C, Navas-Carretero S et al. (2015) Profile of European adults interested in internet-based personalised nutrition: the Food4Me study. Eur J Nutr 55(2), 759-769.

28. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2015) Design and baseline characteristics of the Food4Me study: a web-based randomised controlled trial of personalised nutrition in seven European countries. Genes Nutr 10, 1-13.

29. Vissers D, Verrijken A, Mertens I et al. (2010) Effect of long-term whole body vibration training on visceral adipose tissue: a preliminary report. Obes Facts 3, 93-100.

30. Skender ML, Goodrick GK, Del Junco DJ et al. (1996) Comparison of 2-year weight loss trends in behavioral treatments of obesity: diet, exercise, and combination interventions. J Am Diet Assoc 96, 342-346.

31. Villareal DT, Chode S, Parimi N et al. (2011) Weight loss, exercise, or both and physical function in obese older adults. N Engl J Med 364, 1218-1229.

32. Ross R, Dagnone D, Jones PJ et al. (2000) Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in menA randomized, controlled trial. Ann Intern Med 133, 92-103.

33. Kukkonen-Harjula KT, Borg PT, Nenonen AM et al. (2005) Effects of a weight maintenance program with or without exercise on the metabolic syndrome: a randomized trial in obese men. Prev Med 41, 784-790.

34. McManus K, Antinoro L, Sacks F (2001) A randomized controlled trial of a moderate-fat, low-energy diet compared with a low fat, low-energy diet for weight loss in overweight adults. Int J Obes 25, 1503.

35. Yeh M, Rodriguez E, Nawaz H et al. (2003) Technical skills for weight loss: 2-y follow-up results of a randomized trial. Int J Obes 27, 1500.

36. Heshka S, Anderson JW, Atkinson RL et al. (2003) Weight loss with self-help compared with a structured commercial program: a randomized trial. JAMA 289, 1792-1798.

37. Silva MN, Vieira PN, Coutinho SR et al. (2010) Using self-determination theory to promote physical activity and weight control: a randomized controlled trial in women. J Behav Med 33, 110-122.

38. Hakala P, Karvetti R-L, Rönnemaa T (1993) Group vs. individual weight reduction programmes in the treatment of severe obesity--a five year follow-up study. Int J Obes Rel Metab Dis: J Int Assoc Stud Obes 17, 97-102.

39. Gold BC, Burke S, Pintauro S et al. (2007) Weight loss on the web: A pilot study comparing a structured behavioral intervention to a commercial program. Obesity 15, 155-155.

40. Ashwell M, Howarth E, Chesters D et al. (2014) A web-based weight loss programme including breakfast cereals results in greater loss of body mass than a standardised web-based programme in a randomised controlled trial. Obes Facts 7, 361-375.

41. Rothert K, Strecher VJ, Doyle LA et al. (2006) Web-based Weight Management Programs in an Integrated Health Care Setting: A Randomized, Controlled Trial. Obesity 14, 266-272.

42. Tate DF, Wing RR, Winett RA (2001) Using Internet technology to deliver a behavioral weight loss program. JAMA 285, 1172-1177.

43. Collins CE, Morgan PJ, Jones P et al. (2012) A 12-week commercial web-based weight-loss program for overweight and obese adults: randomized controlled trial comparing basic versus enhanced features. JMIR 14(2), e57.

44. Thomas J, Raynor H, Bond D et al. (2017

) Weight Loss and Frequency of Body Weight Self-monitoring in an Online Commercial Weight Management Program with and Without a Cellular Connected “Smart” Scale: A Randomized Pilot Study. Obes Sci Pract 3(4), 365-372.

45. Blomfield RL, Collins CE, Hutchesson MJ et al. (2014) Impact of self-help weight loss resources with or without online support on the dietary intake of overweight and obese men: the SHED-IT randomised controlled trial. Obes Res Clin Prac 8, e476-e487.

46. McConnon Á, Kirk SF, Cockroft JE et al. (2007) The Internet for weight control in an obese sample: results of a randomised controlled trial. BMC Health Serv Res 7, 206.

47. Naimark JS, Madar Z, Shahar DR (2015) The impact of a Web-based app (eBalance) in promoting healthy lifestyles: randomized controlled trial. JMIR 17(3), p.e56.

48. Balk-Møller NC, Poulsen SK, Larsen TM (2017) Effect of a Nine-Month Web-and App-Based Workplace Intervention to Promote Healthy Lifestyle and Weight Loss for Employees in the Social Welfare and Health Care Sector: A Randomized Controlled Trial. JMIR 19(4) p.e10819, p.e10819.

49. Morgan PJ, Collins CE, Plotnikoff RC et al. (2011) Efficacy of a workplace-based weight loss program for overweight male shift workers: the Workplace POWER (Preventing Obesity Without Eating like a Rabbit) randomized controlled trial. Prev Med 52, 317-325.

50. Kraschnewski JL, Stuckey HL, Rovniak LS et al. (2011) Efficacy of a weight-loss website based on positive deviance: a randomized trial. Am J Prev Med 41, 610-614.

51. Tate DF, Jackvony EH, Wing RR (2006) A randomized trial comparing human e-mail counseling, computer-automated tailored counseling, and no counseling in an Internet weight loss program. Arch Intern Med 166, 1620-1625.

52. Van Wier MF, Ariëns GA, Dekkers JC et al. (2009) Phone and e-mail counselling are effective for weight management in an overweight working population: a randomized controlled trial. BMC Public Health 9, 6.

53. Womble LG, Wadden TA, McGuckin BG et al. (2004) A randomized controlled trial of a commercial internet weight loss program. Obes Res 12, 1011-1018.

54. Chambliss HO, Huber RC, Finley CE et al. (2011) Computerized self-monitoring and technology-assisted feedback for weight loss with and without an enhanced behavioral component. Patient Educ Couns 85, 375-382.

55. Bennett GG, Herring SJ, Puleo E et al. (2010) Web-based Weight Loss in Primary Care: A Randomized Controlled Trial. Obesity 18, 308-313.

56. Harvey-Berino J, West D, Krukowski R et al. (2010) Internet delivered behavioral obesity treatment. Prev Med 51, 123-128.

57. Crane MM, Lutes LD, Ward DS et al. (2015) A randomized trial testing the efficacy of a novel approach to weight loss among men with overweight and obesity. Obesity 23, 2398-2405.

58. McDoniel SO, Wolskee P, Shen J (2010) Treating obesity with a novel hand-held device, computer software program, and Internet technology in primary care: the SMART motivational trial. Patient Educ Couns 79, 185-191.

59. Carpenter RA, Finley C, Barlow CE (2004) Pilot test of a behavioral skill building intervention to improve overall diet quality. J Nutr Educ Behav 36, 20-26.

60. Aldana SG, Greenlaw RL, Salberg A et al. (2006) The Behavioral and Clinical Effects of Therapeutic Lifestyle Change on Middle-aged Adults. Prev Chronic Dis 3(1), A05.

61. Baron JA, Gleason R, Crowe B et al. (1990) Preliminary trial of the effect of general practice based nutritional advice. Br J Gen Pract 40, 137-141.

62. Maskarinec G, Chan CLY, Meng L et al. (1999) Exploring the Feasibility and Effects of a High-Fruit and -Vegetable Diet in Healthy Women. Cancer Epidemiol Biomarkers Prevent 8, 919-924.

63. Roderick P, Ruddock V, Hunt P et al. (1997) A randomized trial to evaluate the effectiveness of dietary advice by practice nurses in lowering diet-related coronary heart disease risk. Br J Gen Pract 47, 7-12.

64. Coates RJ, Bowen DJ, Kristal AR et al. (1999) The Women's Health Trial Feasibility Study in Minority Populations: Changes in Dietary Intakes. Am J Epidemiol 149, 1104-1112.

65. Steptoe A, Perkins-Porras L, McKay C et al. (2003) Behavioural counselling to increase consumption of fruit and vegetables in low income adults: randomised trial. BMJ 326, 855-860.

66. Vandelanotte C, De Bourdeaudhuij I, Sallis J et al. (2005) Efficacy of sequential or simultaneous interactive computer-tailored interventions for increasing physical activity and decreasing fat intake. Ann Behav Med 29, 138-146.

67. Delichatsios HK, Friedman RH, Glanz K et al. (2001) Randomized trial of a "talking computer" to improve adults' eating habits. Am j Health Prom 15, 215-224.

68. Anderson E, Winett R, Wojcik J et al. (2001) A computerized social cognitive intervention for nutrition behavior: Direct and mediated effects on fat, fiber, fruits, and vegetables, self-efficacy, and outcome expectations among food shoppers. Ann Behav Med 23, 88-100.

69. Brug J, Steenhuis I, van Assema P et al. (1996) The Impact of a Computer-Tailored Nutrition Intervention. Prev Med 25, 236-242.

70. Irvine AB, Ary DV, Grove DA et al. (2004) The effectiveness of an interactive multimedia program to influence eating habits. Health Educ Res 19, 290-305.

71. Oenema A, Tan F, Brug J (2005) Short-term efficacy of a web-based computer-tailored nutrition intervention: Main Effects and Mediators. Ann Behav Med 29, 54-63.

72. Stevens VJ, Glasgow RE, Toobert DJ et al. (2002) Randomized trial of a brief dietary intervention to decrease consumption of fat and increase consumption of fruits and vegetables. Am J Health Prom 16, 129-134.

73. Winett RA, Anderson ES, Bickley PG et al. (1997) Nutrition for a lifetime system: a multimedia system for altering food supermarket shoppers' purchases to meet nutritional guidelines. Comput Human Behav 13, 371-392.

74. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2016) Effect of personalized nutrition on health-related behaviour change: evidence from the Food4me European randomized controlled trial. Int J Epidemiol 46, 578-588.

75. Block G, Wakimoto P, Mandel R et al. (2004) A Randomized Trial of the Little by Little CD-ROM: Demonstrated Effectiveness in Increasing Fruit and Vegetable Intake in a Low-income Population. PCD 1(3) A08-A08.

76. Foreyt JP, Goodrick GK, Gotto AM (1981) Limitations of behavioral treatment of obesity: Review and analysis. J Behav Med 4, 159-174.

77. Avenell A, Brown TJ, McGee M et al. (2004) What interventions should we add to weight reducing diets in adults with obesity? A systematic review of randomized controlled trials of adding drug therapy, exercise, behaviour therapy or combinations of these interventions. J Hum Nutr Diet 17, 293-316.

78. Mitchell LJ, Ball LE, Ross LJ et al. (2017) Effectiveness of dietetic consultations in primary health care: a systematic review of randomized controlled trials. J Acad Nutr Diet 117, 1941-1962.

79. Sorgente A, Pietrabissa G, Manzoni GM et al. (2017) Web-based interventions for weight loss or weight loss maintenance in overweight and obese people: a systematic review of systematic reviews. JMIR 19, e229.

80. Sherrington A, Newham J, Bell R et al. (2016) Systematic review and meta-analysis of internet-delivered interventions providing personalized feedback for weight loss in overweight and obese adults. Obes Rev 17, 541-551.

81. Neville LM, Milat AJ, O'Hara B (2009) Computer-tailored weight reduction interventions targeting adults: a narrative systematic review. Health Promot J Austr 20, 48-57.

82. Arem H, Irwin M (2011) A review of web-based weight loss interventions in adults. Obes Rev 12(5) e236-e243.

83. Celis-Morales C, Abraham S, Keenan P et al. (2015) Effect of web-based tailored lifestyle interventions on fruit and vegetable consumption in adults: A systematic review and meta-analysis of randomised controlled trials. Proc Nutr Soc 74, (OCE1).

84. Neve M, Morgan PJ, Jones P et al. (2010) Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. Obes Rev 11, 306-321.

85. Vandelanotte C, Spathonis KM, Eakin EG et al. (2007) Website-Delivered Physical Activity Interventions: A Review of the Literature. Am J Prev Med 33, 54-64.

CHAPTER 3 Reproducibility and validity of the EatWellQ8 web-based food frequency questionnaire against a paper-based food frequency questionnaire and a 4-day weighed food record

Original Paper

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Keywords:
Web-based; Kuwait; WFR; app; FFQ; validation; weighed food record; dietary assessment;

B Al-Awadhi was responsible for the Arabic translations and the addition of 83 portion size images included in the online EatWellQ8 FFQ. B Al-Awadhi was also responsible for the validation study: ethics application, participant recruitment, data collection, analysis and writing the manuscript.

3.1 Abstract

Background: The web-based EatWellQ8 food frequency questionnaire (FFQ) was developed as a dietary assessment tool for healthy adults in Kuwait. Validation against reliable instruments and an assessment of its reproducibility are required to ensure its accuracy in computing nutrient intake.

Objective: To assess the reproducibility and validity of the EatWellQ8 FFQ against a paper based FFQ (PFFQ) and a 4-day weighed food record (WFR).

Methods: Reproducibility of the EatWellQ8 FFQ was assessed using test-retest methodology. Participants were required to complete the FFQ at two time points, 4 weeks apart. To assess validity of the EatWellQ8 FFQ, a subset of the participants were asked to complete a PFFQ or a 4-day WFR 1 week after administration of the EatWellQ8 FFQ. The level of agreement between nutrient and food group intakes was estimated by repeated EatWellQ8 FFQ. The EatWellQ8 FFQ, the PFFQ and 4-day WFR were also evaluated using Bland-Altman methodology and classified into quartiles of daily intake. Crude unadjusted correlation coefficients were also calculated for nutrients and food groups.

Results: A total of 99 Kuwaiti participants (65% female: 35% male) completed the study, 53 participated in the reproducibility study and the 4-day WFR validity study (mean age 37.1 ± 9.9 years) and a further 46 participated in the PFFQ validity study (mean age 36.2 ±8.3 years). Crude unadjusted correlations for repeated EatWellQ8 FFQs ranged from (0.37-0.93) for nutrients and food groups (P<0.01). Mean cross-classification into “exact agreement plus adjacent” was 88% for nutrient intakes and 86% for food groups, and Bland-Altman plots showed good agreement for energy-adjusted macronutrient intakes. Association between the EatWellQ8 FFQ and PFFQ varied, with crude unadjusted correlations ranging from (0.42-0.73) (P<0.05). Mean cross-classification into “exact agreement plus adjacent” was 84% for nutrient intake and 74% for food groups. Bland-Altman plots showed moderate agreement for both energy and energy-controlled nutrient intakes. Crude unadjusted correlations for the EatWellQ8 FFQ and the 4-day WFR ranged from (0.40-0.88) (P<0.01). Mean cross-classification into “exact agreement plus adjacent” was 85% for nutrient intake and 83% for food groups. Bland-Altman plots showed moderate agreement for energy-adjusted macronutrient intakes.

Conclusions: Results indicate that the web-based EatWellQ8 FFQ is reproducible for assessing nutrient and food group intake and has moderate agreement compared to a PFFQ and a 4-day WFR for measuring energy and nutrient intakes.

3.2 Introduction

According to the World Health Organization (WHO), non-communicable diseases (NCDs) remain the main cause of global premature mortality (1). Diets rich in energy, saturated fat and low in fruits and vegetables have been associated with the development of NCDs (2; 3). Inaccurate dietary assessment methods may be a serious obstacle in understanding the impact of dietary factors on disease (4). Several dietary assessment methods are available which include; food frequency questionnaire (FFQ), diet history, weighed food record and 24-hour dietary recall (5). The 24-hour recall requires the individual to recall the foods consumed during the foregoing 24-hour period and are collated during an interview with a dietitian/nutritionist (6; 7). Food records require individuals to list all weighed foods and beverages consumed over a period of generally 3-7 consecutive days (6). The diet history requires questioning the respondents on the frequency of their consumption of usual dietary intakes (8). FFQs require respondents to state the frequency of intake of a predefined list of foods over a specified period of time and are one of the most commonly used tools to assess the relationship between diet, health and disease (7).

With the widespread availability of the Internet, there has been a growing interest in utilizing the web to assess dietary intake and deliver health related messages. Traditional dietary assessment methods have been customized for Internet use in research as they allow for the direct storage of data and automatic generation of nutrition outputs (9; 10). In addition, web-based dietary assessment methods may include photographs of food portion sizes increasing ease of use for respondents and can be designed to be user-friendly and tailored towards a specific target group (11; 12). Compared to printed FFQs, web-based FFQs can be pre-programmed ensuring that all questions are fully answered, are found to be more cost-effective and can include photographs to increase users understanding and assessment of portion sizes (11; 12).

The present study is part of the EatWellQ8 study that aims to investigate whether web-based personalized nutrition (PN) (based on dietary intake, and anthropometrics) is as effective as face-to-face communication of PN in Kuwait. Kuwait currently has the highest adult obesity levels in the gulf region (13). Latest findings indicate that around 78% of adult men and 82% of women in Kuwait, are either overweight or obese (14).

The novel EatWellQ8 FFQ was developed to assess dietary intake in Kuwait and includes 146 food items and photographs of food portion sizes. The validated Food4Me FFQ, European Prospective Investigation of Cancer (EPIC)-Norfolk FFQ (version CAMB/PQ/6/1205) and a PFFQ for Kuwait were used as a guide in the development of the EatWellQ8 FFQ food items and categories of food (15; 16; 17; 18). Good agreement has been shown previously between the web-based Food4Me FFQ and the EPIC-Norfolk FFQ for the estimation of energy-adjusted nutrient intakes (17; 18). The aim of this study was to develop and test the reproducibility of the EatWellQ8 FFQ for assessment of food and nutrient intake in a Kuwaiti population for use in the EatWellQ8 study and to compare estimates of dietary intakes using this tool with data obtained from a 4-day WFR and a validated paper Kuwaiti FFQ (PFFQ) (16).

3.3 Methods

3.3.1 Study Sample

A sample size between 50-100 is necessary in order to accurately evaluate Bland-Altman limits of agreement (LOA) between two methods (5). Participants aged 18-65 years were recruited from Kuwait through email, poster advertisement, word of mouth, booths at colleges/health institutions and social media (WhatsApp, Facebook, YouTube video, Instagram). Participants were then provided with an information sheet clarifying the study, a consent form or an assent form (for participants aged 18 to 21 years) and asked to complete a web-based screening questionnaire. Participants were emailed a feedback response dependent on whether or not they met the inclusion criteria. A minimal set of exclusion criteria were applied (subjects under 18 years old, pregnant or lactating, no or limited access to the internet, following a prescribed diet, including a weight reducing diet in the previous three months, diabetes, coeliac disease, Crohn's disease and prior chronic medical conditions requiring continuing therapeutic intervention apart from hypertension medication and statins). The study received ethical approval from the Research Ethics Committee at the University of Reading (School of Chemistry, Food and Pharmacy Research Ethics Committee, Ref No. 13/17) and conformed with the Declaration of Helsinki. The study also received ethical approval from the Research Ethics Committee at Dasman Diabetes Institute, Kuwait (RA-2015-018).

3.3.2 Study Design

To assess reproducibility of the EatWellQ8 FFQ, 100 participants were asked to complete the web-based FFQ twice, 4 weeks apart for intake over the past month. To assess validity of the EatWellQ8 FFQ, participants were also asked to complete a 4-day WFR 1-week after completing the web-based FFQ. An additional 50 participants were asked to take the EatWellQ8 FFQ at baseline and to complete a validated PFFQ for Kuwait a week after completing the web-based FFQ. The Kuwait PFFQ and the 4-day WFR were delivered to the participants in person or sent via email depending on the participant's preference. Participants were asked to complete the forms and hand them in person or to scan and email them to the researcher. Participants were asked to complete a usability survey after completing the first EatWellQ8 FFQ (19). All participants were requested to maintain their usual diet during the study.

3.3.3 The EatWellQ8 FFQ

The web-based EatWellQ8 self-administered semi-quantitative FFQ was designed to measure nutritional and dietary intakes of individuals living in Kuwait. The design and development of the novel EatWellQ8 FFQ was led by researchers from the Hugh Sinclair Unit of Human Nutrition and the Biomedical Engineering section at The University of Reading. The validated Food4ME FFQ, the well-validated EPIC-Norfolk FFQ (version CAMB/PQ/6/1205) and a valid semi-quantitative FFQ for Kuwait were used as a guide in the development of the novel FFQ, for identifying food items and categorizing food into different food groups (15; 16). To ensure that the EatWellQ8 FFQ was suitable for use amongst people in Kuwait, participants were able to choose between two language choices (Arabic and English). The novel FFQ comprised of 146 food items that represented food items and composite dishes commonly consumed in Kuwait. Several new foods that are commonly consumed in Kuwait were added to the existing food categories, for example pomegranate, guava and mango were added to the fruit list and "Lebanese bread, Iranian bread" were added to the bread and savory biscuit list. A new food section entitled "Kuwaiti composite dishes" was added which included 23 food items such as "Machbous laham, Biryani and Harees", to ensure that commonly consumed foods were included in the FFQ. In addition, traditional Kuwaiti desserts such as "Konafa, mamoul, lgaimat" were added to the sweets and snacks section to ensure inclusion of most of the commonly consumed food items. Alcoholic drinks and pork were removed from the FFQ as they are not commonly consumed items and also to respect the religious culture in Kuwait. Food items on the web-based

FFQ appear as a list where all the food items are displayed on one single page, as compared with displaying foods in food groups that are presented over several consecutive pages.

3.3.4 Photographs

Portion size photographs for 64 of the foods were derived from the Food4Me food portion size photograph list. The remaining 83 food items were purchased from local supermarkets and local restaurants and bakeries in Kuwait. All foods were prepared and photographed in Dasman Diabetes Institute (DDI), Kuwait over a period of 7days/sessions by a professional photographer from DDI. Photographs were taken in the Demo-Kitchen at DDI using the same lighting and a standard dining set of plates and cutlery that were positioned consistently for each session. All foods were weighed using calibrated portable food scales (Salter, UK) and the calculated Food4Me portion sizes were used as a guide for all the food items.

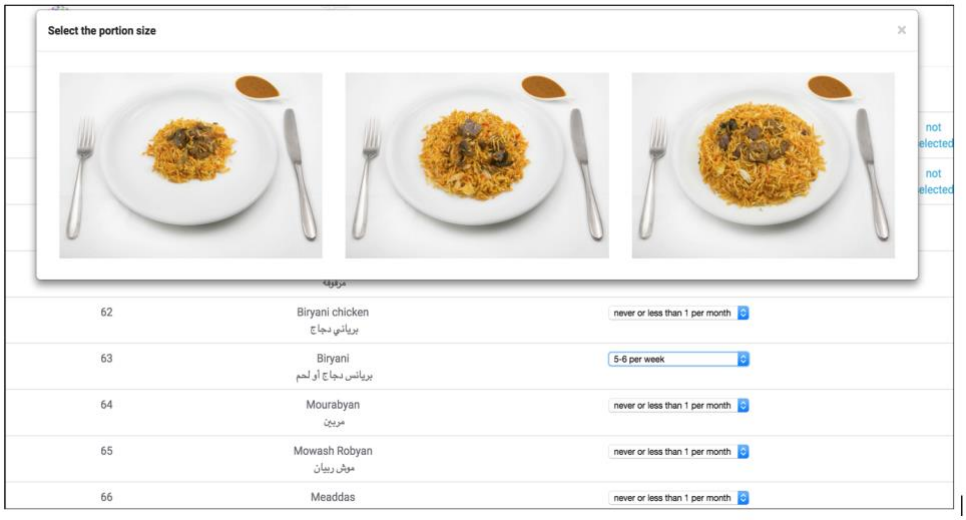

Figure 3. 1.Screenshot of the web-based EatWellQ8 FFQ illustrating the 3 portion size photographs for assessment of portion size

3.3.5 The 4-Day Weighed Food Record

Participants were asked to record all food items and beverages consumed over a 4-day period that included 3 weekdays (Sunday to Thursday) and 1 weekend day (Friday to Saturday). Prior to beginning the WFR, participants were asked to attend a preliminary training session at DDI given by a dietitian on how to describe food products and use the provided food scales (Salter Disc Electronic Kitchen Scales SKU#1036 WHSSDR). Participants were given the flexibility of estimating portion sizes when they were unable to weigh the food items (for example, when dining out).

3.3.6 The Kuwait Validated FFQ

A total of 50 participants were asked to complete a PFFQ after completing the initial web-based FFQ. The Kuwait Validated FFQ is a self-administered semi-quantitative food frequency questionnaire (FFQ) that was developed in 2009. The FFQ was developed to target the frequency of consumption and portion sizes of food and beverages regularly consumed by the Kuwaiti population (16). Standardized portions of the food items and beverages were used to estimate portion sizes and 9 frequencies ranging from “never/once a month” to “more than 6 times/day” were used for frequency estimation (16). The FFQ included questions on the average intake of 201 food items over the past 4 months. However, the time frame was lessened to one month for the purpose of the validation study. The food items were divided into the following fourteen groups: ‘cereals’, ‘composite dishes’, ‘marag (stew)’, ‘soups’, ‘meat dishes’, ‘snacks’, ‘desserts’, ‘dairy products’, ‘beverages’, ‘fruits’, vegetables’, ‘stuffed vegetables’, ‘salads’ and ‘miscellaneous’. Food intakes (g/day) were calculated by multiplying the portion of each food listed in the FFQ by the frequency of consumption and by the nutrient composition of the food using the USDA nutrient database (16).

3.3.7 Dietary Intake Analysis

Estimated dietary intake data from the EatWellQ8 FFQ were generated automatically by the web-based EatWellQ8 app, which was described previously by Franco et al (19). Nutritional composition and portion sizes of the 146 food items were calculated using the Food4Me food list (20), 5th and 6th editions of the McCance and Widdowson’s *The Composition of Foods* (21; 22), the Kingdom of Bahrain Food composition Tables (23) and a national Kuwait Food Composition List (24). From these lists, the most commonly consumed food items were selected and used to calculate the composition of the lists of foods in the EatWellQ8 FFQ. The nutritional compositions of all the Kuwaiti

composite dishes were found using the Kingdom of Bahrain food composition list and a Kuwait food composition list (23; 24). Portion sizes were primarily derived using the Food4Me food list (17; 18). To calculate the portion sizes, the food codes for each of the frequently consumed foods were identified from the Food4Me database and used to formulate the code for the food items in the FFQ. PASW Statistics version 24 (SPSS Inc Chicago, IL, USA) was used to calculate the 25th, 50th and 75th percentile of daily food intake, which correspond to small, medium and large portion sizes of these foods when consumed by the general population (17). Estimated nutrient intakes for the PFFQ were analyzed using an excel file that was based on the web-based EatWellQ8 programmed system. The 4-day WFR intakes were analyzed using Nutritics software (version 1.8, database MW6, Nutritics Ltd., Co. Dublin, Ireland).

3.3.8 Over/under reporting

Participants' results were excluded from the analysis if their daily energy intake was found to be less than 500kcal or greater than 4500kcal (calculated using the Henry equation) in any of the methods (25).

3.3.9 Statistical analysis

Statistical analyses were performed using SPSS (version 24.0, PASW, Chicago, IL, USA). Normality was assessed using a Shapiro-Wilk test and log transformation was used for non-parametric data when necessary. A paired *t* test was performed to assess differences in participants' energy intakes (Kcal) between the methods used. Standard deviations and mean nutrient intakes were calculated for baseline, repeated EatWellQ8 FFQ, PFFQ and 4-day WFR. Comparisons between nutrient intakes were performed using a general linear model (GLM) analysis, which was controlled further for energy, and gender where there was a significant interaction between nutrient intake and gender. To check for normality, data was analyzed using a Shapiro-Wilk test and either the Pearson or Spearman correlation coefficient (SCC) were used for normally or not normally distributed data respectively. Correlations were considered statistically significant if they had a P value of <0.05.

To test for agreement between the different dietary intake methods and repeated EatWellQ8 FFQ, cross-classification of nutrient intakes to assess the percentage of participants classified in the following quartiles: exact agreement (percentage of cases

cross-classified into the same quartile), exact agreement plus adjacent (percentage of cases cross-classified into the same or adjacent quartile), disagreement (percentage of cases cross-classified 2 quartiles apart), and extreme disagreement (percentage of cases cross-classified into extreme quartiles). The Bland-Altman (26) method was used to further analyze the LOA for energy intakes and macronutrients between the repeated EatWellQ8 FFQ and between the 3 methods (EatWellQ8 FFQ, WFR, PFFQ). Based on the Bland-Altman method, dietary intake methods were found to be repeatable/comparable if greater than 95% of data plots fell within the 2-standard deviation of the mean (LOA) and by calculating the bias calculated by the mean difference and standard deviation of the differences.

3.4 Results

A total of 235 participants were screened for the study, of which 218 were found to be eligible. Participants were excluded (n=17) due to incomplete FFQs or not fulfilling the screening requirements due to medication use, food allergies or an existing illness. A high dropout rate of 48.6% was found which was mainly due to participants' unwillingness to complete all aspects of the study. 110 participants completed the EatWellQ8 FFQ1, of which 60 completed EatWellQ8 FFQ2 and a 4-day WFR and 50 were asked to complete a PFFQ. In total, 18 participants were excluded from analysis due to reported energy intakes of <500 Kcals or >4500 Kcals [25]. Of these, 53 participants completed the second EatWellQ8 FFQ, 46 completed EatWellQ8 FFQ2 and the 4-day WFR and 46 participants completed the PFFQ. An illustration of the flow of the participants is found in Figure 3.2. Demographic characteristics based on self-report are shown in Table 3.1. No significant differences were found between age and BMI for females and males. A higher percentage of females completed both studies: 65.3% in the validation study and 66.4% in the reproducibility study.

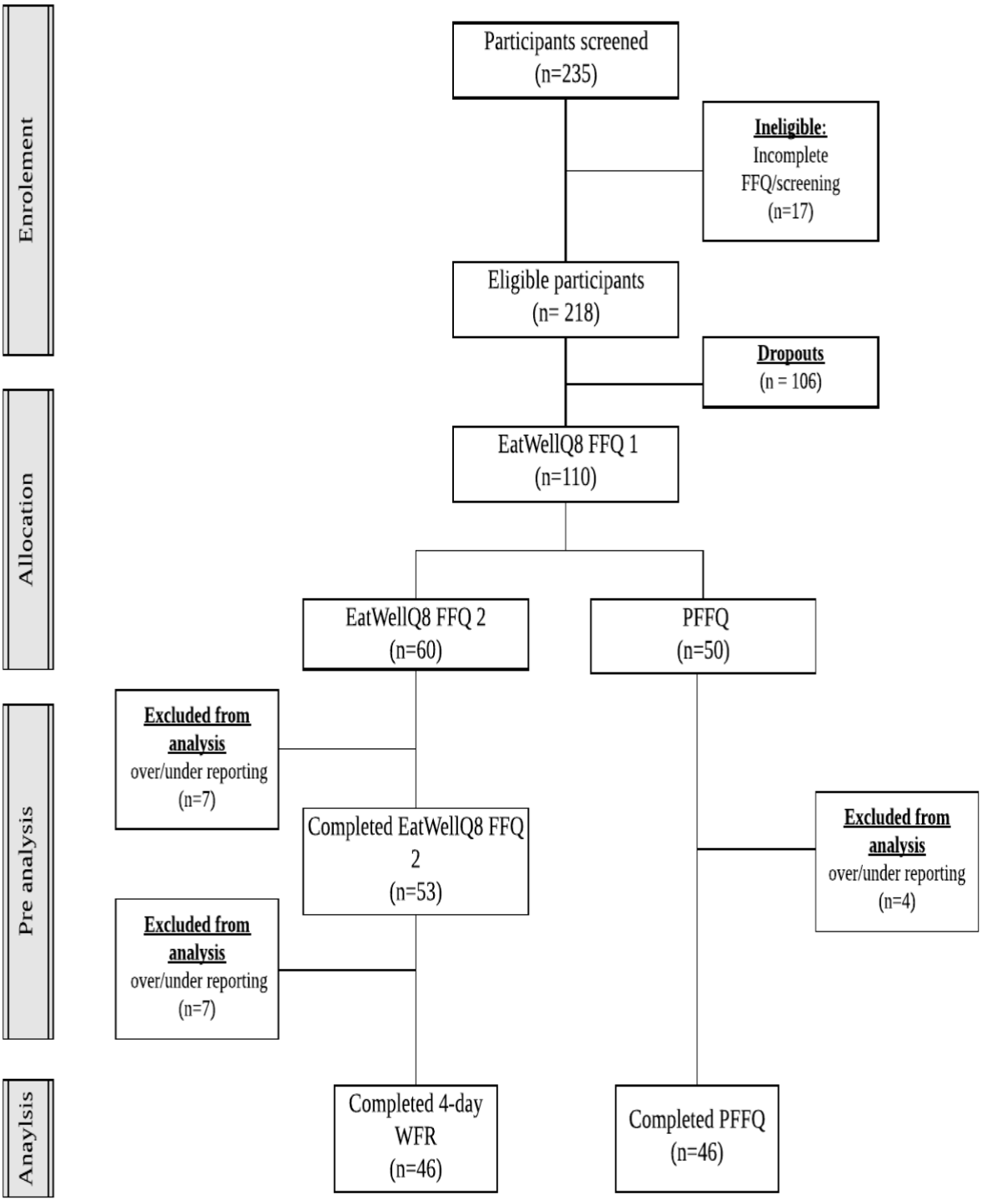

Figure 3. 2 Participants flow during the study

Table 3. 1 Demographic characteristics of participants that completed the reproducibility and validation studies

Study	**N**	**Demographic characteristics, mean (SD)**	
		Age (years)	BMI (Kg/m2)
Reproducibility			
All	53	37 (9.9)	25.6 (4.4)
Females	35	36 (9.8)	24.9 (4.6)
Males	18	39 (9.7)	26.8 (3.5)
Validation			
All	92	36 (8.3)	25.2 (4.4)
Females	60	37 (9.2)	24.3 (4.4)
Males	32	34 (6.1)	27.0 (3.9)

BMI= Body Mass Index

3.4.1 Reproducibility of the EatWellQ8 FFQ

3.4.2 Comparison of nutrient intake between repeated EatWellQ8 FFQ

No significant differences were found between macronutrient and micronutrient intakes evaluated in FFQ1 and FFQ2 (Table 3.2). Correlations were found to be significant for all nutrients (P<0.01) and ranged from 0.37 (polyunsaturated fatty acids (PUFA) % TE) to 0.82 (iron) with a mean value of 0.67 (Table 3.3). Results of the cross-classifications for percentage of participants classified into quartiles of exact agreement ranged from 40% (PUFA%TE) to 62% (total folate). Classifications of exact agreement plus adjacent, ranged from 77% (monounsaturated fatty acids (MUFA) %TE) to 100% (energy Kcal). Disagreement was relatively low, the mean percentage of participants classified into quartiles of disagreement was 8% and the mean of participants classified into extreme disagreement was 1.4%.

The Bland and Altman plots for estimates of energy (Kcal), protein % total energy (TE), total fat (%TE) and carbohydrate (%TE) intakes are shown in Figure 3.3. Good agreement was found in the Bland and Altman plots as the majority of the cases fell within the 95% limit of agreement. The EatWellQ8 FFQ presented good reproducibility for the evaluation of daily fat intake, with less than 4% of cases outside the LOA. For energy and carbohydrate, less than 6% fell outside the LOA and 7% for protein. Based on the LOA values, greater agreement was found for protein (%TE) compared to energy, total fat and total carbohydrate (%TE). There was no significant bias identified for any nutrient. Variation between estimates of energy and energy-adjusted macronutrient intakes increased with higher mean intakes (figure 3.3).

Table 3. 2 Mean daily energy and nutrient intakes estimated by repeated measures of the web-based EatWellQ8 FFQ (n=53)

Nutrient	EatWellQ8 FFQ1 (Mean (SD))	EatWellQ8 FFQ2 (Mean (SD))	*P* value[a]	*P* value[b]
Energy (kcal)	2724 (1355)	2524 (1232)	0.09[c]	-
Total Fat (g)	104.7 (56.2)	96.1 (50.2)	0.79	0.79
Total Fat (% TE)	34.2 (7.7)	34.2 (7.8)	0.96	0.96
SFA (g)	43.5 (27.0)	38.5 (22.1)	0.49	0.49
SFA (% TE)	14.0 (4.4)	13.6 (4.8)	0.73	0.73
MUFA (g)	45.4 (25.0)	40.0 (21.4)	0.34	0.34
MUFA (% TE)	14.9 (4.2)	14.3 (3.9)	0.41	0.41
PUFA (g)	18.0 (9.1)	17.5 (8.9)	0.46	0.46
PUFA (% TE)	6.1 (1.7)	6.4 (1.7)	0.58	0.58
Omega 3 (g)	0.17 (0.2)	0.20 (0.4)	0.47	0.47
Protein (g)	117.8 (57.3)	111.4 (52.2)	0.84	0.84
Protein (% TE)	17.7 (4.1)	18.5 (5.1)	0.53	0.54
Carbohydrate (g)	348 (197	323 (182)	0.87	0.88
Carbohydrate (% TE)	51.1 (9.8)	50.3 (10.7)	0.76	0.77
Total sugars (g)	149 (91)	134 (79)	0.69	0.69
Total sugars (%TE)	22.1 (9.2)	21.4 (7.3)	0.67	0.67
Calcium (mg)	1288 (682)	1192 (633)	0.86	0.86
Total folate (µg)	405 (204)	358 (167)	0.29	0.29
Iron (mg)	16.8 (9.5)	15.0 (7.8)	0.41	0.41
Total carotene (µg)	6581(6161)	5548 (4079)	0.41	0.41
Riboflavin (mg)	2.3 (1.2)	2.2 (1.1)	0.90	0.89
Thiamin (mg)	2.1 (1.1)	1.9 (0.9)	0.78	0.77
Vitamin B6 (mg)	2.8 (1.2)	2.7 (1.2)	0.85	0.85
Vitamin B12 (µg)	5.2 (3.3)	5.4 (3.4)	0.33	0.33
Vitamin C (mg)	200 (116)	183 (135)	0.77	0.76
Vitamin A RE (µg)	1319 (1048)	1153 (718)	0.48	0.48
Retinol (µg)	241 (190)	258 (191)	0.15	0.15
Vitamin D (µg)	3.1 (2.3)	3.4 (3.2)	0.36	0.36
Vitamin E (mg)	15.4 (7.5)	14.3 (7.6)	0.89	0.89
Na (mg)	3159 (1570)	2948 (1485)	0.99	0.99

[a] Controlled for energy
[b] Controlled for energy and gender
[c] Value derived from paired sample t-test
%TE= Percentage Total Energy, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids, RE= Retinol Equivalent, Na= Sodium

Table 3. 3 Unadjusted correlation coefficients and cross-classification of quartiles of mean energy and nutrient intakes derived from repeat measures of the web-based EatWellQ8 FFQ (n=53)

Nutrient	Correlation	Quartiles, % Exact agreement[b]	Exact agreement plus adjacent[c]	Disagreement[d]	Extreme disagreement[e]
Energy (kcal)	0.79 [a]	51	100	0	0
Total Fat (g)	0.75 [a]	53	87	13	0
Total Fat (% TE)	0.42 [a]	40	81	15	3
SFA (g)	0.68 [a]	51	92	7	0
SFA (% TE)	0.53 [a]	47	81	11	7
MUFA (g)	0.77 [a]	53	92	5	2
MUFA (% TE)	0.49 [a]	40	77	15	2
PUFA (g)	0.69 [a]	53	91	5	3
PUFA (% TE)	0.37 [a]	36	74	19	8
Omega 3 (g)	0.44 [a]	51	83	13	3
Protein (g)	0.74 [a]	55	91	7	2
Protein (% TE)	0.74 [a]	42	92	3	2
Carbohydrate (g)	0.78 [a]	57	94	5	0
Carbohydrate (% TE)	0.54 [a]	42	83	21	0
Total sugars (g)	0.77 [a]	53	94	5	0
Total sugars (%TE)	0.63 [a]	42	87	13	0
Calcium (mg)	0.76 [a]	45	94	5	0
Total folate (µg)	0.81 [a]	62	92	7	0
Iron (mg)	0.82 [a]	55	92	3	0
Total carotene (µg)	0.38 [a]	57	94	5	0
Riboflavin (mg)	0.75 [a]	55	92	7	0
Thiamin (mg)	0.76 [a]	57	92	5	2
Vitamin B6 (mg)	0.69 [a]	53	85	15	0
Vitamin B12 (µg)	0.66 [a]	47	87	9	3
Vitamin C (mg)	0.75 [a]	49	87	13	0
Vitamin A RE (µg)	0.42 [a]	60	98	2	0
Retinol (µg)	0.57 [a]	51	87	11	2
Vitamin D (µg)	0.63 [a]	45	81	13	5
Vitamin E (mg)	0.81 [a]	57	94	5	0
Na (mg)	0.75 [a]	51	92	7	0

[a] $P<0.01$

[b] Exact agreement, % of case cross-classified into the same quartile.

[c] Exact agreement plus adjacent, % of cases cross-classified into the same or adjacent quartile.

[d] Disagreement, % of cases cross-classified 2 quartiles apart.

[e] Extreme disagreement, % of cases cross-classified into extreme quartiles

%TE= Percentage Total Energy, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids, RE= Retinol Equivalent, Na= Sodium

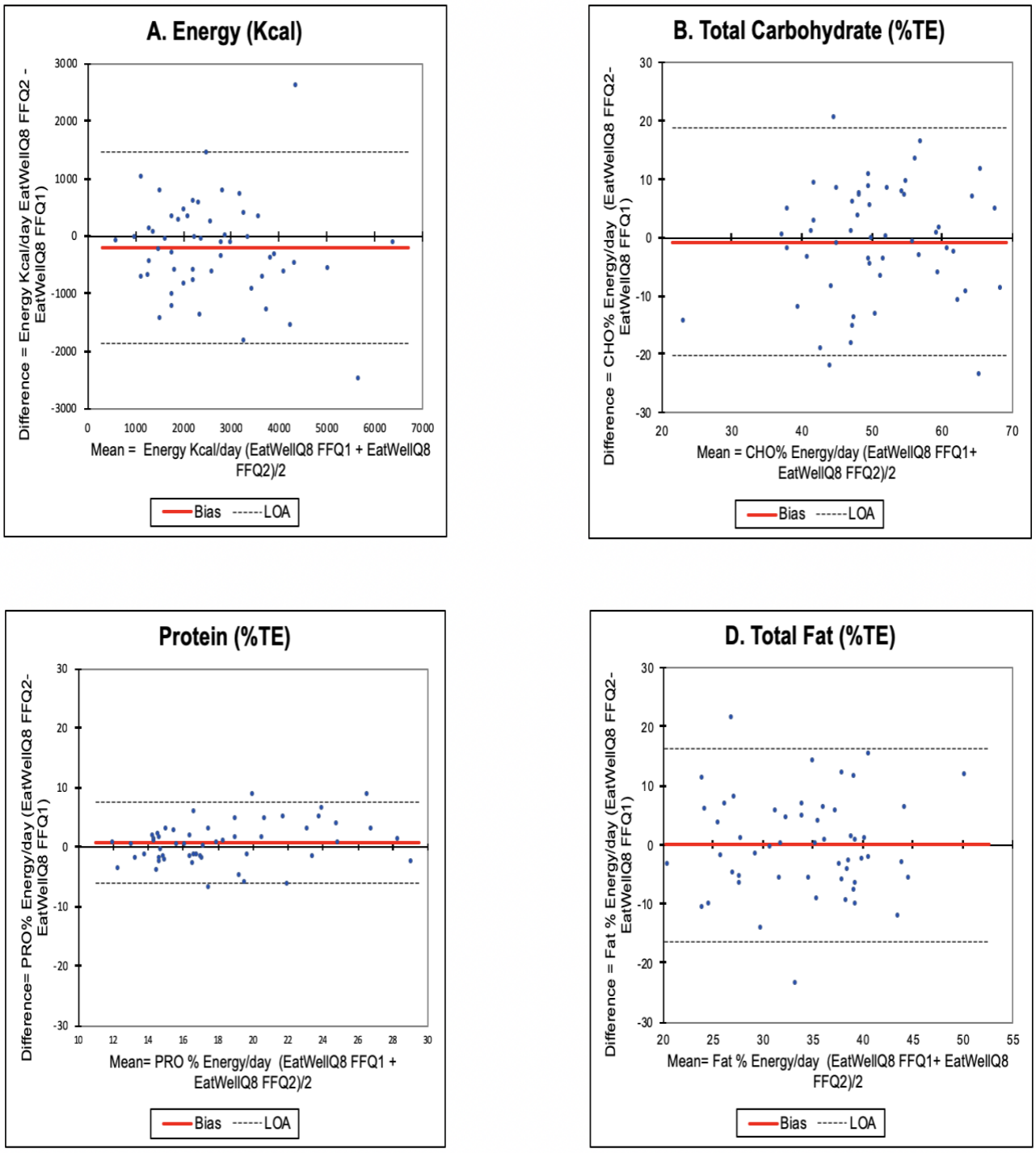

Figure 3. 3 Reproducibility study Bland-Altman plots for (a) energy, (b) total carbohydrate, (c) protein, and (d) total fat with the Bias (mean difference) and limits of agreement.

The solid line represents the Bias (mean difference) and the dotted lines represent the limits of agreement (LOA)
%TE= Percentage Total Energy, CHO= Carbohydrates, PRO= Protein

3.4.3 Comparison of Food Group Intakes Between Repeated EatWellQ8 FFQ

Food items were categorized into 32 food groups in order to assess the differences between repeated administrations of the web-based EatWellQ8 FFQ. SCCs ranged from 0.40 (savories) to 0.93 (meat products) with a mean value of 0.67 (Table 3.4). Significant correlations were found for all food groups (P<0.01).The cross-classification of participants classified into quartiles of exact agreement ranged from 45% (salad vegetables) to 76% (meat products). Moderately high classifications of exact agreement plus adjacent were found, which ranged from 66% (confectionary and savoury snacks) to 98% (meat products).

Table 3. 4 Spearman correlation coefficients (SCC) and cross-classification of quartiles of food group intake derived from repeat measures of the web-based EatWellQ8 FFQ (n=53)

Nutrient	Correlation [a]	Quartiles,% Exact agreement [b]	Exact agreement plus adjacent [c]	Disagreement [d]	Extreme disagreement [e]
Rice, pasta, grains and starches	0.57	51	86	11	2
Savories (lasagne, pizza)	0.40	49	75	16	7
White bread (rolls, tortillas, crackers)	0.67	60	83	9	7
Wholegrain and brown breads and rolls	0.56	57	77	16	5
Breakfast cereals and porridge	0.76	67	91	7	2
Biscuits	0.58	63	83	10	6
Cakes, pastries and buns	0.80	66	91	8	0
Milk	0.72	58	90	10	0
Cheeses	0.51	58	85	10	5
Yoghurts	0.59	48	80	15	2
Ice cream, creams and desserts	0.79	68	91	6	2
Eggs and egg dishes	0.84	71	96	3	0
Fats and oils (eg,butter, low-fat spreads, hard cooking fats)	0.83	65	95	3	2
Potatoes and potato dishes, Chipped, fried and roasted potatoes	0.88	75	93	6	0
Peas, beans and lentils and vegetable and pulse dishes	0.82	73	91	5	3
Green vegetables	0.67	63	81	18	0
Carrots	0.75	66	93	3	3
Salad vegetables (e.g., lettuce)	0.64	45	85	11	3

Other vegetables (e.g., onions)	0.65	63	88	3	8
Tinned fruit or vegetables	0.70	53	83	13	3
Bananas	0.81	71	93	5	2
Other fruits (e.g., apples, pears, oranges)	0.76	71	88	11	0
Nuts and seeds, herbs and spices	0.71	68	86	8	5
Fish and fish products/dishes	0.76	65	90	6	3
Red meat (e.g., beef, veal, lamb, etc.)	0.85	70	90	8	0
Poultry (chicken and turkey)	0.59	53	83	13	3
Meat products (e.g., burgers, sausages, pies, processed meats)	0.93	76	98	2	0
Sugars, syrups, preserves and sweeteners	0.46	53	76	11	11
Confectionary, savory snacks	0.37	46	66	23	10
Soups, sauces, miscellaneous foods	0.64	61	83	10	6
Teas and coffees	0.63	48	88	10	2
Fruit Juice and Fizzy Drinks	0.43	45	68	20	11

[a] $P<0.01$
[b] Exact agreement, % of case cross-classified into the same quartile.
[c] Exact agreement plus adjacent, % of cases cross-classified into the same or adjacent quartile.
[d] Disagreement, % of cases cross-classified 2 quartiles apart.
[e] Extreme disagreement, % of cases cross-classified into extreme quartiles.

3.4.4 Validation of the EatWellQ8 FFQ

3.4.5 Comparison of Nutrient Intakes between the EatWellQ8 FFQ and the Kuwait PFFQ

No significant differences were found between 70% of the macronutrients and micronutrients evaluated by the EatWellQ8 FFQ1 and the PFFQ (Table 3.5). Estimated energy intakes were found to be significantly higher (difference = 398 Kcals/day), 17.3% higher, (P<0.001) in the EatWellQ8 FFQ1 when compared to the PFFQ.

After controlling for energy, comparable estimated intakes of macronutrients and micronutrients were observed for the EatWellQ8 FFQ1 and the PFFQ except for saturated fatty acids (SFA) and MUFA (g, %TE) which were significantly higher for EatWellQ8 FFQ compared to the PFFQ (P<0.001). Furthermore, estimated intakes of total folate (P<0.01), retinol (P<0.001) and vitamin B12 (P<0.001) were higher in the PFFQ than EatWellQ8 FFQ.

With the exception of omega 3 FA and retinol, correlations were found to be significant for all nutrients (P<0.01) and ranged from 0.42 (Vitamin D) to 0.73 (Energy) with a mean value of 0.54 (Table 3.6). Results of the cross-classifications for percentage of participants classified into quartiles of exact agreement ranged from 35% (total fat) to 57% sodium (Na), exact agreement plus adjacent, ranged from 76% (total fat, %TE) to 93% (energy) with low levels of disagreement (13.4%) and extreme disagreement (2.4%).

Overall, moderate agreement was found in the Bland and Altman plots between the EatWellQ8 and the paper form of PFFQ with 87% of all cases falling within the 95% limit of agreement (Figure 3.4). The EatWellQ8 FFQ presented good validation for the evaluation of energy and daily intake of fat, with approximately 4% of cases fell outside the LOA. For daily intake of carbohydrate, less than 6% fell outside the LOA and for protein 8%fell out of the LOA. Protein (%TE) had the narrowest LOA which signifies better agreement compared to energy, total fat (%TE) and carbohydrate (%TE). The bias (mean difference) between energy intakes was significantly higher (398 Kcal/day) with greater intakes reported in the EatWellQ8 FFQ. High mean bias was found for total fat (-3.05 %TE) compared with total carbohydrate (2.67%TE) and protein (1.20 %TE). No other significant differences were observed.

Table 3. 5 Mean daily energy and nutrient intakes estimated by web-based EatWellQ8 FFQ and a PFFQ and general linear model (GLM) results (n=46)

Nutrient	EatWellQ8 FFQ (Mean (SD))	PFFQ (Mean (SD))	*P* value[a]	*P* value[b]
Energy (kcal)	2297 (779)	1899 (505)	<0.001[c]	-
Total Fat (g)	92.1 (40.8)	69.1 (23.4)	0.12	0.12
Total Fat (% TE)	35.5 (7.8)	32.4 (5.1)	0.13	0.13
SFA (g)	38.4 (17.9)	26.9 (9.1)	0.01	0.01
SFA (% TE)	14.9 (4.8)	12.6 (2.7)	0.01	0.01
MUFA (g)	39.5 (19.5)	26.4 (9.7)	0.00	0.00
MUFA (% TE)	15.1 (4.3)	12.3 (2.3)	0.00	0.00
PUFA (g)	16.1 (7.8)	13.1 (6.5)	0.64	0.58
PUFA (% TE)	6.2 (1.7)	6.1 (1.8)	0.93	0.96
Omega 3 (g)	0.1 (0.2)	0.3 (0.3)	0.00	0.00
Protein (g)	104 (41)	93 (41)	0.35	0.33
Protein (% TE)	18.2 (5.0)	19.4(6.1)	0.39	0.37
Carbohydrate (g)	280 (102)	241 (70)	0.53	0.53
Carbohydrate (% TE)	49.1 (10.5)	51.2 (7.9)	0.53	0.54
Total sugars (g)	125 (52)	105 (32)	0.56	0.53
Total sugars (%TE)	22.3 (8.8)	22.6 (6.2)	0.53	0.53
Calcium (mg)	1126 (542)	933 (358)	0.86	0.84
Total folate (µg)	323 (135)	328 (116)	0.01	0.01
Iron (mg)	13.5 (5.7)	11.5 (4.0)	0.48	0.49
Total carotene (µg)	5042 (3430)	4781 (4325)	0.82	0.82
Riboflavin (mg)	2.0 (0.9)	1.8 (0.7)	0.30	0.31
Thiamin (mg)	1.7 (0.7)	1.5 (0.4)	0.18	0.18
Vitamin B6 (mg)	2.4 (0.8)	2.1 (0.8)	0.77	0.77
Vitamin B12 (µg)	4.8 (2.8)	5.5 (3.2)	0.00	0.00
Vitamin C (mg)	163 (141)	156 (98)	0.67	0.68
Vitamin A RE (µg)	1054 (590)	1110 (796)	0.22	0.22
Retinol (µg)	237 (138)	387 (452)	0.00	0.00
Vitamin D (µg)	2.6 (2.0)	2.3 (1.7)	0.48	0.45
Vitamin E (mg)	12.7 (7.0)	9.5 (3.9)	0.44	0.45
Na (mg)	2701 (1058)	2102 (771)	0.21	0.21

[a] Controlled for energy
[b] Controlled for energy and gender
[c] Value derived from paired sample t-test
%TE= Percentage Total Energy, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids, RE= Retinol Equivalent, Na= Sodium

Table 3. 6 Unadjusted correlation coefficients and cross-classification of quartiles of mean energy and nutrient intakes derived from comparative measures of a PFFQ to the web-based EatWellQ8 FFQ (n=46)

Nutrient	Correlation	Quartiles, % Exact agreement[b]	Exact agreement plus adjacent[c]	Disagreement[d]	Extreme disagreement[e]
Energy (kcal)	0.73 [a]	53	93	7	0
Total Fat (g)	0.59 [a]	35	87	13	0
Total Fat (% TE)	0.45 [a]	48	76	24	0
SFA (g)	0.68 [a]	46	93	4	0
SFA (% TE)	0.49 [a]	52	83	17	0
MUFA (g)	0.62 [a]	39	83	11	0
MUFA (% TE)	0.44 [a]	50	80	15	4
PUFA (g)	0.64 [a]	52	85	15	0
PUFA (% TE)	0.58 [a]	35	91	9	0
Omega 3 (g)	0.19	24	63	28	9
Protein (g)	0.59 [a]	48	83	17	0
Protein (% TE)	0.57 [a]	48	87	9	4
Carbohydrate (g)	0.66 [a]	56	85	11	4
Carbohydrate (% TE)	0.51 [a]	48	83	13	4
Total sugars (g)	0.59 [a]	54	87	11	2
Total sugars (%TE)	0.45 [a]	50	80	15	4
Calcium (mg)	0.63 [a]	52	87	13	0
Total folate (µg)	0.51 [a]	37	83	15	2
Iron (mg)	0.46 [a]	39	78	20	2
Total carotene (µg)	0.59 [a]	46	85	11	4
Riboflavin (mg)	0.71 [a]	48	91	9	0
Thiamin (mg)	0.63 [a]	48	87	13	0
Vitamin B6 (mg)	0.65 [a]	48	83	17	0
Vitamin B12 (µg)	0.47 [a]	43	83	11	7
Vitamin C (mg)	0.51 [a]	35	89	4	7

Vitamin A RE (µg)	0.51 [a]	48	83	11	7
Retinol (µg)	0.27	35	76	13	11
Vitamin D (µg)	0.42 [a]	39	76	22	2
Vitamin E (mg)	0.62 [a]	50	87	13	0
Na (mg)	0.55 [a]	57	85	11	4

[a] $P<0.01$
[b] Exact agreement, % of case cross-classified into the same quartile.
[c] Exact agreement plus adjacent, % of cases cross-classified into the same or adjacent quartile.
[d] Disagreement, % of cases cross-classified 2 quartiles apart.
[e] Extreme disagreement, % of cases cross-classified into extreme quartiles
%TE= Percentage Total Energy, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids,RE= Retinol Equivalent, Na= Sodium

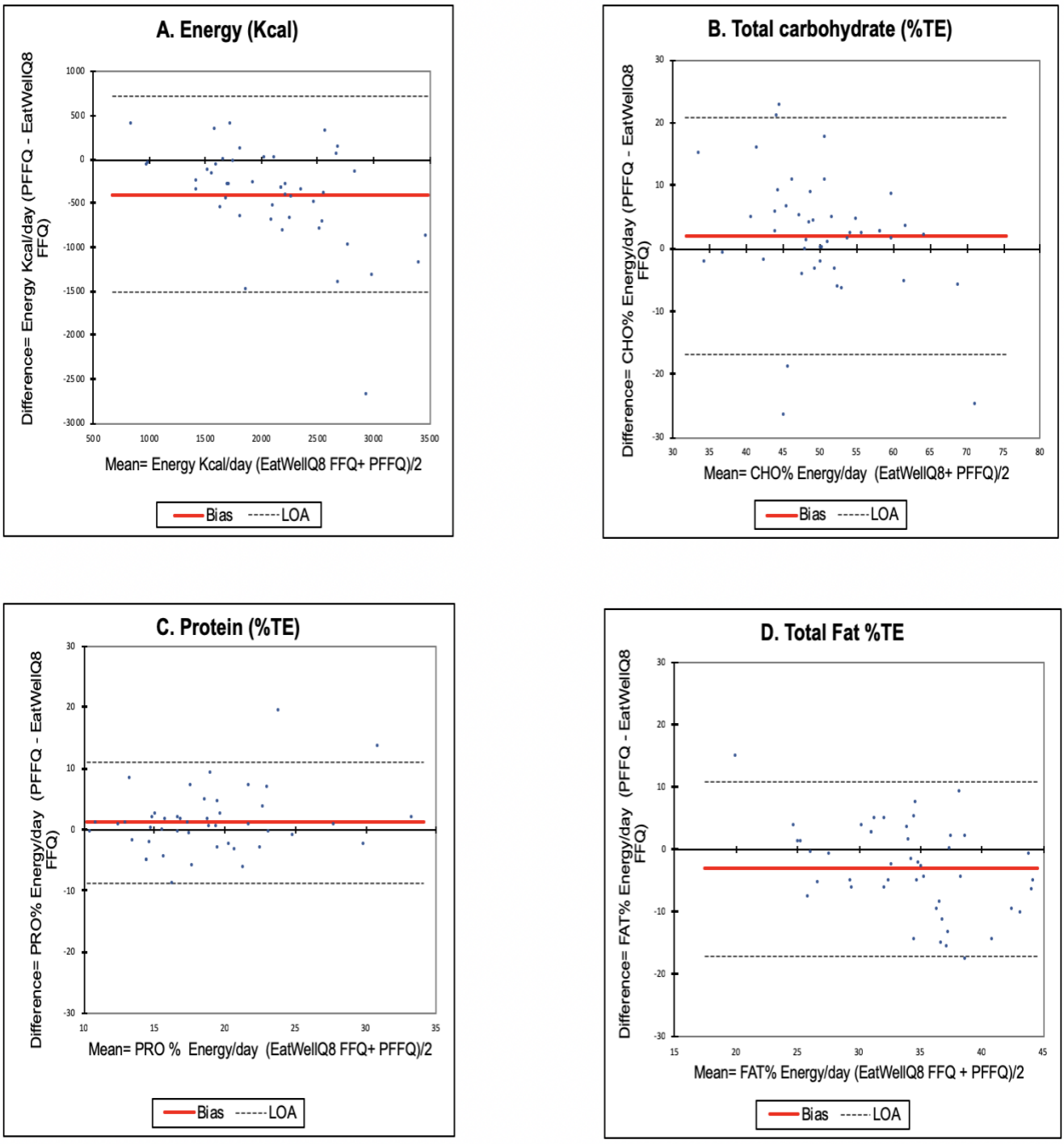

Figure 3. 4 Validation study Bland-Altman plots comparing the EatWellQ8 FFQ to a PFFQ for (a) energy, (b) total carbohydrate, (c) protein, and (d) total fat with the Bias (mean difference) and limits of agreement.

The solid line represents the Bias (mean difference) and the dotted lines represent the limits of agreement (LOA)
%TE= Percentage Total Energy, CHO= Carbohydrates, PRO= Protein

3.4.6 Comparison of Food Group Intakes Between the EatWellQ8 FFQ and the Kuwait PFFQ

SCCs ranged from 0.51 (bananas) to 0.22 (fish and fish products/dishes) (Table 3.7). With the exception of fish and fish products/dishes, significant correlations were found for all food groups (P<0.05). The cross-classification percentages of participants classified into quartiles of exact agreement ranged from 60% (soups, sauces and miscellaneous foods) to 24% (white bread). Classifications of exact agreement plus adjacent ranged from 65% (ice cream, creams and desserts) to 82% (teas and coffees). The mean percentage of participants classified into quartiles of disagreement was 15% and for extreme disagreement was 9%.

Table 3. 7 Spearman correlation coefficients (SCC) and cross-classification of quartiles of food group intake derived from the web-based EatWellQ8 FFQ and PFFQ (n=46)

Nutrient	Correlation [a]	Quartiles,% Exact agreement[b]	Exact agreement plus adjacent[c]	Disagreement[d]	Extreme disagreement[e]
Rice, pasta, grains and starches	0.29 [b]	37	73	17	9
Savories (lasagne, pizza)	0.32[b]	39	76	20	4
White bread (rolls, tortillas, crackers)	0.33 [b]	24	78	11	11
Wholegrain and brown breads and rolls	0.43[a]	50	71	17	7
Breakfast cereals and porridge	0.39[a]	54	80	9	11
Biscuits	0.34 [b]	43	76	11	13
Cakes, pastries and buns	0.41[a]	37	74	19	7
Milk	0.36 [b]	39	72	22	7
Cheeses	0.50 [a]	45	74	15	4
Yoghurts	0.34 [b]	35	76	11	13
Ice cream, creams and desserts	0.39 [a]	48	65	26	8
Eggs and egg dishes	0.44 [a]	47	80	11	8
Fats and oils (eg,butter, low-fat spreads, hard cooking fats)	0.45 [a]	50	76	17	7
Potatoes and potato dishes, Chipped, fried and roasted potatoes	0.32 [b]	40	73	13	13
Peas, beans and lentils and vegetable and pulse dishes	0.37 [b]	52	80	13	7
Green vegetables	0.31 [b]	35	78	11	11
Carrots	0.32 [b]	41	69	17	13
Salad vegetables (e.g., lettuce)	0.37 [b]	37	65	32	2
Other vegetables (e.g., onions)	0.37 [b]	37	73	15	11
Tinned fruit or vegetables	0.35 [b]	41	73	11	15
Bananas	0.51 [a]	50	84	4	9
Other fruits (e.g., apples, pears, oranges)	0.42 [a]	32	82	13	4

Nuts and seeds, herbs and spices	0.30 [b]	39	69	17	13
Fish and fish products/dishes	0.22	54	69	11	20
Red meat (e.g., beef, veal, lamb, etc.)	0.36 [b]	37	71	21	7
Poultry (chicken and turkey)	0.40 [a]	50	70	21	8
Meat products (e.g., burgers, sausages, pies, processed meats)	0.41 [a]	47	71	17	11
Sugars, syrups, preserves and sweeteners	0.34 [b]	56	70	17	13
Confectionary, savory snacks	0.39 [a]	43	78	9	13
Soups, sauces, miscellaneous foods	0.42 [a]	60	76	11	13
Teas and coffees	0.43 [a]	37	82	13	4
Fruit Juice and Fizzy Drinks	0.42 [a]	52	80	9	13

[a] $P<0.01$
[b] $P<0.05$
[c] Exact agreement, % of case cross-classified into the same quartile.
[d] Exact agreement plus adjacent, % of cases cross-classified into the same or adjacent quartile.
[e] Disagreement, % of cases cross-classified 2 quartiles apart.
[f] Extreme disagreement, % of cases cross-classified into extreme quartiles.

3.4.7 Comparison of Nutrient Intakes between the EatWellQ8 FFQ and a 4-day WFR

Estimated macronutrient intakes were found to be similar between the EatWellQ8 FFQ and 4-day WFR after controlling for energy (Table 3.8). However, estimated intakes of SFA (g, %TE) (P<0.00), MUFA (g) (P<0.03), MUFA (g) (P<0.04), omega 3 FA (g) (P<0.01), total carbohydrates (P<0.05) and total sugars (g, %TE) (P<0.05) were significantly higher in the EatWellQ8 FFQ compared to the 4-day WFR. Significantly higher estimated intakes of folate, total carotene, thiamin, vitamin B6, vitamin C, vitamin A RE, and sodium (P<0.05) were found for the EatWellQ8 FFQ compared with the 4-day WFR. Similar results were found after controlling for both energy and gender.

Significant correlation for all nutrients was found at the P<0.01 level, correlation coefficients ranged from 0.40 (iron) to 0.88 (energy) with a mean value of 0.61 (Table 3.9). The percentage of volunteers classified into quartiles of exact agreement ranged from 28% (PUFA, g) to 67% (energy, Kcal). Values were higher for classifications of exact agreement plus adjacent and ranged from 71% (MUFA, %TE) to 95% (protein, g). Mean percentage of volunteers classified into quartiles of disagreement was 11% and less than 2% of volunteers were classified into extreme disagreement.

In total, good agreement between the methods was found as less than 5% of cases fell outside of the LOA for the all of the plots (Figure 3.5). Based on the LOA values, highest agreement was found for protein (%TE) compared to energy total carbohydrate (%TE) and total fat (%TE). Bias (mean difference) between energy intakes was small (81 Kcal/day) with greater values estimated in the EatWellQ8 FFQ. Higher bias for energy-adjusted total carbohydrate (4.39 %TE) and total fat (1.2%TE) intakes was measured in the EatWellQ8 FFQ. However, higher bias for energy-adjusted protein (1.65% TE) intakes was measured in the 4-day WFR.

Table 3. 8 Mean daily energy and nutrient intakes estimated by the web-based EatWellQ8 FFQ and 4-day WFR and general linear model (GLM) results (n=46)

Nutrient	EatWellQ8 FFQ (Mean (SD))	WFR 4-day (Mean (SD))	*P* value[a]	*P* value[b]
Energy (kcal)	2199 (862)	2119 (772)	0.17[c]	-
Total Fat (g)	84.2 (39.0)	74.3 (27.6)	0.08	0.08
Total Fat (% TE)	34.0 (7.4)	32.8 (8.5)	0.47	0.48
SFA (g)	36.8 (18.2)	28.0 (12.0)	0.00	0.00
SFA (% TE)	14.8 (3.8)	11.9 (2.8)	0.00	0.00
MUFA (g)	35.8 (17.9)	29.8 (13.9)	0.04	0.04
MUFA (% TE)	14.5 (4.1)	13.2 (5.1)	0.17	0.17
PUFA (g)	14.5 (6.8)	11.7 (6.5)	0.03	0.03
PUFA (% TE)	5.9 (1.6)	5.2 (2.7)	0.07	0.07
Omega 3 (g)	0.1 (0.2)	0.3 (0.3)	0.00	0.00
Protein (g)	106 (50)	112 (55)	0.11	0.11
Protein (% TE)	19.3 (5.2)	21.00 (6.44)	0.16	0.16
Carbohydrate (g)	272 (117)	238 (102)	0.03	0.03
Carbohydrate (% TE)	49.8 (9.7)	45.4 (9.5)	0.03	0.03
Total sugars (g)	130 (74)	104 (63)	0.03	0.03
Total sugars (%TE)	23.1 (8.2)	19.3 (8.1)	0.03	0.02
Calcium (mg)	1191 (668)	1005 (508)	0.07	0.07
Total folate (µg)	345 (152)	288 (121)	0.02	0.02
Iron (mg)	13.4 (5.4)	11.9 (5.0)	0.13	0.13
Total carotene (µg)	5106 (4439)	3407 (3480)	0.04	0.04
Riboflavin (mg)	2.1 (1.2)	1.9 (1.1)	0.40	0.40
Thiamin (mg)	1.8 (0.8)	1.4 (0.5)	0.001	0.001
Vitamin B6 (mg)	2.5 (1.2)	2.0 (0.9)	0.01	0.01
Vitamin B12 (µg)	5.3 (3.5)	6.6 (11.3)	0.37	0.38
Vitamin C (mg)	178 (153)	126 (80)	0.04	0.04
Vitamin A RE (µg)	1057 (766)	739 (497)	0.02	0.02
Retinol (µg)	223 (147)	202 (112)	0.56	0.57
Vitamin D (µg)	2.6 (1.9)	2.9 (1.8)	0.26	0.26
Vitamin E (mg)	11.8 (6.7)	10.6 (5.3)	0.39	0.39
Na (mg)	2552 (898)	2010 (815)	0.00	0.00

[a] Controlled for energy
[b] Controlled for energy and gender
[c] Value derived from paired sample t-test
%TE= Percentage Total Energy, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids, RE= Retinol Equivalent, Na= Sodium

Table 3. 9 Unadjusted correlation coefficients and cross-classification of quartiles of mean energy and nutrient intakes derived from comparative measures of a 4-day WFR (N=46) to the web-based EatWellQ8 FFQ

Nutrient	Correlation	Quartiles, % Exact agreement[b]	Exact agreement plus adjacent[c]	Disagreement[d]	Extreme disagreement[e]
Energy (kcal)	0.88 [a]	67	93	6	0
Total Fat (g)	0.69 [a]	52	84	4	2
Total Fat (% TE)	0.47 [a]	37	80	15	4
SFA (g)	0.80 [a]	47	93	4	2
SFA (% TE)	0.56 [a]	37	84	15	0
MUFA (g)	0.52 [a]	45	78	19	2
MUFA (% TE)	0.45 [a]	41	71	26	2
PUFA (g)	0.49 [a]	28	84	10	4
PUFA (% TE)	0.55 [a]	45	84	13	2
Omega 3 (g)	0.49 [a]	50	80	13	2
Protein (g)	0.81 [a]	58	93	7	0
Protein (% TE)	0.57 [a]	35	89	9	2
Carbohydrate (g)	0.72 [a]	65	91	8	0
Carbohydrate(%TE)	0.70 [a]	45	89	10	0
Total sugars (g)	0.72 [a]	56	91	8	0
Total sugar (%TE)	0.57 [a]	41	95	6	2
Calcium (mg)	0.74 [a]	52	91	8	0
Total folate (µg)	0.68 [a]	63	89	11	0
Iron (mg)	0.40 [a]	32	80	10	8
Total carotene (µg)	0.53 [a]	46	80	15	4
Riboflavin (mg)	0.68 [a]	54	89	10	0
Thiamin (mg)	0.58 [a]	46	83	15	2
Vitamin B6 (mg)	0.59 [a]	41	78	19	2
Vitamin B12 (µg)	0.73 [a]	56	91	9	0
Vitamin C (mg)	0.76 [a]	57	91	8	0
Vitamin A RE(µg)	0.57 [a]	43	83	17	0
Retinol (µg)	0.40 [a]	39	82	9	9
Vitamin D (µg)	0.50 [a]	45	78	19	2
Vitamin E (mg)	0.64 [a]	41	93	2	4
Na (mg)	0.55[a]	52	83	17	0

a *P*<.01
b Exact agreement, % of case cross-classified into the same quartile.
c Exact agreement plus adjacent, % of cases cross-classified into the same or adjacent quartile.
d Disagreement, % of cases cross-classified 2 quartiles apart.
e Extreme disagreement, % of cases cross-classified into extreme quartiles.
%TE= Percentage Total Energy, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids, RE= Retinol Equivalent, Na= Sodium

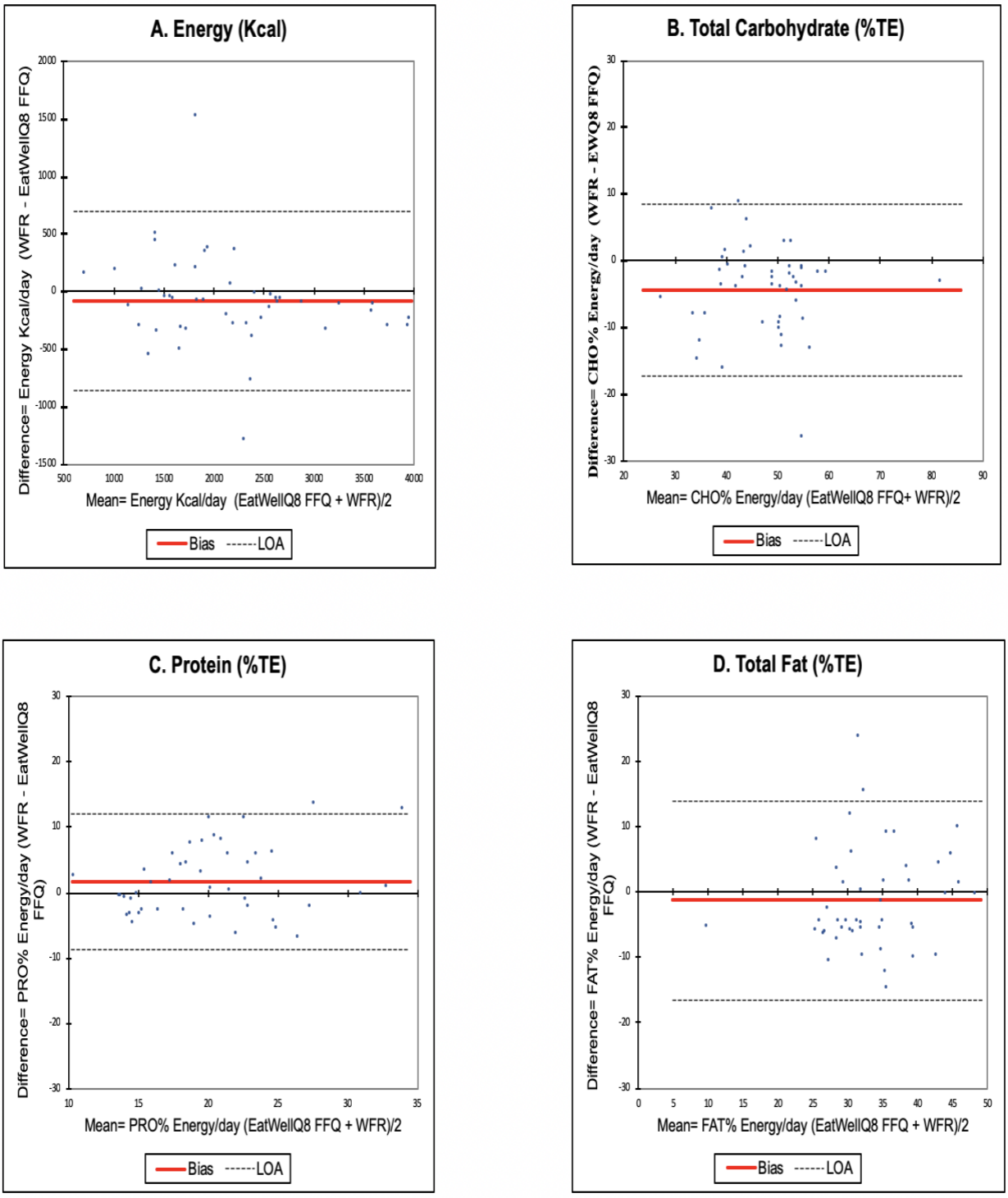

Figure 3. 5 Validation study Bland-Altman plots comparing the EatWellQ8 FFQ to a 4-day WFR for (a) energy, (b) total carbohydrate, (c) protein, and (d) total fat with the Bias (mean difference) and limits of agreement.

The solid line represents the Bias (mean difference) and the dotted lines represent the limits of agreement (LOA).
%TE= Percentage Total Energy, CHO= Carbohydrates, PRO= Protein

3.4.8 Comparison of Food Group Intakes between the EatWellQ8 FFQ and 4-Day WFR

Table 3.10 presents the correlation coefficients and cross-classifications of mean food group intakes between the EatWellQ8 FFQ and a 4-day WFR. SCCs ranged from 0.30 (bananas) to 0.88 (red meat). Significant correlations were found for all food groups ($P<.05$). The cross-classification percentages of participants classified into quartiles of exact agreement ranged from 28% (green vegetables) to 65% (wholegrain and brown breads and rolls). Relatively high classifications of exact agreement plus adjacent were found that ranged from 71% (green vegetables) to 97% (red meat). The mean percentage of participants classified into quartiles of disagreement was 11% and for extreme disagreement was 5%.

Table 3. 10 Spearman correlation coefficients (SCC) and cross-classification of quartiles of food group intake derived from the web-based EatWellQ8 FFQ and 4-day WFR (n=46)

Nutrient	Correlation[a]	Quartiles, % Exact agreement[b]	Exact agreement plus adjacent[c]	Disagreement[d]	Extreme disagreement[e]
Rice, pasta, grains and starches	0.37[b]	37	80	15	4
Savories (lasagne, pizza)	0.45[a]	34	80	17	2
White bread (rolls, tortillas, crackers)	0.81[a]	60	91	9	0
Wholegrain and brown breads and rolls	0.74 [a]	65	91	9	0
Breakfast cereals and porridge	0.36[b]	41	76	11	13
Biscuits	0.53[a]	39	80	13	7
Cakes, pastries and buns	0.64 [a]	63	89	6	6
Milk	0.48 [a]	45	84	7	9
Cheeses	0.84 [a]	56	95	4	0
Yoghurts	0.36 [b]	45	73	20	7
Ice cream, creams and desserts	0.33 [b]	45	82	9	9
Eggs and egg dishes	0.76 [a]	54	95	2	2
Fats and oils (eg,butter, low-fat spreads, hard cooking fats)	0.84 [a]	58	93	7	0
Potatoes and potato dishes, Chipped, fried and roasted potatoes	0.76 [a]	60	93	7	0
Peas, beans and lentils and vegetable and pulse dishes	0.79 [a]	65	93	4	2
Green vegetables	0.31[b]	28	71	26	2
Carrots	0.72 [a]	65	91	2	7
Salad vegetables (e.g., lettuce)	0.59 [a]	43	84	13	2
Other vegetables (e.g., onions)	0.56 [a]	67	84	7	9

Tinned fruit or vegetables	0.31 [b]	43	74	17	9
Bananas	0.30 [b]	45	71	13	15
Other fruits (e.g., apples, pears, oranges)	0.40 [a]	43	78	24	4
Nuts and seeds, herbs and spices	0.66 [a]	41	85	13	2
Fish and fish products/dishes	0.63 [a]	54	91	4	4
Red meat (e.g., beef, veal, lamb, etc.)	0.88 [a]	65	97	2	0
Poultry (chicken and turkey)	0.53 [a]	50	84	13	2
Meat products (e.g. ,burgers, sausages, pies, processed meats)	0.37 [b]	43	73	15	13
Sugars, syrups, preserves and sweeteners	0.43 [a]	43	78	13	11
Confectionary, savoury snacks	0.30 [b]	52	71	15	13
Soups, sauces, miscellaneous foods	0.57 [a]	63	84	2	13
Teas and coffees	0.44 [a]	43	76	21	2
Fruit Juice and Fizzy Drinks	0.61 [a]	54	82	11	7

[a] $P<0.01$
[b] $P<0.05$
[c] Exact agreement, % of case cross-classified into the same quartile.
[d] Exact agreement plus adjacent, % of cases cross-classified into the same or adjacent quartile.
[e] Disagreement, % of cases cross-classified 2 quartiles apart.
[f] Extreme disagreement, % of cases cross-classified into extreme quartiles.

3.5 Discussion

The present study aimed to evaluate the reproducibility of the EatWellQ8 FFQ and to test its validity against a semi quantitative Kuwaiti PFFQ and a 4-day WFR. The EatWellQ8 FFQ has been developed to assess dietary and nutrient intake in the EatWellQ8 study that will investigate the effectiveness of delivering personalized face-to-face dietary advice compared to web-based dietary advice in Kuwait. It included images of three different portion sizes for each food item to aid in portion size estimation and food recognition. The need to develop a culturally sensitive FFQ that reflected the diet of the Kuwaiti population was a necessity to avoid misclassifications of dietary intakes. Results of the present study indicated that the EatWellQ8 FFQ is a suitable tool with moderate validity for the assessment of nutrient and food intake in a sample of healthy adults living in Kuwait.

3.5.1 Reproducibility

Overall, the EatWellQ8 FFQ had good reproducibility for the estimation of nutrient intakes and food groups over a period of 4-weeks. The correlation coefficients for all nutrients were significant, compared well with previous studies and nearly all fell within the acceptable range of 0.5-0.7 for reproducibility trials proposed by Cade et al. (5; 18; 27; 28; 29; 30; 31). Similarly, strong associations were found between food groups with a mean SCC value of 0.67, which was comparable to previous web-based FFQ reproducibility studies by Fallaize et al. and Vereecken et al. that reported mean correlations of 0.75 and 0.64 (18; 32). However, a limitation in the trial by Vereecken et al. was the short assessment time between repeatability of the FFQs of only 1 to 2 weeks which may have impacted the power of the trial (32). The utilization of correlation analysis to assess agreement has been questioned as it only measures the degree of association between two variables and does not assess agreement (5; 26). Cross-classifications in to quartiles of agreements and Bland-Altman plots were therefore used to measure agreement. Analysis of cross-classifications of exact plus adjacent agreement of energy, nutrients and food group intakes (mean value of 88%) indicated a high level of agreement and a low level of misclassification (<10%), similar to the results of previous web-based FFQ studies (12; 18). The high level of reproducibility may be in part due to the short period (4-weeks) between FFQ administrations, as true changes in dietary intakes are less likely to occur within a short period of time (33). These data were also supported by the level of reproducibility from the Bland-Altman

analysis for energy controlled total protein, fat and carbohydrate, which compared well with findings from Fallaize et al. and Papazian et al. (18; 34). Limitations to the trial by Papazian et al. was the relatively small sample size of n=38 and the short interval time between FFQ administrations of 3 weeks which may have impacted trial outcomes (34).

Results from several previous reproducibility studies have shown greater intakes in energy and nutrient intakes in the first FFQ compared to the second FFQ (12; 18; 28; 31; 35). No significant differences between intakes were observed in this study, except for SFA and MUFA, however, quantitatively higher estimated energy and nutrient intakes were found in the initial administration of the EatWellQ8 FFQ compared to the second administration, which may be due to questionnaire boredom as a result of the short time period between FFQs (5; 36). However, it has been proposed that the good reproducibility between the EatWellQ8 FFQ may be influenced by the short interval between FFQ administration. It has been proposed that if the interval time between FFQs is short (1 to 6 months), participants' memory may influence the outcome, leading to overestimation in the reproducibility (18; 37). In contrast, underestimation was found in FFQs with longer time intervals (>6 months) due to changes in dietary habits (38). We were keen for participants not to change dietary habits and explicitly asked for no change which could have contributed to good reported reproducibility in our study. An additional factor that may have contributed to the good reproducibility is use of photographs as an aid to food portion size estimation. It has been proposed that reproducibility is enhanced in FFQs that take into account food portion sizes, especially when participants were allowed to specify their own portion size (5).

3.5.2 Validity

Overall, the results of the validation study demonstrated moderate agreement between the EatWellQ8 FFQ and two dietary collection tools for the estimation of energy and nutrient intakes; a PFFQ and a 4-day WFR. This was reflected by the higher level of bias being estimated by the EatWellQ8 FFQ for macronutrients (except for protein) and the level of disagreement in the cross-classifications, particularly in relation to food groups. Mean absolute intakes for most of the nutrients did not differ significantly between the EatWellQ8 FFQ and the PFFQ. However, significant differences were found for specific FA (for example, SFA) which could possibly be due to differences in the food items presented in the FFQs. Similar to previous findings by Forster et al.(17) and Beasley et al.(28), compared to a PFFQ, the EatWellQ8 FFQ estimates of energy

intakes were significantly higher (P<0.001). It has been reported that under-estimation of dietary intake is common in PFFQs which has been proposed to be due to errors such as skipped questions and a broad/vague use of portion size description (30). With the exception of two nutrients (omega 3 FA, retinol), SCC fell within the range considered as acceptable for FFQ validations trials from 0.4-0.7 (39; 40). The mean SCC for nutrients attained in the present trial (r=0.54) is higher than the one reported for a web-based FFQ validated against a PFFQ (r=0.47) and the one reported in the validation of a web-based diet history questionnaire against a 4-day WFR (28; 41). The weakest SCC were found for fat and specific FA (for example, MUFA) and this finding was supported further in the results of cross-classifications which have also shown least agreement for FA. This may be explained by a higher within subject variation in fat intakes. In the present study, correlation coefficients for food groups were found to be relatively lower to the correlations found in trials by Forster et al. and Boeckner et al. that ranged from 0.42 to 0.90 which may be due to differences in the length of the FFQs and number of food groups analysed (17; 42). Wide variations were observed in SCC between the EatWellQ8 FFQ and the PFFQ for food groups which may suggest that participants were able to estimate certain food items (for example, bananas) more accurately (43). Proposed reasons for these variations are answering fatigue as a result of the length of the FFQs and may be a result of an overestimation of items that are perceived as healthy such as vegetables and fruits, which is also common in other web-based FFQs (18; 41). Results of cross-classification for energy and nutrient intakes indicate that most participants were classified into exact plus adjacent quartiles that ranged from 76% to 93% and extreme disagreement/misclassification was <5% for most nutrients. Comparable cross-classifications that ranged from 77% to 99% were found when the Food4Me online FFQ was validated against the well validated EPIC-Norfolk FFQ (17). However, disagreement was high for food groups especially for the food groups that were located at the end of PFFQ (for example Ice cream, creams and desserts) suggesting answering fatigue. Results of the Bland-Altman plots have shown moderate agreement between the methods for estimates of energy and energy-adjusted macronutrient intakes and least agreement was for % fat TE. A possible reason for the disagreement between the tools may be due to participants' inability to assess portion sizes accurately using the PFFQ due to the lack of food photographs of portion sizes.

The EatWellQ8 FFQ was found to estimate higher energy, nutrient and food group intakes compared to the 4-day WFR. These results where expected as it has been

found in previous studies that FFQs that contain >100 items tend to show an overestimation in energy, nutrient and food intakes compared to WFR and 24-hour recalls which may be due to underestimation of the latter methods or overestimation of FFQ (37; 44). Comparable percentages of individuals classified into quartiles of exact agreement (mean= 49%) and exact plus adjacent agreement (mean=84%) were found between the EatWellQ8 FFQ and the 4-day WFR for energy, nutrient intakes and food groups and low levels of disagreement were found. Cross-classifications were within the range reported in previous trials which have both validated against weighed food records (18; 45). Results of the Bland-Altman plots have established good agreement between the two methods for energy and energy-adjusted macronutrient intakes. In addition, 28 of 30 nutrients measured had a correlation of higher than the 0.40 threshold recommended by Cade et al. (5). The relatively short period between administrations of the two methods (7 to 10 days) could have contributed to the high correlations. Highly variable SCC were found for food group intakes that ranged from 0.29 for bananas to 0.88 for red meat with a mean value of 0.55, results from previous studies found similarly high variations that ranged from 0.09 to 0.95 (18; 25; 46; 47). However, it may be difficult to compare our results to previous studies due to differences in the type of food record used, food items included in specific food groups, and differences in the time intervals in each of the studies. Variations between the EatWellQ8 FFQ and the 4-day WFR were greatest for bananas, green vegetables, meat products and tinned fruit or vegetables. This may be due to overestimations by the FFQ of foods perceived as healthy and can be due to the WFR being relatively short in duration (4 days) which may not reflect the individuals' dietary habits compared to the EatWellQ8 FFQ which conveys the diet over the previous month, especially for the foods that are not consumed regularly (48). The wide variations observed in correlations between the EatWellQ8 FFQ and the 4-day WFR may indicate whether volunteers could accurately estimate the consumption of some food items compared to others (18; 43). Compared to previous work that compared FFQs to WFR, our results have shown strong agreement for red meat (r=0.88) intake and fish and fish products which are often consumed less frequently than other groups. A possible reason could be the differences in diets consumed in Gulf compared to Western countries (49) and may be due to the short interval between the administration of the FFQ and the 4-day WFR.

3.5.3 Strengths and Limitations

This study had many strengths, which included the comparison of the EatWellQ8 FFQ with two frequently utilized methods for dietary collection, one of them being the gold standard (a WFR) and a PFFQ to assess the reproducibility and validity of the EatWellQ8 FFQ (18). Moreover, the sample size in this validation study was found to be adequate and comparable to the sample size used in previous studies (18; 30; 45; 50). Another strength to our study is that the validation of the EatWellQ8 FFQ was assessed in a nationally representative sample of the population rather than a convenient sample and hence represents the population at large.

Limitations of the validation study include the short interval time between administrations of the comparison tools (WFR and PFFQ) and the EatWellQ8 FFQ administration (7 to 10 days) which may have resulted in similarity of responses between the tools. However, 4-8 weeks was chosen as when used in the EatWellQ8 study this is the interval in which we will be assessing the participants diets to determine change. The addition of composite Kuwaiti dishes may have led to double reporting of food items and overestimation of intakes of calories. Another limitation was the length of the PFFQ that was used for comparison which included more than 200 items and may have led to questionnaire tiring/boredom and underreporting of food items and may have therefore compromised the results. In addition, although the use of non-consecutive days in the 4-day WFR may be a strength in which it can capture a diversity of food intakes over a period of a week, it may also have resulted in participants not filling in the diet record properly and therefore under/over reporting of food items. Among the main limitations is the high drop-out rate which may have resulted from participants' unwillingness to complete all three aspects of the study and may have impacted the overall study population.

3.6 Conclusions

In conclusion, the web-based self-administered EatWellQ8 FFQ, developed to assess energy and nutrient intake in healthy adults living in Kuwait, was found to have good reproducibility and moderate validity compared to a PFFQ and a 4-day WFR. The results indicate that the novel web-based FFQ could be used as a dietary intake tool for the assessment of dietary intake in healthy adults living in Kuwait.

3.7 Acknowledgements

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3.8 References

1. World Health Organization (2018) Noncommunicable diseases country profiles 2018

. Geneva: World Health Organization Licence: CC BY-NC-SA 3.0 IGO, 223.

2. Margetts B (2003) FAO/WHO launch expert report on diet, nutrition and prevention of chronic diseases. Public Health Nutr 6, 323-325.

3. Roberts CK, Barnard RJ (2005) Effects of exercise and diet on chronic disease. J Appl Psychol 98, 3-30.

4. Alkerwi Aa, Guillaume M, Zannad F et al. (2010) Nutrition, environment and cardiovascular health (NESCAV): protocol of an inter-regional cross-sectional study. BMC Public Health 10, 698-698.

5. Cade J, Thompson R, Burley V et al. (2002) Development, validation and utilisation of food-frequency questionnaires – a review. Public Health Nutr 5, 567-587.

6. Tucker KL (2007) Assessment of usual dietary intake in population studies of gene–diet interaction. Nutr Metab Cardiovas 17, 74-81.

7. Thompson FE, Subar AF, Loria CM et al. (2010) Need for technological innovation in dietary assessment. J Am Diet Assoc 110, 48-51.

8. Jain M, Howe GR, Rohan T (1996) Dietary Assessment in Epidemiology: Comparison of a Food Frequency and a Diet History Questionnaire with a 7-Day Food Record. Am J Epidemiol 143, 953-960.

9. Falomir Z, Arregui M, Madueño F et al. (2012) Automation of Food Questionnaires in Medical Studies: A state-of-the-art review and future prospects. Comput Biol Med 42, 964-974.

10. Ngo J, Engelen A, Molag M et al. (2009) A review of the use of information and communication technologies for dietary assessment. Br J Nutr 101, S102-S112.

11. Matthys C, Pynaert I, De Keyzer W et al. (2007) Validity and Reproducibility of an Adolescent Web-Based Food Frequency Questionnaire. J Am Diet Assoc 107, 605-610.

12. Labonte ME, Cyr A, Baril-Gravel L et al. (2012) Validity and reproducibility of a web-based, self-administered food frequency questionnaire. Eur J Clin Nutr 66, 166-173.

13. Elkum N, Al-Arouj M, Sharifi M et al. (2015) Prevalence of childhood obesity in the state of Kuwait. Pediatr Obes 11(6), e30-e34.

14. Musaiger AO, Al-Kandari FI, Al-Mannai M et al. (2014) Perceived barriers to weight maintenance among university students in Kuwait: the role of gender and obesity. Environ Health Prev Med 19, 207-214.

15. EPIC (2013) European Prospective Investigation of Cancer EPIC-Norfolk food frequency questionnaire (FFQ) entry and processing documentation. http://www.srl.cam.ac.uk/epic/epicffq/websitedocumentation_2111.html, February 12, 2018.

16. Dehghan M, Al-Hamad N, McMillan CR et al. (2009) Comparison of a semi-quantitative food frequency questionnaire with 24-hour dietary recalls to assess dietary intake of adult Kuwaitis. SMJ 30, 159-161.

17. Forster H, Fallaize R, Gallagher C et al. (2014) Online dietary intake estimation: the Food4Me food frequency questionnaire. JMIR 16(6) e150.

18. Fallaize R, Forster H, Macready AL et al. (2014) Online dietary intake estimation: Reproducibility and validity of the Food4Me food frequency questionnaire against a 4-day weighed food record. JMIR 16, e190.

19. Franco RZ, Alawadhi B, Fallaize R et al. (2017) A Web-Based Graphical Food Frequency Assessment System: Design, Development and Usability Metrics. JMIR Human Factors, 4(2), e13.

20. Ryan N, O'Donovan C, Forster H et al. (2015) New tools for personalised nutrition: The Food4Me project. Nutr Bull 40, 134-139.

21. Food Standard Agency (2014) McCance and Widdowson's the composition of foods: Royal Society of Chemistry.

22. Chan W (1995) Meat poultry and game: fifth supplement to the fifth edition of McCance and Widdowson's The composition of foods: Royal Society of Chemistry.

23. Musaiger A (2011) Food composition tables for Kingdom of Bahrain. Food Composition Tables for Kingdom of Bahrain.

24. Dashti B, Al-Awadi F, Khalafawi M et al. (2001) Nutrient contents of some traditional Kuwaiti dishes: proximate composition, and phytate content. Food Chem 74, 169-175.

25. Hu FB, Rimm E, Smith-Warner SA et al. (1999) Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. Am J Clin Nutr 69, 243-249.

26. Bland JM, Altman D (1986) Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 327, 307-310.

27. Chiu TH, Huang H-Y, Chen K-J et al. (2014) Relative validity and reproducibility of a quantitative FFQ for assessing nutrient intakes of vegetarians in Taiwan. Public Health Nutr 17, 1459-1466.

28. Beasley JM, Davis A, Riley WT (2009) Evaluation of a web-based, pictorial diet history questionnaire. Public Health Nutr 12, 651-659.

29. Timon CM, Blain RJ, McNulty B et al. (2017) The development, validation, and user evaluation of Foodbook24: a web-based dietary assessment tool developed for the Irish adult population. JMIR 19(5), e158.

30. Kristal AR, Kolar AS, Fisher JL et al. (2014) Evaluation of web-based, self-administered, graphical food frequency questionnaire. J Acad Nutr Diet 114, 613-621.

31. Cantin J, Latour E, Ferland-Verry R et al. (2016) Validity and reproducibility of a food frequency questionnaire focused on the Mediterranean diet for the Quebec population. Nutr Metab Cardiovas 26, 154-161.

32. Vereecken C, De Bourdeaudhuij I, Maes L (2010) The HELENA online food frequency questionnaire: reproducibility and comparison with four 24-h recalls in Belgian–Flemish adolescents. Eur J Clin Nutr 64, 541.

33. Cade JE, Burley V, Warm D et al. (2004) Food-frequency questionnaires: a review of their design, validation and utilisation. Nutr Res Rev 17, 5-22.

34. Papazian T, Hout H, Sibai D et al. (2016) Development, reproducibility and validity of a food frequency questionnaire among pregnant women adherent to the Mediterranean dietary pattern. Clin Nutr 35, 1550-1556.

35. Collins CE, Boggess MM, Watson JF et al. (2014) Reproducibility and comparative validity of a food frequency questionnaire for Australian adults. Clin Nutr 33, 906-914.

36. Wong SS, Boushey CJ, Novotny R et al. (2008) Evaluation of a computerized food frequency questionnaire to estimate calcium intake of Asian, Hispanic, and non-Hispanic white youth. J Am Diet Assoc 108, 539-543.

37. Fernández-Ballart JD, Piñol JL, Zazpe I et al. (2010) Relative validity of a semi-quantitative food-frequency questionnaire in an elderly Mediterranean population of Spain. Br J Nutr 103, 1808-1816.

38. Tsubono Y, Nishino Y, Fukao A et al. (1995) Temporal change in the reproducibility of a self-administered food frequency questionnaire. Am J Epidemiol 142, 1231-1235.

39. Willett WC (1994) Future directions in the development of food-frequency questionnaires. Am J Clin Nutr 59, 171S-174S.

40. Willett W (1998) Nutritional epidemiology: monographs in epidemiology and biostatistics: 2nd ed. In: Willet (WC) (ed). Oxford University Press: New York.

41. González Carrascosa R, García Segovia P, Martínez Monzó J (2011) Paper and pencil vs online self-administered food frequency questionnaire (FFQ) applied to university population: a pilot study. Nutr Hosp 26, 1378-1384.

42. Boeckner LS, Pullen CH, Walker SN et al. (2002) Use and reliability of the World Wide Web version of the Block Health Habits and History Questionnaire with older rural women. J Nutr Educ Behav 34, S20-S24.

43. Fidanza F, Gentile MG, Porrini M (1995) A self-administered semiquantitative food-frequency questionnaire with optical reading and its concurrent validation. Eur J Epidemiol 11, 163-170.

44. Verger EO, Armstrong P, Nielsen T et al. (2017) Dietary assessment in the MetaCardis Study: development and relative validity of an online food frequency questionnaire. J Acad Nutr Diet 117, 878-888.

45. Sanjeevi N, Freeland-Graves J, George GC (2017) Relative Validity and Reliability of a 1-Week, Semiquantitative Food Frequency Questionnaire for Women Participating in the Supplemental Nutrition Assistance Program. J Acad Nutr Diet 117, 1972-1982. e1972.

46. Feskanich D, Rimm EB, Giovannucci EL et al. (1993) Reproducibility and validity of food intake measurements from a semiquantitative food frequency questionnaire. J Am Diet Assoc 93, 790-796.

47. Mazzeo T, Roncoroni L, Lombardo V et al. (2016) Evaluation of a modified Italian European prospective investigation into cancer and nutrition food frequency questionnaire for individuals with celiac disease. J Acad Nutr Diet 116, 1810-1816.

48. Apovian CM, Murphy MC, Cullum-Dugan D et al. (2010) Validation of a web-based dietary questionnaire designed for the DASH (dietary approaches to stop hypertension) diet: the DASH online questionnaire. Public Health Nutr 13, 615-622.

49. Musaiger A (1990) Nutritional disorders associated with affluence in Bahrain. Fam Pract 7, 9-13.

50. Lee Y, Park K (2016) Reproducibility and validity of a semi-quantitative FFQ for trace elements. Br J Nutr 116, 864-873.

CHAPTER 4 Online and face-to-face personalised nutrition advice is more effective at motivating healthier dietary choices than population-based nutrition advice in Kuwait – The EatWellQ8 RCT

Original Paper

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4.1 Abstract

Background: Most strategies to improve dietary quality follow a “one size fits all” approach. Recent studies have shown that Personalised Nutrition (PN), tailored to individual requirements, is able to improve dietary intakes, yet limited focus has been given to the effectiveness of face-to-face compared with online methods.

Objective: To assess the impact of (1) web-based PN advice, (2) face-to-face PN advice and (3) web-based standardised dietary advice, on adherence to healthy diets in Kuwait.

Methods: Free-living adults in Kuwait were recruited for the 12-week randomised controlled trial (EatWellQ8) and randomised to receive: face-to-face PN; web-based PN or web-based standardised nutrition (control) advice. Dietary intake and self-reported anthropometric measurements were assessed at baseline, 6 and 12 weeks. A validated food frequency questionnaire (FFQ) modified from the EPIC FFQ for a Kuwaiti population was used to assess food and nutrient intake. Diet quality was assessed using the modified Alternative Healthy Eating Index (m-AHEI).

Results: In total, 320 participants completed the study. Due to over/underreporting, 100 participants were included in the analysis (71% female, 29% male) with a mean age of 38.6 years (SD 14.3), and body mass index (BMI) of 25.1 kg/m$_2$ (SD 4.2). After 12-weeks intervention, m-AHEI scores increased significantly in both PN intervention groups (face-to-face PN 19%, web-based PN 12%) compared to controls (4%) (P<0.01) and PN groups had significantly higher intakes of vegetables and fruits compared with controls (P<0.017). The face-to-face PN intervention group also significantly increased their intakes of oily fish and fibre compared with the control group (P<0.017). The face-to-face PN group significantly reduced weight and BMI compared to web-based PN and control group participants (P<0.01).

Conclusions: Amongst adults living in Kuwait, PN, regardless of the method used for delivery, was found to be more effective than population-based dietary advice at motivating healthier dietary choices. However, face-to-face PN was found to be more effective at inducing weight-loss in adults compared to web-based PN and population-based advice.

Trial Registration: The EatWellQ8 trial was registered on the ClinicalTrial.gov (NCT03396263)

Keywords: Personalized nutrition; web-based; EatWellQ8; healthy eating index; face-to-face nutrition; food frequency questionnaire; FFQ; app

4.2 Introduction

According to the World Health Organisation (WHO), non-communicable diseases (NCD) such as cardiovascular disease (CVD), cancer and diabetes mellitus account for approximately 40 million deaths each year (1). NCDs are the leading cause of global annual premature deaths in both men and women between the ages of 30 to 70 (1). In the Middle East region, NCDs are estimated to cause 2.2 million deaths per year (2). Kuwait currently has the highest adult obesity levels in the region, with 70% of adult men and 73% of women either overweight or obese (3).

Globally, the main risk factors for the development of NCDs are a combination of unhealthy dietary and lifestyle choices which include; excessive intakes of saturated fatty acids, physical inactivity, tobacco use, high salt diets and excess alcohol consumption (4). It is estimated that 80% of CVDs may be prevented with the adoption of a healthy lifestyle that includes a healthy diet and an active physical activity (PA) level (5). The majority of the strategies adopted previously to prevent or reduce the development of NCDs have used a standardised approach that targets the population and are not tailored to an individual's specific needs (6). This guidance has varying and often limited success and the utilisation of an alternate strategy such as personalised nutrition (PN) has been reported as a more effective dietary intervention (7). PN or tailored nutrition utilises information based on individual's characteristics to develop a diet that is tailored towards the individual's nutritional requirements. Compared to standardised nutrition advice, the delivery of advice in a personalised manner is perceived as more personally relevant and has been shown to be a more effective approach to promote positive dietary changes (8). Tailored nutrition advice may be based on dietary intakes, genotype and phenotype characteristics and on individual goals and health targeted behaviours(9). Advances in genomic research has increased the interest in nutrition advice tailored towards an individuals' genotype for reducing the risk of NCDs (8; 10; 11), however, mixed findings have been reported (8; 12). The large European Food4me trial investigated the impact of personalised web-based nutrition advice which was developed from different levels of personalisation (diet, genotype or phenotype), and demonstrated non-significant differences in dietary change between the levels of personalisation (8). However, the Food4me trial did find that online PN advice, based on dietary intake (evaluated by means of a validated Food Frequency Questionnaire (FFQ) (13) with photographs), was more effective at improving adherence to dietary advice than standard population guidance (8).

Alongside technological advances, web-based methods for assessing food intakes and delivering dietary advice are replacing or supplementing written and face-to-face methods (14; 15). In addition, face-to-face nutrition can be expensive, time consuming and inhibits large scale implementation (16). However, a review by Contento and colleagues found that consumers tend to have a preference for face-to-face nutrition advice that target behaviour change (17). With the widespread use of the Internet, several studies have focused on delivering web-based nutrition advice (8; 18; 19; 20; 21; 22). Use of the Internet is rising globally, and current data has indicated that 85.2% of the population of Europe and 65.0% in the Middle East use the internet (23). The use of web-based applications provides an alternative strategy to face-to-face nutrition counselling, may be more cost-effective and is able to reach a larger population. Web-based advice can also be personalised and is accessible from the individual's home, making it more practical than face-to-face interventions where patients/individual users are required to attend a clinic for consultation (24). Given the differences in cost and reach between face-to-face and web-based nutrition, it is prudent to evaluate the effectiveness of these different approaches. Therefore, the hypotheses of the EatWellQ8 randomised control trial (RCT) were: i) PN dietary advice is more effective at motivating dietary change than web-based population advice, ii) personalised face-to-face dietary advice and web-based PN advice are equally efficacious at implementing dietary change in Kuwait.

4.3 Methods

The EatWellQ8 study was a 12-week, three-arm dietary RCT conducted in Kuwait to compare the effectiveness of PN advice provided either in a web-based format or face-to-face compared with general population dietary advice delivered online, on dietary change and health related outcomes. The study was given a favourable ethical opinion for conduct (Ref No. 13/17) from the School of Chemistry, Food and Pharmacy Research Ethics Committee, University of Reading and the Research Ethical Committee at Dasman Diabetes Institute (DDI), Kuwait (RA-2015-018). The study was registered at clinicaltrials.gov (NCT03396263) and conformed with the Declaration of Helsinki.

4.3.1 Participants

Free-living individuals living in Kuwait aged 21-65 years without diagnosed disease were eligible for inclusion in the study. The exclusion criteria included: following a prescribed diet including weight loss in the last 3 months, pregnancy or lactating, limited or no Internet access, diagnosed with a metabolic or other diseases or condition that may alter their nutrition requirements (e.g. diabetes, thyroid disease), known food allergy or food intolerance and were receiving medication apart from hypertension medication and statins. Recruitment was conducted in Kuwait via social media (Instagram, Facebook), posters at DDI, and word of mouth. In addition, recruitment stands were placed in DDI, local collages and shopping centres. Participants were contacted using emails and text messages.

Participants were randomised in an automatic format by the system using the random function (25) which runs in the browser. The system generated an arbitrary number between 0 and 2 and depending on its value the participants were allocated to one of the three intervention groups upon completion of screening.

4.3.2 Study design

Interested participants were directed to the study website (eatwellq8.org) (26), where the consent form and the participant information sheet were available for reading and download. Both forms were available in English and Arabic. Account creation and online consent agreement were completed using the website. Participation in the trial was voluntary and participants were informed that they are able to withdraw from the trial at any time without any consequences and without giving any explanations as to why they wished to withdraw. At baseline, participants were required to fill a screening questionnaire on the study website that included questions about their socio-economic status, health status, whether they were not living in Kuwait, pregnant or lactating, on any medication, had any food intolerances or allergies and whether they had metabolic diseases. Participants that answered yes to any of the above questions were excluded from the study and a popup message informed them that they were unsuitable for the study and were thanked for their time. Volunteers were randomised to one of the two PN (web-based PN and face-to-face PN) intervention groups or to a control group for a 3-month period. To measure dietary and PA change, all participants were required to complete the web-based EatWellQ8 FFQ, provide anthropometric data (e.g. weight, age) and complete the Baecke PA questionnaire at baseline, weeks 6 and 12 (27). Furthermore, reminders in the form of text messages and emails were sent to the

participants at those two time points. Only participants that were randomised in the web-based and face-to-face PN groups received PN information, weight management and PA advice based on their individual dietary intake, anthropometrics and PA levels. Participants in the web-based PN group received the PN in a feedback form upon completion of the web-based FFQ and face-to-face PN participants received the advice during a 30-minute consultation with a dietitian that was delivered either face-to-face (at DDI) or via Skype. To minimize bias and ensure that both intervention groups received the same PN information, advice received in the face-to-face PN group was identical to the advice received in the web-based PN (incorporated from the feedback reports generated by the online system). Control group participants received web-based non-personalised dietary and PA advice based on the UK general healthy eating guidelines as to our knowledge there are no current Kuwait dietary guidelines available. All participants received a personalised dietary feedback report at week 12. A description of the study design is presented in figure 4.1.

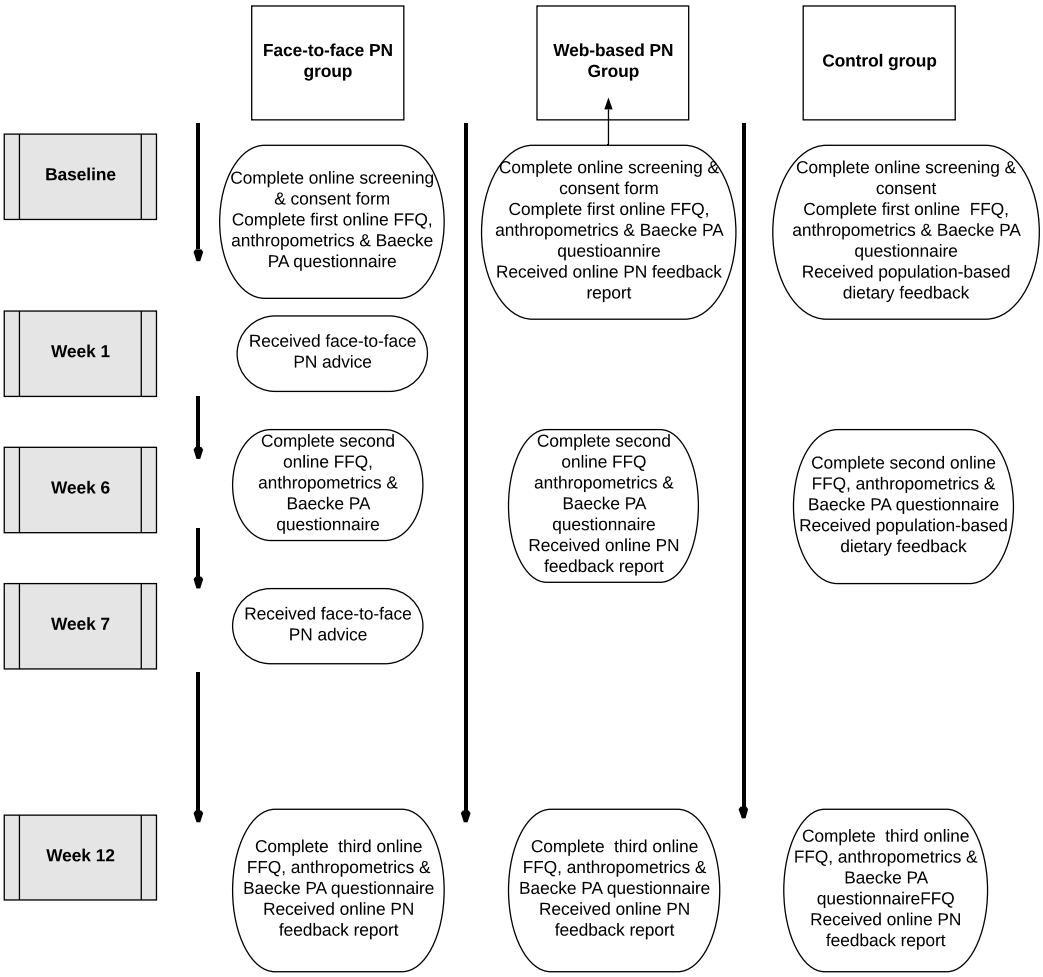

Figure 4. 1 Study design of the EatWellQ8 randomised control trial. Online FFQ refers to the 146 item EatWellQ8 web-based FFQ

4.3.3 Outcome measures

The primary outcome of the study was change in m-AHEI overall score and individual m-AHEI components between baseline and 12 weeks. Due to the strong established correlation found between the Alternate Healthy Eating Index (AHEI) and CVD development and health, a modified version of the AHEI was used to assess improvements and change in dietary quality (28; 29; 30; 31). The AHEI was chosen as it was based on nutrient and foods that were found to be predictors of chronic disease risk factors, inversely proportional with the development of CVD and obesity and positively associated with PA and dietary intake indicators (28; 32). A modified version of the AHEI (m-AHEI) was used and it was further adapted to the UK dietary guidelines (31) as to our knowledge, there were no Kuwait dietary guidelines available (table 4.1). To facilitate participants understanding and data visualization, the maximum score was changed from 10 to 100 and the 10 inadividual components of the m-AHEI were also handled equally with the overall score ranging from 0 to 100 (31; 33). Changes from baseline in targeted m-AHEI components that were delivered to the PN interventions (web-based PN and face-to-face PN) were further assessed. The secondary outcomes included change in energy intakes, targeted nutrient intakes, PA and anthropometrics between baseline and 12 weeks which included obesity related measures (e.g. body mass index (BMI)). Changes in targeted nutrients such as omega 3 fatty acid (FA), total folate, polyunsaturated fatty acid (PUFA) and fibre were assessed as they are common indicators for dietary improvements (8).

Table 4. 1 Modified Alternative Healthy Eating Index (m-AHEI) components and score criteria[a]

Component	Criteria for minimum score (0)	Criteria for maximum score (100)
Vegetables, servings/d	0	≥5
Fruits, servings/d	0	≥4
Whole grains, g/d		
Women	0	≥75
Men	0	≥90
Dairy products[b], servings/d	0	≥3
Nuts and legumes[c], servings/d	0	≥1
PUFA[d], % of total energy	≤2	≥10
Long-chain (n-3) fats (EPA + DHA)[e], mg/d	0	≥250
Free sugars[f], % of total energy	≥15	0
Red and processed meat, servings/d	≥1.5	≤0.03
Sodium[g], mg/d	Highest decile	Lowest decile

[a] Primary AHEI was defined by Chiuve et al. (29)
[b] This component was not part of the original AHEI
[c] Vegetable protein was not included in the calculation of the m-AHEI score
[d] Reported as "Healthy fats"
[e] Reported as "Oily fish"
[f] Reported as "Sugars"
[g] Reported as "Salt". Values of the highest and lowest deciles were derived from the Food4me study (8)

4.3.4 Dietary assessment

All participants were required to complete the web-based EatWellQ8 FFQ, provide anthropometrical data (e.g. weight, height) and complete the Baecke PA questionnaire at baseline and weeks 6 and 12. The EatWellQ8 FFQ was based on the validated Food4Me FFQ (13) and the well-validated European Prospective Investigation of Cancer (EPIC)-Norfolk FFQ (version CAMB/PQ/6/1205) (34) and a paper-form FFQ for Kuwait (35). Participants were encouraged to complete the FFQ in one sitting/session, they were offered the possibility to save the FFQ, in case of interruption or loss of Internet connection. An incomplete FFQ expired after 24 hours. The EatWellQ8 FFQ comprised of 146 food items that revolved around food items and composite dishes that are commonly consumed in Kuwait and were considered nutritionally significant. Validity of the online EatWellQ8 FFQ was assessed against a 4-day weighed food record and a paper-form FFQ in Kuwait (36). For the purpose of the study, a version of eNutri (30; 31), a novel online PN advice system was developed. Dietary intakes from the FFQ were compared with m-AHEI scores and were determined to be either sufficient, low or high or too low or too high. Once the top three dietary concerns had been

identified by the system, specific messages that were previously developed by dietitians to advise change in dietary intake for those foods were presented in the report, beginning with the m-AHEI component that received the lowest score. The system also calculated the participants' BMI and ideal weight range, and provided feedback on their PA level, based on the Baecke PA questionnaire (27). To increase the user friendliness and acceptability of the system, all of the information was available in both English and Arabic. Full details of the web-based graphical FFQ system is described elsewhere (38) and images of the PN advice and general control advice can be found in figure 4.2.

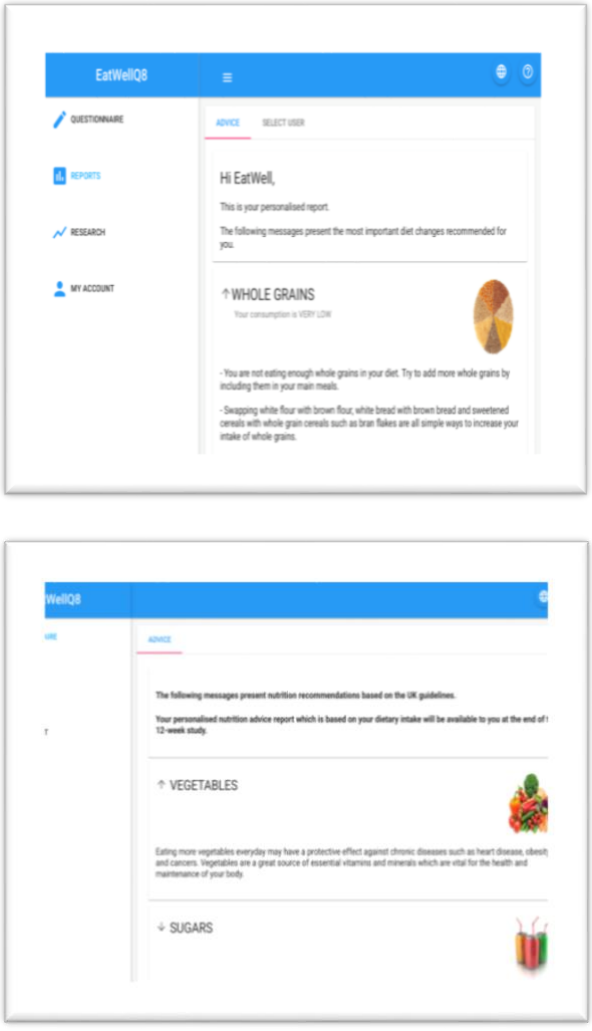

Figure 4. 2 Screenshots of the PN advice and generalised control advice

4.3.5 Intervention groups

4.3.6 Web-based personalised nutrition group (web-based PN)

Participants in the web-based PN group received a personalised feedback report upon completion of the EatWellQ8 FFQ and Baecke PA questionnaire at each time point (baseline, weeks 6 and 12). Each report included tailored feedback based on the dietary, weight management and PA information provided by the participant. The personalised feedback reports were generated by the web application (eNutri) and consisted of four main sections (30). The first section targeted the participants top three dietary concerns that were based on the outcomes of the m-AHEI components (28). The second section focused on the PA levels of the participant and gave targeted exercise goals, the third section revolved around weight management and contained personalised information about the individuals' weight and BMI goals. The final section revolved around the participants' m-AHEI overall score and scores of the m-AHEI components. The tailored feedback reports were the only source of dietary information given to the web-based participants throughout the trial period.

4.3.7 Face-to-face personalised nutrition group (face-to-face PN)

Upon completion of the EatWellQ8 FFQ and Baecke PA questionnaire at baseline and week 6, a message regarding the arrangement of the personalised dietary consultation with a dietitian appeared to the participants randomised to the face-to-face PN group. In addition, face-to-face PN group participants were contacted by email and text messages and invited to come to DDI for a 30-minute face-to-face consultation with a dietitian. All advice was given verbally and consultations were arranged within a week of online FFQ completion. Participants had the choice to come in for an in-person consultation or to have a skype consult depending on preference. The information delivered during the PN face-to-face consultations was derived from the online feedback report and was therefore identical to the advice received in the web-based PN intervention. Dietitians were further informed to consult solely based on the information in the personalised feedback forms.

4.3.8 Control group

Participants randomized to the control group completed the EatWellQ8 FFQ and Baecke PA questionnaire at baseline, weeks 6 and 12 of the trial. Following completion of the questionnaires, control group participants received web-based generalised dietary advice based on the Eatwell healthy eating guidelines in the UK at baseline and week 6 (38). The standardised recommendations included three general advice that were selected randomly by the eNutri app on dietary intakes of fruits and vegetables, oily fish, dairy, whole grains, nut and legumes, red and processed meat, healthy fats, sugar intakes and salt. In addition, the recommendations included advice about maintaining a healthy body weight and standardized PA recommendations.

4.3.9 Evaluation of the web-based FFQ and the feedback reports

Following trial completion, participants were invited to partake in an online follow-up survey one month after trial completion which comprised of 32 questions based on participants' perceptions of the feedback reports and web-based FFQ. In total, 21 questions were Likert items and 11 include free-text**.**

4.3.10 Statistical Analysis

Statistical analysis was performed using SPSS (version 25.0, PASW, Chicago, IL, USA). Participants were excluded from analysis if daily energy intakes were less than 500 Kcals and greater than 4500 Kcals which is considered improbable (13; 39). Normality of data was assessed using a Shapiro-Wilk test and log transformation was used for non-parametric data when necessary. Study participants characteristics (BMI, age, gender, education levels and language choice) were compared using independent sample t-tests.

To answer our research question ('Does web-based PN encourage individuals to follow a healthier diet and lifestyle when compared to general population advice and similar to face-to-face nutrition advice?'), assessments of intervention effects on the m-AHEI components and nutrients were analysed. An analysis of covariance using a generalised linear model (GLM) with baseline data as covariates was used. Other covariates that may influence usual dietary intakes such as age, BMI and sex were also included (40). The primary assessment was a comparison between the mean of the intervention groups (either face-to-face PN and web-based PN) at baseline to 12-

weeks, to the mean of the control group and a comparison between the mean of the intervention groups. Comparisons between group outcome measures were also conducted for the 10 m-AHEI food components (fruits, vegetables, wholegrains, dairy, healthy fats, oily fish, red meat and processed meats, free sugar and salt) where significant post-hoc values were calculated to identify the effects between groups. Post-hoc values were calculated using a Bonferroni test and were considered significant if the P-value was <0.017 which was based on the Bonferroni correction. Secondary outcomes, which included targeted nutrient intakes, and anthropometrical data such as weight, height and BMI were assessed using an analysis of covariance using baseline values as covariates.

The second part of the analysis focused on the intervention group participants that received the top 3 dietary advice based on outcomes of the m-AHEI and comparison between groups was assessed using analysis of covariance, and post-hoc tests were analysed using a Bonferroni test and were considered significant if P-value was <0.017. Mean and percentages were calculated for categorical data (Likert) questions in the follow-up study and a Fisher's exact test was used to assess for differences between the intervention groups.

The current study was powered based on the outcomes of the Food4Me trial (8), with an anticipated increase of 7% for the intervention groups (face-to-face PN and web-based PN) compared to the control group (mean=50, SD=10; Alpha=0.05; Power=0.8) in the m-AHEI score. With these variables, the recruitment target group sizes would be n=98 per group, with an anticipated 20% dropout rate, a total sample size of n=352 was required (41).

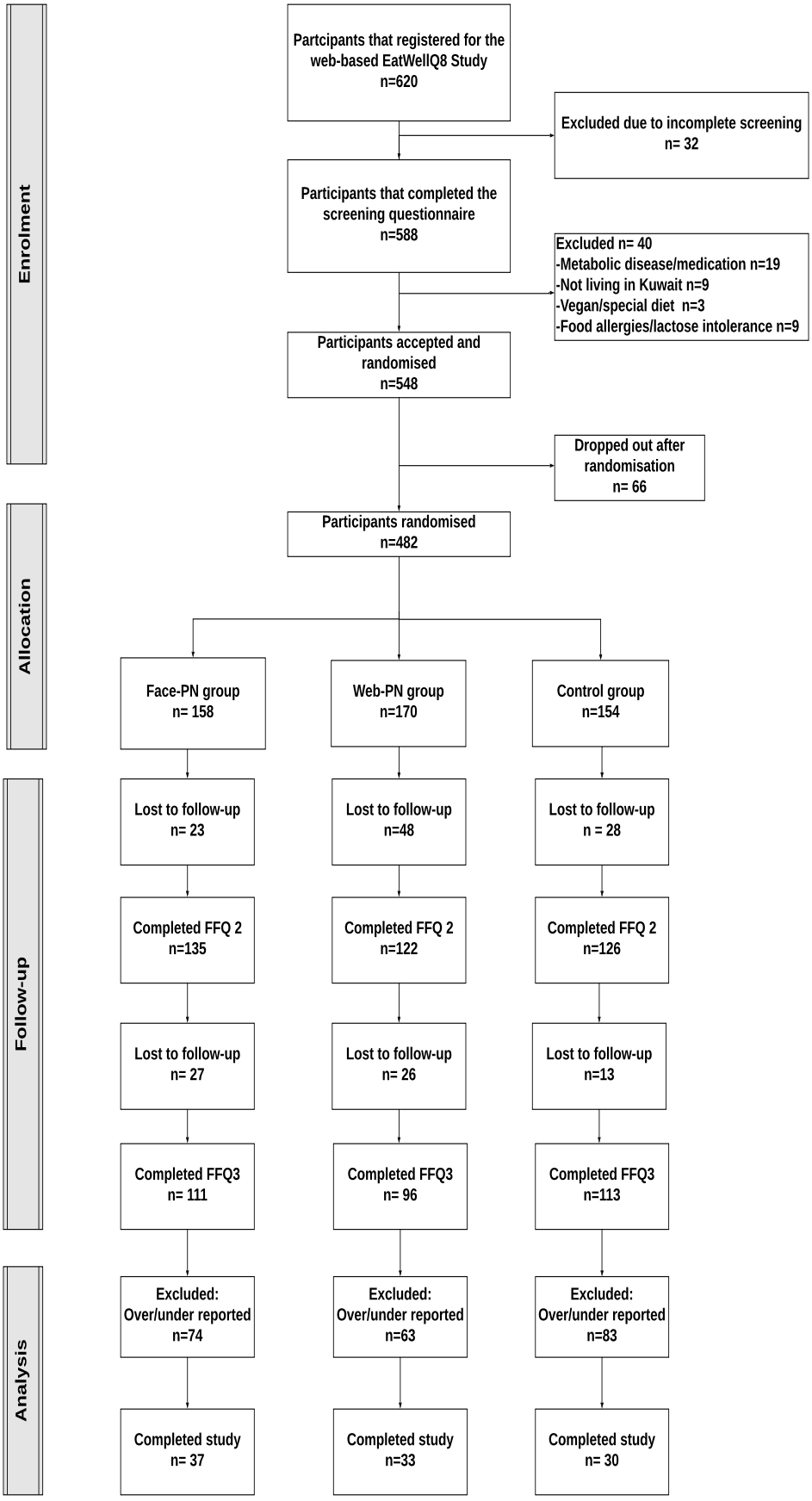

Figure 4. 3 Flow Diagram for the EatWellQ8 Study

4.4 Results

4.4.1 Participants

The flow diagram of the study is shown in Figure 4.3. A total of 620 participants registered on the online study, out of which n=588 completed the screening questionnaire. A total of 40 participants were excluded from the trial for not meeting the study criteria. The remaining n=548 participants were randomised to the study, however, 66 participants dropped out following randomisation. In total, 482 participants completed the baseline FFQ, but a high number of participants were lost to follow-up (n=162), and a total of n=320 completed all three FFQs. A further 220 participants were excluded from the analysis due to over/under reporting of energy intakes, leaving n=100 for analysis; face-to-face PN group n=37 (n=23 Skype consults, n=14 face-to-face consults), web-based PN group n=33 and control group n=30 participants. Demographic characteristics of participants based on self-report can be found in Tables 4.2. In summary, 71% of participants were females, the mean age was 38.6 (10.4) (range 21-65) years, mean BMI was 25.1(4.2) kg/m_2, 5% reported to be underweight, 82% were normal weight, 13% were overweight and none were obese. The majority of participants (54%) chose to fill the online FFQ in English and the primary method of recruitment was reported to be via word-of- mouth (57%), compared to social media (39%) with 13% via other methods of recruitment.

Table 4. 2 Baseline characteristics of the EatWellQ8 participants (n=100)

Variables	Face-PN group	Web-PN group	Control group	aP-value
Total (n%)	37 (37.0%)	33 (33.0%)	30 (30.0%)	
Sex				
Female, n (%)	27 (73.0%)	22 (66.7%)	22 (73.3%)	
Male, n (%)	10 (27.0%)	11 (33.3)	8 (26.7%)	0.95
Age (years)				
Mean	38.5 (10.5)	39.5 (10.9)	37.8 (9.8)	0.68
Range	21-63	22 - 65	22 - 57	
Language chosen				
Arabic n (%)	13 (35.1)	17 (51.5%)	16 (53.0%	
English n (%)	24 (64.9%)	16 (48.5%)	14 (46.7%)	0.09
Anthropometrics				
Height (cm)	169.5 (10.1)	168.6 (9.6)	167.2 (10.9)	0.94
Weight (kg)	73.6 (14.0)	73.1 (16.1)	70.8 (12.6)	0.23
BMI (kg/m_2)	25.1 (4.1)	25.4 (4.5)	24.8 (4.0)	0.62
Baecke: Physical activity level (PAL) score	8.2 (1.0)	8.3 (0.9)	8.1(1.1)	0.70
Weight status, n (%)				
Underweight	3 (8.1%)	1 (3.0%)	1 (3.3%)	
Normal weight	30 (81.1%)	28 (84.8%)	24 (80.0 %)	
Overweight	4 (10.8%)	4 (12.1%)	5 (16.7%)	
Obese	0 (0%)	0 (0%)	0 (0%)	0.79
Education level, n (%)				
Less than secondary	0 (0%)	2 (6.1%)	1 (3.3%)	
Secondary school graduate	3 (8.1%)	5 (15.2%)	4 (13.3%)	
Vocational training/college graduate	8 (21.6%)	6 (18.2%)	8 (26.7%)	
Undergraduate degree	17 (45.9 %)	9 (27.3 %)	8 (26.7%)	
Postgraduate degree	9 (24.3%)	11 (33.3%)	9 (30.0%)	0.09
Method of recruitment n, (%)				
Email	4 (10.8%)	7 (21.2%)	5 (16.7%)	
Facebook	5 (13.5%)	1 (3.0%)	3 (10.0 %)	
Instagram	3 (8.1%)	1 (3.0 %)	1 (3.0%)	
Twitter	4 (10.8%)	2 (6.1%)	3 (10.0%)	
Word-of-Mouth	17 (45.9%)	22 (66.7%)	18 (60.0%)	
Other	8 (21.6%)	2 (6.1%)	3 (10.0%)	0.72

Data are presented as mean (standard deviation) or as mean (%) for categorical variables. aP values derived from a chi-squared test
BMI= Body Mass Index

4.4.2 Effect of the 12-week intervention on the m-AHEI scores

Participants in the face-to-face PN and web-based PN groups improved their m-AHEI score significantly more (19% and 12% respectively) than the control group (4%) following 12-week intervention (P<0.01) (Table 4.3). After 12-weeks, significant differences were found between the groups in the m-AHEI components vegetables, fruits, oily fish and sugar (P<0.05). However, further Post-hoc analysis has implied that between group significance was found between the intervention groups (face-to-face PN and web-based PN) and the control group for vegetables and fruits only (P<0.017). In addition, significant difference was found between the intervention groups for oily fish (P<0.02), but post-hoc analysis has indicated that the difference was only between the face-to-face PN and control groups (P<0.01). Although post-hoc analysis did suggest differences between the intervention groups and the control group for m-AHEI sugar component, it did not reach the required level of P<0.017. No evidence of difference between the PN intervention groups was observed for m-AHEI or m-AHEI components.

Table 4. 3 Effect of the 12-week intervention on the m-AHEI and components scores

	[a]Face-to-face PN		[a]Web-based PN		[a]Control		Δ Face - Δ Control (95% CI)	Δ Face- Δ Web (95% CI)	Δ Web- Δ Control (95% CI)	TE P-value
	Baseline mean (SD)	Δ from baseline	Baseline mean (SD)	Δ from baseline	Baseline mean (SD)	Δ from baseline				
n	37		33		30					
m-AHEI Score	48.9 (13.7)	9.1 (8.9)	51.5 (12.2)	6.2 (11.1)	51.3 (13.0)	1.8 (8.7)	5.3 (1.5 to 9.0)*	1.2 (-2.4 to 4.9)	4.0 (0.2 to 7.8)*	0.008
Vegetables	52.1 (37.6)	17.3 (33.0)	54.7 (33.2)	16.5 (26.4)	51.2 (33.8)	-3.4 (30.9)	19.4 (4.8 to 34.1)*	-2.6 (-17.35 to 11.7)	22.1 (7.3 to 36.8)*	0.007
Fruits	77.7 (31.1)	9.4 (19.5)	84.6 (27.8)	11.4 (25.4)	78.8 (31.2)	-2.8 (25.0)	12.5 (0.9 to 23.5)*	-2.1 (-13.1 to 8.9)	14.3 (2.6 to 25.9)*	0.021
Whole-grains	53.2 (40.5)	15.1 (31.5)	60.1 (39.1)	10.3 (47.3)	53.1 (38.9)	7.0 (32.2)	7.9 (-11.0 to 26.9)	4.6 (-13.8 to 23.1)	3.3 (-16.1 to 22.8)	0.689
Dairy	68.8 (34.1)	12.6 (23.5)	69.4 (30.8)	10.1 (35.7)	76.3 (31.5)	1.7 (27.7)	11.0 (-3.1 to 25.3)	2.4 (-11.4 to 16.2)	8.6 (-5.9 to 23.3)	0.280
Nuts and legumes	45.0 (32.5)	7.4 (35.8)	51.9 (34.0)	3.2 (42.2)	44.6 (33.5)	0.5 (40.8)	7.0 (-12.2 to 26.2)	3.9 (-14.8 to 22.6)	3.1 (-16.6 to 22.8)	0.737
Oily fish	49.1 (35.9)	10.2 (31.8)	55.7 (40.1)	1.5 (20.3)	54.2 (38.0)	-5.4 (17.6)	15.4 (3.2 to 27.5)*	8.0 (-3.6 to 19.8)	7.3 (-5.1 to 19.7)	0.042

Healthy fats	52.9 (19.3)	6.2 (14.0)	54.2 (20.1)	4.7 (19.1)	52.8 (19.1)	6.7 (13.7)	-0.8 (-8.3 to 6.6)	0.9 (-6.3 to 8.2)	-1.7 (-9.4 to 5.8)	0.675
Red and processed meat	14.3 (26.1)	5.1 (11.9)	10.9 (20.3)	4.2 (8.8)	11.5 (23.9)	5.0 (16.6)	3.3 (-5.8 to 6.4)	1.2 (-4.7 to 7.2)	-0.9 (-7.2 to 5.3)	0.831
Sugars	19.9 (22.1)	11.2 (33.2)	21.4 (21.6)	8.3 (19.4)	20.5 (22.2)	-4.6 (20.4)	15.7 (3.2 to 28.2)	2.8 (-9.2 to 15.1)	12.9 (-0.2 to 25.6)	0.032
Salt	62.1 (32.0)	2.1 (17.4)	58.1 (34.2)	3.0 (18.8)	58.1 (30.6)	2.7 (17.3)	1.1 (-7.5 to 8.7)	0.5 (-7.8 to 8.8)	0.6 (-8.1 to 9.4)	0.830

Data are presented as adjusted means (SD) and as the difference between the three intervention groups face-to-face PN, web-based PN and Control) with the corresponding 95% confidence intervals (CI). All analyses were adjusted for baseline values. Scores are based on the m-AHEI and have been converted from a maximum total score of 10 to a maximum possible score of 100 for each m-AHEI component.

TE= Treatment Effects, PN= Personalised Nutrition, SD= Standard Deviation, m-AHEI= Modified Alternative Healthy Eating Index, Δ= Change

* P value <0.017 for post-hoc values based on a Bonferroni correction

4.4.3 Effect of the 12-week intervention on the secondary outcomes

In addition to anthropometric analysis, assessments of energy and key nutrients; dietary fibre, sugar, total fat, saturated fat, salt, PUFA, omega 3 fatty acids and folate were analysed in order to determine targeted nutrient intakes (9) (Table 4.4). Overall, participants that received personalised dietary advice in both intervention groups (face-to-face PN and web-based PN) improved their dietary intakes and anthropometric measurements compared to control group participants. Compared to the web-based PN and control groups, participants in the face-to-face PN group significantly reduced their BMI (kg/m_2) and weight (kg) (P<0.01). In addition, compared to control group participants, face-to-face PN group significantly improved their intakes of fibre (g/day) P<0.017. Although differences were found between the personalised intervention groups (face-to-face PN and web-based PN) compared to the control group for the intakes of omega 3 FA (g/day) and total folate (µg/day), it did not reach the required level of P<0.017.

Table 4. 4 Effect of the 12-week intervention on anthropometric outcomes and targeted dietary intakes

	Face-to-face PN		Web-based PN		Control		TE Δ Face - Δ Control (95% CI)	TE Δ Face- Δ Web (95% CI)	TE Δ Web- Δ Control (95% CI)	TE P-value
	Baseline mean (SD)	Δ from baseline	Baseline mean (SD)	Δ from baseline	Baseline mean (SD)	Δ from baseline				
n	37		33		30					
Anthropometrics										
BMI (kg/m_2)	25.1 (4.1)	-0.5 (0.5)	25.4 (4.5)	-0.0 (0.5)	24.8 (4.0)	0.1 (0.5)	-0.6 (-0.9 to -0.3)*	-0.5 (-0.8 to -0.2)*	-0.1 (-0.3 to - 0.1)	0.008
Weight (kg)	73.6 (14.0)	-1.7 (1.6)	73.1 (16.1)	0.0 (1.7)	70.8 (12.6)	0.3 (1.6)	-2.0 (-2.9 to -1.2)*	-1.9 (-2.8 to -1.1)*	-0.02 (-2.8 to -1.1)	0.012
Baecke: PAL (Score)	8.3 (1.0)	0.9 (1.1)	8.4(0.9)	0.7 (0.7)	8.2 (1.1)	0.8 (1.2)	0.1 (-0.3 to- 0.5)	0.1 (- 0.3 to 0.5)	0.1 (-0.4 to 0.5)	0.721
Dietary intakes										
Energy (Kcal/day)	2434 (1166)	-22.7 (281.1)	2722 (1215)	102.8 (718.8)	2671 (1103)	103.9 (534.1)	-190.2 (-438.6 to 57.6)	-136.5 (-375.4 to 101.2)	-53.2 (-307.6 to 200.6)	0.712
Energy (Kj/day)	10698 (4708)	-94.1 (1180.2)	11392 (5087)	428.2 (3010.4)	11179 (4618)	435.2 (2235.1)	-786.5 (-2372.5 to1159.4)	-643.0 (-2643.5 to 1357.5)	-140.2 (-2024.8 to 1731.7)	0.691
Total Fat (g/day)	100 (50.9)	-1.4 (46.3)	94 (45.1)	4.7 (39.0)	103 (50.8)	0.4 (34.8)	-8.2 (-23.3 to 7.2)	-0.28 (-15.7 to 15.1)	-7.9 (-23.3 to 8.1)	0.576

Total Folate (µg/day)	366.8 (214.4)	129.0 (253.8)	398.6 (191.1)	119.2 (203.6)	346.5 (149.4)	12.5 (96.2)	126.80 (35.3 to 220.2)	7.60 (-81.3 to 97.1)	120.2 (25.6 to 214.9)	0.021
Omega 3 FA (g/day)	0.16 (0.1)	0.1 (0.2)	0.19(0.2)	0.1 (0.2)	0.16 (0.1)	-0.0 (0.1)	0.2 (0.1 to 0.3)	0.08 (0.0 to 0.1)	0.1 (0.04 to 0.2)	0.009
PUFA (g/day)	17.0 (9.1)	1.9 (12.8)	19.6 (10.8)	1.0 (14.5)	18.6 (9.8)	-1.9 (13.4)	1.0 (-4.2 to 5.8)	-0.7 (-5.6 to 4.2)	1.5 (-3.7 to 6.6)	0.831
Fibre (g/day)	29.5 (17.3)	10.7 (20.3)	33.6 (17.0)	5.5 (15.7)	29.4 (15.1)	-1.1 (14.2)	10.2 (2.8 to 17.5)*	3.3 (-3.8 to 10.4)	6.9 (-0.6 to 14.3)	0.012
SFA (g/day)	35.8 (20.3)	4.7 (22.3)	41.3 (21.8)	2.2 (18.2)	41.9 (20.3)	6.5 (19.5)	-6.8 (-14.4 to 0.7)	0.2 (-7.5 to 7.1)	-6.6 (-14.3 to 1.1)	0.143
Total Sugar (g/day)	150 (83)	-5.4 (66.9)	159 (88)	-5.5 (54.7)	161 (80)	2.3 (70.3)	-16.7 (-39.8 to 6.3)	-5.3 (-27.5 to 16.9)	-11.4 (-35.1 to 12.3)	0.352
Salt (g/day)	3.0 (2.5)	-0.1 (0.6)	3.1 (1.7)	-0.0 (0.7)	2.9 (1.4)	0.1 (0.8)	-0.2 (-0.5 to 0.1)	-0.06 (-0.3 to 0.3)	-0.3 (-0.5 to 0.3)	0.314

Data are presented as adjusted means (SD) and as the difference between the three intervention groups (Face-to-face PN, Web-based PN and Control) with the corresponding 95% confidence intervals (CI). All analyses were adjusted for baseline values. Scores are based on the m-AHEI and have been converted from a maximum total score of 10 to a maximum possible score of 100 for each m-AHEI component.

TE= Treatment Effects, PN= Personalised Nutrition, SD= Standard Deviation, m-AHEI= Modified Alternative Healthy Eating Index, ∆= Change, BMI= Body Mass Index, PAL= Physical Activity Level, FA= Fatty Acid, PUFA= Polyunsaturated Fatty Acid, SFA= Saturated Fatty Acid

* P value <0.017 for post-hoc values based on a Bonferroni correction

4.4.4 Effect of the 12-week intervention on participants that received targeted nutritional advice based on the m-AHEI components

Table 4.5 presents the number of participants (percentage) that received targeted dietary messages based on the m-AHEI components. m-AHEI components were included if the total number of messages was >20 and or ≥ 6 in each intervention group to minimise chances of type II error. In total, four m-AHEI components; fruit, dairy, salt and healthy fats were excluded from analysis as they did not meet the criteria. In summary, 30% of participants received messages to improve their red and processed meat intake, 28% of participants received messages due to high sugar intakes, 11% received messages to improve their intakes of nuts and legumes, 12% were asked to improve intakes of oily fish, 10% of total participants received messages to improve their wholegrain intake and 9% received messages to improve intakes of vegetables. The changes in m-AHEI components from baseline to week 12 based on the total number of messages received by the personalised intervention groups and the control group based on their dietary status is shown in Table 4.6. Significant differences were found between the intervention groups and the control group for the m-AHEI components ‘nut and legumes’ (P=0.01) and ‘sugars’ (P=0.01).

Table 4. 5 Top three messages presented to the intervention groups representing the lowest scores for the components[a] of the m-AHEI

m-AHEI component	Face-to-face PN group	Web-based PN group	Control group	Total
Red & processed meats n (%)	26 (29%)	26 (31 %)	21 (23.3%)	73 (30%)
Sugars n(%)	25 (28%)	23 (28%)	20 (22.2%)	68 (28%)
Nuts & legumes n (%)	12 (13%)	7 (8%)	8 (11%)	27 (11%)
Oily fish n (%)	10 (11%)	12 (15%)	8 (8.9%)	30 (12%)
Wholegrains n (%)	9 (10%)	9 (11%)	7 (9%)	25 (10%)
Vegetables n (%)	8 (9%)	6 (7%)	10 (14%)	24 (9%)
Total	90	83	74	247

[a] m-AHEI components are arranged based on the top three dietary messages delivered to the personalised intervention groups and the control group. Changes in the m-AHEI components were included if the total number of messages was >20 and or ≥ 6 in each intervention group. As each participant received three messages, n=247 is the total number of messages.

Table 4. 6 Changes in the m-AHEI components from baseline to week 12 for participants in the intervention groups and control group[a]

m-AHEI component[a]	Face-to-face PN		Web-based PN		Control		TE Δ Face - Δ Control (95% CI)	TE Δ Face- Δ Web (95% CI)	TE Δ Web- Δ Control (95% CI)	TE P-value
	Baseline mean (SD)	Δ from baseline	Baseline mean (SD)	Δ from baseline	Baseline mean (SD)	Δ from baseline				
Red and processed meats n=73	25.4 (35.5)	0.8 (26.7)	6.9 (18.8)	2.8 (20.1)	10.1 (22.8)	-3.4 (17.8)	11.8 (-2.5 – 26.2)	6.4 (-6.8 – 19.7)	5.4 (-8.4 – 19.4)	0.132
Sugars n=68	24.3 (28.4)	10.8 (25.9)	20.1 (20.9)	9.3 (22.5)	32.1 (23.1)	-12.7 (21.5)	19.0 (8.8 – 29.3)*	4.2 (-6.1 – 14.1)	14.7 (4.1 – 25.3)*	0.013
Nuts and legumes n=27	51.4 (30.9)	6.5 (19.2)	29.1 (43.8)	12.5 (33.3)	27.6 (27.8)	-24.5 (31.9)	36.4 (8.8 – 63.9)*	-1.4 (-28.5 – 25.5)	37.8 (9.2 – 66.5)*	0.015
Oily fish n=30	44.3 (32.6)	6.6 (35.8)	38.9 (37.8)	18.1 (28.3)	28.1 (41.0)	3.8 (18.9)	11.4 (-10.1 – 33.0)	-8.6 (-27.3 – 10.5)	20.0 (-0.1 – 40.6)	0.154
Wholegrains n=25	39.7 (40.4)	36.0 (47.2)	35.8 (48.5)	33.0 (44.2)	76.4 (37.0)	-21.3 (27.4)	36.8 (-2.1 – 75.5)	5.1 (-29.2 – 39.3)	31.7 (-7.6 – 71.6)	0.142
Vegetables n=24	54.0 (34.8)	9.6 (30.1)	39.0 (36.2)	16.0 (39.4)	59.7 (40.4)	-2.1 (22.6)	9.6 (-17.4 – 36.8)	-1.0 (-32.2 – 30.1)	10.7 (-19.5 – 40.9)	0.681

[a] m-AHEI components are arranged based on the top three dietary messages delivered to the personalised intervention groups and the control group. Changes in the m-AHEI components were included if the total number of messages was >20 and or ≥ 6 in each intervention group. As each participant received three messages, n=247 is the total number of messages. Scores are based on the m-AHEI and have been converted from a maximum total score of 10 to a maximum possible score of 100 for each m-AHEI component. TE= Treatment Effects, PN= Personalised Nutrition, SD= Standard Deviation, m-AHEI= Modified Alternative Healthy Eating Index, Δ= Change.

* P value <0.017 for post-hoc values based on a Bonferroni correction

4.4.5 Evaluation of the web-based EatWellQ8 FFQ and feedback reports

In total, 48 out of 320 participants completed the feedback follow-up study, 4 weeks after trial completion. Responses to selected questions from the feedback questionnaire completed by the intervention group participants (face-to-face ad web-based groups) are shown in Table 4.7. When asked whether the advice provided enough examples of foods they should eat more of, a significant difference was noted in which 29% of web-based group participants compared to 0% face-to-face group participants strongly agreed to the question ($P<0.05$). Moreover, a higher percentage of participants in the face-to-face PN (80%) strongly agreed/agreed that they were still following healthy eating advice compared to (52%) in the web-based PN group although this difference was not statistically significant. Questions regarding the evaluation of the EatWellQ8 FFQ are found in Table 4.8. To determine participants reputability and understanding of the online FFQ and whether group placement had any impact on FFQ outcomes, evaluations between the study groups were performed. In total, 25% of control group participants disagreed that the online FFQ asked enough questions to provide the site with a good overview of their diets compared to 0% responses in the intervention groups $P<0.05$. No significant differences were found for the responses to any of the other questions.

Table 4. 7 Feedback responses from participants in the PN intervention groups in regards to the personalised reports (n=32)

Question	Group	Responses n(%)				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. Before I took part in the EatWellQ8 study I was already motivated to make changes to my diet	Face-to-face PN (n=15)	5 (33)	8 (53)	2 (13)	0 (0)	0 (0)
	Web-based PN (n=17)	10 (59)	5 (29)	0 (0)	1 (6)	0 (0)
	[a]P-value	0.37				
2. The healthy eating advice given by the EatWellQ8 site is still, to this day, motivating me to improve my diet	Face-to-face PN (n=15)	3 (20)	9 (60)	3 (20)	0 (0)	0 (0)
	Web-based PN (n=17)	4 (23)	5 (29)	5 (29)	3 (17)	0 (0)
	[a]P-value	0.23				
3. I had enough information about how the healthy eating score was calculated	Face-to-face PN (n=15)	1(7)	5 (33)	8 (53)	1 (7)	0 (0)
	Web-based PN (n=17)	4 (24)	5 (29)	6 (35)	2 (12)	0 (0)
	[a]P-value	0.49				
4. Advice from the EatWellQ8 site changed some of my eating/drinking habits, even if only for a short time	Face-to-face PN (n=15)	4 (27)	8 (53)	3 (20)	0 (0)	0 (0)
	Web-based PN (n=17)	6 (35)	6 (35)	4 (24)	1 (6)	0 (0)
	[a]P-value	0.76				
5. Before I took part in the study, I was confident I knew what constitutes a ‘healthy’ diet	Face-to-face PN (n=15)	4 (27)	8 (53)	2 (13)	0 (0)	1 (6)
	Web-based PN (n=17)	3 (20)	8 (47)	3 (18)	2 (12)	0 (0)
	[a]P-value	0.76				

6. Thinking about my diet as a whole, I feel the advice from the site encouraged me to eat more healthily	Face-to-face PN (n=15)	5 (33)	8 (53)	2 (13)	0 (0)	0 (0)
	Web-based PN (n=17)	5 (29)	7 (41)	5 (29)	0 (0)	0 (0)
	[a]P-value	0.44				
7. The advice provided enough examples of foods I should eat more of	Face-to-face PN (n=15)	0 (0)	7 (47)	6 (40)	0 (0)	0 (0)
	Web-based PN (n=17)	5 (29)	3 (18)	7 (41)	0 (0)	0 (0)
	[a]P-value	0.02				
8. My dietary restrictions weren't considered	Face-to-face PN (n=15)	1 (7)	0 (0)	11 (73)	3 (20)	0 (0)
	Web-based PN (n=17)	0 (0)	3 (18)	11 (65)	1 (6)	2 (12)
	[a]P-value	0.14				
9. The advice was not suited to my lifestyle	Face-to-face PN (n=15)	0 (0)	3 (20)	11 (73)	1 (6)	0 (0)
	Web-based PN (n=17)	0 (0)	2 (12)	11 (65)	2 (12)	2 (12)
	[a]P-value	0.49				
10. I was aware of the health benefits of having a higher healthy eating index score	Face-to-face PN (n=15)	1 (7)	7 (41)	7 (41)	0 (0)	0 (0)
	Web-based PN (n=17)	4 (24)	6 (35)	6 (35)	1 (6)	0 (0)
	[a]P-value	0.49				

[a]P values derived from a Fisher's exact test. PN= Personalised Nutrition

Table 4. 8 Participants feedback responses related to the usability of the EatWellQ8 FFQ (n=48)

Question	Group	Responses n(%)				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. The questionnaire asked enough questions to provide the site with a good overview of my diet	Face-to-face PN (n=15)	3 (20)	7 (47)	5 (33)	0 (0)	0 (0)
	Web-based PN (n=17)	7 (41)	5 (29)	5 (29)	0 (0)	0 (0)
	Control (n=16)	0 (0)	10 (63)	2 (13)	4 (25)	0 (0)
	[a]P-value	0.04				
2. I remembered that I was only recording my food and drink intake for the past month	Face-to-face PN (n=15)	0 (0)	4 (27)	11 (73)	0 (0)	0 (0)
	Web-based PN (n=17)	4 (24)	1 (6)	10 (59)	1 (6)	1 (6)
	Control (n=16)	0 (0)	1 (7)	13 (81)	2 (13)	0 (0)
	[a]P-value	0.39				
3. I would be willing to answer more questions to give the site a better overview of my diet even if it took longer to complete	Face-to-face PN (n=15)	1 (7)	9 (60)	5 (33)	0 (0)	0 (0)
	Web-based PN (n=17)	3 (18)	9 (53)	4 (24)	0 (0)	0 (0)
	Control (n=16)	1 (7)	9 (56)	6 (38)	0 (0)	0 (0)
	[a]P-value			0.24		
4. The questionnaire was too long	Face-to-face PN (n=15)	0 (0)	10 (67)	3 (20)	1 (7)	1 (7)
	Web-based [a]PN (n=17)	1 (7)	7 (41)	4 (24)	4 (24)	1 (6)
	Control (n=16)	0 (0)	9 (56)	4 (25)	3 (19)	0 (0)
	[a]P-value	0.79				
5. For each type of food, I understood how I should select the most relevant portion size on the site	Face-to-face PN (n=15)	0 (0)	4 (25)	9 (60)	1 (7)	1 (7)
	Web-based PN (n=17)	2 (12)	5 (29)	6 (35)	4 (24)	0 (0)
	Control (n=16)	0 (0)	2 (13)	10 (63)	2 (13)	0 (0)
	[a]P-value	0.27				

6. For each type of food, I understood how often I ate these foods on the site	Face-to-face PN (n=15)	0 (0)	5 (33)	7 (47)	2 (13)	1 (7)
	Web-based PN (n=17)	0 (0)	2 (12)	10 (59)	3 (18)	2 (12)
	Control (n=16)	0 (0)	2 (13)	12 (75)	2 (13)	0 (0)
	[a]P-value	0.29				
7. A tutorial showing how to complete the food and drink questionnaire would be useful	Face-to-face PN (n=15)	2 (13)	1 (7)	12 (80)	0 (0)	0 (0)
	Web-based PN (n=17)	4 (24)	3 (18)	10 (59)	2 (13)	2 (13)
	Control (n=16)	2 (12)	1 (6)	11 (69)	2 (13)	0 (0)
	[a]P-value	0.32				
8. I would prefer to answer fewer questions even if the site had a less accurate overview of my diet	Face-to-face PN (n=15)	1 (7)	3 (20)	8 (53)	2 (13)	1 (7)
	Web-based PN (n=17)	3 (18)	3 (18)	7 (41)	2 (12)	2 (12)
	Control (n=16)	0 (0)	2 (13)	10 (63)	4 (25)	0 (0)
	[a]P-value	0.70				

[a]P values derived from a Fisher's exact test. PN= Personalised Nutrition

4.5 Discussion

Compared to standard population-based guidance, PN advice was more effective at motivating change towards a healthier diet in free-living non-diseased individuals living in Kuwait. Moreover, there were no significant differences in dietary change between PN advice delivered face-to-face or online. However, it was observed that compared to web-based PN and population-based advice, face-to-face PN was more effective at inducing weight-loss. It was shown that PN advice delivered online was an effective strategy for motivating dietary changes in individuals in Kuwait.

To our knowledge, our study is the first to assess face-to-face PN, web-based PN advice and population-based advice and provides evidence that web-based PN is as effective as face-to-face PN at improving dietary intake. This supports results of a study that assessed in-person dietary advice compared to web-based dietary advice for low-income adults which found no differences between the delivery methods. Dietary parameters were improved significantly at the end of the trial in both groups (42) . However, the aforementioned study did not confirm whether the in-person advice was delivered in a one-to-one consultation or group setting (42). Interestingly, another trial that focused at improving vegetable and fruit intakes of low-income families observed that web-based advice was superior to in-person advice delivered in a group setting (43) .

Results of the present study are also in line with outcomes from the Food4Me RCT that showed web-based PN advice to be more effective than generalised dietary advice at improving the diet quality among European adults after a 6 month on-line intervention (8). Compared with population-based dietary advice, we observed that participants who received tailored dietary advice had significantly higher overall m-AHEI scores. Similarly, findings from the Food4Me and EatWellUK trials have demonstrated significant increases in the overall HEI (Healthy Eating Index) scores of PN intervention participants compared to generalised controls (8; 31).

Tailored dietary advice has been shown to be superior at enhancing dietary intakes of healthy foods compared to standardised advice, in particular daily servings of fruits using web and non-web-based delivery methods, which suggests an overall preference towards PN (44; 45; 46; 47; 48). In line with a meta-analysis that demonstrated the effectiveness of web-based PN at enhancing dietary intakes of fruit and vegetables

compared to non-PN dietary advice, outcomes from the present study have shown significant improvements in intakes of fruit and vegetables in the two PN groups compared to the control group (49). Similarly, findings from a RCT that assessed the effectiveness of following a Mediterranean diet in conjunction with different levels of phenotypic and genotypic PN, showed that compared to the non-PN group, PN significantly improved the diet scores for fruit and their overall dietary scores (50). Based on results from our feedback analysis more than 56% of participants agreed that the PN advice motivated them to follow a healthier diet even after the study terminated and 78% agreed that the advice had motivated them to follow a generally healthier diet.

In addition, results of the present study demonstrated reductions in sugar consumption in the PN intervention groups compared to controls. Significant reductions in sugar-sweetened beverage intake (-0.3 servings per day; SD 0.1) were also found in a study investigating web-based PN feedback, with or without the addition of text messages, when compared with controls that received no feedback (48). It has been suggested that high sugar intakes may contribute to the premature development of obesity (51) and other NCD risk factors, and findings from our study compare favourably to a previous targeted PN intervention, which has aimed at more broadly reducing intakes of energy dense foods by reducing high energy snack consumption rather than focusing on sources of energy in the diet (45). Findings from the Food4Me study have also demonstrated significant improvements in salt intakes in the groups that received the PN interventions compared to population based advice controls (8). Although, results of the present trial did not signify differences between the interventions in salt intakes, improvements in salt intake in intervention groups and the control group were found at the end of the trial. Possible reasons for this finding may be due to the relatively short trial length, group sample size and due to reporting bias.

Improvements were found for total folate and omega 3 FA intakes in both PN intervention groups compared to the control group, which probably reflect the significant increases in fruit and vegetable intakes and oily fish respectively. Comparable results were found in the Food4Me trial that showed significant improvements in intakes of folate in the PN intervention groups compared to control group participants (8). Outcomes from the Food4Me trial has also demonstrated the effectiveness of PN interventions at significantly reducing saturated fatty acid (SFA) levels amongst adults from seven European countries (8). In the present trial, SFA

intakes were not targeted, however, reductions in SFA from baseline levels were found in both PN groups, although they were not significantly different to controls.

Of the targeted PN messages based on the three lowest m-AHEI scores received by the intervention groups, significant improvements in the nuts and legumes, and sugars m-AHEI components were observed following PN intervention compared to baseline values and controls. Non-significant improvements were found for the remaining m-AHEI components supporting findings from the EatWellUK trial (31). Reasons for the non-significance may relate in part to small sample size in each component and relatively short study length.

Our findings also support evidence of the beneficial effects of face-to-face PN at improving oily fish and intakes of fibre compared to standardized dietary advice (52; 53; 54; 55; 56). Outcomes of face-to-face PN intervention in the present study are in line with a systematic review that investigated the effectiveness of dietetic consultations in primary care settings compared to standardized advice received in control groups (provided by minimal in-person nutrition counseling or with nutrition fact sheets) at improving dietary intakes, healthy outcomes (including BMI) and weight-loss (57). A favourable outcome in the current trial is the achievement of significant reductions in weight and BMI in the face-to-face PN group compared to the web-based PN group and controls. This may highlight a preference towards in-person weight-loss counseling compared to other delivery methods which is comparable to findings from a recent systematic review by Mitchell et al. (57). Although, significant reductions in weight and BMI were not achieved in the web-based PN weight-loss intervention group, this result is in line with mixed findings from previous meta-analyses regarding the effectiveness of online weight-loss and concluded that there is a lack of high-quality research that focused primarily at web-based weight-loss (58; 59).

4.5.1 Strengths and limitations

Based on the observed effect of the study and the large number of participants that had to be excluded from analysis due to misreporting, a retrospective power calculation (using the results from this study) was conducted, which indicated that an increase of 18% for the intervention groups compared to the control group in the m-AHEI (mean=49, SD=12, Alpha=0.05, Power=0.8) would require a group size of n=28. Therefore, a total sample of n=100 would seem sufficient to identify differences

between groups in this study. To our knowledge, the current trial is the first study in Kuwait that examined the effectiveness of web-based PN advice using a novel online FFQ that has been designed and validated for the collection of dietary intakes of Kuwaiti adults. An added strength is that it emphasised dietary change by encouraging, as an example, healthy fats and oily fish intakes rather than reducing total fat. However, the present trial had several limitations. The first limitation is the over/under reporting that was found in approximately 60% of study completers, which reduced the sample size. Several reasons may have contributed to the observed over/under reporting, including loss of participant's interest in the study and relatively long FFQ length. Results of the usability questionnaire may further elucidate the reasons behind misreporting as over 56% of participants thought that the FFQ was too long and 27% would rather answer fewer questions even if the advice provided was less accurate. However, when asked whether the users would be willing to answer more questions to give accurate assessments of dietary intakes, more than 66% agreed and most of the participants responded with "neutral" to the majority of the questions which may highlight the issue of questionnaire boredom in this study sample. In addition, it has been suggested that FFQs generally overestimate energy intakes, which may have also caused over reporting of dietary intakes (60). Furthermore, the inclusion of composite Kuwaiti dishes could have led to double reporting of certain food items such as rice, chicken and meat and may therefore have contributed to some overestimation of energy intake. Moreover, participants were not given instructions on how to complete the web-based FFQ, which may have increased the likelihood of participants' misunderstanding of how to complete the online FFQ leading to inappropriate choice of food portions and frequencies. Consideration of clear instructions would be advised for future online FFQ as more than 27% of participants that completed the feedback questionnaires agreed that the inclusion of video tutorials would be beneficial. It is important to note that over/under reporting was not an issue in the validation of the EatWellQ8 FFQ trial against a four-day weighed food record and a paper-form FFQ (37). However, the EatWellQ8 validation study did include a face-to-face session with a dietitian prior to starting the study which was not included in the current study. Similar studies such as Food4Me included screening for over/under reporters which was not performed in the current trial and may therefore have increased chances of misreporting (8).

Finally, greater than 70% of participants were women and a low percentage of participants reported to be overweight/obese, therefore our results may not be

generalisable to the population. These limitations could be addressed in future web-based work that is targeted at enhancing the dietary intakes of individuals. To avoid such errors, future studies with larger sample size, are more sex balanced and include web-based FFQs that incorporate video instructions may be beneficial.

4.6 Conclusions

In conclusion, in adults living in Kuwait, web-based PN advice was as effective at enhancing diet quality as face-to-face PN compared to population-based advice. Furthermore, face-to-face PN was more effective at inducing weight-loss in adults compared to web-based PN and population-based advice.

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4.8 References

1. World Health Organization (2018) Noncommunicable diseases country profiles 2018. Geneva: World Health Organization Licence: CC BY-NC-SA 3.0 IGO, 223.

2. World Health Organization (2014) Global status report on alcohol and health, 2014: World Health Organization.

3. Ministry of Health (2014) KUWAIT NUTRITION SURVEILLANCE SYSTEM 2014 ANNUAL REPORT. https://wwwmohgovkw/Renderers/ShowPdfashx?Id=aa1caabd-6aea-4dbb-9441-c9768458941d, November 21, 2018.

4. Diem G, Brownson RC, Grabauskas V et al. (2016) Prevention and control of noncommunicable diseases through evidence-based public health: implementing the NCD 2020 action plan. Glob Health Promo 23, 5-13.

5. World Health Organization (2010) Action plan for the prevention of avoidable blindness and visual impairment, 2009-2013: World Health Organization.

6. National Health Service (2018) Eat Well. https://www.nhs.uk/live-well/eat-well/the-eatwell-guide/ (accessed August 28 2018)

7. Adamson AJ, Mathers JC (2004) Effecting dietary change. Proc Nutr Soc 63, 537-547.

8. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2016) Effect of personalized nutrition on health-related behaviour change: evidence from the Food4me European randomized controlled trial. Int J Epidemiol 46, 578-588.

9. Ordovas JM, Ferguson LR, Tai ES et al. (2018) Personalised nutrition and health. BMJ 361, k2173.

10. Celis-Morales C, Lara J, Mathers JC (2015) Personalising nutritional guidance for more effective behaviour change. Proc Nutr Soc 74, 130-138.

11. Nielsen DE, El-Sohemy A (2014) Disclosure of genetic information and change in dietary intake: a randomized controlled trial. PlosOne, 9, e112665.

12. Marteau TM, French DP, Griffin SJ et al. (2010) Effects of communicating DNA-based disease risk estimates on risk-reducing behaviours. Cochrane Database Syst Rev 10.

13. Fallaize R, Forster H, Macready AL et al. (2014) Online dietary intake estimation: Reproducibility and validity of the Food4Me food frequency questionnaire against a 4-day weighed food record. JMIR 16, e190.

14. Stumbo PJ (2013) New technology in dietary assessment: a review of digital methods in improving food record accuracy. Proc Nutr Soc 72, 70-76.

15. Thompson FE, Subar AF, Loria CM et al. (2010) Need for technological innovation in dietary assessment. J Am Diet Assoc 110, 48-51.

16. Marshall AL, Leslie ER, Bauman AE et al. (2003) Print versus website physical activity programs: a randomized trial. Am J Prev Med 25, 88-94.

17. Contento I, Balch GI, Bronner YL et al. (1995) The effectiveness of nutrition education and implications for nutrition education policy, programs, and research: a review of research. J Nutr Educ 27(6) 277-418.

18. Moore TJ, Alsabeeh N, Apovian CM et al. (2008) Weight, blood pressure, and dietary benefits after 12 months of a Web-based Nutrition Education Program (DASH for health): longitudinal observational study. JMIR 10(4), e52.

19. Naimark JS, Madar Z, Shahar DR (2015) The impact of a Web-based app (eBalance) in promoting healthy lifestyles: randomized controlled trial. JMIR 17(3), e56.

20. Verheijden M, Bakx JC, Akkermans R et al. (2004) Web-based targeted nutrition counselling and social support for patients at increased cardiovascular risk in general practice: randomized controlled trial. JMIR 6(4), e44.

21. Oenema A, Tan F, Brug J (2005) Short-term efficacy of a web-based computer-tailored nutrition intervention: Main Effects and Mediators. Ann Behav Med 29, 54-63.

22. Noah SA, Abdullah SN, Shahar S et al. (2004) DietPal: a Web-based dietary menu-generating and management system. JMIR 6(1), p.e4.

23. Miniwatts Marketing Group (2018) World Internet Users Statistics and 2018 World Population Stats. https://www.internetworldstats.com/stats.htm (accessed Nov 12 2018

24. Forster H, Walsh MC, Gibney MJ et al. (2016) Personalised nutrition: the role of new dietary assessment methods. Proc Nutr Soc 75, 96-105.

25.MozDevNet(2017)Math.https://developer.mozilla.org/enUS/docs/Web/JavaScript/Reference/Global_Objects/Math (accessed 12-10-2017)

26. EatWellQ8 (2018) EatWellQ8. https://eatwellq8.org/#/ (accessed 12-03-2018 2018)

27. Baecke JA, Burema J, Frijters JE (1982) A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr 36, 936-942.

28. Chiuve SE, Fung TT, Rimm EB et al. (2012) Alternative Dietary Indices Both Strongly Predict Risk of Chronic Disease. J Nutr 142, 1009-1018.

29. McCullough ML, Willett WC (2006) Evaluating adherence to recommended diets in adults: the Alternate Healthy Eating Index. Public Health Nutr 9, 152-157.

30. Franco RZ, Fallaize R, Lovegrove JA et al. (2018) Online dietary intake assessment using a graphical food frequency app (eNutri): Usability metrics from the EatWellUK study. PlosOne, 13, e0202006.

31. Franco R, Fallaize, R, Lovegrove, J, Hwang, F, (2018) Effectiveness of Online Personalised Nutrition Advice for Adults: Evidence from the EatWellUK Web-based Randomised Control Trial. in preparation.

32. Fallaize R, Livingstone K, Celis-Morales C et al. (2018) Association between diet-quality scores, adiposity, total cholesterol and markers of nutritional status in European adults: findings from the Food4Me study. Nutrients, 10, 49.

33. Fallaize R, Franco, R, Hwang, F, Lovegrove, J (2019) Evaluation of the eNutri automated personalised nutrition app by Nutrition Professionals in the UK. PlosOne, 14(4) e0214931.

34. Bohlscheid-Thomas S, Hoting I, Boeing H et al. (1997) Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the German part of the EPIC project. European Prospective Investigation into Cancer and Nutrition. Int J Epidemiol 26, S59.

35. Dehghan M, Al-Hamad N, McMillan CR et al. (2009) Comparison of a semi-quantitative food frequency questionnaire with 24-hour dietary recalls to assess dietary intake of adult Kuwaitis. SMJ 30, 159-161.

36. Alawadhi B, Fallaize, R, Franco, R, Hwang, F, Lovegrove, J, (2018) Reproducibility and validity of the EatWellQ8 web-based food frequency questionnaire against a paper-based food frequency questionnaire and a 4-day weighed food record in preparation.

37. Franco RZ, Alawadhi B, Fallaize R et al. (2017) A Web-Based Graphical Food Frequency Assessment System: Design, Development and Usability Metrics. JMIR Human Factors, 4(2), e13.

38. National Health Service (28 January 2019) The Eatwell Guide.

39. Hébert JR, Peterson KE, Hurley TG et al. (2001) The effect of social desirability trait on self-reported dietary measures among multi-ethnic female health center employees. Ann Epidemiol 11, 417-427.

40. Crispim S, Geelen A, Souverein O et al. (2011) Biomarker-based evaluation of two 24-h recalls for comparing usual fish, fruit and vegetable intakes across European centers in the EFCOVAL Study. Eur J Clin Nutr 65, S38.

41. ClinCalc (2019) Sample Size Calculator Determines the minimum number of subjects for adequate study power. https://clincalccom/stats/samplesizeaspx, January 16 2019.

42. Neuenschwander LM, Abbott A, Mobley AR (2013) Comparison of a Web-Based vs In-Person Nutrition Education Program for Low-Income Adults. J Acad Nutr Diet 113, 120-126.

43. Bensley RJ, Anderson JV, Brusk JJ et al. (2011) Impact of Internet vs Traditional Special Supplemental Nutrition Program for Women, Infants, and Children Nutrition Education on Fruit and Vegetable Intake. J Am Diet Assoc 111, 749-755.

44. Storm V, Dörenkämper J, Reinwand DA et al. (2016) Effectiveness of a web-based computer-tailored multiple-lifestyle intervention for people interested in reducing their cardiovascular risk: a randomized controlled trial. JMIR 18(4), e78.

45. Springvloet L, Lechner L, de Vries H et al. (2015) Short-and medium-term efficacy of a Web-based computer-tailored nutrition education intervention for adults including cognitive and environmental feedback: randomized controlled trial. JMIR 17(1), e23.

46. Wright JL, Sherriff JL, Dhaliwal SS et al. (2011) Tailored, iterative, printed dietary feedback is as effective as group education in improving dietary behaviours: results from a randomised control trial in middle-aged adults with cardiovascular risk factors. Int J Behav Nutr Phys Act 8(1), 43.

47. Hutchesson M, Collins C, Morgan P et al. (2014) Changes to dietary intake during a 12-week commercial web-based weight loss program: a randomized controlled trial. Eur J Clin Nutr 68, 64.

48. Kerr DA, Harray AJ, Pollard CM et al. (2016) The connecting health and technology study: a 6-month randomized controlled trial to improve nutrition behaviours using a mobile food record and text messaging support in young adults. Int J Behav Nutr Phys Act 13(1), 52.

49. Celis-Morales C, Abraham S, Keenan P et al. (2015) Effect of web-based tailored lifestyle interventions on fruit and vegetable consumption in adults: A systematic review and meta-analysis of randomised controlled trials. Proc Nutr Soc 74, (OCE1).

50. Livingstone KM, Celis-Morales C, Navas-Carretero S et al. (2016) Effect of an Internet-based, personalized nutrition randomized trial on dietary changes associated with the Mediterranean diet: the Food4Me Study. Am J Clin Nutr 104(2), 288-297.

51. World Health Organization (2018) Preparing for the third meeting of the UN high-level meeting on NCDs and strengthening the role and contribution of the private sector: roundtable of selected CEOs and high-level executives of multinationals and independent global experts on NCDs: discussion paper:No. WHO/NMH/ADGO/18.97. World Health Organization.

52. Lanza E, Schatzkin A, Daston C et al. (2001) Implementation of a 4-y, high-fiber, high-fruit-and-vegetable, low-fat dietary intervention: results of dietary changes in the Polyp Prevention Trial. Am J Clin Nutr 74, 387-401.

53. Francis SL, Taylor MLJJotADA (2009) A Social Marketing Theory− based diet-education program for women ages 54 to 83 years improved dietary status. J Am Diet Assoc 109, 2052-2056.

54. Arcand JAL, Brazel S, Joliffe C et al. (2005) Education by a dietitian in patients with heart failure results in improved adherence with a sodium-restricted diet: a randomized trial. Am Heart J 150(4), 716-e711.

55. Wong S, Lau E, Lau W et al. (2004) Is dietary counselling effective in increasing dietary calcium, protein and energy intake in patients with osteoporotic fractures? A randomized controlled clinical trial. J Hum Nutr Diet 17, 359-364.

56. Wolff S, Legarth J, Vangsgaard K et al. (2008) A randomized trial of the effects of dietary counseling on gestational weight gain and glucose metabolism in obese pregnant women. IJO 32, 495.

57. Mitchell LJ, Ball LE, Ross LJ et al. (2017) Effectiveness of dietetic consultations in primary health care: a systematic review of randomized controlled trials. J Acad Nutr Diet 117, 1941-1962.

58. Sorgente A, Pietrabissa G, Manzoni GM et al. (2017) Web-based interventions for weight loss or weight loss maintenance in overweight and obese people: a systematic review of systematic reviews. JMIR 19, e229.

59. Hutchesson M, Rollo M, Krukowski R et al. (2015) eH ealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis. Obesity Reviews, 16(5), 376-392.

60. Cade J, Thompson R, Burley V et al. (2002) Development, validation and utilisation of food-frequency questionnaires – a review. Public Health Nutr 5, 567-587.

CHAPTER 5 Comparison between diet and nutritional intake in UK and Kuwaiti adults - data from EatWellQ8 and EatWellUK RCTs

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5.1 Abstract

Background: The adoption of unhealthy dietary regimens have been linked with increased global levels of non-communicable diseases (NCDs), yet minimal focus has been given to assess and compare the dietary intakes between countries. The EatWellQ8 and EatWellUK web-based trials have incorporated a novel personalised nutrition (PN) assessment app (eNutri) to compare the effectiveness of online PN advice to generalised advice. To assess diet quality, a modified version of the Alternative Healthy Index (m-AHEI) was developed for use in the eNutri app.

Objectives: To evaluate the baseline characteristics, diet quality and nutrient intakes of participants using the novel eNutri PN app in EatWellQ8 and EatWellUK trials and to compare the dietary outcomes to current UK dietary recommendations.

Methods: Baseline data of free-living participants from the EatWellQ8 and EatWellUK trials that were randomised in to PN advice groups or to a general advice group, aged 18-85 years, served as the reference data for the current trial. Assessments of dietary intakes, m-AHEI score and individual m-AHEI components, anthropometric measurements and levels of physical activity were compared via independent samples t-tests and a generalised linear model (GLM). Comparisons between dietary intakes and UK dietary recommendations were assessed using a one sample t-test. The three diet messages (based on the lowest m-AHEI component scores) presented to participants in each trial were compared.

Results: Baseline data of 517 participants (EatWellQ8 n=208, EatWellUK n=309) (74% females, mean age=40.7±13.8, range 18-85 years) participants was assessed. Energy intakes were 21% higher in EatWellQ8 compared to EatWellUK ($P<0.001$). Micronutrient intakes were significantly higher, except for iron, vitamin C and sodium in EatWellUK compared with EatWellQ8 ($P<0.01$). EatWellUK had higher % energy from fats and protein, but lower sugars and fibre and a 5.6% higher overall m-AHEI compared with EatWellQ8 ($P<0.01$). Individual m-AHEI component scores were also significantly higher in EatWellUK for vegetables, dairy, free sugars, red and processed meats and oily fish ($P<0.01$). Top three dietary concerns in the EatWellQ8 study were high intakes of red and processed meats (26%), free sugars (24%) and salt (11%). 42% of targeted PN messages in the EatWellUK study were increasing intakes of nuts and legumes (24%), wholegrains (18%) and 22 % were targeted towards reducing intakes of red and processed meats.

Conclusions: Results reflect overall healthier dietary intakes by the EatWellUK participants compared to participants in the EatWellQ8 study. Results also suggest

that dietary advice needs differ both at an individual and at a geographical level confirming the effectiveness of PN methods.

5.2 Introduction

According to the World Health Organisation (WHO), non-communicable diseases (NCDs) including cardiovascular disease (CVD), type 2 diabetes mellitus (DM) and obesity are the primary cause of global premature deaths, and are responsible for the annual death of approximately 15 million women and men aged 30-70 years (1). NCDs are related to modifiable risk factors: namely unhealthy diets, sedentary lifestyles, smoking and excessive alcohol intakes (2). Diets high in energy-dense foods, refined sugars, salt and saturated fats, coupled with low intakes of fruits, vegetables, and wholegrains are associated with the development of NCDs (2; 3).

Modifications in diet and physical activity (PA) have been shown to be successful at reducing the development of CVDs, some cancers and type 2 DM (2; 4; 5). In addition, it has been estimated by the WHO that following a healthy diet and lifestyle may prevent the development of approximately 40% of cancer cases (6). Therefore, the development of public health strategies that are aimed at improving the diet and lifestyles of individuals are necessary (7). The majority of strategies that have been adopted to enhance dietary intake follow a “one size fits all” approach rather than a tailored method that meets an individual’s specific dietary requirements. Personalised Nutrition (PN) aims to improve the dietary intake and health of individuals and to minimize the risk of chronic disease. PN has been adopted to develop tailored nutritional advice for individuals and may incorporate both genotypic and phenotypic assessments, as well as medical and nutritional needs (8; 9). Trials such as the Food4Me study have assessed the effectiveness of delivering personalised web-based dietary advice. The Food4Me study compared PN based on dietary intake to standard population-based advice and found that web-based PN was more effective at improving the dietary intakes of individuals (8). Interest in utilising the web to deliver health related messages, including dietary assessment methods has increased with higher global internet use. Current estimates indicated that Internet usage increased by >520% in Europe and by >4300% in the Middle East since 2000 (10). Web based health education messages that target specific characteristics of individuals have been applied to several health related behaviours to encourage adults to adopt a well-balanced diet (11). The advantages of utilising the web to deliver tailored nutrition advice in comparison to traditional in-person consultations include cost-effectiveness, increased accessibility amid large geographically distributed populaces and increased convenience (12).

Based on the findings of a review that evaluated popular diet apps, it was established that freely available commercial apps lacked the ability of providing PN advice (13). Our research group have developed a novel web-based app (eNutri) (14) that is capable of assessing dietary intake and providing PN advice which has been used in the EatWellUK and EatWellQ8 studies to compare web-based tailored nutrition advice to population based advice delivered online (15; 16). The EatWellQ8 trial also investigated the delivery of face-to-face PN compared to web-based PN and population-based advice in Kuwait. Although global preventative actions to reduce the development of NCDs have taken place, minimal focus has been given to compare dietary intakes and lifestyles between countries (17; 18). In addition, recent data from UK National Diet and Nutrition Survey (NDNS) and the National Nutrition Survey of the State of Kuwait (NNSSK) have shown that the majority of adults from both countries were not meeting daily requirements for fibre, free sugars, fruit and vegetables, saturated fatty acids (SFA) and oily fish (19; 20).Therefore, this paper aims to report and compare the baseline dietary intake and diet quality scores assessed by the eNutri app, validated and used by the participants recruited to the EatWellQ8 and the EatWellUK studies to assess any dietary differences between these populations and to compare dietary outcomes to current UK dietary recommendations.

5.3 Methods

5.3.1 Dietary assessment- eNutri system

For the purpose of the EatWellUK and EatwellQ8 studies, eNutri (14), a novel web-based app that provides automated PN advice, was developed. The incorporation of an automatic PN decision system was a novel feature as none of the previously developed web-based dietary systems provided automatic PN advice (13). To increase the usability of the eNutri app, it was accessible using different commonly used devices which included mobile phones, tablets and computers (14). The validated Food4Me food frequency questionnaire (FFQ) was used by the eNutri app to assess dietary intake in the UK population (21) and a novel validated FFQ, adapted from the Food4Me and Kuwaiti FFQs was developed to assess dietary intake in the Kuwaiti populations(22). These food and nutrient data were then used to generate personalised dietary advice based on an 11-item modified US Alternative Healthy Eating Index (represented as m-AHEI). The Alternate Healthy Eating Index (AHEI) was chosen as it was based on nutrient and foods that were found to be predictors of chronic disease risk factors,

inversely proportional with the development of CVD and obesity and positively associated with PA and dietary intake indicators (23; 24). The PN reports generated by the eNutri app began with a tailored greeting followed by dietary messages about the three top nutritional concerns that the participant should consider improving. The eNutri system automatically selected the top three messages based on the lowest scores received from the m-AHEI components, which included; vegetables, fruits, nuts and legumes, dairy, wholegrains, oily fish, healthy fats, red and processed meats, free sugars, salt and alcohol. The eNutri system was developed alongside end-users to evaluate user understanding of the feedback reports and nutrition professionals that further assessed the feedback reports and compared the advice to professional recommendations (25). To accommodate the eNutri system for use in the EatWellQ8 trial, the m-AHEI component alcohol was removed as alcohol use is forbidden in Kuwait. The PN report also included weight management advice based on the participants BMI and PA advice based on the validated Baecke PA questionnaire. A section named the “Healthy Eating Score” presented the scores for the m-AHEI components based on a bar ranging from 0 to 100%. The colour of the bar represented the m-AHEI score for each component, red denoted a low score, yellow a moderate score and green a high score. The m-AHEI presented scores as percentages in order to facilitate participants understanding of the scoring system. In addition to the PN reports, the eNutri system automatically generated generalised feedback reports for participants randomised to the control group. The generalised reports included advice based on the UK dietary guidelines and included generalised weight management and PA sections (15; 16).

5.3.2 EatWellQ8 study

5.3.2.1 Study design

The EatWellQ8 study was a three-month, three-arm, web-based randomised control trial (RCT) that assessed the effectiveness of delivering PN online advice compared to similar PN advice given face-to-face with standardised dietary advice delivered online on improving diet intake and measures of body weight in a Kuwaiti population. The EatWellQ8 study received a favorable ethical opinion for conduct from the School of Chemistry, Food and Pharmacy Research Ethics Committee, University of Reading (Ref No. 13/17) and the Research Ethical Committee at Dasman Diabetes Institute (DDI), Kuwait (RA-2015-018). The study was registered at the ClinicalTrials.gov

website (NCT03396263) and compiled with the Helsinki declaration and described in detail in Awadhi et al (16).

5.3.2.2 Participants

Details of the study participants have been published previously (16) but in brief the inclusion criteria for participation in the EatWellQ8 study were; free-living adults between the ages of 21 to 65 years living in Kuwait that had access to the Internet. Recruitment of participants was via the Internet in order to mimic a real web-based PN resource. The trial was also supported by local advertising through social media methods, word of mouth and posters in addition to recruitment stands in DDI, local collages and shopping centers. Clinical dietitians in Kuwait were responsible for all recruitment methods. Participants interested in the EatWellQ8 study were sent a link to the study website (EatWellQ8.org) where they were guided to log in and register. Once they created an account, they were required to read and download the information sheet and accept the consent form (forms were available in both English and Arabic). It was made clear to participants that participation in the trial was voluntary and they were able to withdraw without any obligations at any time. As an incentive, all participants were informed that they would receive a PN report upon completion of the trial.

Participants were excluded based on the following criteria; pregnant or lactating, no or limited internet access, adhering to a weight management diet in the last 3 months, food intolerance or food allergy, on medications (with the exception of statins and hypertension medications) and diagnosed with a metabolic disease that impacted their dietary intakes (e.g. coeliac disease, diabetes).

5.3.2.3 Intervention design

Full details of the study procedure have been described elsewhere (16). Briefly, participants were randomised to a personalised face-to-face group, web-based personalised group or to a population-based advice control group. All participants were asked to complete registration and complete the screening questionnaire and provide weight and height measurements prior to trial commencement. Once screening has been completed, participants were required to fill a Baecke PA questionnaire followed by the 146-food item EatWellQ8 FFQ. The EatWellQ8 FFQ was validated using a four-

day weighed food record (WFR) and a validated Kuwaiti paper-form FFQ (22). All information was available in both English and Arabic to increase user acceptability and friendliness.

5.3.2.4 EatWellQ8 FFQ

For the purpose of the trial, a novel web-based 146 food item FFQ questionnaire was developed (22). The EatWellQ8 FFQ was based on the validated Food4Me FFQ (21) and the well-validated European Prospective Investigation of Cancer (EPIC)-Norfolk FFQ (version CAMB/PQ/6/1205) (26) and a paper-form FFQ for Kuwait (27). The novel FFQ comprised of 146 food items that represented food items and composite dishes commonly consumed in Kuwait. Alcoholic drinks and pork were removed from the FFQ as they are not commonly consumed items and also to respect the religious culture in Kuwait. Participants were given the choice to select from photographs of three portion sizes to facilitate participants portion size estimation and to choose from 9 frequencies ranging from “never/once a month” to “more than 6 times/day”. This was fully validated and showed good comparison with the gold standard weighed food diet diary methods and good repeatability (22).

5.3.2.5 Outcome measures

The primary outcome was change in m-AHEI overall score and individual m-AHEI components between baseline and 12 weeks assessed using a web-based validated FFQ (21; 22). The secondary outcomes were changes in anthropometric measurements such as body mass index (BMI) and levels of PA between baseline and 12 weeks which included obesity related measures (16). However, this analysis will focus only on baseline data.

5.3.3 EatWellUK study

5.3.3.1 Study design

The EatWellUK study was a three-month, web-based blinded RCT that compared the effectiveness of delivering web-based PN dietary advice to web-based generalized population-based dietary advice in the UK. The EatWellUK study received a favorable ethical opinion for conduct from the School of Chemistry, Food and Pharmacy Research Ethics Committee, University of Reading (Ref No. 13/17) and performed in

accordance with the Helsinki declaration. The trial was also documented at ClinicalTrials.gov (NCT03250858). Details of the study have been previously published by Franco et al (15).

5.3.3.2 Participants

In brief, non-diseased adults aged 18 years and over, living in the UK with access to the Internet were able to participate in the EatWellUK trial. Participants were recruited using the volunteer database at the Hugh Sinclair Unit of Human Nutrition (University of Reading), via social media (Facebook and twitter), online advertisements, University of Readings' mailing list, word of mouth and via a university press release. Similar to the EatWellQ8 study, interested parties were sent a link to the EatWellUK trial website (EatWellUK.org) where they were required to register and login. Following account formation, participants were asked to download and read the information sheet and to accept the terms in the consent form. Trial participation was voluntary and participants were informed that they could withdraw from the study whenever they preferred without any consequences. To improve retention, participants were informed that upon completion of the first FFQ they would enter a prize draw for a £50 amazon voucher which is dependent on the completion of the trial.

5.3.3.3 Exclusion criteria

The same exclusion criteria applied in the EatWellQ8 trial was used in the EatWellUK trial (refer to EatWellQ8 exclusion criteria).

5.3.3.4 Intervention design

EatWellUK participants were randomised to either a web-based PN group or to a control group. At baseline, all participants were required to register online and complete a screening questionnaire, provide weight and height, complete the Baecke PA questionnaire and a web-based FFQ. Full details of the study protocol can be found elsewhere (15).

5.3.3.5 EatWellUK FFQ

For the EatWellUK study, the food list and portion sizes were derived from the Food4Me FFQ (21). Similar to the EatWellQ8 FFQ, participants were given a choice of three portion sizes and 9 frequencies ("never/once a month" to "more than 6 times/day) for each food item.

5.3.3.6 Outcome measures

The primary outcome of the EatWellUK trial was changes in dietary intake from baseline to 12 weeks and secondary outcomes were based on changes in weight or BMI and PA levels between baseline and weeks 12 of the trial.

5.3.4 Randomisation

Both studies used an automated design formulated by the system using the random function for subject randomisation (28) that operated in the browser. The system formulated an arbitrary number between 0 and 1 for EatWellUK, and 0 and 2 for the EatWellQ8 study, and the participants were proportionally allocated to one of the three intervention groups in the case of the EatWellQ8 trial and one of two intervention groups in the EatWellUK trial.

5.3.5 Statistical analysis

For the current analysis, baseline data was used from the EatWellQ8 and EatWellUK trial. To compare between trials, all analysis was performed using SPSS (version 25.0, PASW, Chicago, IL, USA). Normality was assessed using a Shapiro-Wilk test and log transformation was used for non-parametric data when necessary. Characteristics of participants which included; BMI, age, gender, education levels and methods of recruitment or report were compared using independent sample t-tests and categorical data were compared using a chi-square test. Given the significant difference in gender and age between the two populations, an analysis of covariance using a generalised linear model (GLM) with covariates gender and age was used to assess differences between the overall m-AHEI scores and individual components (fruits, vegetables, dairy, wholegrains, nut and legumes, oily fish, healthy fats, red and processed meats, free sugars, salt). Comparisons in alcohol intake were not performed as alcohol intakes were only collected in the EatWellUK trial. A GLM was also used to assess differences

in macronutrient and micronutrient intakes between the trials. A one sample t-test was used to assess differences between current UK dietary recommendations and the trials (29; 30; 31). To minimize error related to over/under reporting, participants were excluded from analysis if they had daily energy intakes less than 500 Kcals and greater than 4500 Kcals which is considered improbable (21; 32). Significance was set at the 0.05 level.

5.4 Results

5.4.1 Baseline characteristics

Baseline characteristics of participants based on self-report can be found in Table 5.1. In total, the baseline data of 517 participants were included in this study out of which n=208 were from the EatWellQ8 and n=309 from the EatWellUK trials. In summary, 74% of participants were females, the mean age was 40.7 ± 13.8 years (range 18-85 years) and mean BMI was 25.1 ± 4.1) kg/m_2. 54% of participants fell within the healthy BMI criteria, 3% were underweight, 42.5% were overweight/obese and 1.5% were morbidly obese. The majority of participants were well educated with 68% reported having an undergraduate or postgraduate degree. The percentage of female participants was significantly higher in the EatWellUK trial (80%) compared to the percentage of females in the EatWellQ8 trial (64%) *P*<0.001. EatWellUK participants were significantly older (mean age 41.3 ± 14.9 years, range 18-84) compared to EatWellQ8 participants (mean age 38.6 ±10.4 years, range 21-63) P<0.001. Significant differences were found in the level of education distribution with significantly more participants reported to have undergraduate or postgraduate degrees in the EatWellUK trial (73.7%) compared to (57.1%) in the EatWellQ8 trial. Whilst word-of-mouth was the main method of recruitment in the EatWellQ8 trial, email recruitment was most effective in EatWellUK trial.

Table 5. 1 Baseline characteristics of participants in the EatWellQ8 trial (n=208) in comparison with participants from the EatWellUK trial (n=309)

	Total	Country		
		Kuwait	UK	[a]P Value
Sex, female n (%)	382 (74.0)	133 (64.0)	249 (80.5)	<0.0001
Age categories n (%)				
18-24	51 (10.0)	17 (8.1)	34 (11)	<0.0001
24-39	219 (42.0)	103 (49.5)	116 (37.5)	
40-54	148 (29.0)	64 (30.7)	84 (27.8)	
55-64	66 (13.0)	23 (11.1)	43 (13.9)	
65+	33 (6.0)	1 (0.5)	32 (10.4)	
Baecke PAL n (SD)	7.98 (1.34)	8.2 (1.0)	7.8 (1.5)	0.06
Baecke PAL categories mean (%)				
Leisure	2.8 (35.0)	2.8 (34.0)	2.9 (37.0)	
Sports	2.5 (31.0)	2.5 (30.0)	2.5 (32.0)	
Work	2.5 (31.0)	2.9 (35.0)	2.3 (29.0)	
BMI n(SD)	25.1 (4.7)	25.1 (4.2)	25 (4.0)	0.81
BMI n (SD) females	24.9 (5.0)	24.8 (4.6)	24.8 (5.2)	
BMI n (SD) males	25.6 (3.5)	25.6 (3.2)	25.6 (3.8)	
BMI categories n (%)				
Underweight	15 (3.0)	6 (2.8)	9 (2.9)	0.51
Healthy	280 (54.0)	110 (52.8)	170 (55.0)	
Overweight	165 (32.0)	69 (33.2)	96 (31.1)	
Obese	49 (10.0)	22 (10.5)	27 (8.7)	
Morbidly obese	8 (1.5)	1 (0.5)	7 (2.3)	
Educational level n (%)				
Less than secondary	9 (2.0)	8 (3.8)	1 (0.3)	<0.0001
Secondary school	71 (14.0)	30 (14.4)	41 (13.3)	
Vocational training	90 (17.0)	51 (24.5)	39 (12.6)	
Undergraduate	173 (34.0)	66 (31.7)	107 (34.6)	
Postgraduate	174 (34.0)	53 (25.4)	121 (39.1)	
Reported n (%)				
Email	151 (29.0)	28 (13.5)	123 (40.0)	<0.0001
Facebook	66 (13.0)	20 (9.6)	46 (15.0)	
Instagram	12 (2.0)	12 (5.7)	0 (0)	
Twitter	49 (10.0)	14 (6.7)	35 (11.6)	
Word of mouth	165 (32.0)	116 (56.0)	49 (16)	
Other	73 (14.0)	18 (8.6)	55 (17.8)	

Data are presented as mean (standard deviation) or as total n (%) for categorical data
[a]P values derived from a chi-squared test
BMI=Body Mass Index, PAL= Physical Activity Level, SD= Standard Deviation

5.4.2 Comparison of nutrients intakes between EatWellQ8 and EatWellUK participants

The macronutrient and micronutrient intakes of participants are shown in Table 5.2. Estimated energy intakes were 21% higher in EatWellQ8 compared to EatWellUK (P<0.001). Results of % total energy (TE) intakes from macronutrients suggest variations between the trials in the main sources of energy. Compared to EatWellUK, %TE from carbohydrates (53.3 ± 6.9) vs (44.2 ± 8.3) and total sugars (24.2 ± 7.6) vs (22.7 ± 7.4) were found to be significantly higher in the EatWellQ8 trial (*P*<0.01). Overall consumption of fat was found to be significantly higher in EatWellUK compared to EatWellQ8 which was reflected in the results of mean daily %TE from total fat (37.2 ± 6.6) vs (33.5 ± 6.0), saturated fatty acids (SFA, %TE) (14.6 ± 3.4) vs (13.3 ± 3.1) and monounsaturated fatty acids (MUFA, %TE) (13.9 ± 3.1) vs (12.4 ± 3.1) (*P*<0.01). Daily intakes of %TE from protein (17.0 ± 3.3) vs (16.2 ± 3.31) were also found to be significantly higher in the EatWellUK trial (P<0.01). Assessments of micronutrient intakes indicated differences between the trials. Mean daily values for omega 3 fatty acids (g/day), total folate (µg/day), total carotene (µg/day), riboflavin (mg/day), vitamin B12 (µg/day) and vitamin D were found to be significantly higher in the EatWellUK compared to EatWellQ8 (*P*<0.05). Significantly higher daily intakes of fibre (g/day), iron (mg/day), vitamin C (mg/day) and sodium (mg/day) were found in the EatWellQ8 trial (*P*<0.01). There was no difference between countries for polyunsaturated fatty acids (PUFA), calcium, thiamine, vitamin B6 and vitamin E.

Compared to current UK dietary recommendations, significant differences were found for nearly all the nutrients from both trials. Estimated energy intakes from the EatWellQ8 trial (2589 ± 1166 Kcal) were found to be significantly higher than UK dietary recommendations (2399 Kcal) *P*<0.020. In addition, significantly lower mean energy intakes were found in the EatWellUK trial (2097 ± 902 Kcal) compared to UK recommendations *P*<0.001. Compared to UK dietary recommendations, significantly higher % daily intakes from SFA, MUFA, PUFA, protein and total sugar were found in both trials *P*<0.001. In addition, %TE from carbohydrates was significantly lower than UK recommendations (≤ 50 %TE) in the EatWellUK (44.2 ± 8.3) and significantly higher than recommendations in the EatWellQ8 trial (53.3 ± 6.9) *P*<0.001. Compared to current UK recommendation of <35% TE from total fat, intakes from the EatWellUK trial were found to be significantly higher (37.2 ± 6.6) %TE *P*<0.001. However, total fat %TE intakes were found to be significantly lower in the EatWellQ8 (33.5 ± 6.0) trial compared to UK dietary recommendations *P*<0.001. Assessments of micronutrients

indicated variations between the trials and current UK dietary recommendations. Significantly higher intakes of micronutrients were found in the trials compared to UK dietary recommendations for; calcium (mg), folate (µg), iron (mg), Riboflavin (mg), Thiamin (mg), vitamin B6 (mg), vitamin B12 (µg), vitamin C (mg), vitamin E (mg) and sodium (mg) $P<0.001$. Compared to UK recommendations of total carotene (5000 µg), intakes were found to be significantly higher (6307 ± 6026 µg) in the EatWellUK trial $P<0.001$. Intakes of fibre (26.7 ± 12.4 g) vs (30 g), omega 3 FA (0.37 ± 0.53 g) vs (0.45 g) and vitamin D (5.1 ± 3.5 µg) vs (10 µg) in the EatWellUK trial were significantly lower than recommendations $P<0.05$. Significantly lower intakes were found in the EatWellQ8 trial for omega 3 FA (0.16 ± 0.17g) vs (0.45 g) and vitamin D (3.5 ± 2.3 µg) vs (10 µg) compared to UK recommendations $P<0.001$. Non-significant differences were found for EatWellQ8 fibre (g) and total carotene (µg) intakes compared to UK recommendations.

Table 5. 2 Mean daily energy and nutrient intakes for participants in the EatWellQ8 (n=208) and the EatWellUK (n=309) trials

Nutrient	Kuwait mean (SD) n=208	UK mean (SD) n=309	P value[a]	DRV/RNI	P value EatWellQ8[b]	P value EatWellUK[b]
Energy (Kcal)	2589 (1166)	2097 (902)	0.001	2399[c]	0.020	<0.001
Fat (%TE)	33.5 (6.0)	37.2 (6.6)	0.001	≤ 35	<0.001	<0.001
SFA (%TE)	13.3 (3.1)	14.6 (3.4)	0.001	≤ 11	<0.001	<0.001
MUFA (%TE)	12.4 (3.1)	13.9 (3.1)	0.001	12	<0.001	<0.001
PUFA (%TE)	6.3 (1.7)	6.2 (1.5)	0.63	6	<0.001	<0.001
Omega 3 FA (g)	0.16 (0.17)	0.37 (0.53)	0.001	0.45	<0.001	<0.02
Protein (%TE)	16.2 (3.31)	17.0 (3.3)	0.01	15	<0.001	<0.001
Carbohydrate (%TE)	53.3 (6.9)	44.2 (8.3)	0.001	≤ 50	<0.001	<0.001
Fibre (g)	29.2 (16.8)	26.7 (12.4)	0.01	30	0.520	<0.001
Total Sugars (% TE)	24.2 (7.6)	22.7 (7.4)	0.01	≤ 5	<0.001	<0.001
Calcium (mg)	1308 (685)	1311 (763)	0.97	700	<0.001	<0.001
Total folate (µg)	370 (190)	419 (214)	0.02	200	<0.001	<0.001
Iron (mg)	15.2 (7.3)	13.2 (5.5)	0.001	11.8[c]	<0.001	<0.001
Total carotene (µg)	5305 (5183)	6307 (6026)	0.02	5000	0.397	<0.001
Riboflavin (mg)	2.2 (1.1)	2.6 (1.6)	0.01	1.2[c]	<0.001	<0.001
Thiamin (mg)	1.9 (0.9)	3.0 (9.4)	0.09	0.9[c]	<0.001	<0.001
Vitamin B6 (mg)	2.4 (1.2)	2.6 (1.2)	0.14	1.2	<0.001	<0.001
Vitamin B12 (µg)	5.7 (3.4)	7.2 (4.3)	0.001	1.5	<0.001	<0.001
Vitamin C (mg)	238 (182)	163 (96.7)	0.001	40	<0.001	<0.001
Retinol (µg)	374 (225)	635 (619)	0.001	600	<0.001	0.43
Vitamin D (µg)	3.5 (2.3)	5.1 (3.5)	0.001	10	<0.001	<0.001
Vitamin E (mg)	13.6 (7.0)	12.7 (6.2)	0.20	4	<0.001	<0.001
Na (mg)	3046 (1969)	2623 (1216)	0.01	1600	<0.001	<0.001

[a] Value derived from a general linear model (GLM) with age and gender as covariates
[b] Value derived from a one-sample T-test
[c] Mean value derived from the average DRV/RNI UK daily requirements for females and males (29;30;31)
%TE= Percentage Total Energy, FA= Fatty Acids, SFA= Saturated Fatty Acids, MUFA= Monounsaturated Fatty Acids, PUFA= Polyunsaturated Fatty Acids, Na= Sodium.

5.4.3 Comparison between the baseline m-AHEI score and m-AHEI components from the EatWellQ8 and EatWellUK trials

The overall m-AHEI score and individual m-AHEI scores for the EatWellQ8 and EatWellUK studies are shown in Figure 5.1. The overall m-AHEI score for the EatWellUK group (mean 56.1 ±12.2%) was found to be significantly higher than m-AHEI score for the EatWellQ8 group (mean 50.5 ± 13.0%) (P<0.01). Lowest m-AHEI scores were found for the component red and processed meats in both the EatWellQ8 (mean 12.6 ± 24.1%) and EatWellUK (mean 26.6 ± 35.8%) and highest m-AHEI was found for the component fruits (mean 80.2 ± 30.2%) in the EatWellQ8 trial and for dairy (mean 89.6 ± 25.3%) in the EatWellUK trial. Overall, compared to EatWellQ8, the m-AHEI scores for the EatWellUK were significantly higher for nearly all the components (P<0.05) with the exception of fruits, nuts and legumes and wholegrains which were found to be significantly higher in the EatWellQ8 study (P<0.001). Comparable intakes were found for healthy fat intake (PUFA) in both studies with a mean intake of 53.3 ±19.3 % for the EatWellQ8 trial and 53.1 ±18.7% for the EatWellUK trial. In addition, non-significant differences were found between the trials for intakes of salt (EatWellQ8; 52.3 ±12.7 %) vs (EatWellUK; 58.5 ± 13.3%).

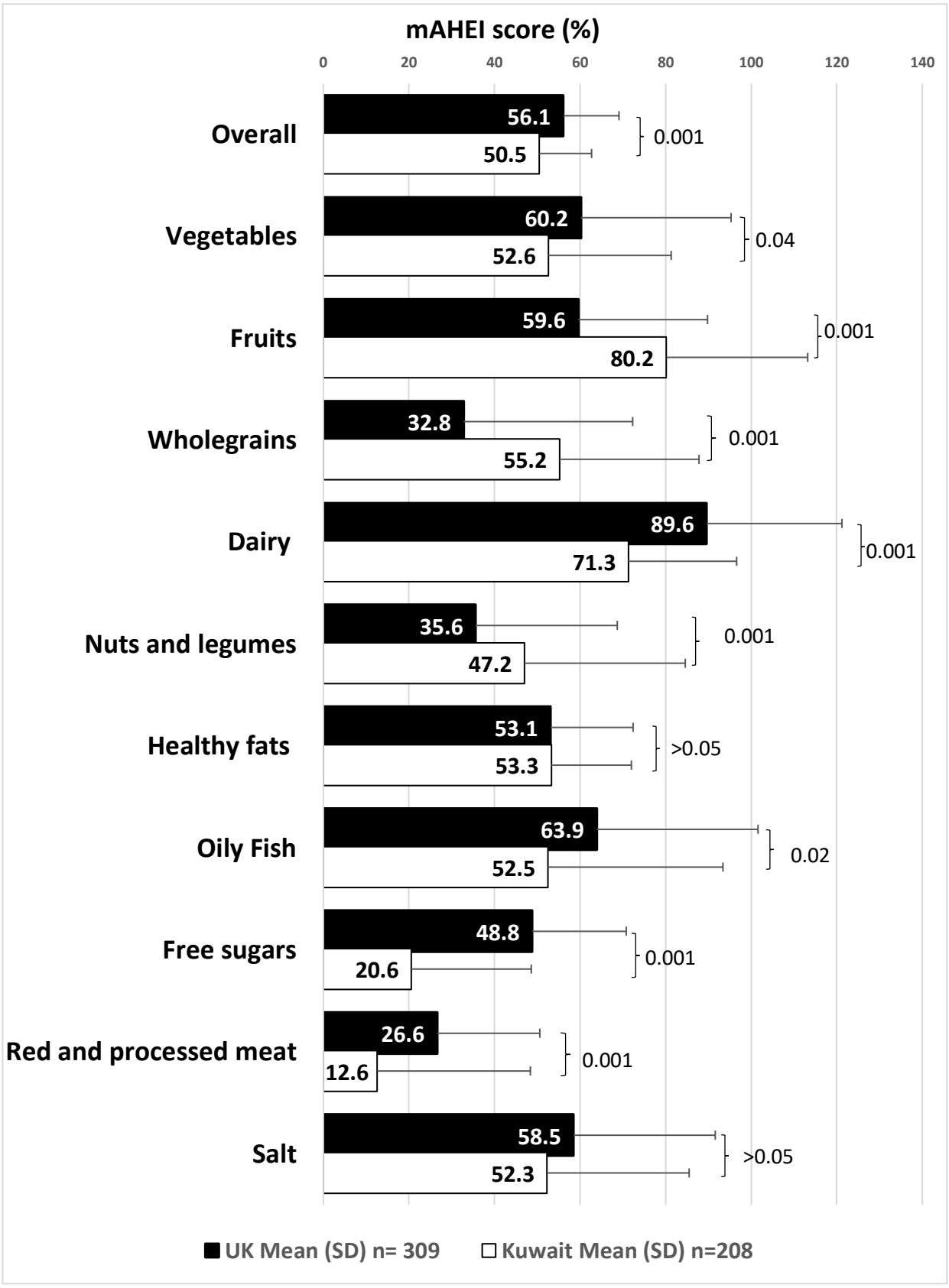

Figure 5. 1 Comparison between the baseline m-AHEI score and m-AHEI components from the EatWellQ8 and EatWellUK trials.

Overall m-AHEI and individual m-AHEI scores are presented as a percentage. Higher scores are considered healthier dietary intakes. Values derived from a general linear model (GLM) with age and gender as covariates.

5.4.4 Comparison between the top dietary messages received in Kuwait compared to the UK based on the m-AHEI scores

The frequency of the three PN messages received by the PN group in the EatWellUK and EatWellQ8 studies are shown in Figure 5.2. Intakes of red and processed meats were comparably high in both trials as more than 26% (117 messages) of tailored dietary messages in the EatWellQ8 trial and approximately 22% (99 messages) of targeted PN messages in the EatWellUK trial were in regards to reducing intakes of red and processed meats. 24% (108 messages) of PN messages in the EatWellQ8 trial were directed towards reducing intakes of free sugars, and 40% of PN messages were directed towards the improvement of intakes of nuts and legumes, oily fish (omega 3 FA), salt and wholegrains. Approximately 10% of PN messages in the EatWellQ8 trial were directed towards the improvement of intakes of fruits, vegetables, dairy and healthy fats (PUFA). Intakes of nuts and legumes and wholegrains were relatively low in the EatWellUK trial as more than 42% of PN messages were directed towards their improvement and 22% of PN messages were to reduce intakes of free sugars and salt and increase intakes of F&V. The remaining 14% of tailored dietary messages in the EatWellUK trial were towards the improvement of oily fish, dairy, healthy fats (PUFA) and alcohol reduction.

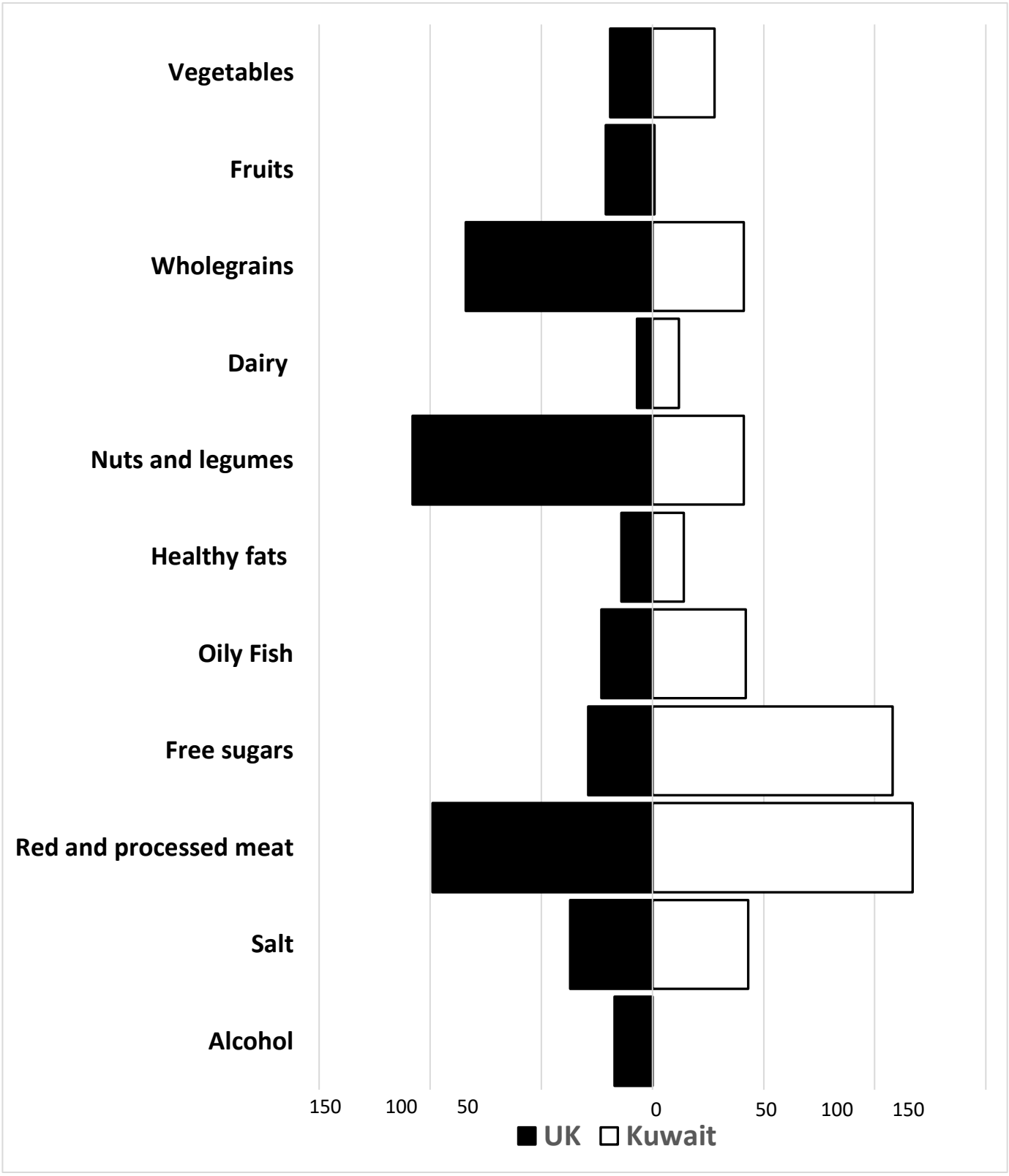

Figure 5. 2 Frequency of the dietary messages received in the EatWellQ8 compared to the EatWellUK studies based on the m-AHEI component scores.

Values represent the total number/frequency of messages received according to each m-AHEI component.
Alcohol was excluded from the EatWellQ8 trial

5.5 Discussion

The current comparative study has examined baseline characteristics, dietary intake and PN messages given to participants in the EatWellQ8 and EatWellUK studies that both utilised the novel web-based eNutri app to assess dietary intakes and deliver tailored nutrition messages. Overall, our results have suggested generally healthier habitual dietary intakes for participants in the EatWellUK trial compared to the EatWellQ8 trial. This was reflected by the overall higher m-AHEI scores, macro/micronutrient intakes, except for higher total fat and SFA, and lower fibre and iron intakes, and the differences between tailored dietary messages received in the EatWellUK compared to the EatWellQ8 trial. Compared to current UK dietary recommendations, significant differences were found for nearly all intakes of macro/micronutrients in both trials. Findings from the present study suggest that diet priorities differ between countries and also at an individual level supporting previous work that has shown that web-based PN is superior to standardised "one-size fits all" recommendations (8).

The observed differences between the EatWellUK and EatWellQ8 trials might be partially due to reporting bias and due to the lack of an instructional page or tutorial as a guide for participants, which may have resulted in an incomplete food recording. Percentage daily %TE from macronutrient intakes differed significantly between the UK and Kuwaiti populations, which may reflect cultural divergences in which foods are commonly consumed and are considered staple foods between the countries. Daily %TE from carbohydrates were found to be significantly higher in EatWellQ8 participants compared to EatWellUK, this reflected data from NNSSK, which was of a similar magnitude (54%TE) for a representative Kuwaiti population (20). Evidence of unhealthy dietary regimens were observed in the EatWellQ8 trial, given that intakes of carbohydrates, sugar and SFA were all significantly higher than recommendations which have been linked with the development of obesity, CVD and type 2 DM (3). Overconsumption of carbohydrates was also found in previous research amongst Kuwaiti nationals supporting findings from the current trial (33). This was also reflected by the significantly higher total sugar intakes and lower m-AHEI score for free sugars in the EatWellQ8 trial compared to the EatWellUK, although intakes of sugar were far above recommendations of ≤5 g/day in both trials (19; 20). Total fat intakes and SFA intakes were significantly higher in the EatWellUK trial, which is found to be in line with recent findings from NDNS that has suggested that current UK mean intakes exceeded

recommendations for SFA and total fat which have been linked with the development of CVD, obesity and certain cancers (3; 19).

Findings from the current study demonstrate that intakes of most vitamins and minerals, except iron and vitamin C, were higher in EatWellUK compared to EatWellQ8 study, despite higher energy intake in EatWellQ8, which may reflect consumption of more nutrient dense foods by UK participants. Our findings support data from the NNSSK which has shown that vitamin and mineral deficiencies were common in Kuwait for several micronutrients including calcium, vitamin D and folate, although there was a noticeable overconsumption in macronutrient intakes (20). Vitamin D intakes were also significantly lower than recommendations in the EatWellUK trial which reflect NDNS data of low vitamin D (plasma 25-hydroxy vitamin D levels) in all UK age groups (34). Such findings may suggest poor dietary practises in both trials due to the suggested evidence between vitamin D deficiencies and the increased risk of osteoporosis, CVD and diabetes (35). Furthermore, significantly higher sodium intakes were found in the EatWellQ8 trial in comparison to EatWellUK which was reflected by lower m-AHEI scores for salt intakes in the EatWellQ8 and higher sodium intakes compared to the EatWellUK trial. This supports findings from NNSSK data and previous research which have also shown that estimated salt intakes of approximately 12g/day in the Gulf region, which is more than double the WHO advice (20; 33; 36). However, it is important to note that salt intakes from both EatWellQ8 and EatWellUK studies exceeded recommendations from both countries which has been found to be a primary contributor to CVD morbidity (19; 20; 37). Omega 3 FA intakes were significantly lower than recommendations of 0.45 g/day in both trials, which may further reflect less than optimal diet regimens due to the suggested evidence between omega 3 FA intakes and cardiac health (3; 18).

Outcomes from the present study implied that EatWellUK participants were following a generally healthier dietary lifestyle compared to EatWellQ8 participants, which was also demonstrated by the higher overall m-AHEI scores and individual m-AHEI scores. In general, EatWellUK participants achieved higher m-AHEI scores from dairy, vegetables, oily fish and consumed less free sugars, red and processed meats and salt compared to the EatWellQ8 participants. Interestingly, according to NDNS data, over the past decade, evidence of increased intakes of vegetables, oily fish and decreased consumptions of sugar-sweetened beverages was found amongst the UK population, although quantitatively the changes are relatively small (19). Furthermore,

lower than recommended intakes of fibre were apparent in the EatWellUK study which were reflected in the lower intakes of fruits, wholegrains and nuts and legumes. In turn, these findings may also suggest unhealthy dietary regimens from the EatWellUK trial as low fibre intakes have been linked with the development of colorectal cancer, CVD, type 2 DM and obesity (38).

Results of the top three tailored messages that were based on the m-AHEI that received the lowest scores signified several differences between the EatWellQ8 and EatWellUK populations. An interesting finding was that red and processed meats intake was one of the main dietary concerns in both the populations, as more than 20% of participants in both studies received tailored dietary messages regarding this issue and is reflected in the higher salt and sodium intake. Red and processed meat intakes were also a dietary concern in data from NNSSK and NDNS and efforts to lower red and processed meats to an average intake of 70 g/day have been recommended by the Scientific Advisory Committee on Nutrition (SACN), UK in 2011 (19; 20; 29). Furthermore, more than 42% of PN messages in the EatWellUK trial were targeted towards increasing the consumption of wholegrains and nuts and legumes in line with NDNS data and is reflected in the lower fibre intake (19). Unlike EatWellUK participants, approximately 24% of PN messages addressed to EatWellQ8 participants were in regards to high free sugar intakes and 20% were directed towards high intakes of salt and low intakes of omega 3 FA. Similarly, findings from previous research in Kuwait and NNSSK data have also indicated that overconsumption of sugar and low intakes of omega 3 FA are dietary concerns that need to be addressed (20; 33).

There are several factors that may have contributed to the poor dietary choices made by the EatWellQ8 participants which include the mass availability of low-cost high caloric foods and subsidized food policies available to all Kuwaiti individuals (33). According to recent data that compared the prevalence of diabetes and comorbidities in four Gulf countries, Kuwait had the highest prevalence of type 2 DM (40.3%) in adults and it was suggested that unhealthy dietary lifestyles are one of the main contributors to its development (39). Such findings support further the results from our trial of low m-AHEI scores in the EatWellQ8 trial for free sugars, intakes of salt and red and processed meats.

5.5.1 Strengths and limitations

An important strength of the current trial is that it compared the baseline data of two independent trials that have utilised the same novel web-based PN app (eNutri) and followed the same study approach amongst participants from different countries and cultural backgrounds. An additional strength is that both the EatWellQ8 and EatWellUK trials used validated FFQs (21; 22) with photographs of portion sizes to be used in the trials. However, there are some limitations that need to be addressed. Firstly, to facilitate and increase recruitment to the trials, interested individuals were able to register online which may in turn have influenced the participant sample by recruiting generally healthy individuals with nutritional interests leading to recruiting samples that are not totally representative of the general population. The fact that more than 70% of participants were women also supports the aforementioned point that the study sample may not be generalisable to the target population. Furthermore, both trials depended on self-report which increased the chances of reporting or selection bias, especially of food items that are perceived as healthy, although this is an issue with all studies which use dietary assessment methods for assessing food and nutrient intakes. More specifically, use of a FFQ relies on retrospectively recording of dietary intake and may be limited by issues with recall. However full validation of the eNutri FFQs was performed, which indicated good comparability with the gold standard prospective diet diary assessment technique (21; 22). All measurements of anthropometric data were self-reported which may have introduced some errors.

Baseline characteristics from our study population have indicated that the majority of participants (74%) were well-educated women between the ages of 24-39 years which may suggest volunteer bias and non-homogeneity in the overall study sample. These findings are in line with participant characteristics from previous web-based nutrition trials which have also demonstrated a predominance of highly educated female volunteers (40; 41). Previous literature has also demonstrated that the higher the socioeconomic status of women, they were more likely to have improved dietary intakes and were more willing to partake in research compared to men which may be linked with differences in life interests (19; 42). Furthermore, more than 70% of participants were between the ages of 24 to 54 years of age and may be linked to the web-based design of the trials which may have led to lower participation by older participants. Approximately 43 % of overall participants reported BMI levels >25 kg/m_2 and merely 32% of participants reported to be involved in regular sport activity which

decreases the prejudice of skewness towards participation of healthy individuals that follow active lifestyles in web-based nutrition trials, supporting findings from previous research (43). Self-reported recruitment methods differed significantly between the trials as word of mouth was found to be the main method in the EatWellQ8 trial and email in the EatWellUK trial which may be linked with differences in cultural preferences between the countries. In the future, longer-term web-based trials with a larger and more heterogeneous sample that incorporate web-based PN systems would be beneficial to further assess comparisons between dietary intakes and to further understand the effectiveness of delivering online PN advice to individuals.

5.6 Conclusions

In conclusion, results of the current trial reflect overall healthier dietary intakes in a UK sample compared with a sample from Kuwait, except for dietary SFA, fibre and iron. Macro/micronutrient intakes from both trials met or significantly exceeded the current UK dietary recommendations, except for omega 3 FA, vitamin D and fibre, emphasising the need for more effective dietary change approaches. Dietary intakes from the EatWellUK and EatWellQ8 studies differed both at an individual and at a geographical level, which highlights an increased necessity for effective tailored dietary advice.

5.7 Acknowledgements

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5.8 References

1. World Health Organization (2018) Noncommunicable diseases country profiles 2018

. Geneva: World Health Organization Licence: CC BY-NC-SA 3.0 IGO, 223.

2. World Cancer Research Fund / American Institute for Cancer Research Food, nutrition, physical activity, and the prevention of cancer: a global perspective, World Cancer Research Fund. Washington DC: AICR, 2007

3. Marmot M (2018) Diet, cancer, and NCD prevention. Lancet Oncol 19, 863-864.

4. Dyson PA TD, Breen C, Duncan A, Elvin E, Goff L, Hill A, Kalsi P, Marsland N, McArdle P, Mellor D (2018) Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. Diabetic Med 35(5), 541-547.

5. Estruch R, Ros E, Salas-Salvadó J et al. (2018) Primary prevention of cardiovascular disease with a mediterranean diet supplemented with extra-virgin olive oil or nuts. N Engl J Med 378(25), e34.

6. World Health Organization (2017) Noncommunicable diseases: progress monitor 2017.

7. Hyseni L, Atkinson M, Bromley H et al. (2017) The effects of policy actions to improve population dietary patterns and prevent diet-related non-communicable diseases: scoping review. Eur J Clin Nutr 71, 694.

8. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2016) Effect of personalized nutrition on health-related behaviour change: evidence from the Food4me European randomized controlled trial. Int J Epidemiol 46, 578-588.

9. Ordovas JM, Ferguson LR, Tai ES et al. (2018) Personalised nutrition and health. BMJ 361, k2173.

10. Miniwatts Marketing Group (2018) World Internet Users Statistics and 2018 World Population Stats. http://www.internetworldstats.com/stats.htm (accessed November 11 2017

11. Brug J, Steenhuis I, van Assema P et al. (1996) The Impact of a Computer-Tailored Nutrition Intervention. Prev Med 25, 236-242.

12. Forster H, Walsh MC, Gibney MJ et al. (2016) Personalised nutrition: the role of new dietary assessment methods. Proc Nutr Soc 75, 96-105.

13. Franco RZ, Fallaize R, Lovegrove JA et al. (2016) Popular nutrition-related mobile apps: a feature assessment. JMIR mHealth uHealth 4(3), e85.

14. Franco RZ, Fallaize R, Lovegrove JA et al. (2018) Online dietary intake assessment using a graphical food frequency app (eNutri): Usability metrics from the EatWellUK study. PlosOne, 13, e0202006.

15. Franco R, Fallaize, R, Lovegrove, J, Hwang, F, (2018) Effectiveness of Online Personalised Nutrition Advice for Adults: Evidence from the EatWellUK Web-based Randomised Control Trial. in preparation.

16. Alawadhi B, Fallaize, Rosalind, Franco, Rodrigo, Hwang, Faustina, Lovegrove, Julie (2018) The effectiveness of web and face-to-face personalised nutrition advice compared with population-based nutrition advice in Kuwait – The EatWellQ8 RCT in preparation.

17. World Health Organization (2018) Preparing for the third meeting of the UN high-level meeting on NCDs and strengthening the role and contribution of the private sector: roundtable of selected CEOs and high-level executives of multinationals and independent global experts on NCDs: discussion paper:No. WHO/NMH/ADGO/18.97. World Health Organization.

18. Diem G, Brownson RC, Grabauskas V et al. (2016) Prevention and control of noncommunicable diseases through evidence-based public health: implementing the NCD 2020 action plan. Glob Health Promo 23, 5-13.

19. Bates B, Collins, D, Cox, L, Nicholson, S, Page, P, Roberts, C, Steer, T, Swan, G (2019) National Diet and Nutrition Survey: Years 1 to 9 of the Rolling Programme (2008/2009 – 2016/2017): Time trend

and income analyses. Public Health England: London, UK.

20. Al-Hooti S, Zaghloul S, Alomirah H et al. (2010) National nutrition program for the State of Kuwait: phase I-national nutrition survey of the State of Kuwait. Final Report, KISR 10246.

21. Fallaize R, Forster H, Macready AL et al. (2014) Online dietary intake estimation: Reproducibility and validity of the Food4Me food frequency questionnaire against a 4-day weighed food record. JMIR 16, e190.

22. Alawadhi B, Fallaize, R, Franco, R, Hwang, F, Lovegrove, J, (2018) Reproducibility and validity of the EatWellQ8 web-based food frequency questionnaire against a

paper-based food frequency questionnaire and a 4-day weighed food record in preparation.

23. Chiuve SE, Fung TT, Rimm EB et al. (2012) Alternative Dietary Indices Both Strongly Predict Risk of Chronic Disease. J Nutr 142, 1009-1018.

24. Fallaize R, Livingstone K, Celis-Morales C et al. (2018) Association between diet-quality scores, adiposity, total cholesterol and markers of nutritional status in European adults: findings from the Food4Me study. Nutrients, 10, 49.

25. Fallaize R, Franco RZ, Hwang F et al. (2019) Evaluation of the eNutri automated personalised nutrition advice by users and nutrition professionals in the UK. PloSOne 14, e0214931.

26. Bohlscheid-Thomas S, Hoting I, Boeing H et al. (1997) Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the German part of the EPIC project. European Prospective Investigation into Cancer and Nutrition. Int J Epidemiol 26, S59.

27. Dehghan M, Al-Hamad N, McMillan CR et al. (2009) Comparison of a semi-quantitative food frequency questionnaire with 24-hour dietary recalls to assess dietary intake of adult Kuwaitis. SMJ 30, 159-161.

28.MozDevNet(2017)Math.https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Math (accessed 12-10-2017)

29. Scientific Advisory Committee on N (2012) Dietary reference values for energy: The Stationery Office.

30. Carbohydrates S (2015) Health Report (2015) Scientific Advisory Committee on Nutrition.

31. Scientific Advisory Committee on N (2016) SACN vitamin D and health report.

32. Hébert JR, Peterson KE, Hurley TG et al. (2001) The effect of social desirability trait on self-reported dietary measures among multi-ethnic female health center employees. Ann Epidemiol 11, 417-427.

33. Zaghloul S, Al-Hooti SN, Al-Hamad N et al. (2013) Evidence for nutrition transition in Kuwait: over-consumption of macronutrients and obesity. Public Health Nutr 16, 596-607.

34. Roberts C, Steer T, Maplethorpe N et al. (2018) National Diet and nutrition survey results from years 7–8 [combined) of the rolling Programme [2014/2015–2015/2016). London: Public Health England.

35. Pereira-Santos M, Costa PRdF, Assis AMO et al. (2015) Obesity and vitamin D deficiency: a systematic review and meta-analysis. Obes Rev 16, 341-349.

36. Alhamad N, Almalt E, Alamir N et al. (2015) An overview of salt intake reduction efforts in the Gulf Cooperation Council countries. Cardiovasc Diagn Ther 5, 172.

37. Jackson A (2003) Scientific Advisory Committee on Nutrition Salt and Health. The Stationery Office, London, UK.

38. Gibson R, Eriksen R, Chambers E et al. (2019) Intakes and Food Sources of Dietary Fibre and Their Associations with Measures of Body Composition and Inflammation in UK Adults: Cross-Sectional Analysis of the Airwave Health Monitoring Study. Nutrients 11, 1839.

39. Morgan SA, Ali MM, Channon AA et al. (2019) Prevalence and correlates of diabetes and its comorbidities in four Gulf Cooperation Council countries: evidence from the World Health Survey Plus. J Epidemiol Community Health 73(7), 630-636.

40. Andreeva VA, Salanave B, Castetbon K et al. (2015) Comparison of the sociodemographic characteristics of the large NutriNet-Santé e-cohort with French Census data: the issue of volunteer bias revisited. J Epidemiol Community Health 69, 893-898.

41. Pizzi C, De Stavola BL, Pearce N et al. (2012) Selection bias and patterns of confounding in cohort studies: the case of the NINFEA web-based birth cohort. J Epidemiol Community Health 66, 976-981.

42. Galea S, Tracy M (2007) Participation rates in epidemiologic studies. Ann Epidemiol 17, 643-653.

43. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2015) Design and baseline characteristics of the Food4Me study: a web-based randomised controlled trial of personalised nutrition in seven European countries. Genes Nutr 10, 1-13.

CHAPTER 6 Discussion and conclusions

6.1 Introduction

Adherence to lifestyles that include healthy dietary intakes have been shown to be effective at reducing the development and progression of non-communicable diseases (NCDs) (1; 2). The utilisation of an effective method to deliver the advice to the individual is important to achieve improved dietary intakes. Currently, the two main methods used to deliver dietary advice use face-to-face consultations or web-based approaches (3). Based on previous findings, personalisation of dietary advice delivered either face-to-face or via the web have been shown to be more effective than standardised "one size fits all" advice (4; 5). However, previous trials have focused on assessing the effectiveness of personalised dietary interventions to controls that received general information and not at comparing the effectiveness of the methods used to deliver the tailored advice. There is a need to tackle unhealthy dietary intakes and lifestyles in Kuwait as current estimates have suggested that more than 70% of Kuwaiti adults are either obese or overweight (6). In order to better understand the effectiveness of delivering dietary advice, it was important that an extensive search of literature related to the effectiveness of delivering dietary and weight-loss information using face-to-face and web-based methods was undertaken, which was undergone and reported in Chapter 2. Evidence suggests that the majority of face-to-face nutrition interventions resulted in dietary and weight-loss improvements compared to controls that received minimal or no intervention, especially when the intervention was tailored (4). Results have also suggested that web-based tailored advice may be more successful at inducing short-term weight-loss and dietary change compared to standardised advice (7). Inconsistent results were found in trials that assessed the effectiveness of web-based dietary advice compared to non-web-based nutrition interventions (7). Minimal focus has been given to compare the effectiveness of both delivery methods or utilise a combined delivery approach and results of previous trials were inconsistent (8; 9; 10; 11). Thus, the present thesis aimed to (i) examine the efficacy of web-based and face-to-face dietary interventions on dietary changes in adults; (ii) test the validation and reproducibility of a dietary web-based assessment tool (the EatWellQ8 FFQ) in Kuwait; (iii) examine the feasibility of delivering web-based personalised nutrition (PN) advice to face-to-face dietary advice in Kuwait (the EatWellQ8 trial) (iv) assess the dietary intake of adults in Kuwait compared to the UK using baseline data from the EatWellQ8

and the EatWellUK studies and compare the dietary outcomes to current UK dietary recommendations.

6.2 Summary of findings

A substantial worldwide increase in utilising technology has taken place over the past few years (12). In the past decade, the majority of web-based interventions were only accessed using a computer which has led to the development of the term eHealth, described as the employment of Internet and associated means to consign health advice (13; 14). The ability of eHealth to deliver health related advice at diminished costs and its increased accessibility compared to traditional methods, were a few of its advantages, however, a notable problem with eHealth interventions included high attrition rates (15). Mobile health or mHealth, refers to the delivery of health advice via smart phones or tablets, which allows increased accessibility and has therefore been suggested to be more efficient at minimising intervention drop-out rates compared to eHealth (14). Furthermore, a general preference towards eHealth and mHealth dietary collection tools has been suggested when compared with paper-form and traditional interviews (16; 17; 18; 19). For the purpose of the current thesis, a novel mobile responsive eHealth app (eNutri) was developed that was able to provide personalised dietary advice and assess dietary intakes of individuals (20; 21). To assess dietary intake, the eNutri app incorporated the novel EatWellQ8 online food frequency questionnaire (FFQ) and chapter 3 of the thesis demonstrated the validation and reproducibility of the FFQ. In addition, the effectiveness of the eNutri app at delivering tailored nutrition advice was tested in chapter 4 of the thesis.

It has been estimated that 90% of UK adults use the Internet and on average spend nearly 9 hours of their day engaged in social media use and telecommunications (22; 23). Similarly, recent findings have also shown that more than 98% of the population in Kuwait utilise the Internet (24). Such findings are of significance to health providers as NCDs are the cause of greater than 70% of annual deaths worldwide (25). Actions to alleviate risk factors associated with the development of NCDs in Kuwait are a key necessity as obesity rates in Kuwait are on the rise despite government policy for reduction, and it has been estimated that nearly 63% of adults are inactive and more than 75% of the adults are either overweight or obese (26; 27). Interest in utilising the Internet to provide tailored dietary advice has risen with advances in technology and increased consumer preferences towards personalised health advice (28; 29; 30; 31). It has

been hypothesised in the current thesis that the delivery of web-based PN will result in comparable improvements in dietary change and weight loss as face-to-face PN recommendations in comparison to generalised nutrition advice delivered online in adults living in Kuwait. In order to demonstrate that, a novel web-based culturally sensitive FFQ that reflected the diet of the Kuwaiti population was developed and its reproducibility and validation were tested against a 4-day weighed food record (WFR) and a semi-quantitative validated paper-form FFQ (PFFQ) for Kuwait (chapter 3). To our knowledge, the EatWellQ8 is the first web-based FFQ to collect dietary information in Kuwait as previous work have focused on utilizing traditional pen and paper FFQs such as the one used by Dehgan et al. that validated a PFFQ to a 24 hour recall (32). However, a main limitation to that study is that it only relied on correlation coefficients to assess validation and reproducibility (32). In addition, the analysis only looked at a total of fourteen nutrients and therefore may have impacted the outcomes of the trial (32). In the development of the EatWellQ8 FFQ, the validated Food4Me FFQ, European Prospective Investigation of Cancer (EPIC)-Norfolk FFQ (version CAMB/PQ/6/1205) and a PFFQ for Kuwait were used as a guide for food items and categories of food (17; 32; 33; 34). It has been previously proposed that an accurate dietary assessment tool is required to achieve an association between dietary intake and health outcomes (35; 36). The novel FFQ comprised of 146 food items that represented food items and composite dishes commonly consumed in Kuwait. The benefits of using web-based technology is that it can support user understanding of portion sizes by utilizing photographs of actual food portions(12). In the case of the EatWellQ8 FFQ, the FFQ included images of three portion sizes for each food item and the choice from 9 frequencies ranging from “never or less than 1 per month” to “more than 6 per day”. The use of multiple food photographs of portion sizes has been found to be useful in previous studies especially for foods that lacked a standard portion size (30; 36; 37; 38). However, the potential for error due to self-reporting of food portions is likely as there is limited data in regards to the accuracy of portion size self-reporting in novel automated technologies (39). It was hypothesized previously that the EatWellQ8 web-based FFQ would have good reproducibility and agreement for the assessment of food and nutrient intakes in Kuwait. The outcomes from the validation study reported in chapter 3, did support the hypothesis that the web-based EatWellQ8 FFQ had good reproducibility, however, only moderate agreement for the assessment of food and nutrient intakes in Kuwait was found. Only moderate agreement was found due to the higher level of bias being estimated by the EatWellQ8 FFQ compared to both tools. Moreover, variations between the EatWellQ8 FFQ and both dietary tools were highest

for green vegetables and bananas, possible reasons for such variations may be a result of an overestimation of items that are perceived as healthy such as vegetables and fruits, which is a common finding in other web-based FFQs (17). Comparable results were found when the repeatability and validity of the Food4Me online FFQ were assessed against a 4-day WFR (17). When the Food4Me online FFQ was validated against a 4-day WFR and the well-validated EPIC FFQ, greater bias was being estimated by the Food4Me FFQ compared to both tools, supporting our results (17; 34). The fact that both the EatWellQ8 and Food4Me FFQs included food photographs to aid in portion size estimations may have led to this higher level of bias. On the contrary, findings from a trial by Gonzalez et al. have suggested that mean dietary intakes were significantly higher for energy and the majority of macronutrients for a paper and pencil FFQ compared to a web-based FFQ (40). However, a main limitation to the trial was the small sample size (n=37) which may have impacted the power to notice significant differences(40). Based on these findings, the EatWellQ8 FFQ was found to be an acceptable tool for online dietary assessment in Kuwait and was incorporated in the eNutri app and utilized in the EatWellQ8 trial (chapter 4) to examine the effectiveness of the delivery of web-based PN compared to face-to-face PN advice and generalized dietary advice in Kuwait. Results from the EatWellQ8 trial are of an essence to future research especially in the Middle East, as our trial is the first to assess web-based tailored dietary information in the Gulf region and to utilize an app that is able to assess dietary intakes and to deliver PN.

Findings from the EatWellQ8 FFQ validation and reproducibility study (chapter 3) have shown that misreporting was not an issue as only 18 participants were excluded due to misreporting of energy intakes. This was in contrast to the results from the EatWellQ8 trial (chapter 4) as approximately 68% of completers were excluded from analysis due to overreporting. A possible reason for that is that prior to participation in the EatWellQ8 validation and reproducibility trial, participants were given detailed instructions on how to complete the FFQ by dietitians, whilst EatWellQ8 volunteers received no instructions which may have influenced these results. To further understand the reasons for over-reporting in the EatWellQ8 trial, a follow-on project was developed which included questions regarding the usability of the FFQ. Results of the follow-up trial have demonstrated that approximately 30% of participants agreed to the question “A tutorial showing how to complete the food and drink questionnaire would be useful”, suggesting the importance of the inclusion of instructional advice in future web-based dietary trials.

Findings from a recent meta-analysis that assessed the effectiveness of face-to-face individualised nutrition consultations with dietitians in primary health care facilities to enhance dietary intake and induce weight-loss have shown to be successful when compared to control groups that received either minimal or usual care or no intervention at all (4). Moreover, when web-based tailored dietary advice was compared with generalised "one size fits all" advice, findings from recent literature have demonstrated that web-based PN was more effective at improving dietary intake of individuals (30; 41). However, based on the results from a review by Franco et al. none of the existing dietary apps have a decision tree that is able to generate tailored dietary advice, further highlighting the significance of the eNutri app (42). Chapter 4 of the thesis describes the effectiveness of delivering web and face-to-face PN advice to population-based advice-The EatWellQ8 study. To assess diet quality, a modified version of the alternate healthy eating index (AHEI) was used in the EatWellQ8 trial as the AHEI has been found to be a powerful indicator for the development of cardiovascular disease (CVD) and chronic diseases (43). In addition, it has been suggested that repeated healthy eating index (HEI) scores can be used to evaluate variations among populations, target particular dietary concerns and therefore provide essential insight for future planning of dietary interventions (44). Findings from this chapter supported the hypothesis that web-based PN advice is as effective at improving dietary intake of healthy individuals in Kuwait when compared to face-to-face PN advice. Such findings are key to future web-based dietary research as there is growing interest in web-based delivery of dietary advice due to its cost-effectiveness, wide availability, accessibility and anonymity in comparison to face-to-face PN interventions (45). In addition, results of the EatWellQ8 trial have also shown that web-based and face-to-face PN are more effective at improving dietary intake compared to controls that received generalised web-based dietary advice, in line with previous research including the Food4Me trial that collected web-based dietary data across 7 research centres in Europe (4; 30). Similarly, results of a systematic review signified an inverse relationship between higher HEI and AHEI with decreased risk for cancer, deaths related to CVD and type 2 diabetes mellitus (DM) (46; 47). This emphasises the benefits that are associated with an increase of 15% in the m-AHEI scores, which were reported in the PN groups in the EatWellQ8 trial. Supporting findings from the EatWellQ8 trial, improvements in dietary intake of at least one dietary food group were also identified in several previous articles that assessed the effectiveness of tailored dietary advice delivered either face-to-face or via the web at improving intakes of fruit, vegetable, sugar, fibre, and omega 3 rich

fish intakes compared to non-tailored dietary advice (29; 41; 48; 49; 50; 51; 52). However, results of the EatWellQ8 study also suggested that face-to-face PN advice was more effective at inducing weight-loss when compared with web-based PN advice and standardised advice. In line with our data, results from a systematic review on the effectiveness of web-based weight-loss and weight maintenance has demonstrated that compared to face-to-face interventions, web-based interventions were less effective at promoting weight-loss (53). Findings from the systematic review have also suggested that results of web-based weight-maintenance were more promising especially when the web-based intervention was more enhanced or tailored (53). Therefore, possible reasons for the minimal web-based weight-loss that was achieved in our trial was due to the short trial length and that generally, weight-loss is more complex than just diet quality improvement. In the EatWellQ8 trial participant preference towards face-to-face PN was suggested as the overall m-AHEI scores and the majority of individual m-AHEI component scores were higher at 12-weeks in the face-to-face PN intervention in comparison to participants in the web-based PN group, although this did not reach statistical significance. Preference for face-to-face dietary advice delivery has also been found in previous research that assessed consumer preference towards PN in eight countries in the European Union (EU) (3; 54; 55). Results of the trials have also suggested that online PN is convenient as long as it was supported with face-to-face contact (55). Furthermore, Fallaize et al. has suggested that there was increased concern towards the quality of tailored feedback received from online sources of tailored nutrition (3). On the contrary, EatWellQ8 PN groups responded positively to questions related to the quality of the dietary advice in the feedback questionnaire. For example, when asked: “The healthy eating advice given by the EatWellQ8 site is still, to this day, motivating me to improve my diet” and “Thinking about my diet as a whole, I feel the advice from the site encouraged me to eat more healthily”, more than 70% of participants from both PN groups responded that they agree to the questions. Such findings further signify the role of eHealth and mHealth at assessing and delivering dietary information.

Results of targeted PN advice in the EatWellQ8 trial have also demonstrated non-significant differences between the two PN intervention groups which strengthens the effectiveness of both methods for the delivery of PN advice. Assessments were also taken for targeted nutrient intakes such as omega 3 Fatty acids, fibre and calcium, total folate and PUFA as they are common indicators for dietary improvements (30) and to further assess the m-AHEI individual component scores. In line with results from the

Food4Me trial (30), significant improvements were found in the PN intervention groups for two of the targeted nutrients (total folate and omega 3 FA) compared to the control group which may also reflect increased consumption of fruit and vegetables and oily fish intakes and further demonstrate the effectiveness of tailored dietary advice. This was exemplified further in results of the comparative study which compared web-based dietary data between the EatWellQ8 and EatWellUK trial (chapter 5) have suggested that diet priorities differed between countries and at an individual level adding further to the need for personalisation in dietary advice.

Improvements in dietary intakes of adults in Kuwait is of necessity as results from this comparison study (chapter 5) have demonstrated overall lower modified alternative healthy eating (m-AHEI) scores in Kuwaiti adults who took part in the EatWellQ8 trial when compared to a sample from the EatWellUK representing UK adults. Limited focus has been given to assess dietary intakes between countries, especially those in different continents. Results from this comparative trial may give a clearer understanding about the differences and similarities between both countries and to view whether there is a pattern of overconsumption of specific types of food that may impact the overall quality of diets consumed. The study aimed to compare diet and nutritional intakes in UK and Kuwaiti adults using baseline data derived from the EatWellQ8 and EatWellUK trials by the use of the eNutri PN app compare them with UK recommendations. Findings from this comparison, supported the hypothesis that the diet of adults in Kuwait will be of a lower nutritional quality compared to UK adults. Data from the National Nutrition Survey of the State of Kuwait (NNSSK) have also indicated dietary concerns regarding overconsumption of energy dense, nutrient poor food which also included sugar, salt and red and processed meat intakes that have all been linked with the early development of NCDs (56). Findings by Zaghloul et al. have shown that around 78-100% of Kuwait adults exceeded intakes of carbohydrates (including sugar rich beverages) and protein, emphasising the concern towards overconsumption in Kuwait (57). However, unhealthy dietary practises were also found in the EatWellUK trial as dietary fat intakes including saturated fatty acid (SFA) were significantly higher in the EatWellUK trial compared to EatWellQ8, however, intakes of SFA exceeded recommendations in both trials. Possible reasons for this may be due to significantly higher intakes of dairy found in the EatWellUK trial and may also be as a result of reporting bias by EatWellQ8 participants of food items that are perceived as high fat. Although the overall diet quality of EatWellQ8 participants was lower in the EatWellQ8 trial, fibre intakes were significantly higher than EatWellUK values which

may reflect the lower reported intakes of fruits, wholegrains and nuts and legumes by participants in the EatWellUK trial. However, according to NNSSK data, more than two thirds of Kuwaitis in all age groups were not meeting fibre recommendations (56). This finding may further suggest over reporting of food items that are perceived as healthy by EatWellQ8 participants. Results from both trials have suggested insufficient intakes of omega 3 FA and vitamin D intakes which were found to be in line with results from NNSSK and UK National Diet and Nutrition Survey (NDNS) data that have shown lower than recommended intakes for both nutrients by both populations (56; 58). Such findings further assert the necessity of adopting tailored dietary advice in both countries to tackle specific nutrient deficiencies. Intakes of the majority of micronutrients were found to be lower in the EatWellQ8 trial compared to EatWellUK participants further suggesting the lower diet quality of adults in Kuwait and were found to be in line with previous data (56; 57). On the contrary, vitamin C intakes were found to be significantly higher in the EatWellQ8 trial compared to EatWellUK which may be due to the significantly higher fruit intakes found in the EatwellQ8 trial. However, vitamin C intakes From the EatWellUK trial were above the UK recommendations and therefore did not pose a nutritional concern (58). Iron intakes were found to be significantly higher in the EatWellQ8 trial compared to EatWellUK, which as a population mean were within recommendations. The higher EatWellQ8 iron intakes may reflect the high red and processed meat intakes found in the EatWellQ8 trial, although intakes were also high in EatWellUK trial.

Recent findings from a three country trial (UK, New Zealand and Australia) has demonstrated that 62% of dietitians use mHealth apps in their practice (59). However, results of the trial have established the absence of tailored feedback available in mHealth apps as most lacked capabilities beyond a food diary, and provided minimal dietary data on achieving improved dietary intakes (60; 61). Based on the findings from this thesis, the inclusion of a tailored online PN system effectively improved dietary change compared to standardised advice. It has also been shown that significant weight-loss was achieved only in the group that received face-to-face dietary advice, highlighting the effectiveness of in-person weight change. The utilisation of a combined approach that includes face-to-face and PN online apps may be beneficial, especially for weight-loss and weight-loss maintenance. In addition, it was proposed that a combination of face-to-face dietary consultations with the utilisation of mHealth apps are the preferred approach to improve the knowledge driven from dietary consultations(59).

6.3 Conclusions

In conclusion, the utilisation of effective methods to deliver dietary and weight-loss advice are an essential step towards the achievement of successful dietary and weight-loss change. Most of the current methods used to deliver dietary advice incorporate either face-to-face or web-based approaches. Evidence from dietary interventions suggests that compared to standardized controls, the majority of face-to-face dietary interventions were successful at improving dietary and weight-loss outcomes, and web-based dietary interventions may be beneficial at improving dietary change and short-term weight-loss. Preference towards personalisation of dietary advice has risen as PN may be tailored towards an individuals' specific dietary, phenotypic or genotypic requirements. With rising obesity and NCD levels in Kuwait, the current thesis aimed to assess the effectiveness of personalised face-to-face and web-based dietary advice to population based advice in free-living adults in Kuwait (The EatWellQ8 study). For the purpose of the trial, a novel web-based FFQ (EatWellQ8) was developed and was found to have good reproducibility and moderate agreement towards a 4-day WFR and a paper-based Kuwaiti FFQ. The development of a new dietary collection tool that revolves around the diet of individuals in Kuwait was a necessity to ensure accurate assessments of dietary and nutrient intakes. The EatWellQ8 FFQ was integrated in to the eNutri PN automated app to be used in the EatWellQ8 trial. The incorporation of the eNutri automated app to deliver PN advice was found to be effective at enhancing dietary change. Evidence from the current thesis suggests that tailored dietary advice, regardless of the method of delivery, was found to be more effective at enhancing dietary change compared to population based advice in Kuwait. Compared to UK adults, the overall diets of Kuwaiti individuals were found to be of lower quality based on the m-AHEI. These findings may be used to reinforce the evidence between the effectiveness of personalization of dietary advice compared to population based advice in free living adults. The evidence that web-based PN was as effective as face-to-face PN at enhancing dietary change may further suggest that web-based PN may be used as an alternative to face-to-face PN. Nonetheless, as a result of the limitations of misreporting, high dropout rates and trial length that may have impacted the study power, future long term trials with larger and more heterogenous samples that focus on delivering PN advice are essential to strengthen these outcomes.

6.4 Recommendations for future work

- Generally, the Gulf population follow similar dietary habits. An area of interest would be to further assess the validity of the EatWellQ8 FFQ amongst other Gulf countries and assess whether it can be utilised in future research as a dietary assessment tool in Gulf countries other than Kuwait.

- With increased worldwide use of mobile phones and their increased mobility, an area worth investigating in future studies is the effectiveness of personalisation in mHealth and mobile responsive apps and face-to-face dietary advice in randomised control trials, that may incorporate an additional hybrid approach intervention to examine the maintenance of long-term dietary and weight-loss change. The incorporation of an interactive online dietary support system especially in maintenance trials may maximise contact with participants and may therefore aid in decreasing attrition rates in future trials.

- Future work should investigate the effectiveness of web-based PN that incorporates more individualised dietary regimens such as vegetarian diets as there has been an increased consumer preference towards personalisation of dietary advice (3). Whilst the eNutri app did deliver PN advice, it was generated on participants that are generally healthy and do not follow a specific diet and was therefore found to be restrictive and lacked the ability to benefit the whole population. Therefore, the incorporation of a mHealth app that takes in to account different dietary needs is beneficial to further understand the impact of tailoring of web-based dietary advice.

- Results of the EatWellQ8 study have indicated that more than 70% of the participants were young well-educated females and similar trends were found in previous research that require voluntary participation. Future personalised dietary studies may investigate more sex balanced trials that include participants from different socio-economic backgrounds and education levels in order to better represent targeted populations that may also encompass individuals with learning disabilities.

- One of the main problems that was faced in the EatWellQ8 trial was misreporting of dietary intakes. It has been suggested that several reasons may have led to misreporting which include; FFQ boredom, double reporting due to composite dishes and user misunderstanding on how to complete the dietary assessment tool. The incorporation of video tutorials to better assist participants in future online dietary research may help in alleviating such a problem.

- Due to the advantages of web-based interventions which include cost-effectiveness, increased accessibility and that they may enhance self-control as they allow individuals to self-monitor their weight and goals, future work should investigate further the effectiveness of long-term personalised weight-loss and weight maintenance that incorporate personalised goal settings and asses their effectiveness on different populations.

- Finally, to better understand the effect of web-based tailored dietary advice, more randomised control trials that are longer term, heterogeneous and gender balanced that are carried out amongst different populations are required. The incorporation of the AHEI score as a measure of the diet quality will help in assessing whether it is a ubiquitous measure of dietary improvements across different populations.

6.5 References

1. Marmot M (2018) Diet, cancer, and NCD prevention. Lancet Oncol 19, 863-864.

2. World Health Organization (2018) Noncommunicable diseases country profiles 2018. Geneva: World Health Organization Licence: CC BY-NC-SA 3.0 IGO, 223.

3. Fallaize R, Macready AL, Butler LT et al. (2015) The perceived impact of the National Health Service on personalised nutrition service delivery among the UK public. Br J Nutr 113, 1271-1279.

4. Mitchell LJ, Ball LE, Ross LJ et al. (2017) Effectiveness of dietetic consultations in primary health care: a systematic review of randomized controlled trials. J Acad Nutr Diet 117, 1941-1962.

5. Oosterveen E, Tzelepis F, Ashton L et al. (2017) A systematic review of eHealth behavioral interventions targeting smoking, nutrition, alcohol, physical activity and/or obesity for young adults. Prev Med 99, 197-206.

6. Ministry of Health (2014) KUWAIT NUTRITION SURVEILLANCE SYSTEM 2014 ANNUAL REPORT. https://wwwmohgovkw/Renderers/ShowPdfashx?Id=aa1caabd-6aea-4dbb-9441-c9768458941d, November 21, 2018.

7. Sorgente A, Pietrabissa G, Manzoni GM et al. (2017) Web-based interventions for weight loss or weight loss maintenance in overweight and obese people: a systematic review of systematic reviews. JMIR 19, e229.

8. Neuenschwander LM, Abbott A, Mobley AR (2013) Comparison of a Web-Based vs In-Person Nutrition Education Program for Low-Income Adults. J Acad Nutr Diet 113, 120-126.

9. Crane MM, Lutes LD, Ward DS et al. (2015) A randomized trial testing the efficacy of a novel approach to weight loss among men with overweight and obesity. Obesity 23, 2398-2405.

10. Bennett GG, Herring SJ, Puleo E et al. (2010) Web-based Weight Loss in Primary Care: A Randomized Controlled Trial. Obesity 18, 308-313.

11. Harvey-Berino J, West D, Krukowski R et al. (2010) Internet delivered behavioral obesity treatment. Prev Med 51, 123-128.

12. Cade JE (2017) Measuring diet in the 21st century: use of new technologies. Proc Nutr Soc 76, 276-282.

13. Escoffery C, McCormick L, Bateman K (2004) Development and process evaluation of a web-based smoking cessation program for college smokers: innovative tool for education. Patient Educ Couns 53, 217-225.

14. Quiñonez SG, Walthouwer MJL, Schulz DN et al. (2016) mHealth or eHealth? Efficacy, use, and appreciation of a Web-based computer-tailored physical activity intervention for Dutch adults: a randomized controlled trial. JMIR 18, e278.

15. Dennison L, Morrison L, Conway G et al. (2013) Opportunities and challenges for smartphone applications in supporting health behavior change: qualitative study. JMIR 15(4), :e86.

16. Boushey CJ, Kerr DA, Wright J et al. (2009) Use of technology in children's dietary assessment. Eur J Clin Nutr 63, S50.

17. Fallaize R, Forster H, Macready AL et al. (2014) Online dietary intake estimation: Reproducibility and validity of the Food4Me food frequency questionnaire against a 4-day weighed food record. JMIR 16, e190.

18. Thompson FE, Dixit-Joshi S, Potischman N et al. (2015) Comparison of interviewer-administered and automated self-administered 24-hour dietary recalls in 3 diverse integrated health systems. Am J Epidemiol 181, 970-978.

19. Hutchesson MJ, Rollo ME, Callister R et al. (2015) Self-monitoring of dietary intake by young women: online food records completed on computer or smartphone are as accurate as paper-based food records but more acceptable. J Acad Nutr Diet 115, 87-94.

20. Fallaize R, Franco, R, Hwang, F, Lovegrove, J (2019) Evaluation of the eNutri automated personalised nutrition app by Nutrition Professionals in the UK. PlosOne, 14(4) e0214931.

21. Franco RZ, Alawadhi B, Fallaize R et al. (2017) A Web-Based Graphical Food Frequency Assessment System: Design, Development and Usability Metrics. JMIR Human Factors, 4(2), e13.

22. Office for National Statistics (2018) Internet users, UK: 2018. Internet use in the UK annual estimates by age, sex, disability and geographical location. https://wwwonsgovuk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2018 October 12, 2018.

23. The Office of Communications OFCOM (2016) Communications Market Report 2016. https://wwwofcomorguk/__data/assets/pdf_file/0024/26826/cmr_uk_2016pdf September 22, 2018.

24. Internet World Stats (2018) Kuwait Internet Usage and Telecommunications .Internet World stats Usage and Population statistics https://www.internetworldstats.com/me/kw.htm, November 1, 2018.

25. World Health Organization (2017) Noncommunicable diseases: progress monitor 2017.

26. Badr H, Maktabi MA, Al-Kandari M et al. (2019) Review of Non-Communicable Disease Research Activity in Kuwait: Where is the Evidence for the Best Practice? Ann Glob Health 85(1).

27. Musaiger AO, Al-Kandari FI, Al-Mannai M et al. (2014) Perceived barriers to weight maintenance among university students in Kuwait: the role of gender and obesity. Environ Health Prev Med 19, 207-214.

28. Springvloet L, Lechner L, de Vries H et al. (2015) Short-and medium-term efficacy of a Web-based computer-tailored nutrition education intervention for adults including cognitive and environmental feedback: randomized controlled trial. JMIR 17(1), e23.

29. Kerr DA, Harray AJ, Pollard CM et al. (2016) The connecting health and technology study: a 6-month randomized controlled trial to improve nutrition behaviours using a mobile food record and text messaging support in young adults. Int J Behav Nutr Phys Act 13(1), 52.

30. Celis-Morales C, Livingstone KM, Marsaux CF et al. (2016) Effect of personalized nutrition on health-related behaviour change: evidence from the Food4me European randomized controlled trial. Int J Epidemiol 46, 578-588.

31. Recio-Rodríguez JI, Martín-Cantera C, González-Viejo N et al. (2014) Effectiveness of a smartphone application for improving healthy lifestyles, a randomized clinical trial (EVIDENT II): study protocol. BMC Public Health 14, 254.

32. Dehghan M, Al-Hamad N, McMillan CR et al. (2009) Comparison of a semi-quantitative food frequency questionnaire with 24-hour dietary recalls to assess dietary intake of adult Kuwaitis. SMJ 30, 159-161.

33. EPIC (2013) European Prospective Investigation of Cancer EPIC-Norfolk food frequency questionnaire (FFQ) entry and processing documentation.

http://www.srl.cam.ac.uk/epic/epicffq/websitedocumentation_2111.html, February 12, 2018.

34. Forster H, Fallaize R, Gallagher C et al. (2014) Online dietary intake estimation: the Food4Me food frequency questionnaire. JMIR 16(6) e150.

35. Chen J, Cade JE, Allman-Farinelli M (2015) The most popular smartphone apps for weight loss: a quality assessment. JMIR mHealth uHealth 3(4), e104.

36. Carter M, Albar S, Morris M et al. (2015) Development of a UK online 24-h dietary assessment tool: myfood24. Nutrients 7, 4016-4032.

37. Bradley J, Simpson E, Poliakov I et al. (2016) Comparison of INTAKE24 (an online 24-h dietary recall tool) with interviewer-led 24-h recall in 11–24 year-old. Nutrients 8, 358.

38. Hercberg S, Castetbon K, Czernichow S et al. (2010) The Nutrinet-Sante Study: a web-based prospective study on the relationship between nutrition and health and determinants of dietary patterns and nutritional status. BMC Public Health 10, 242.

39. Illner AK, Freisling H, Boeing H et al. (2012) Review and evaluation of innovative technologies for measuring diet in nutritional epidemiology. Int J Epidemiol 41, 1187-1203.

40. González Carrascosa R, García Segovia P, Martínez Monzó J (2011) Paper and pencil vs online self-administered food frequency questionnaire (FFQ) applied to university population: a pilot study. Nutr Hosp 26, 1378-1384.

41. Celis-Morales C, Abraham S, Keenan P et al. (2015) Effect of web-based tailored lifestyle interventions on fruit and vegetable consumption in adults: A systematic review and meta-analysis of randomised controlled trials. Proc Nutr Soc 74, (OCE1).

42. Franco RZ, Fallaize R, Lovegrove JA et al. (2016) Popular nutrition-related mobile apps: a feature assessment. JMIR mHealth uHealth 4(3), e85.

43. McCullough ML, Willett WC (2006) Evaluating adherence to recommended diets in adults: the Alternate Healthy Eating Index. Public Health Nutr 9, 152-157.

44. Shatenstein B, Nadon S, Godin C et al. (2005) Diet quality of Montreal-area adults needs improvement: estimates from a self-administered food frequency questionnaire furnishing a dietary indicator score. J Am Diet Assoc 105, 1251-1260.

45. Tate DF, Wing RR, Winett RA (2001) Using Internet technology to deliver a behavioral weight loss program. JAMA 285, 1172-1177.

46. Schwingshackl L, Hoffmann G (2015) Diet quality as assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension score, and health outcomes: a systematic review and meta-analysis of cohort studies. J Acad Nutr Diet 115, 780-800.

47. Schwingshackl L, Bogensberger B, Hoffmann G (2018) Diet quality as assessed by the healthy eating index, alternate healthy eating index, dietary approaches to stop hypertension score, and health outcomes: an updated systematic review and meta-analysis of cohort studies. J Acad Nutr Diet 118, 74-100.

48. Lanza E, Schatzkin A, Daston C et al. (2001) Implementation of a 4-y, high-fiber, high-fruit-and-vegetable, low-fat dietary intervention: results of dietary changes in the Polyp Prevention Trial. Am J Clin Nutr 74, 387-401.

49. Francis SL, Taylor MLJJotADA (2009) A Social Marketing Theory− based diet-education program for women ages 54 to 83 years improved dietary status. J Am Diet Assoc 109, 2052-2056.

50. Arcand JAL, Brazel S, Joliffe C et al. (2005) Education by a dietitian in patients with heart failure results in improved adherence with a sodium-restricted diet: a randomized trial. Am Heart J 150(4), 716-e711.

51. Storm V, Dörenkämper J, Reinwand DA et al. (2016) Effectiveness of a web-based computer-tailored multiple-lifestyle intervention for people interested in reducing their cardiovascular risk: a randomized controlled trial. JMIR 18(4), e78.

52. Rhodes KS, Bookstein LC, Aaronson LS et al. (1996) Intensive nutrition counseling enhances outcomes of National Cholesterol Education Program dietary therapy. J Am Diet Assoc 96, 1003-1010.

53. Sorgente A, Pietrabissa G, Manzoni GM et al. (2017) Web-based interventions for weight loss or weight loss maintenance in overweight and obese people: a systematic review of systematic reviews. JMIR 19, e229.

54. Stewart-Knox B, Kuznesof S, Robinson J et al. (2013) Factors influencing European consumer uptake of personalised nutrition. Results of a qualitative analysis. Appetite 66, 67-74.

55. Berezowska A, Fischer ARH, Ronteltap A et al. (2014) Understanding consumer evaluations of personalised nutrition services in terms of the privacy calculus: a qualitative study. Public Health Genom 17(3), 127-140.

56. Al-Hooti S, Zaghloul S, Alomirah H et al. (2010) National nutrition program for the State of Kuwait: phase I-national nutrition survey of the State of Kuwait. Final Report, KISR 10246.

57. Zaghloul S, Al-Hooti SN, Al-Hamad N et al. (2013) Evidence for nutrition transition in Kuwait: over-consumption of macronutrients and obesity. Public Health Nutr 16, 596-607.

58. Bates B, Collins, D, Cox, L, Nicholson, S, Page, P, Roberts, C, Steer, T, Swan, G (2019) National Diet and Nutrition Survey: Years 1 to 9 of the Rolling Programme (2008/2009 – 2016/2017): Time trend and income analyses. Public Health England: London, UK.

59. Chen J, Lieffers J, Bauman A et al. (2017) The use of smartphone health apps and other mobile h ealth (mHealth) technologies in dietetic practice: a three country study. J Hum Nutr Diet 30, 439-452.

60. DiFilippo KN, Huang W-H, Andrade JE et al. (2015) The use of mobile apps to improve nutrition outcomes: a systematic literature review. J Telemed Telecare 21, 243-253.

61. Wharton CM, Johnston CS, Cunningham BK et al. (2014) Dietary self-monitoring, but not dietary quality, improves with use of smartphone app technology in an 8-week weight loss trial. J Nutr Educ Behav 46, 440-444.

APPENDICES

APPENDIX 1. Ethical approvals

1.1. **Ethical approval for the EatWellQ8 validation and Reproducibility trial from the Research Ethics Committee at the University of Reading**

CH

Catherine Hale [redacted]
Fri 18/09/2015 14:50
Balqees A. Z. E. Alawadhi [redacted]

Hi Belle,

They have accepted your submission but will want to see final with signatures early next week.

Thanks

Cat

Catherine Hale
Research Secretary, Reading School of Pharmacy
Research & Ethics Secretary, School of Chemistry, Food and Pharmacy
1.05 Food and Nutritional Sciences Building
Whiteknights
PO Box 226
Reading
RG6 6AP

Tel: [redacted]
If using Satellite Navigation to find the University, please enter RG6 6UR which should lead you directly to our campus.

1.2. **Ethical approval from DDI for the EatWellQ8 FFQ validation and Reproducibility and EatWellQ8 trials**

معهد دسمان للسكري
Dasman Diabetes Institute

INTERNAL MEMORANDUM

To: **Ms. Balqees Al Awadhi**
Principal Investigator

DATE: 12 October 2015
REF: RA/180/2015

[redacted]

FROM: **Ms. Rashmi Shiju**
Rapporteur
Ethical Review Committee

CC: **Dr. Abdullah Bennakhi**
Chairman
Ethical Review Committee

SUBJECT: **DDI Protocol No: RA 2015-018**
Protocol title: "Randomised Control Trial to evaluate the effectiveness of web-based versus face-to-face personalised nutrition in Kuwait (Eat Well Q8)."

STATUS OF APPROVAL : **Conditional**

The above referenced proposal and related documents were reviewed by the Ethical Review Committee (ERC) on 10 September 2015.

The Committee recommended the approval of the proposal provided that the following concerns are addressed:

1. The committee recommends using the bilingual informed consent form of Dasman Diabetes Institute.
2. It is mentioned in the protocol that the procedures of Ministry of Health is to be followed. It is not clear to the committee whether MOH approval is obtained or not? Committee recommends that Dasman Diabetes Institute's ethics name should be mentioned.
3. Participant information sheet indicates that two of the questionnaires will take approximately 30 minutes to complete. It is not clear to the committee that both questionnaires will complete in 30 minutes or each questionnaire will take 30 minutes.
4. The age criteria is mentioned as 18-65 years however in the State of Kuwait, 21 years is the age of majority so assent must be obtained along with parental consent if participants below 21 years to be recruited.

Please forward your reply to the ERC as soon as possible. Final approval of the protocol and consent form is pending the review and acceptance of a satisfactory reply by the ERC.

Research Affairs/Ethical Review Committee
P.O Box 1180, Dasman 15462, Kuwait| T[redacted]
Website[redacted]

1.3 **Ethical approval for the EatWellQ8 trial from the Research Ethics Committee at the University of Reading**

Fwd: Study 13/17 - Minor amendments Inbox ×

Julie Lovegrove <[redacted]
to Rodrigo, Faustina, me, Rosalind

Dear All,

Good news on the EatWellQ8. The ethics application has been approved using the system as it is now set up.

We can now begin the study.

This is an early Christmas Presents!

I hope you all have a relaxing and enjoyable Christmas.

Best wishes
Julie

Begin forwarded message:

From: Bob Rastall [redacted]
Subject: RE: Study 13/17 - Minor amendments
Date: 20 December 2017 10:17:31 GMT
To: Rosalind Fallaize [redacted]Barbara Parr [redacted]
Cc: Julie Lovegrove [redacted]

Hi all

APPENDIX 2.

2.1 EatWellQ8 FFQ

FOOD AND AMOUNT									
VEGETABLES Fresh, frozen or tinned الخضار	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Broccoli (القرنبيط)									
Cabbage (ملفوف)									
Carrot (جزر)									
Cauliflower (قرنابيط)									
Chili (فلفل)									
Cucumber (خيار)									
Eggplant (باذنجان)									
Garlic (ثوم)									
Sweet pepper (فلفل حلو)									
Okra (بامية)									
Lettuce (خس)									
Mixed vegetables, cooked (خضرة مشكلة)									
Onions (raw or cooked) (بصل)									
Spinach (السبانخ)									

Sweet potatoes (فندال)									
Olive (green or black) (زيتون)									
Tomatoes (طماطم)									
Corn (ذرة)									
Mushroom (مشروم)									
Avocado (أفوكادو)									
FRUITS Fresh, frozen الفاكهه	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Apple (تفاح)									
Banana (الموز)									
Dates (Ratab/tamar) (رطب/تمر)									
Grapes (عنب)									
Guava (جوافة)									
Kiwi (كيوي)									
Mango (مانجو)									
Melon (شمام)									
Orange (برتقال)									
Berries (Strawberry, blueberry, blackberry, raspberry) (أنواع التوت)									
Peach (خوخ)									
Pears (كمثرى)									
Pomegranate (رمان)									

Watermelon (بطيخ)									
Tinned Fruit (فاكهه معلبة)									
BREAD AND SAVOURY BISCUITS (one slice/roll or biscuit)	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Brown Toast bread (توست أسمر)									
White toast (توست أبيض)									
Irani bread (خبز ايراني)									
Lebnani bread brown (خبز لبناني أسمر)									
Lebnani bread-white (خبز لبناني أبيض)									
Bread roll white (samoon) (صمون أبيض)									
Bread roll (brown) (صمون أسمر)									
Shaboora (savoury crackers) (شابوره)									
Savoury Biscuit (بسكويت) (بسكوت مالح)									

CEREALS	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Breakfast wholegrain e.g. branflakes (كورن فليكس كامل الحبوب)									
Breakfast cereal non whole grain e.g. cornflakes (كورن فليكس عادي)									
Muesli, oats (شوفان)									
POTATOES, RICE AND PASTA البطاط , الارز, المعكرونة	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
White rice (أرز أبيض)									
Brown rice (أرز أسمر)									
Potatoes, baked or boiled (بطاطا مسلوقة, بالفرن)									
Potatoes mashed (بطاطا مهروسه)									
Fried potatoes/ chips (بطاطا مقلية)									

Lasagne, Bashamel (لازانيا, بشاميل)									
Pasta (spaghetti, macaroni, noodles) (معكرونة)									
Spring roles (سبرينج ر ول)									
Pizza (بيتزا)									
KUWAITI DISHES Remember: if you reported any of the dishes e.g machbous deyay Do Not mention it again under Rice and Chicken in the other sections. المأكولات الكويتية (هذه المأكولات تعد من ضمن أكلك اليومي . اذا اكلت مجبوس الدجاج فهذا يعتبر حصة من الدجاج و الارز فلايجب أن تحسبهم مره أخرى.	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Machbous laham (rice with meat or									

chicken)Separate them to deyay and laham (مجبوس لحم)									
Mourkokah (chicken with wheat dumplings) (مرقوقه)									
Biryani (rice with meat or chicken) (بريانس دجاج أو لحم)									
Mowash Rebyan (rice with split lentil and shrimp)(موش)									
Meaddas (rice with whole lentil) (معدس)									
Jareesh (crackle wheat with minced meat & vegetables) (جريش)									
Harrees (fine crackle wheat with									

meat & vegetables) (هريس)									
Motabak samak (rice with fish) (مطبق سمج)									
Daccouse (tomatoes with spices) (دقوس)									
Marag (chicken, fish or shrimp stew) ,(مرق دجاج, سمج, ربيان)									
Marag bamia (Orkra stew with meat) (مرق لحم و باميه)									
Addas (lentils) (مرق عدس أو شوربة)									
Fatayer, jibin, labneh etc (فطاير جبن, لبنه الخ)									
Shawerma chicken, meat									

(شاويرما دجاج او لحم)									
MEAT AND FISH اللحوم و الاسماك	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Fish (cooked) (سمك مطبوخ)									
Fried fish e.g. fish fingers (سمك مقلي)									
White fish e.g. Hamour, zbaidy (سمك أبيض مثل الزبيدي, هامور الخ)									
Non smoked oily, fresh e.g. salmon, tuna , mayd, sboor (سمك غني بالزيت غير مدخن سالمون, ميد, صبور)									
Non Smoked oily fish canned e.g.tuna, sardines (سمك غير مدخن معلب, تونا, ساردين)									
Smoked oily fish e.g. salmon (سمك مدخن سالمون)									
Shell fish, e,g, crab, prawn									

(مأكولات بحريه, القبقب, الروبيان)									
Sushi (سوشي)									
Meat (lamb) (Mutton) (لحم الضأن)									
Meat beef (steak, roast, grilled) (لحم ستيك, مشوي)									
Chicken or other poultry e.g. turkey (دجاج)									
Luncheon meats: salami, turkey, mortadella, (لحوم بارده, المرتاديلا الخ)									
Beef or chicken burgers (همبرجر لحم او دجاج)									
Sausages (سوسج)									
Liver, organ meats (كبده الخ)									
DAIRY PRODUCTS AND FATS (Remember, this includes amount in tea, coffee, cereal	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day

and milk as a drink) منتجات الابان و الدهون (هذه تشمل الكمية اللتي تضاف بالشاي, القهوة, الكورن فليكس و شرب الحليب لوحده)									
Milk, Laban (butter milk) (whole milk) (حليب أو لبن كامل الدسم)									
Low fat milk or , Laban (حليب أو لبن قليل الدسم)									
Skimmed milk or laban (حليب أو لبن خالي الدسم)									
Condensed milk (حليب مركز حالي)									
Flavoured milk (chocolate, strawberry, banana etc) (حليب بالشوكولاته, فراوله الخ)									

Soya, almond milk etc (حليب الصويا, اللوز الخ)									
Fruit yogurt (روب بالفاكهه)									
Yogurt (plain) (روب) Full cream (روب كامل الدسم)									
Yogurt (plain) Low fat (روب قليل الدسم)									
High fat cheeses e.g cheddar, (جبن غني الدهون الجيدر)									
Medium fat cheeses e.g. Haloumi, feta (جبن متوسط الدسم الحلوم,الفيتا)									
Cream cheese (جبن الكريمي أو جبن قلاص)									

Low fat cheeses e.g. mozzarella, cottage cheese, جبن قليل الدسم (الموزاريلا, قريش)									
Lebneh (لبنه)									
Eggs, boiled, scrambled , fried (بيض مقلي, مسلوق الخ)									
Low fat salad cream/ mayonnaise (صلصة السلطه قليلة الدسم)									
Salad cream (mayonnaise) (صلصة السلطه العادية)									
Other salad dressing (tablespoon) (صلصة)									
Butter (الزبده)									
Margarine (المارجرين)									
Olive oil (tablespoon) (زيبت الزيتون)									

Other vegetable oil (tablespoon) (زيت تباتية أخرى)									
SWEETS AND SNACKS الحلويات و المأكولات الخفيفه	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Sweets biscuits, chocolate e.g. (one) (بسكوت حالي بالكريكه أو الشكولاته)									
Sweets biscuits plain e.g. mary (one) (بسكوت حالي)									
Chocolates , single, squares (قطعة شوكولاتة)									
Chocolate bars (شريط شوكولاته)									
Ice cream, ice lollies (ايس كريم)									

Cakes, e.g. plain, fruit, home baked (كيك, خالي أو بالفاكهه خبز البيت)									
Cakes ready made (كيك جاهز)									
Pastries e.g. croissants, muffins, donuts ready made (كرواسون, مافين, دونت جاهز)									
Pastries e.g. croissants, muffins, donuts home baked (كرواسون, دونت, مافين خبز البيت)									
Sweets , toffee (حلاو)									
Arabic sweets e.g. lgaimat,, kunafa etc (حلويات عربيه القيمات, كونافه)									

Sugar added to coffee, tea (teaspoon) (سكر مضاف للشاي و القهوه)									
Nuts e.g. peanuts etc (المكسرات)									
Chips, crisps (بطاط)									
Jam, honey, Peanutbutter (مربى, عسل, زبدة الفول السوداني)									
Pickles, ketchup (مخلل, كاشب)									
DRINKS (المشروبات)	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
Tea black, green, herbal (الشاي, أحر, أخضر, أعشاب)									
Coffee (القهوه)									
Cappucino, latte etc (كابوشينو, لاتي الخ)									
Arabic coffee (قهوه عربيه)									

Hot chocolate (شوكولاتا ساخنه)									
Pure fruit juice 100 % juice (عصير طبيعي)									
Fizzy drinks, e.g. cola, lemonade, etc (مشروبات غازيه)									
Diet fizzy drinks (مشروبات غازيه دايت)									
Juice drinks (عصير بانكتار, او شراب العصير)									

APPENDIX 3.

3.1 EatWellUK trial paper (In preparation)

Original Paper

Effectiveness of Online Personalised Nutrition Advice for Adults: Evidence from the EatWellUK Web-based Randomised Control Trial

Abstract

Background:

Objective:

Methods:

Results:

Trial Registration: The EatWellUK study was registered at ClinicalTrials.gov (NCT03250858)

Keywords: personalised nutrition; online; app; healthy eating index; web-based; FFQ; Food Frequency Questionnaire; EatWellUK;

Introduction

Non-communicable diseases (NCD) account for almost two thirds of deaths globally. The main recommendations for addressing this issue are related to lifestyle changes, such as the encouragement of healthier diets, physical activity (PA) and the reduction of tobacco use and alcohol consumption [1]. The current public health strategies to address this challenge are not personalised to individuals. The “5 a day” campaign to encourage the consumption of 5 portions of fruits or vegetables a day [2] and the Eatwell Guide [3] are examples of dietary guidance within the UK. The “5-a-day” campaign was associated with modest increases, particularly in fruit consumption, immediately after its launch[4], however these were not maintained and currently only a quarter of the UK population meet the recommendations of the “5 a day” campaign [5]. These and other data have motivated investigations into the efficacy of personalised nutrition (PN) on behaviour change [6].
The Internet has considerable potential to improve health-related food choice at low-cost, via apps for example. However, a recent review revealed that none of the popular nutrition-related mobile apps reviewed had a decision engine capable of providing personalised diet advice [7]. Evidence from the Food4Me study indicated that online PN advice, based on dietary intake (assessed using a validated Food Frequency Questionnaire (FFQ) with photographs [8]), was more effective in improving adherence to dietary advice than standard population guidance [9]. Their decision tree for tailoring the advice was executed manually by the researchers and automated after the completion of the Randomised Control Trial (RCT) [10], but this automated decision tree is not publicly available. The authors of the current article are not aware of any similar online PN RCT delivered automatically [11].
In order to help address this need, a mobile web app capable of delivering automated PN advice (eNutri) was developed and its effectiveness was evaluated during an online RCT, where personalised advice was delivered automatically by the app, immediately after completion of an online FFQ. Its dietary advice was derived according to adherence to an 11-item modified Alternative Healthy Eating Index (m-AHEI). The Alternative Healthy Eating Index (AHEI) was selected for its strong association with cardiovascular disease (CVD) and health [12][13]. The aim of this RCT was to investigate the effectiveness of this online PN advice tool, based on an individual’s dietary intake and sex, in increasing diet quality

compared with population dietary advice delivered online. This study tested the hypothesis that personalised dietary advice is more effective at motivating beneficial dietary change then general dietary public health guidance.

Methods

The EatWellUK study was a randomised, controlled, blinded, dietary intervention, which was delivered online. It compared the effect of automated personalised food-based dietary advice compared with population dietary advice (control) delivered online, on change in diet quality (assessed by m-AHEI) and specific foods and nutrients intake. The study was subject to ethical review according to the procedures specified by the University of Reading (School of Chemistry, Food and Pharmacy Research Ethics Committee) and was given a favourable ethical opinion for conduct (Ref No. 13/17) and conformed with the Declaration of Helsinki. It was registered at ClinicalTrials.gov (NCT03250858).

Participants

Participants were recruited from the Hugh Sinclair Unit of Human Nutrition's volunteer database (University of Reading), University mailing lists, social media (Facebook and Twitter), a university press release, online advertisements and word of mouth. Interested parties received information with links to the Consent Form and Participant Information Sheet hosted on the study website (eatwelluk.org), where these documents were available for reading and downloading. The online account creation, using e-mail and password, and the consent agreement were completed directly in the study website. It was made clear that participation was voluntary and that they were free to withdraw at any time without giving reason and without detriment. Participants were informed that they would need to complete online questionnaires at baseline, week 6 and week 12. There was no payment associated with participation, but all participants who completed the first set of questionnaires received an e-mail regarding a prize draw (4 prizes of £50 Amazon Vouchers were available) subject to the completion of the final questionnaire, which was included to improve participant retention. All contact with participants was via the website or e-mail.

Only subjects aged 18 years and older were included in the study. Screening was semi-automated in the web app where a minimal set of exclusion criteria were applied automatically (not living in the UK, pregnant, lactating, receiving face-to-face nutrition services, lactose intolerance, food allergies or diabetes). Other indications of potential exclusion were analysed by the researchers manually (self-report of health conditions, metabolic disorders, illness, medication and specific dietary requirements).

At the end of the screening form, participants were asked to report how they heard about the study, selecting from the following options: e-mail, Facebook, Instagram, Twitter, word-of-mouth or other. E-mails and social media links were created with customized URLs so that the application could also track the click source automatically [14], [15]. The participants were randomised automatically by the app using a random function [16] which ran in the browser. It generated a random number between 0 and 1. Depending on the value (lower or upper half of the interval) the participant was allocated to one of the two groups: PN or control.

Study protocol

The eNutri app had multiple functions [17]. It asked participants to complete a graphical FFQ [18] which was based on a previously validated FFQ [8], calculated the components of the m-AHEI [12], derived PN advice based on the m-AHEI score, and presented food-based dietary recommendations, together with a progress report. It also calculated and presented the ideal weight range of the participants, based on the Body Mass Index (BMI), and provided feedback on their PA level, based on the Baecke questionnaire [19]. In the version deployed in this study, the inputs to the decision engine generating the nutrition feedback were

limited to a participant's diet data and sex. The EatWellUK RCT included the following groups:

- Control group: web-based delivery of non-personalised dietary and PA advice based on the UK general healthy eating guidelines.
- Personalised group: web-based delivery of personalised food-based dietary, PA and weight management advice based on the individual's dietary intake, anthropometrics and PA levels (assessed by the Baecke questionnaire [19]).

Participants were asked to complete the online FFQ, the Baecke PA questionnaire [19] and provide their self-reported weight at baseline and weeks 6 and 12 during the intervention, and they received general (control group) or personalised (personalised group) advice at baseline and week 6. All participants received personalised recommendations at week 12 (upon completion of the study).

Although participants were encouraged to complete the FFQ in one session, it was important to offer the possibility to save the FFQ, in case of interruption or temporary Internet disconnection. Hence, each food selection was saved individually (after the portion size selection), and the participants could return to the last saved food item when they logged into the system again. Incomplete FFQs expired after 24 hours.

The interval between FFQs was also managed by the app. The second FFQ was made available only after 41 days (one day before the completion of 6 weeks) and the third (and final) FFQ after 77 days (11 weeks). If the participant logged into the system during the intervening intervals, a message was shown indicating the date when their next FFQ would be available. Textbox 1 summarizes the EatWellUK study procedure.

Textbox 1. EatWellUK study procedure

1. Online recruitment, providing the participant information sheet and consent form.
2. Account creation via the eatwelluk.org website.
3. Online consent form agreement.
4. Semi-automated screening.
    a. Manual screening for textual analysis (descriptions).
5. Participant's characteristics (gender, age, height, level of education).
6. Group allocation (randomization).
7. Weight, PA questionnaire and FFQ.
8. System usability scale (SUS) questionnaire.
9. Presentation of online advice.
10. Online advice evaluation.

Steps 1 to 9 were completed once at baseline (week 0) (˜20 minutes in total) [18]. The first completion of step 7 served as baseline data. Steps 7 and 9 were presented again in week 6 and week 12. Optional step 10 was presented only at the end of the study.

Outcome measures

Changes from baseline in dietary intake at 6 and 12 weeks were assessed via a FFQ [18]. The AHEI [12] was used as the foundation for the measuring the quality of the diet and to quantify the dietary intake changes. Some modifications were applied to the original AHEI to adapt it to the UK dietary guidelines and to improve its use as the decision engine for the

nutrition recommendation (i.e. not only the dietary intake assessment). The modified version of the index was named m-AHEI, which is described in Table 1. The maximum component score was changed from 10 to 100, in order to facilitate the data visualization and progress monitoring to the participant. The report design was presented in [20]. All of the 11 individual components were weighted equally and the overall score ranged from 0 to 100.

Table 1. Modified Alternative Healthy Eating Index (m-AHEI) components and score criteria[a]

Component	Criteria for minimum score (0)	Criteria for maximum score (100)
Vegetables, servings/d	0	≥5
Fruits, servings/d	0	≥4
Whole grains, g/d		
Women	0	≥75
Men	0	≥90
Dairy products[b], servings/d	0	≥3
Nuts and legumes[c], servings/d	0	≥1
PUFA[d], % of total energy	≤2	≥10
Long-chain (n-3) fats (EPA + DHA)[e], mg	0	≥250
Free sugars[f], % of total energy	≥15	0
Red and processed meat, servings/d	≥1.5	≤0.03
Sodium[g], mg/d	Highest decile	Lowest decile
Alcohol[h], drinks/d		
Women	≥2.5	≤1.5
Men	≥3.5	≤2

[a] The original AHEI was defined by Chiuve et al in [12]. Modifications for this intervention are indicated in the table with superscripts. Components have also been reordered, such that the components for which consumption is to be encouraged appear together at the top of the table.

[b] This component was not part of the original AHEI

[c] Vegetable protein was not included in the calculation of the m-AHEI score

[d] Presented to participants as "Healthy fats"

[e] Presented to participants as "Oily fish"

[f] Component was modified to "Free sugars" and presented as "Sugars"

[g] Presented to participants as "Salt". Highest and lowest deciles based on the Food4me study

[h] Score for non-drinkers was modified from the original AHEI where non-drinkers received a score of 2.5 out of 10

The original "sugar-sweetened beverages and fruit juice (serving/d)" was modified to "Free sugars (% of total energy)" to meet the recent recommendations in the UK [21][22]. Regarding the "alcohol" component, in the original AHEI non-drinkers received a score of 2.5 out of 10. This component was modified because this score could encourage non-drinkers to have moderated alcohol consumption. This type of recommendation was considered inappropriate, especially due to challenges related to alcoholism [23]. The "dairy products"

component was not present in the original AHEI but introduced to meet European guidelines such as the Netherland's recommendations: "take a few portions of dairy produce daily, including milk or yogurt" [24] and French "consume foods that are rich in calcium (mainly dairy products…) [25]. The original "Trans Fat" component was excluded after simulations with data from a prior study, which indicated limitations in the FFQ food list to estimate this component accurately (i.e. participants could receive a good score on this component due to a lack of food items in the food list with a significant proportion of trans fatty acids in their composition).

The effectiveness of the decision engine was captured in terms of users' actual diet change, using the m-AHEI as a primary outcome measure. Three diet messages were presented based on the three lowest m-AHEI component scores following each FFQ , following a protocol published previously [18][20].

Secondary outcome measures were weight and PA level. Changes from baseline were measured for self-reported weight (kg) at 6 and 12 weeks. Only two questionnaires per participants were considered in the outcome analysis, based on the date closest to the target date (12 weeks). Weight variation was combined with height (constant for adults) and reported as BMI variation (kg/m^2). A healthy BMI ranges from 18.5 to 25.0 kg/m^2, hence an ideal weight for a participant was presented as the midpoint at 21.75 kg/m^2. This approach was used to tailor the textual messages and visual representations in the app (i.e. coloured bars on the scale to represent the ideal weight range) [18].

As participants could be advised to either gain or lose weight, an analysis of the change in BMI without taking into account the direction of the change (i.e. increase/decrease) would not capture the effectiveness of the recommendation (i.e. opposite variations across participants would cancel one another). Thus, in the study, the absolute difference from the current BMI to the ideal BMI was analysed to see if the personalised advice decreased this difference significantly, in comparison to the control group.

Regarding PA levels, change was measured from baseline in self-reported PA (Baecke questionnaire) at 6 and 12 weeks. After each use of the app, all participants in the personalised group received their overall PA scores, followed by the three categories scores (sports, leisure and work), as defined by Baecke et al [19]. Messages related to the sports and leisure categories were provided, according to the participant's score in each category. As it was deemed unlikely for participants to have much control over the nature of their activities at work, no personalised message regarding the work category was provided [18]. Participants in the personalised group were able to see a progress report after each diet questionnaire. Participants in the control group were only able to see this report at the end of the study.

Online report evaluation

After completion of the study, the personalised online report was evaluated via nine questions regarding the users' perceived system effectiveness [26] and perceptions on its design. The first six questions were Likert items. The final three questions offered the possibility to write comments. The questionnaire is presented at the end of the results section, together with participants' responses.

Statistical analysis

For an individual m-AHEI component (e.g. fruits), a smaller treatment effect is expected if the participant in the personalised group did not receive advice for changing that specific component. Furthermore, the subgroup of participants with lower scores in the control group for a specific component have greater room to improve their score for that component than the group as a whole. In order to consider these points in the analysis, besides the treatment effect calculation for the two whole groups, it was also calculated for

the participants in the personalised group who received personalised messages for a specific component in comparison with the matched participants in the control group [27].
This RCT was powered based on the outcomes of a similar study [9], expecting an increase of 6.5% (mean=49.58, SD=9.51;Alpha=0.05; Power=0.8) in the m-AHEI. With these variables, the recruitment target 330 participants considering a 20% dropout rate.

Results

Participants

A total of 438 participants created accounts in the web application. Table 2 presents which recruitment sources were reported by the participants and also the results of the URL automatic tracking.

Table 2. Recruitment sources reported by the participants and automatically detected by the app

Recruitment Source	Self-report	Automatic URL track
e-mail	164 (37.4%)	199 (45.4%)
Facebook	59 (13.5%)	26 (5.9%)
Twitter	43 (9.8%)	11 (2.5%)
Instagram	0 (0.0%)	0 (0.0%)
Word-of-mouth	63 (14.4%)	0 (0.0%)
Other	72 (16.4%)	34 (7.8%)
Not available	37 (8.4%)	168 (38.4%)
Total	438 (100%)	438 (100%)

Out of the 438 accounts, 393 participants completed the screening questionnaire. Of these, 29 participants were excluded due to country of residence (n=6), medication (n=8) or dietary requirements such as lactose intolerance (n=10) or food allergy (n=7). Excluding the 29 participants who were not eligible to participate, 364 participants were randomized automatically by the app, but 39 participants did not complete the baseline questionnaire (Figure 1).

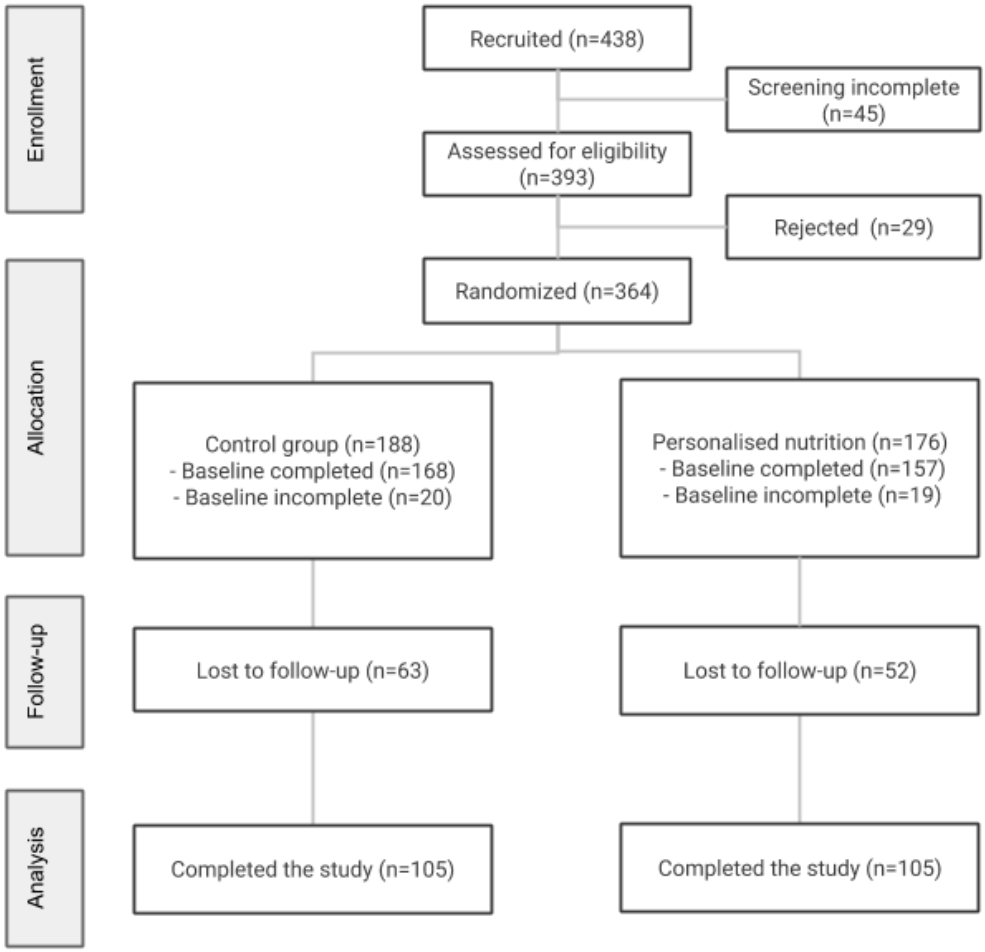

Figure 1. CONSORT flow diagram for the EatWellUK study

Out of the 325 participants who completed the baseline FFQ, 210 completed at least one additional FFQ and these were considered in the RCT. 114 participants from the control (n=54) and PN group (n=60) also completed their third FFQ. At the end of the study, the participants were presented with an optional questionnaire to provide feedback on the report. Of the 123 feedback forms received, 58 were from the control group and 63 from the PN group. These feedback responses were combined since all of the participants were able to see the same report at the end of the study and no significant differences were found between the groups. The characteristics of the participants included in the analysis are presented in Table 3.

Table 3. Characteristics of the EatWellUK study participants

Characteristics	Total	Control	PN
Total, n (%)	210 (100%)	105 (50%)	105 (50%)
Sex			
Female, n (%)	169 (80.5)	88 (41.9)	81 (38.6)
Male n (%)	41 (19.5)	17 (8.1)	24 (11.4)
Level of Education			
Less than secondary	0 (0.0)	0 (0.0)	0 (0.0)
Secondary	25 (11.9)	16 (7.6)	9 (4.3)

College	24 (11.4)	12 (5.7)	12 (5.7)
Bachelor	70 (33.3)	28 (13.3)	42 (20.0)
Postgraduate	91 (43.3)	49 (23.3)	42 (20.0)
Age (years)			
Mean	43.0	42.4	43.6
Range	18-85	20-82	18-85

Diet and physical activity questionnaires

The baseline results of the first set of questionnaires are presented in Table 4.

Table 4. Unadjusted baselines of the control (n=105) and personalised group (n=105) presented as means (SD) for m-AHEI scores, Baecke scores and BMI.

	Unadjusted Baseline	
Variables	**Control (n=105)**	**PN (n=105)**
m-AHEI overall score[b]	58.25 (12.28)	55.95 (11.73)
Vegetables	67.12 (26.97)	58.80 (29.03)
Fruits	64.52 (31.67)	59.97 (34.86)
Whole grains	40.81 (34.72)	34.76 (33.19)
Dairy products	86.26 (29.21)	94.35 (18.79)
Nuts and Legumes	45.95 (37.98)	26.55 (33.79)
Free sugars	44.7 (27.52)	49.81 (27.34)
Red and processed meat	29.82 (37.58)	25.87 (36.51)
Healthy fats	53.46 (18.01)	50.15 (16.50)
Oily fish	60.87 (42.97)	69.82 (37.88)
Salt	55.91 (35.75)	57.31 (31.67)
Alcohol	91.50 (25.57)	88.69 (28.16)
PA (Baecke) overall score	53.25 (10.19)	51.37 (9.83)
Leisure score	59.67 (13.23)	59.05 (13.3)
Sports score	54.67 (21.34)	49.67 (19.09)
Work score	45.46 (11.49)	45.61 (10.94)
Absolute BMI (kg/m^2)	24.64 (5.05)	24.52 (4.93)
Distance to ideal BMI (kg/m^2)	3.84 (4.37)	3.77 (4.21)

Primary outcomes evaluation

Considering the protocol for selecting the second FFQ (i.e. the one closest to the 12-week), the trial resulted in an average interval between FFQs of 10.8 weeks. The analysis by group confirmed that the intervals were equivalent across the control (10.7 weeks) and PN groups (10.8 weeks). The outcomes for the second FFQ were adjusted with the corresponding baseline means as a covariate in order to measure the treatment effect [27]. The results for the m-AHEI scores are presented in Table 5.

Table 5. Effects of the 12-week intervention on the m-AHEI components, considering all of the participants in the control (n=105) and PN groups (n=105)[a]

	Adjusted Mean		Adjusted Δ		Treatment Effect	
Variables	**Control (n=105)**	**PN (n=105)**	**ΔControl (n=105)**	**ΔPN (n=105)**	**ΔPN-ΔControl (95% CI)**	**p**
Overall m-AHEI score	56.85	59.91	-0.25	2.81	3.06 (0.91 to 5.21)	0.005
Vegetables	58.31	55.85	-4.65	-7.11	-2.45 (-8.29 to 3.39)	0.409
Fruits	56.44	58.76	-5.81	-3.48	2.33 (-3.76 to 8.41)	0.452
Whole grains	33.54	32.63	-4.25	-5.16	-0.91 (-7.72 to 5.89)	0.792
Dairy products	89.81	91.56	-0.49	1.25	1.74 (-4.17 to 7.66)	0.562
Nuts and Legumes	40.92	45.97	4.66	9.72	5.05 (-4.35 to 14.45)	0.290
Free sugars	45.78	52.54	-1.48	5.28	6.76 (0.58 to 12.95)	0.032
Red and processed meat	30.35	35.58	2.51	7.74	5.22 (-0.77 to 11.22)	0.087
Healthy fats	52.73	51.12	0.92	-0.68	-1.60 (-5.80 to 2.59)	0.452
Oily fish	62.86	68.6	-2.48	3.25	5.74 (-2.99 to 14.47)	0.197
Salt	64.64	69.79	8.02	13.18	5.15 (-2.10 to 12.40)	0.163
Alcohol	93.08	92.92	2.99	2.83	-0.16 (-5.57 to 5.24)	0.953

[a] Data presented as adjusted means with the baseline values as covariate [27].

The treatment effect observed in the overall m-AHEI score was 3.06 (CI 95% 0.91 to 5.21), which reached statistical significance (p=0.005). Only one individual component (free sugars) had a statistically significant (p=0.032) improvement of 6.76 (CI 95% 0.58 to 12.95) during the intervention period.

All of the participants in the personalised group (n=105) received feedback regarding their m-AHEI overall score and were able to see the progress report with all of the individual m-AHEI scores, however, the focus of the advice was on just 3 personalised diet messages [18]. In other words, the outcomes for individual m-AHEI components presented in Table 5 did not take into account whether a specific participant received a personalised message for that component, but showed how the individual m-AHEI components were affected by the intervention on the whole.

The decision to present three personalised messages per report [28] directly affects the analysis of the outcomes of the personalisation. The higher the number of diet messages presented, the higher the percentage of participants in the personalised group who will receive personalised messages for each component. The same rationale is valid for matched participants in the control group who would have received those messages if they had been randomised to the personalised group, as presented in Table 6. The distribution presented in the final column of Table 6 gives an indication of the individual components coverage applying this specific decision engine for PN in the UK adult population.

Table 6. Messages presented to the personalised group (total n=105) and matched participants in the control group (total n=105) when only messages for the top 3 components in need of change are presented[a].

	Matched Control		PN messages		Total messages	
m-AHEI Component	**n**	**%**	**n**	**%**	**n**	**%**
Red and processed meat	64	10.2	69	11.0	133	21.1

Nuts and Legumes	49	7.8	77	12.2	126	20.0
Whole grains	49	7.8	54	8.6	103	16.3
Salt	33	5.2	26	4.1	59	9.4
Free sugars	32	5.1	20	3.2	52	8.3
Oily fish	33	5.2	18	2.9	51	8.1
Fruits	17	2.7	15	2.4	32	5.1
Healthy fats	14	2.2	10	1.6	24	3.8
Vegetables	8	1.3	13	2.1	21	3.3
Alcohol	7	1.1	9	1.4	16	2.5
Dairy products	9	1.4	4	0.6	13	2.1
Total	**315**	**50**	**315**	**50**	**630**	**100**

[a] Components are ordered by the number of total number of messages that were (personalised group) or would have been (control group) presented to participants. Since each participant received 3 messages, the total of messages is 315 for each group (n=105)

The treatment effect on participants in the personalised group who received personalised messages for a specific component was also calculated in comparison with the matched participants in the control group, as shown in Table 7.

Table 7. Changes in the m-AHEI components from baseline to week 12 for participants in the personalised group who received individual component messages and the matched participants in the control group[a].

m-AHEI Component	**Matched Control**			**Personalised Nutrition**			**Treatment effect**	
	n	**Mean**	**Δ**	**n**	**Mean**	**Δ**	**ΔPN-ΔControl (95% CI)**	**P**
Vegetables	8	38.75	9.85	13	33.00	4.09	-5.75 (-29.03 to 17.52)	0.610
Fruits	17	25.35	2.57	15	28.47	5.69	3.11 (-9.53 to 15.75)	0.618
Whole grains	49	19.89	6.46	54	22.77	9.34	2.89 (-5.07 to 10.84)	0.473
Dairy products	9	35.18	15.11	4	67.59	47.51	32.40 (-19.23 to 84.03)	0.192
Nuts and Legumes	49	34.17	19.18	77	39.40	24.42	5.23 (-7.31 to 17.78)	0.411
Free sugars	32	23.27	6.79	20	39.67	23.19	16.40 (1.46 to 31.35)	0.032
Red and processed meat	64	13.09	9.22	69	18.26	14.39	5.17 (-2.73 to 13.06)	0.198
Healthy fats	14	50.07	7.57	10	52.40	9.90	2.32 (-10.66 to 15.30)	0.714
Oily fish	33	25.92	18.48	18	37.38	29.94	11.46 (-8.95 to 31.87)	0.264

Salt	33	46.54	28.88	26	58.85	41.19	12.31 (-5.09 to 29.70)	0.162
Alcohol	7	45.37	35.99	9	62.71	53.34	17.34 (-35.06 to 69.74)	0.487

[a] Data presented as adjusted means with the baseline values as covariate [27].

Secondary outcomes evaluation

As all of the participants received advice on weight and PA, analysis of matched participants was not required for the secondary outcomes evaluation. Absolute BMI was not affected by the treatment, with both groups reporting a -0.12 kg/m^2 reduction after 12 weeks (Table 8). The mean distances to the ideal BMI decreased (i.e. BMI improvement) less in the control group (-0.06 kg/m^2) than in the personalised group (-0.18 kg/m^2), but this improvement (-0.07 kg/m^2) was not statistically significant (p=0.488). Some participants in the control (n=13) and personalised group (n=21) reported the same weight at week 12 and baseline. The overall Baecke score improved by 0.37 (CI 95% -1.12 to 1.87) but this effect was not significant (p=0.624).

Table 8. Changes in BMI and PA level (Baecke) score from baseline to week 12 for participants in the control (n=105) and personalised group (n=105). Values presented as adjusted means.

	Adjusted Mean		**Adjusted Δ**		**Treatment Effect**	
	Control (n=105)	**PN (n=105)**	**ΔControl (n=105)**	**ΔPN (n=105)**	**ΔPN-ΔControl (95% CI)**	**p**
BMI (kg/m^2)[a]						
Absolute BMI	24.65	24.66	-0.12	-0.12	-0.00 (-0.20 to 0.21)	0.964
Ideal BMI distance	3.79	3.72	-0.06	-0.13	-0.07 (-0.27 to 0.13)	0.488
PA (Baecke) score[b]						
Overall score	52.79	53.16	0.39	0.76	0.37 (-1.12 to 1.87)	0.624
Leisure score	57.28	58.70	-2.12	-0.70	1.42 (-0.87 to 3.71)	0.222
Sports score	55.08	53.17	2.68	0.76	-1.92 (-5.02 to 1.18)	0.224
Work score	46.20	47.62	0.66	2.09	1.43 (-0.16 to 3.01)	0.077

[a] Presented as simple variations and absolute distance to the ideal BMI (21.75 kg/m^2)

[b] Values are reported on a scale between 0 and 100

Online report evaluation

The analysis of the 15 comments provided in the first qualitative question (Table 9) showed that 9 were related to the stages before the diet advice itself (i.e. assessment). Minor issues related to the FFQ (n=3), Baecke questionnaire (n=3) and difficulties finding the link to the online report (n=3) were mentioned. One participant asked to see the scientific evidence for the recommendations (i.e. details of the m-AHEI score calculations) and 5 participants disagreed somehow with the personalised advice provided, mainly due to the dairy products and meat recommendations (n=4).

Table 9. Qualitative user feedback for the open questions related to the personalised report

Question	Yes n (%)	No n (%)
1. Was there anything in the report that you found particularly difficult to understand?	15 (12.2)	108 (87.8)
2. Do you need additional information to help you make changes to your diet at this moment?	6 (4.9)	117 (95.1)
3. Do you have any further comments regarding the feedback you received?	14 (11.4)	109 (88.6)

For the second question (Table 9), five out of the six comments were confirmations of the need for dietary change (e.g. “Diet reflects difficult time in personal life - need to change that”, “more time to prepare meals” and “late night eating”) and one participant requested more scientific explanation of the advice (“If you want me to follow advice I would like to understand the basis”). Out of the 14 comments received in response to the third question (Table 9), three were related to the FFQ. Five comments were about the limitations of the PA feedback (e.g. “I do not think the report is a reflection on my sporting activity”, “I am a successful amateur athlete in good health. I am interested to hear some of the reasoning behind the recommendations you have made for me”). The other six questions were about the diet recommendations and the majority (n=4) mentioned their partial disagreement with some of the diet advice (e.g. “I do not agree with the advice to increase dairy foods. This is a very narrow view of the full picture”, “I have too much salt and meat but I don't think I do”, “It did not reflect I cook from scratch rather than buy ready-made meals”).
The results of the questions related to the quality of the design (first two questions) and the perceived effectiveness of the recommendations [26] are shown in Table 10 using a Likert scale.

Table 10. User evaluation of the online report in a likert scale

Question	Strongly Disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly Agree n (%)
I find the feedback report attractive to read.	2 (1.63)	7 (5.69)	45 (36.59)	61 (49.59)	8 (6.5)
Overall, I understood the feedback report.	2 (1.63)	2 (1.63)	15 (12.2)	84 (68.29)	20 (16.26)
After reading the report, I know how to change my diet to make it healthier.	2 (1.63)	9 (7.32)	29 (23.58)	73 (59.35)	10 (8.13)
The report showed useful advice.	2 (1.63)	10 (8.13)	32 (26.02)	69 (56.1)	10 (8.13)
The report reflected my diet intake.	1 (0.81)	19 (15.45)	33 (26.83)	62 (50.41)	8 (6.5)
I found the application useless.	29 (23.58)	56 (45.53)	27 (21.95)	10 (8.13)	1 (0.81)

Discussion

Principal Results

This RCT was designed to primarily test whether personalised food-based dietary online advice, using the m-AHEI as the foundation of the decision engine, was more effective than generalised population advice at motivating beneficial dietary change. The significant (p=0.005) treatment effect (3.06 points in the m-AHEI scale), as shown in Table 5, represented an increase of 5.36% in the mean m-AHEI baseline (57.10) (Table 4). This result confirmed the hypothesis that the eNutri app is an effective online tool for PN advice, at least in the UK.
Only one m-AHEI component (“Free sugars”) reached significance in the treatment effect (Table 6), but apart from “Vegetables” all the other components had positive effects, indicating that the personalisation could potentially have reached significance with more participants. This study was powered to primarily measure the treatment effect in all the

participants (i.e. not the individual components). The fact that individual m-AHEI scores started from different baselines (Table 4) and are presented to the participants with different probabilities (Table 6) makes it more difficult to reach statistical significance. For example, some m-AHEI components (e.g. “Dairy Products” and “Alcohol”) started with mean baseline values close to the best possible score and were presented to small numbers of participants. This does not mean that these components should be removed from the m-AHEI, but in order to test the significance of the personalisation of these diet messages, a much larger RCT would be necessary, which is viable over the Internet.
The decrease in the distance to the ideal BMI by 0.07 kg/m^2 (Table 8) in 12 weeks does not indicate that similar interventions may be effective for weight loss and control.
The results of the PA questionnaire (Table 8) also did not indicate that this type of personalisation may be effective. It may confirm that more robust and personalised PA trackers, such as GPS or pedometers, may be necessary for delivering effective interventions.
Results presented in Table 10 showed that the participants understood the report and were confident about the next changes in their diets. The first two questions in Table 10indicated good acceptance of the content and design of the report but also showed that its understanding was better than its attractiveness. Further improvements in its design may be necessary. The last four questions in Table 10 showed a good perceived effectiveness of the report by the majority of the participants.

Limitations
The power calculation for this study was based on the expected increase in the overall m-AHEI score. Other studies with more participants, taking into account the baseline values (Table 4) and distribution of messages (Table 6) may be necessary if the individual m-AHEI components are to be analysed. For this reason, where advice on a particular component was delivered to only relatively few participants, the effect of the advice on the component should be read cautiously considering the large confidence intervals described.
Although the design of the diet messages had followed the same structure [18], some messages were presented to only a few participants (Table 6), then the understanding of the report (second question in Table 10) should not be generalized to all the textual diet messages.
The fact that weight was self-reported online may have impacted on the results, especially as some participants may not have had weighing scale at home or were not able to weight themselves for the subsequent app visits (i.e. participants may have re-entered the original value without taking a new measurement). This may justify why 24 participants reported no change in weight, increasing the difficulty to reach statistical significance for the BMI changes.

Comparison with Prior Work
A recent systematic review presented 26 remotely delivered dietary interventions using self-monitoring or tailored feedback. 51 dietary outcomes were analysed in the 23 interventions considered in the meta-analysis, resulting on an average of 2.2 dietary outcomes per intervention. The most popular ones were fruits, vegetables and fat and only three interventions target more than four dietary outcomes. This review also considered interventions delivered over the phone or offline media (e.g. printed reports, CD-ROM). Only seven interventions used modern online methods, such as websites or apps. The aim of this review of the literature was to analyse the effectiveness of these interventions, and the authors concluded that they showed a significant, but small and at risk of bias, positive effect on dietary change [11]. The differences in the dietary outcomes make the

comparisons more difficult, especially because the changes in some dietary outcomes may affect other components not measured during the intervention (e.g. the increase of fruits and vegetables may decrease nuts and legumes), due to the dynamic aspect of diets.
Prior to the EatWellUK study, the most closely-related and important work was the Food4Me study [29], in which 1269 participants completed their 6-month PN study. The researchers also reported no significant effect of personalised advice on BMI (-0.24 kg/m^2) relative to a control group. It is difficult to compare the effectiveness on BMI since the authors did not report the distance to the ideal BMI, as proposed by the current research. The Food4me study used the Healthy Eating Index (HEI) [30], which was the basis for the AHEI [12], as a secondary outcome measure of the quality of the diet. Their treatment effect on the overall HEI was 1.27 (95% CI 0.30 to 2.25, p=0.010), suggesting an improvement in diet quality following PN advice. Participants randomized to receive PN were reported to consume less red meat, salt, saturated fat and energy and also increased their folate intake [9]. Although statistically significant, their increase in the HEI was also relatively small, confirming the challenge to encourage healthier diets and the need of similar studies.

Conclusions

This work presented the treatment effects of a 12-week online RCT with 210 participants, which is likely to be the second largest online dietary intervention in the UK and the only one delivered automatically [11]. It aimed to measure the effectiveness of a novel online PN advice tool (eNutri), using a modified version of the AHEI as the foundation of the decision engine to deliver online personalised food-based dietary advice. Results show that the design and protocol followed by this study motivated change to a healthier diet. The use of eNutri app could contribute to improved diet quality. Findings from this study, including the online report evaluation, are important do improve eNutri or similar apps. The design principles and algorithms can be used and improved by other researchers and institutions interested in online PN advice, especially because the eNutri web app was made publicly available under a permissive open-source license [31]. This work represents an important landmark in the field of automatically delivered online dietary interventions.

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Conflicts of Interest

None declared

Abbreviations

AHEI: Alternative healthy eating index
BMI: Body mass index
CNPq: National Council of Technological and Scientific Development (Brazil)
FFQ: Food frequency questionnaire
Food4me: Food for me project
m-AHEI: Modified alternative healthy eating index
NCD: Non-communicable diseases
PA: Physical activity

PN: Personalised nutrition
RCT: Randomized controlled trial
URL: Uniform resource locator

Multimedia Appendix 1
Multimedia appendices are supplementary files, such as a PowerPoint presentation of a conference talk about the study, additional screenshots of a website, mpeg/Quicktime video/audio files, Excel/Access/SAS/SPSS files containing original data), and questionnaires. See https://jmir.zendesk.com/hc/en-us/articles/115003396688 for further information. Do not include copyrighted material unless you obtained written permission from the copyright holder, which should be uploaded together with your Publication Agreement form as supplementary file.

The Multimedia Appendices must be uploaded online, accompanied by a caption. CONSORT-EHEALTH checklists are always uploaded as Multimedia Appendices. Although this is primarily intended for randomized trials, the section of the checklist describing how an intervention should be reported is also relevant for manuscripts with other evaluation designs.
Before submission, authors of RCTs must **fill in the electronic CONSORT-EHEALTH questionnaire at http://tinyurl.com/consort-ehealth-v1-6** with quotes from their manuscript (if you wish to comment on the importance of the items from the checklist for reporting, please also rate each item on a scale between 1-5). BEFORE you press submit, please generate a pdf of the form with your responses and upload this file as supplementary file entitled CONSORT-EHEALTH V1.6.

References

[1] WHO, "Global status report on noncommunicable diseases 2010," 2010.
[2] National Health Service (NHS), "How to have a balanced diet - Healthy living - NHS Choices." [Online]. Available: https://www.nhs.uk/Livewell/Goodfood/Pages/Healthyeating.aspx. [Accessed: 22-Feb-2018].
[3] UK Government, "The eatwell plate," *NHS*, 2015. [Online]. Available: https://www.gov.uk/government/publications/the-eatwell-guide [http://www.webcitation.org/6gXeDsgOZ]. [Accessed: 05-Apr-2016].
[4] S. Capacci and M. Mazzocchi, "Five-a-day, a price to pay: An evaluation of the UK program impact accounting for market forces," *J. Health Econ.*, vol. 30, no. 1, pp. 87–98, Jan. 2011.
[5] C. Lalji, D. Pakrashi, and R. Smyth, "Can eating five fruit and veg a day really keep the doctor away?," *Econ. Model.*, Aug. 2017.
[6] C. Celis-Morales, J. Lara, and J. C. Mathers, "Personalising nutritional guidance for more effective behaviour change," *Proc. Nutr. Soc.*, vol. 44, no. June 2014, pp. 1–9, 2014.
[7] R. Z. Franco, R. Fallaize, J. A. Lovegrove, and F. Hwang, "Popular Nutrition-Related Mobile Apps: A Feature Assessment.," *JMIR mHealth uHealth*, vol. 4, no. 3, p. e85, Aug. 2016.
[8] R. Fallaize *et al.*, "Online Dietary Intake Estimation: Reproducibility and Validity of the Food4Me Food Frequency Questionnaire Against a 4-Day Weighed Food Record," *J. Med. Internet Res.*, vol. 16, no. 8, p. e190, Aug. 2014.
[9] C. Celis-Morales *et al.*, "Effect of personalized nutrition on health-related behaviour change: evidence from the Food4me European randomized controlled trial," *Int. J. Epidemiol.*, no. August, p. dyw186, Aug. 2016.

[10] H. Forster *et al.*, "Development and automation of a dietary feedback system for the delivery of personalised dietary advice," *Vandevijvere S Swinburn B BMJ Open Nutr Rev Celis-Morales C Genes Nutr*, vol. 4, no. 10OCE4, 2015.
[11] N. Teasdale *et al.*, "Systematic review and meta-analysis of remotely delivered interventions using self-monitoring or tailored feedback to change dietary behavior," *Am. J. Clin. Nutr.*, vol. 107, no. 2, pp. 247–256, Feb. 2018.
[12] S. E. Chiuve *et al.*, "Alternative dietary indices both strongly predict risk of chronic disease.," *J. Nutr.*, vol. 142, no. 6, pp. 1009–18, Jun. 2012.
[13] M. M. L. McCullough and W. C. W. Willett, "Evaluating adherence to recommended diets in adults: the Alternate Healthy Eating Index.," *Public Health Nutr.*, vol. 9, no. 1A, pp. 152–157, 2006.
[14] Google, "URL builders - Analytics Help," 2018. [Online]. Available: https://support.google.com/analytics/answer/1033867?hl=en. [Accessed: 29-Jan-2018].
[15] Angulartics, "Analytics for AngularJS applications," 2018. [Online]. Available: https://github.com/angulartics/angulartics.
[16] Mozilla Developer Network, "Math.random() - JavaScript," 2017. [Online]. Available: https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Math/random.
[17] R. Zenun Franco, "Online Recommender System for Personalized Nutrition Advice," in *Proceedings of the Eleventh ACM Conference on Recommender Systems - RecSys '17*, 2017, pp. 411–415.
[18] R. Franco, R. Fallaize, J. Lovegrove, and F. Hwang, "Online dietary intake assessment using a graphical food frequency app (eNutri): usability study," *Under Rev.*, 2018.
[19] J. A. Baecke, J. Burema, and J. E. Frijters, "A short questionnaire for the measurement of habitual physical activity in epidemiological studies.," *Am. J. Clin. Nutr.*, vol. 36, no. 5, pp. 936–42, Nov. 1982.
[20] R. Fallaize, R. Zenun Franco, F. Hwang, and J. A. Lovegrove, "Evaluation of the eNutri automated personalised nutrition app by Nutrition Professionals in the UK," *Under Rev.*, 2018.
[21] Scientific Advisory Committee on Nutrition, "Carbohydrates and Health," 2015.
[22] G. E. Swan, N. A. Powell, B. L. Knowles, M. T. Bush, and L. B. Levy, "A definition of free sugars for the UK," *Public Health Nutr.*, pp. 1–3, Mar. 2018.
[23] J. Rehm, C. Mathers, S. Popova, M. Thavorncharoensap, Y. Teerawattananon, and J. Patra, "Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders," *Lancet*, vol. 373, no. 9682, pp. 2223–2233, Jun. 2009.
[24] D. Kromhout, C. J. K. Spaaij, J. de Goede, and R. M. Weggemans, "The 2015 Dutch food-based dietary guidelines," *Eur. J. Clin. Nutr.*, vol. 70, no. 8, pp. 869–878, Aug. 2016.
[25] Food and Agriculture Organization of the United Nations, "Food-based dietary guidelines - France." [Online]. Available: http://www.fao.org/nutrition/education/food-based-dietary-guidelines/regions/countries/france/en/. [Accessed: 05-Apr-2018].
[26] B. P. Knijnenburg, M. C. Willemsen, Z. Gantner, H. Soncu, and C. Newell, "Explaining the user experience of recommender systems," *User Model. User-adapt. Interact.*, vol. 22, no. 4–5, pp. 441–504, 2012.
[27] A. J. Vickers and D. G. Altman, "Statistics notes: Analysing controlled trials with baseline and follow up measurements.," *BMJ*, vol. 323, no. 7321, pp. 1123–4, Nov. 2001.
[28] M. C. Rosal, C. B. Ebbeling, I. Lofgren, J. K. Ockene, I. S. Ockene, and J. R. Hebert,

"Facilitating dietary change: the patient-centered counseling model.," *J. Am. Diet. Assoc.*, vol. 101, no. 3, pp. 332–41, Mar. 2001.
[29] C. Celis-Morales *et al.*, "Design and baseline characteristics of the Food4Me study: a web-based randomised controlled trial of personalised nutrition in seven European countries.," *Genes Nutr.*, vol. 10, no. 1, p. 450, Jan. 2015.
[30] P. M. Guenther *et al.*, "Update of the Healthy Eating Index: HEI-2010.," *J. Acad. Nutr. Diet.*, vol. 113, no. 4, pp. 569–80, Apr. 2013.
[31] R. Zenun Franco, "GitHub - Rodrigo Zenun - eNutri," 2018. [Online]. Available: https://github.com/rodrigozenun/enutri.