Impact of Dietary Practices and Physical Activity on Obesity and Overweight in Omani Adults and effectiveness of lifestyle interventions using Smart Phone Applications

Khalid Al Zuhaibi

Thesis submitted to the University of Nottingham

for the degree of Doctor of Philosophy

August 2017

Abstract

Overweight and obesity in Oman have increased dramatically in recent years and are associated with increases in cardiovascular disease and diabetes. This project explored the food choices, dietary intake and physical activity of Omani adults. The effectiveness of smartphone apps on physical activity behaviours in Omani adults was also investigated.

In study 1, a survey was conducted on 500 healthy adults living in Oman during the period from December 2013 to April 2014. Eligible participants completed questionnaires, specifically designed for this study and administrated by trained health educators in all governorates in Oman. 55% of the population studied were either overweight or obese (particularly those over 30y of age). BMI was significantly ($p<0.05$) affected by gender and age group but not by residential area (urban vs rural). Dietary analysis indicated a high consumption of 'fast food' but total energy intakes failed to explain the high incidence of obesity. However, the questionnaire indicated a high level of physical inactivity within the population.

Study 2, implemented in two phases, aimed to investigate the efficacy of three smartphones apps (MapMyFitness, Lose it, and Pacer) on improving physical activity in Omani male and female adults. Phase1 studied male and female Omani citizens living in the UK while phase 2 specifically investigated females living in Oman. Both phases showed significant increases in physical activity amongst the participants though, due to the short period of intervention (4 weeks), this was associated with only modest changes in BMI.

The prevalence of overweight and obesity amongst adults highlights the need for intervention strategies, targeting unhealthy lifestyle behaviours, to curb the prevalence of NCDs in Oman. Smartphone apps, represent potential tool to facilitate changes in lifestyle factors associated with the high prevalence obesity in Omani adults.

Key words: Obesity, physical activity, energy intake, MapMyFitness, Lose it, Pacer, Oman.

Acknowledgements

First and foremost, I would like to thank **Allah (my Glorified Lord)** who has granted me this great opportunity to pursue my higher education and gave me the strength to complete this PhD thesis.

I would like to express my sincere gratitude to my supervisors, **Professor Andrew Salter**, and **Dr. Fiona McCullough** for their continuous support of my PhD for their patience, encouragement, and immense knowledge. Their guidance helped me in all the time of research and writing of this thesis.

Beside my supervisors, I would like to thank the rest of my thesis committee: **Dr. Judy Anne Swift** and **Dr. Andrew Murton**, for their insightful and constructive comments and suggestions which incented me to widen my research from various perspectives.

My thanks go to all members in the Department of Nutritional Science, who gave me access to all research facilities and overwhelmed me with their kindness, cooperation during my research study.

The financial support by "National Program of Postgraduate scholarships" in Oman is greatly acknowledged.

My sincere thanks also go to **Dr. Masood Al Maskari**, for his insightful suggestions during preparing my PhD proposal, and to **Nahla Al Anqoodi**, for her great participation in this study, and to all study participants in Oman and Omani students participants in the University of Nottingham, without which all this work would not have been possible.

Last but not least, I would like to thank my family: my parents, my wife, my children and to my brothers and sisters for supporting me spiritually throughout writing this thesis.

Funding

This research was funded by Ministry of Higher Education in The Sultanate of Oman, as part of National Program for Post Graduate Studies funded.

List of publication and communications

Poster at summer conference 2015: The Future of Animal Products in the Human Diet: Health and Environmental Concerns (6-9 July 2015), Sutton Bonington campus, University of Nottingham, UK. *Organised by The Nutrition Society*. https://www.nutritionsociety.org/

1. **Impact of Dietary Practices on Metabolic Health in Omani Adults.** By K. Al Zuhaibi, F. McCullough and A.M. Salter, *University of Nottingham, Loughborough, Leicestershire, LE12 5RD, UK.*(1)

Oral communications at Spring Conference 2017: Nutrition and Exercise for Health and Performance (28-29 March 2017), University of Stirling, Sterling, Scotland. *Organised by The Nutrition Society*. https://www.nutritionsociety.org/

2. **Effectiveness of health and fitness smartphone applications to improve dietary habits and physical activity in Omani adults** By K. Al Zuhaibi[1], F. McCullough[2] and A.M. Salter[2], *University of Nottingham, Loughborough, Leicestershire, LE12 5RD, UK.*

List of Contents

List of abbreviations

BCTs	Behaviour Change Techniques
BMI	Body Mass Index
BP	Blood Pressure
CHD	Coronary Heart Disease
CMR	Cardiometabolic Risk
CRF	Cardiorespiratory Fitness
CT	Computed Tomography
CV	Cardiovascular Disease
DALYs	Disability-Adjusted Life Years.
DM	Diabetes Mellitus
EFSA	The European Food Safety Authority
EMR	The East Mediterranean Region
FAO	Food and Agriculture Organisation
FBDG	Food-Based Dietary Guideline
FFAs	Free Fatty Acids
GPS	Global Positioning System
HDI	Human Development Index
HF	Heart Failure
HRQOL	Health-Related Quality Of Life
IHD	Ischaemic Heart Disease
MENA	Middle East and North Africa
MHO	Metabolically Healthy Obesity
MRI	Magnetic Resonance Imaging

MS	Metabolic Syndrome
NAFLD	Non-Alcoholic Fatty Liver Disease
NCD	Non-communicable disease.
NGO	Non-Governmental Organisations
NHANES	National Health and Nutrition Examination Surveys
OECD	Organisation for Economic Cooperation and Development
OWHS	The Oman World Health Survey
PA	Physical Activity
PLU	Price Look-Up code
SAT	Subcutaneous Adipose Tissue
SNS	Sympathetic Nervous System
T2D	Type 2 Diabètes Mellites
TTM	The transtheoretical model
UK	The United Kingdom
UNFPA	United Nations Population Fund
UNICEF	Unite Nations Children's Fund
USA	The United States of America
USDA	United States Department of Agriculture
VAT	Visceral Adipose Tissue
WC	Waist Circumference
WCRF	World Cancer Research Fund
WHO	World Health Organisation
WHO/EMRO	Eastern Mediterranean Regional Office of the World Health Organisation.
WHR	Waist Hip Ratio

List of Tables

List of Figures

Chapter 1: Introduction

During the last three to four decades, overweight and obesity have been transformed from relatively minor public health issues that mainly affected the most affluent societies, to become a global public health crisis that severely impairs both health and quality of life. The rapid increase of this pandemic represents a major challenge confronting health and chronic disease prevention around the world and has been fuelled by industrialisation, economic growth, urbanisation, mechanised transport, sedentary lifestyle, and nutritional transition to high calorie diets and processed foods (2) . Overweight and obesity have increased dramatically worldwide in both genders and in all age groups. Recent studies have shown that about two billion people are overweight and one third of them obese (2).

The obesity epidemic was originally observed in the USA and Europe. According to The World Health Organisation (WHO) observatory data, prevalence of overweight and obesity were highest in WHO regions of the Americas and lowest in the South East Asia counterparts during the period from 1978 to 2014 (3). Although obesity is considered as predominantly affecting high-income and developed countries, its prevalence is now increasing in both developing countries and low-and middle-income countries (4). For instance, in some Gulf cooperation council countries (GCC), which include (Oman, Kuwait, Saudi Arabia, Bahrain, Qatar, and United Arab Emirates), more than half of the population is either overweight or obese (5).

The prevalence of obesity has shown some differentiation between genders. In all WHO regions, women, are more likely to be obese than men. In WHO regions of the Americas, Europe, and the East Mediterranean more than 50% of women were overweight. In WHO regions of Africa, East Mediterranean and South East Asia, women have almost double the obesity prevalence of men (6). The prevalence of obesity, in GCC countries, is higher in women and this holds a non-linear association with age (7). The rising prevalence of overweight and obesity in general, and in childhood in particular, forebodes a burden of disease in individuals, as well as health care systems, in the decades to come. Obesity is considered as a major contributor to a wide range of health issues including diabetes, hypertension, cardiovascular diseases (CVD), and even some cancers (8). Globally, it contributes to the death of about three million people every year and creates serious health problems for millions of others, as well as limiting the productivity of individuals and their ability to work (8). Thus, obesity is expensive and requires greater health care expenditure to successfully manage the effects and sequelae.

On a basic level, obesity arises as a result of energy imbalance between calories consumed and the calories expended, creating a state of positive energy balance represented in excess body weight and adipose tissue mass (4). The major drivers of obesity have been much debated, though modern food systems and physical inactivity are now accepted as the predominant factors contributing to the present obesity epidemic. An obesogenic environment, with increased reliance on technologies to perform daily living tasks, and the changes in the global food supply, has been spreading across the word. Such environments offer more energy-dense foods in combination with sociocultural, environmental and economic factors all associated with sedentary lifestyle behaviour and unhealthy dietary habits. Therefore, increasing physical activity or reducing caloric intake (or combination of the two) should theoretically mitigate the problem. Several interventions and strategies have been implemented in different times, and regions in the world, in order to address obesity. However, frequently the success of such strategies and interventions have been limited in their effectiveness. Although technology is being blamed as a contributor to the prevalence of many unhealthy lifestyle behaviours, it is also being developed to play a role in health management and provide solutions to many of the limitations in traditional strategies. Web-based technologies, such as smartphone apps have recently emerged as useful tools in the promotion of physical activity and weight management.

The prevalence of obesity and overweight represents a major challenge for public health in Oman (9). It is hypothesised that this is associated with 'Westernisation' of the Omani diet and adoption of a more sedentary lifestyle. Through a cross-sectional survey, this project, explores dietary practices and physical activity across different regions (urban and rural) of Oman and examines their impact on the prevalence of overweight and obesity. The survey specifically highlights low levels of energy expenditure, rather than intakes. Therefore, study two (an intervention study) was designed to support individuals to improve their lifestyle, knowledge and awareness using mobile phone–based technology.

Study 1: Background

1.1 Definition of overweight and obesity

Overweight and Obesity are defined as abnormal or excessive fat accumulation that may impair health (10). Several methods are used to measure overweight and obesity such as Body Mass Index (BMI), waist-hip ratio, waist circumference, skinfold, and measurement of percentage of body fat. In the 1980s, the approach of the ideal body weight was replaced by BMI, which is derived from the equation: body weight in kilograms divided by height in squared meters (m^2) [kg/m^2]. The classification of obesity by BMI as recommended by the WHO is shown in table 1.1 (11) (12).

Table1.1. Classification of body weight in adults by the WHO (12) .

Classification	BMI	Associated health risks
Underweight	<18.5	Low (but risk of other clinical problems increased)
Normal range	18.5-24.9	Average
Overweight	25.0 or higher	
Pre-obese	25.0-29.9	Increased
Obese class I	30.0-34.9	Moderately increased
Obese class II	35.0-39.9	Severely increased
Obese class III	40 or higher	Very severely increased

1.2 Abdominal obesity (Central obesity)

Abdominal obesity refers to the presence of excessive fat in the abdominal area (the area between the chest and pelvis), that is likely to have a negative impact on health (13). The abdominal fat is located in two main depots, subcutaneous and visceral (intra-abdominal). The main areas of subcutaneous adipose tissue (SAT) are the femerogluteal regions, back and anterior abdominal wall (14). Visceral adipose tissue (VAT) is stored deep in the abdomen, around the internal organs (e.g. liver, pancreas, intestine etc.) (15). Figure 1.1 shows the difference between subcutaneous and visceral fats. About 80% of all body fat is present in the subcutaneous area. Visceral fat comprises up to 10-20% of total fat in men and 5-8% in women, and the amount of visceral fat increase with age in both gender (16). VAT is a prominent risk factor for obesity related metabolic disorders (17), and high levels of VAT are associated with higher cardiometabolic risk (CMR) in comparison with SAT(18) (19). Due to the important association of VAT and SAT with many metabolic and CMR risk factors, the accurate measurement of these fat compartments is increasingly emphasised (18). Computed tomography (CT) and magnetic resonance imaging (MRI) are considered reference methods for assessing VAT and SAT, as they can clearly distinguish between visceral and subcutaneous abdominal fat (20). However, both methods are expensive and cannot be used in large epidemiological studies. Waist-to-hip ratio (WHR) and waist circumference (WC) are often used as anthropometric surrogates to determine central obesity and health risk (21). A WC over 102 cm for men and 88 cm for women is considered to be associated with a substantial increase of risk of metabolic complications (22). Table 1.2 shows the cut-off points and risk of metabolic complications, according to WHO, (2008) (22).

Accumulation of adipose tissue can be triggered by many factors including; hereditary factors, metabolic or endocrine disorders, physical inactivity, various psychological trauma, tumours, and even drugs (such as steroids and antidepressants) (21). There is an increasing evidence that fat distribution differs by gender, and sex hormones play an important role in determining body composition (23). It has been suggested that in men, testosterone has a significant role in determining fat distribution and in maintaining lean mass (24) (25), while in women, oestrogen has been proposed to explain the healthier distribution of fat (26). However, it remains unclear why women have more subcutaneous fat and less visceral fat than men (27). Choo et al (2014) reported that abdominal obesity was associated with impaired health -related quality of life (HRQOL), and this association is influenced by gender, being significant only for women (28).

Table 1.2. WHO cut-off points and risk of metabolic complications

Indicator	Cut-off points	Risk of metabolic complication
Waist circumference	>94 cm (M); >80 cm (W)	Increased
Waist circumference	>102cm (M); >88 cm (W)	Substantially increased
Waist-hip ratio	≥0.90cm(M);≥0.85cm (W)	Substantially increased

M, men; W, women

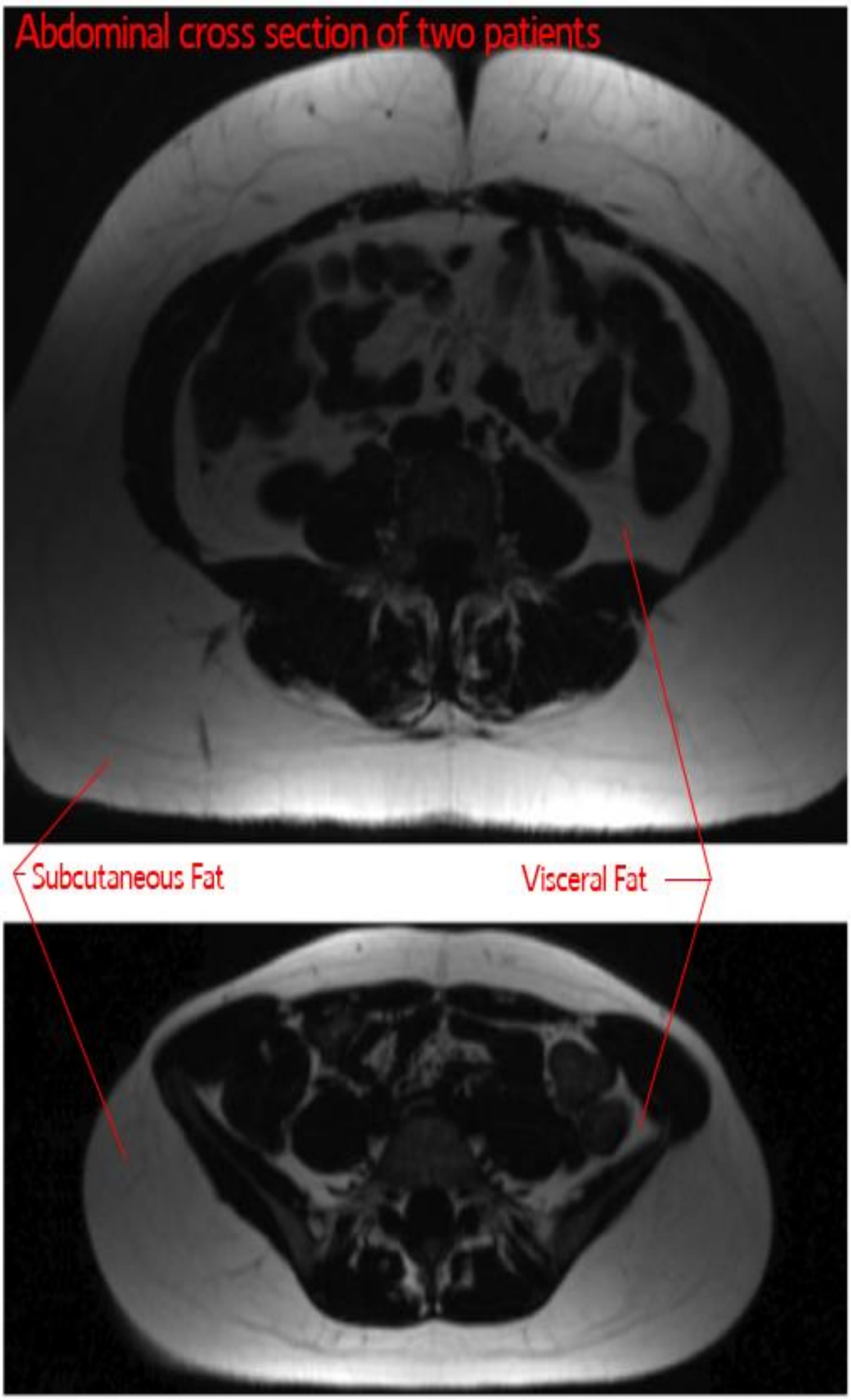


Figure 1.1: The difference between visceral fat and subcutaneous fats

Source of the picture: http://www.drhirani.com/diabetes/difference-visceral-fat-subcutaneous-fat/ (29).

1.3 Health implications of Obesity

1.3.1 Obesity and Co-Morbidities

Obesity is considered as a major contributor to the global burden of non-communicable chronic diseases (NCDs). Increased adiposity is strongly associated with type2 diabetes, dyslipidaemia, cardiovascular disease and other chronic diseases (30). Recent studies have shown that obesity has more pronounced impact on morbidity than mortality. This might be attributed to the increase in number of years that individual suffers from obesity-related disease, which consequently reduces individual's quality of life (2). Overweight and obesity cause adverse metabolic effects on cholesterol, blood pressure, triglycerides and insulin resistance, and the probability of having metabolic abnormalities (31). Therefore, unsurprisingly, obesity is considered as a key risk factor for non-communicable diseases and has been associated with a wide range of chronic conditions, including diabetes, dyslipidaemia, poor mental health, and risk of stroke, cardiovascular disease, osteoarthritis and certain cancers (table 1.3) (32).

Table1.3. Main comorbidities associated with obesity

System	Comorbidity
Gastrointestinal	Pancreatitis Liver disease Colon, pancreatic, gallbladder, & oesophageal cancer
Endocrine/reproductive	Metabolic syndrome Type 2 diabetes mellitus Polycystic ovary syndrome Breast, uterine, & cervical cancer
Cardiovascular	Coronary heart disease Hypertension Cerebrovascular and thromboembolic disease
Respiratory	Obstructive sleep apnoea Obesity-hypoventilation syndrome (Pickwickian syndrome)
Musculoskeletal	Immobility
Genitourinary	Urinary stress incontinence Prostate and renal cancer
Neurological	Idiopathic intracranial hypertension Stroke
Adapted from: Warziski MT, Choo J, Novak J, Burke LE. Obesity. In: Moser DK, Riegel B, editors. Cardiac nursing. A companion to Braunwald's heart disease. Saunders; 2008. Pp 446-462	

1.3.2 Obesity and Metabolic Syndrome (MS)

It is well established that obesity is associated with the increasing prevalence of metabolic syndrome (MS) (33). The first international standard definition for MS was proposed in a WHO consultation in 1988. An individual suffering from MS has at least three of the following risk factors: central obesity, elevated blood pressure (BP), high fasting blood glucose levels, high triglyceride and high cholesterol (34). Many studies have revealed that MS confers a greater risk of morbidity and mortality. People with MS are three times as likely to have a heart attack or stroke and twice as likely to die compared with people without the Syndrome. Moreover, people with MS have a fivefold greater risk of developing type 2 diabetes mellitus. It has been estimated that about 20-25% of the world's adult population have MS (35). In the Middle East, for example, MS is an increasingly common public health problem affecting one in four people with the prevalence increasing with age (36). However, recent evidence has reported that obesity does not always have such adverse effects on the metabolic health of individuals. Recent studies showed that about 10-30% of obese individuals are metabolically healthy despite having excessive body fat accumulation. This phenomenon has recently been described as metabolically healthy obesity (MHO). Little is known about the factors that lead to a delay in the onset of, or protection of, obese individuals from adverse effects on their metabolic health (30). The available evidence indicates that the prevalence of MHO is influenced by many factors including classification criteria, cut-off values for each parameter, as well as lifestyle, ethnicity, sex and age of individuals. Observational studies have shown that the MHO phenotype is linked to lower risk of CVD and mortality, particularly in physically active individuals. Van Vliet-Ostaptchouk et al, conducted a large-scale collaborative study to evaluate the prevalence of MS and MHO among obese individuals using the data from ten European cohort studies from seven different countries. The study showed that in general, the distribution of MS and MHO across the different populations is not equal. While the study revealed a consistently higher prevalence of MHO phenotype in women compared to men and a decrease with age in both sexes, it could not correlate this result with body fat distribution, due to using BMI in defining the obesity status (30). However, Wildman et al (2008) reported no difference between men and women in the prevalence of the MHO phenotype, in the NHANES cohort, when WC was used to define MHO phenotype instead of BMI (37).

1.3.3 Obesity and Heart and Cardiovascular Disease (CVD)

Obesity and its comorbidities have adverse effects on general and cardiovascular health. It promotes CV diseases including hypertension, coronary heart disease (CHD), heart failure (HF), and stroke via several mechanisms including lipid deposition, hyperglycaemia, and the development of a pro-coagulant status (38). Obesity increases the total blood volume, stroke volume, and cardiac output which typically lead to reduction in the systemic vascular resistance for any given blood pressure (figure 1.2). In addition, obesity can cause enlargement of the left atrium due to the increased blood volume as well as alterations in left ventricular (LV) diastolic filling. Due to the remarkable abnormality in LV structure and function associated with obesity, the increase in the prevalence of HF with obesity is not surprising. The Framingham Heart Study of 5,881 participants demonstrated that for every 1 kg/m^2 in BMI increase in men and women, prevalence of HF increases by 5% in men and 7% in women (39). In 2001, Seidell and Halberstadt predicted that disability due to obesity-related CVDs would increase, especially in industrialised countries, because patients in these countries survive CVDs more often than in non-industrialised countries. They also predicted that disability due to obesity-related type 2 diabetes would also increase, mainly in low-and middle-income countries, as insulin supply is often not sufficient in these countries (2).

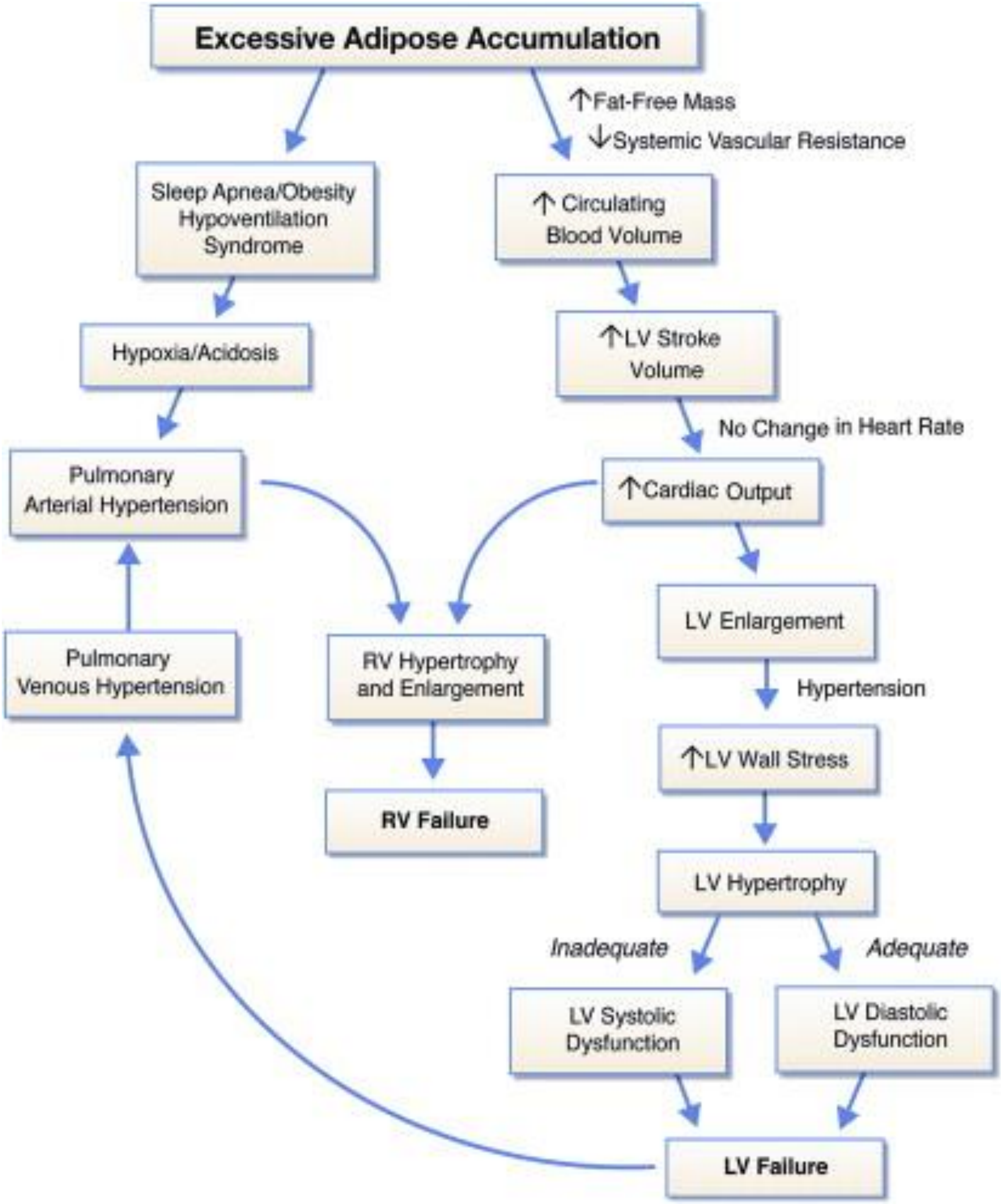


Figure 1.2 Pathophysiology of Obesity Cardiomyopathy.

This diagram shows the central hemodynamic, cardiac structural abnormalities and alterations in ventricular function that may occur in several obese patients and predispose to heart failure. Left ventricular (LV) hypertrophy in severe obesity may be eccentric or concentric. In uncompleted (normotensive) sever obesity, eccentric LV hypertrophy predominates. In severely obese patients with long-standing systemic hypertension, concentric LV hypertrophy is frequently observed and may occur more commonly than eccentric LV hypertrophy. Whether and to what extent metabolic disturbances such as lipotoxicity, insulin resistance, leptin resistance, and altercations of the renin-angiotensin-aldosterone system contribute to obesity cardiomyopathy in humans is uncertain. RV= right ventricular, Adapted with permission from Lavie et al.

1.3.4 Obesity and type 2 diabetes mellitus (T2D)

Obesity, and associated insulin resistance, is the primary cause of type 2 diabetes mellitus (T2D) (40). Studies reveal that the risk of developing T2D increases proportionally with BMI. For each kilogram of weight gained annually over 10 years, the risk of developing T2D increases by 49% in the subsequent 10 years. Conversely, the risk of developing T2D decreases by 33% in the subsequent 10 years, for each kilogram of weight lost annually over 10 years (41). In comparison to normal weight, overweight increases the risk of developing type 2 diabetes three-fold and obesity raises the risk seven-fold. Although metabolically healthy obese individuals are estimated to have half the risk of their metabolically unhealthy counterparts, they still have more risk of developing type 2 diabetes, by factor of four, compared to metabolically healthy normal weight individuals (4).

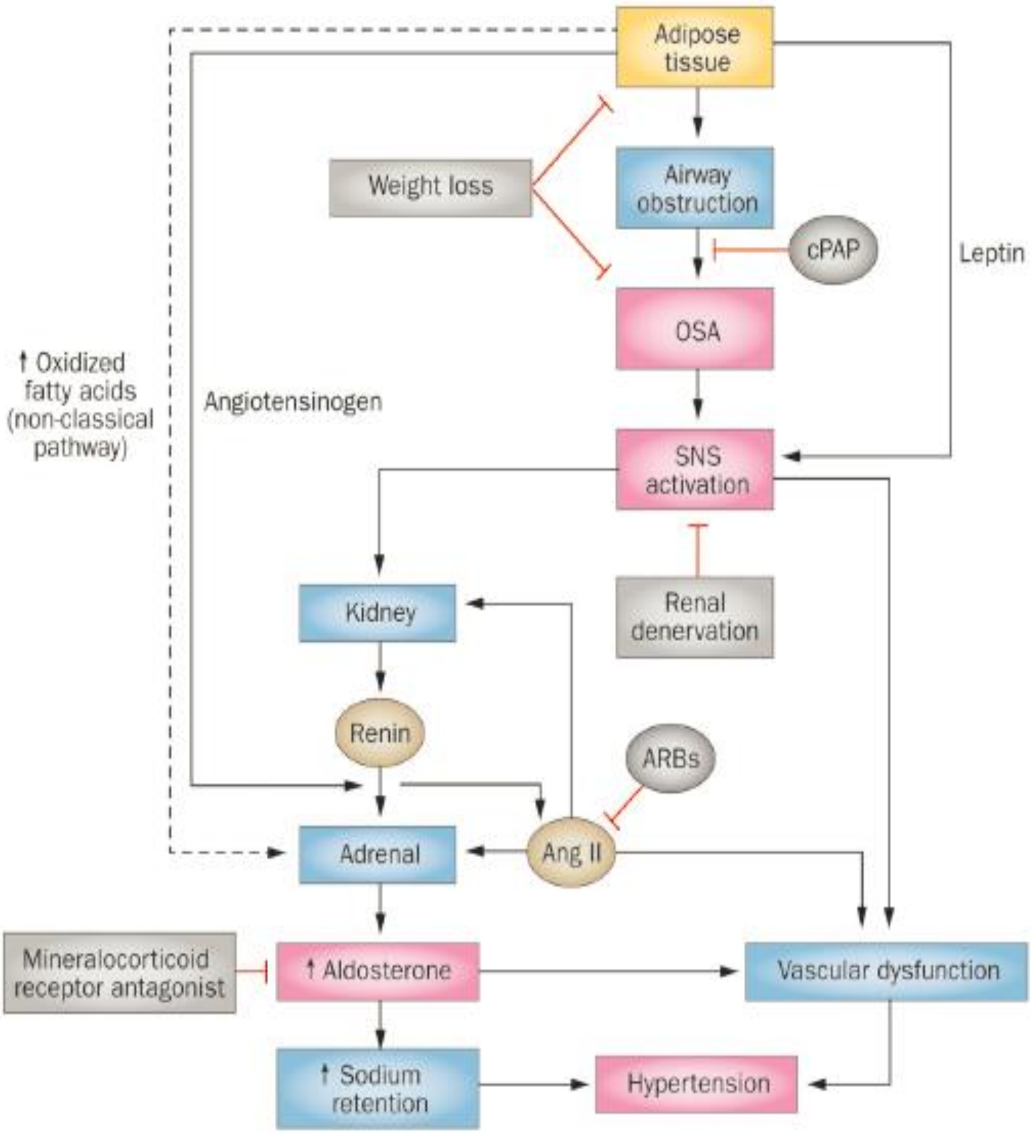
Notably, the global epidemic of T2D is worsening and the prevalence is increasing in parallel with the severity of obesity. A recent WHO report (2014) reported that 422 million people in the world have Diabetes Mellitus (DM), and T2D comprises the majority of people with diabetes. The overwhelming majority (86%) of T2D individuals are overweight or obese; 52% obese, and 8.1% morbidly obese (41). Based on findings from the National Health and Nutrition Examination Survey (1999-2006) concerning the relationship between obesity and T2D in the US adult population, 13.6% of adults surveyed had T2D. Amongst those with T2D, 80.3% and 49.1% were overweight and obese respectively (42). The burden of DM is expected to grow and, by 2030, the prevalence among adults aged 20-79 years is predicted to increase to 439 million (43).

Although fat mass is documented as a major factor influencing the risk of developing T2D, fat distribution is also important and visceral adiposity comprises the greatest risk. Visceral fat content is considered as an independent predictor of insulin resistance. Waist circumference is a useful indicator for subsequent T2D development. There is a linear relationship between the increase of waist circumference and the risk of developing T2D. Recent studies show that race / ethnicity also has an important role in risk of developing T2D. For example, people of Asian origin are at greater risk than those of Caucasian origin, probably due to differences in fat distribution and the associated level of insulin resistance (41).

Type 2 diabetes was recently characterised by impaired fat metabolism as well as glucotoxicity. Glucose homeostasis is, physiologically maintained by a mechanism involving the balance between insulin secretion from pancreatic beta cells and insulin sensitivity of the peripheral tissues, both of which are affected by fat mass (especially visceral fat). Therefore, an excessive fat deposition induced by overconsumption of energy-dense-foods enhances insulin resistance. Free fatty acids (FFAs) delivered to the liver through the portal vein can contribute to the development of non-alcoholic fatty liver disease (NAFLD). In addition, increased FFAs entering the systematic circulation can lead to the occurrence of lipotoxicity in other organs including pancreas, heart and muscle, followed by a vicious cycle of fat damage, inflammation, deteriorating insulin resistance and beta cell insulin secretion, and ultimately occurrence of T2D. While there is a clear association between excess weight gain (especially visceral adiposity) and the development of T2D, it is also clear that clinically significant weight loss is associated with improve glycaemic control in adults with T2D. In 2007, the Look AHEAD Research Group (a large multicentre trial), demonstrated that intentional weight loss in overweight and obese adults with T2D, who participated in intensive lifestyle intervention (decreased caloric intake and increased physical activity), reduced their weight by average of 8.6% compared to 0.7% weight loss in the control group (that were provided with diabetic support and education) (41). Furthermore, the significant weight loss at one year in subjects with T2D was associated with improved diabetes control (44). Due to the epidemiological and pathogenic association between obesity and T2D, the term “diabesity” has recently been used to describe the coexistence of obesity and T2D and indicates the association between obesity with T2D. However, despite the clear link between obesity and T2D, the actual mechanism still needs further clarification given that some obese individuals appear to be protected in some way from developing T2D, and a small number of lean people can develop T2D (41).

1.3.5 Obesity and hypertension

Obesity and hypertension are both components of MS and epidemiological studies have shown a strong aetiological relationship between them. Excess weight gain may lead to development of hypertension (obesity-related hypertension), and the relationship between blood pressure (BP) and BMI appears to be almost linear in different countries. Therefore, it is no coincidence that, as the rate of obesity increases, so does the rate of hypertension. The risk of hypertension is significantly increased by increasing BMI in both men and women (45). It is estimated that obesity is directly related to at least 75% of the incidence of hypertension (46). Although mechanisms of obesity-related hypertension are not yet clearly understood, several studies have indicated that obesity-related hypertension is a multifactorial and polygenic trait. The association between central obesity and both insulin resistance and hypertension form the basis for understanding the pathophysiology of obesity-related hypertension. Potential pathogenetic mechanisms, such as hyperinsulinemia, may contribute to increased incidences of high blood pressure (BP) in obese individuals. Knowing that insulin stimulates the sympathetic nervous system (SNS), and that obese patients have increased SNS activity, a role for insulin-mediated SNS stimulation is likely to be a factor in the pathogenesis of high BP, especially in central obesity (46). Figure 1.3 illustrates the possible mechanisms of obesity-related hypertension and therapeutic strategies (47). High sodium intake is another, well documented, risk factor associated with hypertension. Many health-related organisations (e.g. WHO, The United Nations) have emphasised the contribution of dietary sodium and cardiovascular outcomes. In 2010, 1.65 million deaths from CVDs were attributed to high sodium consumption (above the reference level of 2 g/day). In the same year, the global average level of sodium intake was 3.95 g/day (ranged between 2.2 to 5.5 g/day). Cook et al (2007) reported that salt restriction decreases the risk of hypertension with or without weight loss, in addition to reducing the incidences of CV events (48). During 2003/2004, the UK initiated a nationwide salt reduction programme. Population salt intake decreased 15% by the end of 2011, which has been suggested to be an important contributor to the falls in BP and the reduction in stroke and ischaemic heart disease (IHD) mortality in England between 2003 and 2011(49). Several studies have shown that PA can reduce both weight and BP. It was reported that, in studies lasting 4 to 52 weeks, where PA was the only intervention, aerobic exercise reduced BP by 3/2.4 mm Hg, and the effects can be even more substantial when aerobic exercise is combined with calorie restriction for weight management (46).



Source of the figure: (DeMarco et al., 2014) (47).

Figure 1.3. Possible mechanisms of obesity-associated hypertension and therapeutic strategies.

Adipose tissue releases leptin, angiotensinogen and oxidized fatty acids to stimulate adrenal release of aldosterone via activation of the classic RAAS, as well as a non-classic pathway mediated by oxidized fatty acids. Leptin stimulates the central SNS which in turn leads to renin release from the kidney. Activation of RAAS in other tissues contributes to renal and vascular dysfunction. Increased adipose tissue can lead to OSA, which can be treated by therapeutic weight loss or application of cPAP. OSA leads to activation of the SNS which activates RAAS in the kidney. Increased aldosterone can be reduced with mineralocorticoid receptor antagonists. Abbreviations:↑, increased; ↓, decreased; ARBs, angiotensin type 1 receptor blockers; cPAP, continuous positive airway pressure; OSA, obstructive sleep apnoea; RAAS, renin-angiotensin-aldosterone system; SNS, sympathetic nervous system.

1.3.6 Obesity and cancer

Several studies have shown that the likelihood of developing and dying from cancer is greater in obese men and women (50). Obesity is estimated to contribute to 20% of cancer cases, with the increased risk of malignancy being influenced by body fat distribution, weight change, diet and physical activity (51). It is estimated that globally, three to four million cases of cancers recorded every year, could be prevented by healthy eating and being more physically active (50). The Million Women Cohort Study showed that the 10 out 17 types of cancers in the UK, were significantly associated with increasing BMI. The study also reported that 5% of all cancers among postmenopausal women in the UK were more likely to be attributed to being overweight or obese. Moreover, almost half of the all cases of endometrial cancer and adenocarcinoma, in postmenopausal women, are attributable to overweight or obesity (50). Conversely, weight loss has a significant impact on some types of cancers. De Pergola and Silvestris reported that women who intentionally undertake weight loss of more than 10kg after menopause lowered the risk of breast cancer by 50% (51). The World Cancer Research Fund (WCRF) reported that the most common cancers in obese people are prostate, endometrial, oesophageal adenocarcinoma, postmenopausal breast, colorectal, and renal, whereas those which are less common include leukaemia, lymphoma, multiple myeloma, malignant melanoma, non-Hodgkin’s lymphoma, and thyroid tumours. Recent meta-analysis and observational studies have demonstrated that the association between obesity and cancer is sex specific over several types of malignancies, and this is likely to be true for different geographical populations (51). Ethnicity is another independent factor that impacts on the cancer risk in obese individuals. For instance, African Americans are more likely to develop cancer than Hispanics, who appear to be relatively protected. In addition, the link between increased BMI level and breast cancer is strongest in Asia-Pacific populations (50). Factors other than fat mass *per se* also influence the risk of developing cancers. Studies have revealed that cancers associate more with central obesity (abdominal fat) than with BMI, especially colon, premenopausal breast, endometrium, oesophageal adenocarcinoma and pancreatic tumours (51). With respect to mortality, a longitudinal study on US women has shown a strong positive association between both WC and WHR and cancer mortality, independent of BMI. Jaggers et al recently found that abdominal obesity increased the risk of cancer mortality up to 24% (52). Obesity may also have a negative impact on the treatment of cancer, as it has been reported that chemotherapy dosages for excess weight women receiving breast cancer treatment are often not adequate, when compared to dosages in lean women (53).

1.3.7 Obesity and Mortality

The WHO reported that 65% of the world's populations live in countries where overweight and obesity kill more people than underweight (54). In 2010, overweight and obesity were estimated to account for 3.4 million deaths, and about 4% of disability-adjusted life-years (DALYs) globally (55). Mortality rates increase with increasing levels of overweight (measured by BMI). A large meta-analysis of 97 studies, on almost 2.9 million people, showed that obesity ($BMI \geq 30 kg/m^2$) was significantly associated with mortality compared to normal BMI (18.5-24.9) (56). The adverse effects of higher BMI on mortality are greater in younger cohorts than older ones (38). In the East Mediterranean Region (EMR) obesity has reached alarming levels among both children and adults, and related NCDs have been attributed to more than 50% of total deaths EMR (57). The greatest increase in NCD mortality rate between 2006 and 2015 was in Africa (27%) and EMR (25%) (58). Most of mortality and morbidity burden in EMR is attributed to unhealthy diet, physical inactivity, and tobacco use (59). Consumption of sugar and salt, in most member states, is above WHO recommended levels. Moreover, despite the fact that globally the average trans-fat intake has levelled off, the EMR is experiencing the largest increase in consumption (59). The DALYs, which is measured by risk factor of high BMI, has increased markedly in EMR, as another indicator of the growing obesity burden. The recent WHO Global Burden Study reported that, between 2000 and 2015, DALYs rose by 62 % across the Middle East and North Africa (MENA) with more significant increases in the United Arab Emirates UAE (314%), Oman (161%) compared to the global prevalence (38%) (60).

1.4 Lifestyle factors and obesity (Diet, Physical activity, Awareness)

Chronic NCDs usually occur in middle age, after long exposure to an unhealthy lifestyle involving tobacco use, lack of physical activity (sedentary behaviour), and consumption of diets rich in saturated fats, sugars, and salt. Such lifestyle factors are leading causes of obesity, diabetes mellitus, hypertension, and dyslipidaemia (61). Overweight and obese youths, who tend to be less physically activity compared to those of normal weight, are more likely to develop chronic disease’s risk factors such as type 2 diabetes, coronary heart disease, and stroke in their adulthood (62). The majority of studies considered the food system and physical activity the predominant drivers of the obesity epidemic. Gilmore et al have reported that the fundamental cause of obesity is the long-term positive energy balance, regardless of macronutrient composition of the diet (63). Vandevijvere et al (2015) recorded a significant association between changes in food energy supply in countries of varying income levels and average population body weight in general, and for the high-income countries in particular. The study also suggested that factors such as reduced physical activity could occur simultaneously with an increase in food energy supply and may lead to an increase in body weight (64). Most cases of MS are attributed to inappropriate dietary patterns and sedentary lifestyle (65) (66). There is currently debate about whether increased physical activity or diet restriction is more efficient in combating MS, with many studies suggesting that diet plus exercise has more success in the treatment of MS than exercise or diet a lone (67) (68). It is also known that the risk of having MS is higher in those with lower cardiorespiratory fitness (CRF) (69) (70). In addition, recent studies have demonstrated that physically fit men and women, as compared with those who are physically unfit, had lower amounts of total and abdominal fat for a given BMI (71) (72) (73). Moreover, overweight and obese individuals had lower levels of CRF than normal weight individuals (69) (74).

Physical inactivity has been suggested to be the fourth most important risk factor for the development of chronic disease globally (75). The American College of Sports Medicine and WHO recommend that adults do at least 150 minutes of moderate-intensity activity a week and strength training at least twice a week (76). Steele et al reported that low levels of physical exercise and poor cardiorespiratory fitness are known to predict progression CVD, T2D, and MS in adults (77). Sedentary behaviours such as excessive time spent in watching television or using a computer, are significantly associated with an increased risk of MS (78) (79). Therefore, it is currently recommended that individuals with MS be targeted for therapeutic lifestyle changes, which consist mainly of increases in physical activity and improved diet (80). Longitudinal cohort studies conducted by Wang et al (2004) and Alberti et al (2005) indicated that most chronic diseases of lifestyle, such as CHD, T2D, and hypertension are at least 1.5 to 2.0-fold higher risk with physical inactivity (81) (82). The World Health Organisation reported that the doubling of obesity rates since 1980 is associated with declining rates of physical activity (83). Numerous studies have shown the significant impact of physical activity (PA) in reducing the mortality rates and improving general health and in many countries physical inactivity is a growing public health concern. For instance, in Netherlands results of research study showed that 41% of all adults do not comply with Dutch Public Health Physical Activity Guideline (at least 30 minutes of moderate to vigorous physical activity for at least 5 days of the week). Only 20% of Dutch adults meet the Strenuous Intensity Physical Activity Guideline of at least three. 20 min periods of vigorous exercise per week (84). The WHO physical activity guidelines recommend that individuals accumulate at least 150 minutes of moderate intensity (PA) per week (or equivalent), in bouts of a minimum of 10 minutes in duration. Such activity levels have been demonstrated to result in an improvement of all cause of mortality and disease specific morbidity (85). A systematic review of studies, published from 2000-2010, investigated the association between changes in health-related fitness and the prevalence of risk factors in overweight and/or obese youth. It reported many significant improvements in health outcomes associated with improved physical fitness. Adiposity, cardiovascular, musculoskeletal, metabolic, and mental/ emotional health improved in 60%, 32%, 53%, 41%, and 33% of those studied, respectively (62).

Knowledge and awareness about weight status is also an important issue, which is theoretically associated with weight management and health care costs (86). The perception of weight status among adults has important implications in the prevention of obesity in childhood (87). Barichella et al (2011) reported that in Italy, knowledge about weight management should be improved in both the general population and in health-care professionals. They also indicated that higher age, low education and higher BMI were important determinants in conferring poor weight control and management (87). In the MENA region, although the public awareness of the weight status is growing gradually, the widespread public perception is that obesity is a symptom of diabetes or hypertension, rather than a metabolic disorder in itself. This perception ultimately makes the care of patients more challenging (60). Experts in the region, have identified the main policy gaps that need to be bridged and have urged Governments to set out primary preventative programmes, including education in schools and families. An integrated approach involving nurse practitioners, family physicians as well as social workers, has been demanded in order to address childhood obesity, with more focus on reproductive-aged women. More aggressive regulatory measures should be considered by the government (e.g. bans on the sale of sugary drinks in schools or taxes on unhealthy food). For people who are already obese, experts recommend better training of professionals including improved expertise about the complexities of obesity and creation of multidisciplinary teams including specialists in obesity medicine and management, and dietitians (60).

1.4.1 Effective interventions to improve dietary and physical activity behaviours

Many studies have attempted to improve dietary habits and increase physical activity of a targeted population. These frequently attempt to implement comprehensive intervention strategies to improve knowledge and attitudes toward diet and physical activities, as well as changing unhealthy behaviours and their related risk factors. Different countries have adopted several different intervention strategies to address the unhealthy outcomes. These interventions can be categorised in 6 main domains: media and educational campaigns; labelling and consumer information; taxation, subsidies, and other economic incentives; school and workplace approaches; local environmental changes; and direct restrictions and mandates (88). Focused media campaigns that target multiple cardiovascular risk factors and dietary behaviours simultaneously have been more successful than broad community–based media and educational programs (88) . Focused media campaigns in Australia were associated with increased public awareness and consumption of fruit (from 1.5 to 1.7 servings per day, $P<0.05$) and vegetables (from 2.6 to 3.1 servings per day, $P<0.01$) (89). Similarly, in Pakistan, focused media campaigns led to improvements in dietary habits, such as reduced consumption of meat and increase consumption of fruit and vegetables (90). In United States, the National Cancer Institute, with collaboration from industry and the federal government, initiated the US 5-A-Day for Better Health Campaign, to increase the consumption of fruit and vegetables. Reports on this campaign suggest some success, with increased consumption of fruit and vegetables from ≈2.8 to 4.3 servings per day between 1988 and 1999 (88). Long term community and school-based media and educational campaigns have also been effective in improving dietary habits of school-aged children, younger children (91), as well as adults, in addition to reducing adiposity and cardiovascular risk factors in adults using multiple strategies for communication (92). Shorter-term (weeks to months) media campaigns, have generally increased knowledge of healthy lifestyle messages, such as Fighting Fat, Fighting Fit in the United Kingdom and similar programmes in US and Australia (93) (94) (95). Combining shorter term media campaigns with other means of more direct participation may increase effectiveness. For example, in Fighting Fat, Fighting Fit campaign, people who registered in a 6-month mail-based educational program increased their fruits and vegetable consumption by 1.3 serving per day, reduced their intake of fat and snacks, increased their PA, and lost an average of 2.3kg, reducing the prevalence of obesity by 11% ($P<0.001$ for each compared with baseline) (96). Similarly, in the 5-A- Day campaign, sending newsletters with strategies of improving consumption of fruits and vegetables, as well as goal setting information, increased the frequency and variety of fruit and vegetable consumption (97). In North Karelia, Finland, a media and education-based community intervention reduced consumption of butter, whole-fat dairy, non-lean meats, and salt successfully, and increased the consumption of vegetable oils, and vegetable-oil margarine, low-fat dairy, lean meats, vegetables, berries and fruits (98) (99). Dietary habits of the targeted population improved substantially, and this was associated with declines in blood cholesterol, blood pressure levels and rates of CHD. In 1980, three community-based health educational programs, in the US, were evaluated, with a major focus on media and education to improve multiple cardiovascular diseases simultaneously (88). The Stanford Five-City Project tested a 5-year community-based program that combined behaviour change theory (social learning theory, a communication-behaviour change model), community organisation principles, and social marketing methods. Compared to control groups, the intervention communities showed improvements in several cardiovascular risk factors, including lower blood cholesterol, blood pressure, resting heart rate, weight gain, and smoking prevalence. In contrast, similar strategies in the Minnesota Heart Health Program and the Pawtucket Heart Health Program did not lead to significant improvement in these communities. In Mauritius, a national prevention program was launched to reduce the major risk factors by promoting healthier diets, smoking cessation, reducing alcohol intake and increasing exercise (100). Many strategic programs were implemented to achieve the targets, including media and education efforts, including extensive use of mass media and widespread community, schools, and workplace education activities. From 1987 to 1992, moderate leisure-time physical activity improved from 16.9% to 22.1% in men and from 1.3% to 2.7% in women. Cigarette smoking decreased from 58.2% to 47.2% in men and from 6.9% to 3.7% in women. The prevalence of blood pressure declined from 15% to 12.1% in men and from 12.1% to 10.9% in women. Heavy alcohol use in men and women had also declined substantially, from 38.2% to 14.4% and 2.6% to 0.6% respectively. Legislative measures on cooking oils showed tangible results, represented in the reduction of the mean serum total cholesterol by 15% (from 5.5 to 4.7 mmol/L ($P<0.001$)) (88). Similarly, in Singapore, a sustained multicomponent intervention in 1992 that combined extensive media/education approaches with school, workplace, and environmental strategies collaboration with food industry to produce healthier food choices (101). The evaluation demonstrated significant declines in the prevalence of smoking, hypertension, hypercholesterolemia, and type 2 diabetes mellitus and a significant increase in regular exercise (88). Combining media and education with other approaches, such as environmental changes, to encourage healthier diets and more physical activity have led to reduction in adiposity in children but the effectiveness of media/education component on the physical activity as such is less clear.

Although many traditional interventions resulted in successful weight loss, many individuals regain the weight after the intervention concluded. A number of different strategies have been adopted in order to combat weight regain. In the Look AHEAD study, a randomized clinical trial funded by National Institutes of Health, the interaction between the intervenors and participants continued into the fourth year of the study in order to address the weight regain (102). Another popular intervention in behavioural modification is the use of wellness coaches. This approach has been shown to produce better weight loss in comparison with conventional methods. The key feature of this approach is the delivery of continuous feedback to support behaviour change. However, this approach is expensive and, as such, inappropriate for widespread scalability (63).

Self-monitoring of individual's behaviour during weight management programs allows participants to quickly identify a behaviour that may affect the success to meet the set goals. Self -monitoring behaviours include weighing on a regular basis, recoding food intake and/or exercise frequency and tracking TV or computer use (63). Such systematic observation of individual behaviours during weight management programs has been shown to increase effectiveness and facilitate sustainability (103). For example, individuals who weighed daily lost about 1 BMI unit (kg/m^2) more than individuals who weighed only weekly and 3 BMI units greater than individuals who did not weigh at all (104) (105) (106). Similarly, tracking food intake at least 75% of the time, and self-monitoring of activity are more likely to result in weight loss (107) (108). Glynn et al (2014) reported that for physical activity interventions to be effective, they need to motivate people to undertake changes in their behaviour, and offer realistic goal setting as well as provide regular feedback on activity rates (83). Gilmore et al (2014) reviewed the components of many effective weight management programs and the role of modern technologies such as SMS, websites, and smartphones to improve the effectiveness of such programs. Most successful intervention programs included three common components; a behavioural component that addresses the behaviour change, self-monitoring of individual data (weight and steps), and provision of individualised recommendations and feedback (63). Change for Life Campaign (a public health program launched in 2009 in the UK) is an example of such a program that aims to encourage people to adapt healthy sustainable behaviours, via provision of multiple ideas and tools (e.g. smartphone apps) to disseminate the healthy living messages (109). It urged people to eat well, move more and live longer. The design of the campaign was based on behaviour change theory and evidence from successful behaviour change campaigns (109). Self-monitoring and individualized feedback were provided via several methods including using multiple diet and PA smart phone apps (e.g. breakfast for life, bike for life) (110) (111).

1.4.2 Using modern technology to improve health and fitness

Many public health studies have reported that walking is the most popular mode of PA in both developed and developing countries (85). This is mainly because walking is an inexpensive and easily accessible activity for a large proportion of general population. In addition, fewer physical, social and psychological barriers are associated with walking compared to the other forms of exercise. Walking is considered as a good strategy to promote health and well-being. It has recently been suggested that a daily value of less than 5000 steps/day may be an appropriate index of inactive lifestyle and potentially associated with metabolic risk factors (112).

Due to the rapid developments in technology, and the increased number of internet users worldwide, electronic health (*e* Health) and mobile health (*m* Health) have emerged as new fields in weight management. Such media have the ability to deliver tailored information to a large number of people simultaneously, provide a medium of interaction between participants and personalised feedback from a health care provider. In weight management interventions, *e* Health incorporates each cornerstone feature of successful obesity interventions to aid self-monitoring of weight, food intake, and physical activity through short message service (SMS), email and specific applications (apps) (63). Bennett et al reported greater weight loss with web-based interventions compared to traditional care and suggested that integration of the two interventions should increase the effectiveness of treatment (113). Similarly, Tate et al (2001) observed greater weight loss, and a decrease in waist circumference, when behaviour modification therapy was integrated into a web-based intervention with personalized feedback (114).

SMS has gained popularity as an inexpensive, easy and quick way of communicating with people. Woolford et al (2010) reported that tailored, automated SMS, including diet, lifestyle and behaviour information, has been widely used and well- accepted by adolescents. However, studies of SMS-based diet, physical activity, and behaviour change interventions have reported variable effectiveness (115). Despite all the advantages of SMS, it provides a limited amount of information in a 160-character-limited message (63). Pedometers are useful tools for encouraging walking, and tracking ambulatory physical activity, typically measuring total steps/day (85). However, in a randomised control trail, pedometers were shown to have some disadvantages, including carrying an extra, purchased piece of technology and limited memory and feedback capacity (83).

1.4.3 Smartphone application (apps)

The number of smartphone users is increasing annually globally. In the United States, 77% of Americans owned smartphones in January 2017 compared to 35% in 2011 (116), and the ownership is increasing among every demographic group including low-income populations. Due to the rapid expansion of mobile health (m Health), many health care and fitness apps, aiming to help individuals to change behaviours and improve health, are now available on smartphone operating systems (e.g. iPhone, Android). These apps provide alternatives to the many limitations associated with traditional methods, such as cost effectiveness (many apps are available free for general public), low burden, ease in delivery and capability of wide dissemination. As such, apps have greater potential to be used for weight management and improving general health. For instance, the Change for Life campaign uses smartphone apps (e.g. food smart, sugar smart, smart recipe) to reduce the prevalence of obesity and improve individuals' health (117) (118) (119).

Many of weight management and fitness apps include features that promote behaviour change, such as self-monitoring of weight and steps and personalized feedback. In weight management for example, apps include comprehensive databases of foods, barcodes, and the option for manual entry of unknown foods or favourite recipes. This facilitates self-monitoring, represented as calorie counting to achieve energy balance, through tracking food intake and the portion size of each food consumed. Examples of popular apps using these strategies of recording intake include; MyFitnessPal, Lose it!, FatSecret's Calories Counter, SparkPeople, and Fooducate (120)(121)(122)(123)(124). Carter et al suggested that individuals using an app to monitor dietary intake have significantly more weight loss and higher adherence compared to those using website and traditional pen-and-paper methods (125). Although such apps are helpful, as a self-monitoring tool in weight management, actual energy intake could be subject to the underestimation often associated with self-reporting (126). In order to get more objective assessments of total energy intake, researchers and app developers have recently developed advanced food photography programs using the camera function of the smartphone to capture images of foods and analyse the food photos before and after meals. Food photography programs have been shown to be an accurate and precise measure of energy intake (126) (127). In this approach, an individual is simply instructed to capture a 'before meal' photo. A text message is received after about 15 minutes prompting the user to capture the after-meal photo. Furthermore, users are prompted to report a detailed description of the meal either in text or a voice record form. Users also can use the barcode scan option for the commercial products, as well as using a price look-up (PLU) code for fruits and vegetables. The portion size of the individual meal components and amount consumed are then assessed by the computer program (63). The United States Department of Agriculture (USDA) Food Composition Database is used to analyse each food item and obtain a more objective assessment of total energy intake.

Various physical activity apps have been developed simultaneously with development of apps that track food intake or promote positive health behaviour (63). Similar to dietary intake apps, some physical activity apps (e.g. MyFitnessPal, Lose it!) use self-monitoring strategy by tracking physical activity and exercise occurrences (120) (121) . Such apps include databases of many activities (e.g. aerobic, gardening, swimming, dancing, housework and running) though they are reliant on self-reporting methods. Physical activity apps (e.g. Run Keeper, Endomondo, and Map My Run) have recently been developed to track activities (such as walking, running biking) more accurately through GPS capability in smartphones and track the route, distance, duration, and calories burned.

Although, countless numbers of commercial health care and fitness apps are available, very few have been validated against standard measures of dietary intake and physical activity. Many studies that investigated the effectiveness of internet-based health and fitness applications have focused on the most popular (free and paid) apps listed in iTunes and the Android market. Literature, in general, suggests that diet and physical activity apps have the potential to succeed when self-monitoring, education, and support strategies are incorporated. However, validating diet and physical activity apps against standard objective assessment methods (e.g. accelerometery, doubly labelled water, and directly weighed food) increases the likelihood of success (63).

1.5 Global differences in Obesity

Worldwide, the prevalence of overweight and obesity have been increasing in epidemic proportions over many decades. According to the WHO fact sheet in 2014, 39% of adults (aged 18+) were overweight and 13% were obese (128). In developed countries, 23.8% of boys and 22.6% of girls were overweight or obese in 2013 (55). Furthermore, 26 % of boys and girls in the developing countries were either overweight or obese (55). While it is generally acknowledged that the most affected populations are those in high-income countries, such as in North America, Australia and Europe, more recent increases in population obesity are being seen in low and middle-income countries (2). It has been estimated that two-thirds of the world's obese population now live in developing countries (55). The WHO reported that the prevalence of overweight and obesity in adults (age 20+y) increases as a countries' income level rises to upper middle-income levels (figure 1.4). Overweight is more than twice as high in high income and upper middle-income countries compared to low and lower middle-income countries. The overall prevalence of obesity is four times higher in high income countries compared to low income countries. Women's obesity, in all income levels, is significantly higher than men's, with exception of high income countries where prevalence was similar (129).

The US ranks top for obesity prevalence among men (31.7%) and the second for women (33.9%) after Turkey (34.1%), out of 34 countries according to the Organisation for Economic Cooperation and Development (OECD) (figure 1.5). Over 85% of adults are predicted to be overweight or obese by 2030 in the USA (4). The UK is the 5th in the rank for obesity prevalence among men (24.5%) and 10th for women (25.4%) in OECD countries (figure 1.5). Japan has the lowest prevalence of obesity in men and women (4.5% & 3.3%) respectively (8).

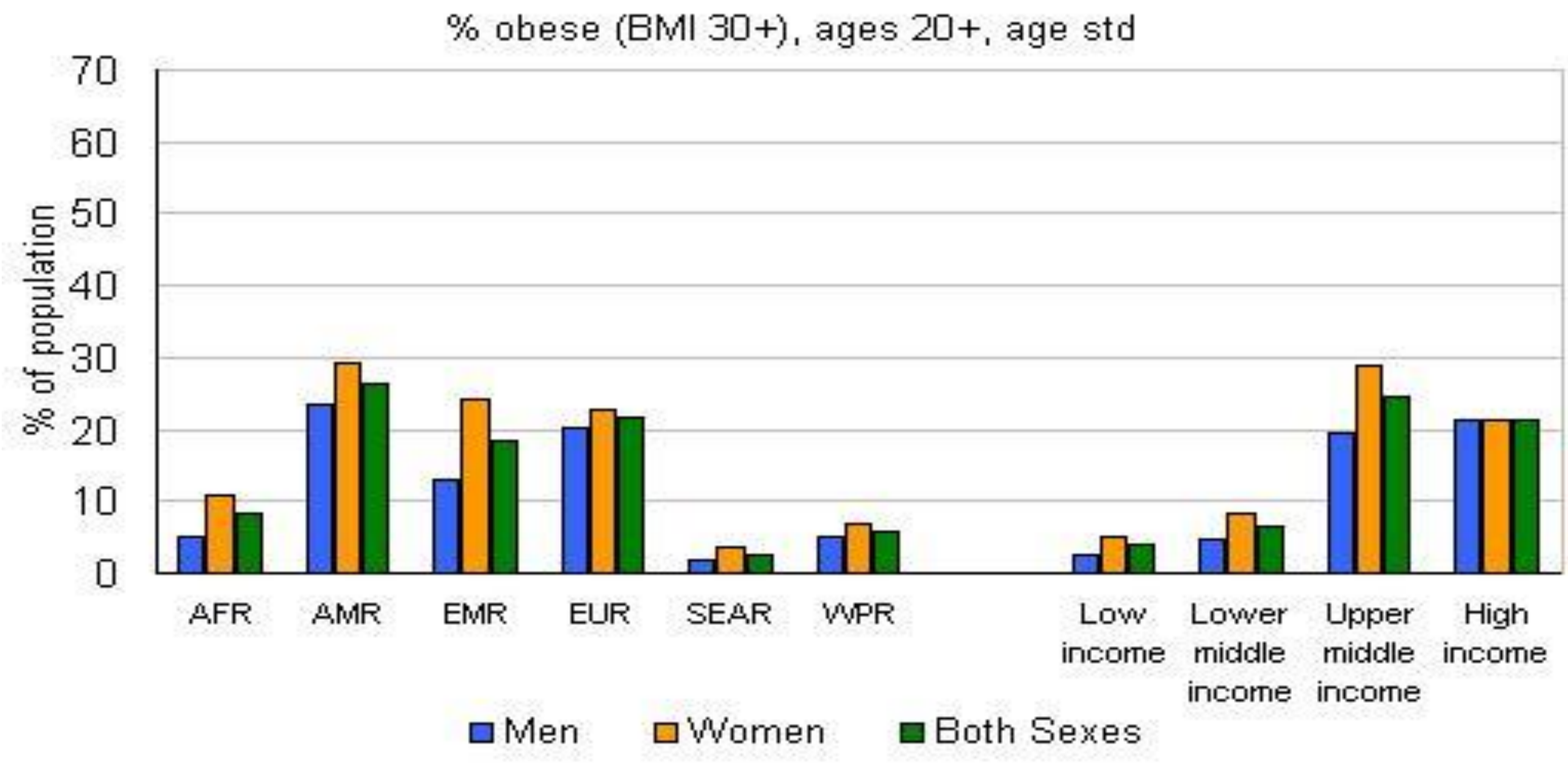


Figure 1.4. Prevalence of obesity by region and income level.
Source: World Health Organisation, Global Health Observatory (GHO) data, (10) **http://www.who.int/gho/ncd/risk_factors/obesity_text/en/**

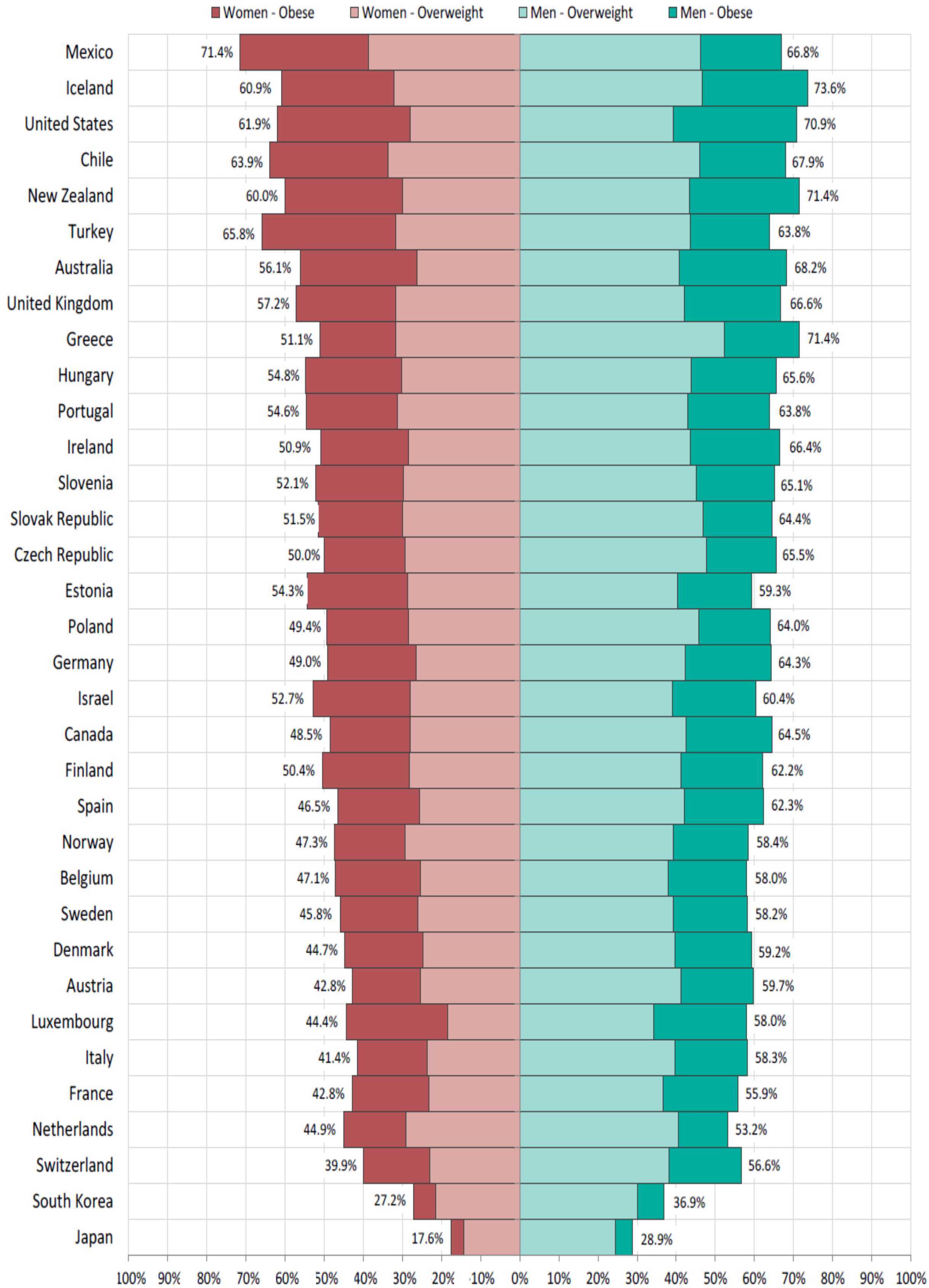
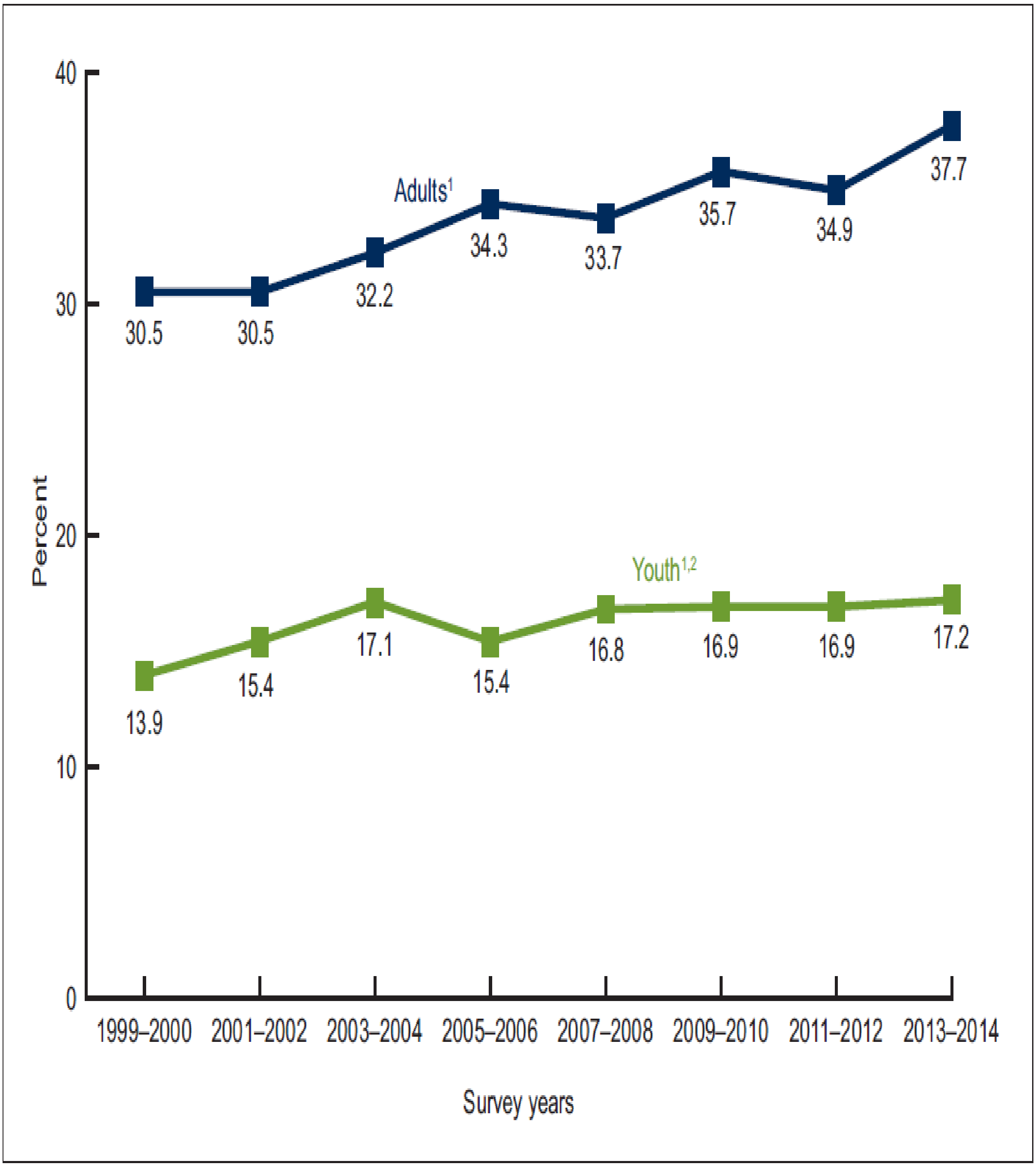


Figure 1.5 International overweight and obese prevalence in adults by OECD country (3).
Data source: The Lancet, Systematic analysis for the Global Burden of Disease Study 2013.

The economic costs of the increasing trends of obesity and its related comorbidities and mortality are striking. In the USA alone, the annual medical burden of obesity and its comorbidities has been estimated to cost about $147 billion in 2008 and that projected expenses will be more than double by 2018, reaching $344 billion, or about 21% of total health care spending (46). International studies show that obesity costs between 2-7% of total health care spending (45). In MENA region, spending on diabetes care (which is exacerbated by obesity), is the highest in the globe (60).

There is some evidence that, in recent years, prevalence of overweight and obesity is levelling off in developed countries. In the US, the comparison of obesity prevalence data from 2003-2004 with 2011-2012 shows no significant increase in obesity for men or women (130). Ogden et al (2015) also found no significant changes in either adults or childhood obesity prevalence in the US between 2003-2004 and 2011-2012, and no significant trend was seen from 2003-2004 through to 2013-2014 (figure 1.6) (131). Rokholm et al (2010) reported that the obesity epidemic, in general, is levelling off in children and adolescents in Australia, Europe, Japan and the USA (132). In comparison with children and adolescents, the tendencies in European adults were more mixed. In Sweden, for example, despite the continuous increase in obesity prevalence in Swedish young men, stability in the prevalence, since 2001, was observed among the general Swedish population. Similarly, signs of levelling off in the prevalence were noted in the general English adult population. In France, obesity prevalence in adults has been stable since 2001 (132).



[1]Significant increasing linear trend from 1999-2000 through 2013-2014.

[2]Test for linear trend for 2003-2004 through 2013-2014 not significant (p>0.05).

Note: All adult estimates are age-adjusted by the direct method to the 2000 U. S. census population using the age groups 20-39, 40-59, and 60 and over.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Survey.

Figure 1.6. Trends in obesity prevalence among adults aged 20 and above (age-adjusted) and youth aged 2-19 years: United States, 1999-2000 through 2013-2014.

1.6 The Middle East and GCC countries

During the past four decades, the Middle East countries (including Arab Gulf countries) have witnessed rapid changes in their socio-economic situation, food consumption patterns and health and lifestyle status. This has been mainly due to increased revenue from oil and gas. Life expectancy have increased from 51y, in 1970, to almost 70y today and the infant death rates have markedly decreased (133). However, the incidence of NCDs and associated mortality have sharply increased. More than 2.2 million people died from NCDs in the region in 2008 and these were mainly from CVDs, cancers, chronic respiratory diseases and diabetes (figure 1.7). More than 34% of NCD mortality was in individuals younger than 60 years (58). The Middle East region ranks among the highest in the world in terms of the prevalence of obesity. Kilpi et al (2014) demonstrated that adult men and women in the Middle East have the second highest mean BMI, after the USA, and the prevalence of overweight and obesity ranged from 50 to 80% with a higher prevalence among women than men (134). Although the EMR is categorised by different socio-economic levels, the prevalence of obesity in high-income countries (such as GCC states) and middle-income countries (such as Egypt, Jordan, Iran and Lebanon) was very similar, which may suggest that cultural rather than economic factors play a major role in determining obesity in the region (134). In countries such as Syria and Jordan, for instance, almost one-third of the population is obese, which is in line with statistics in the US (8). A recent systematic review about the prevalence of overweight and obesity among adults in GCC states showed that 25-50% were overweight and 13-50% were obese (5).

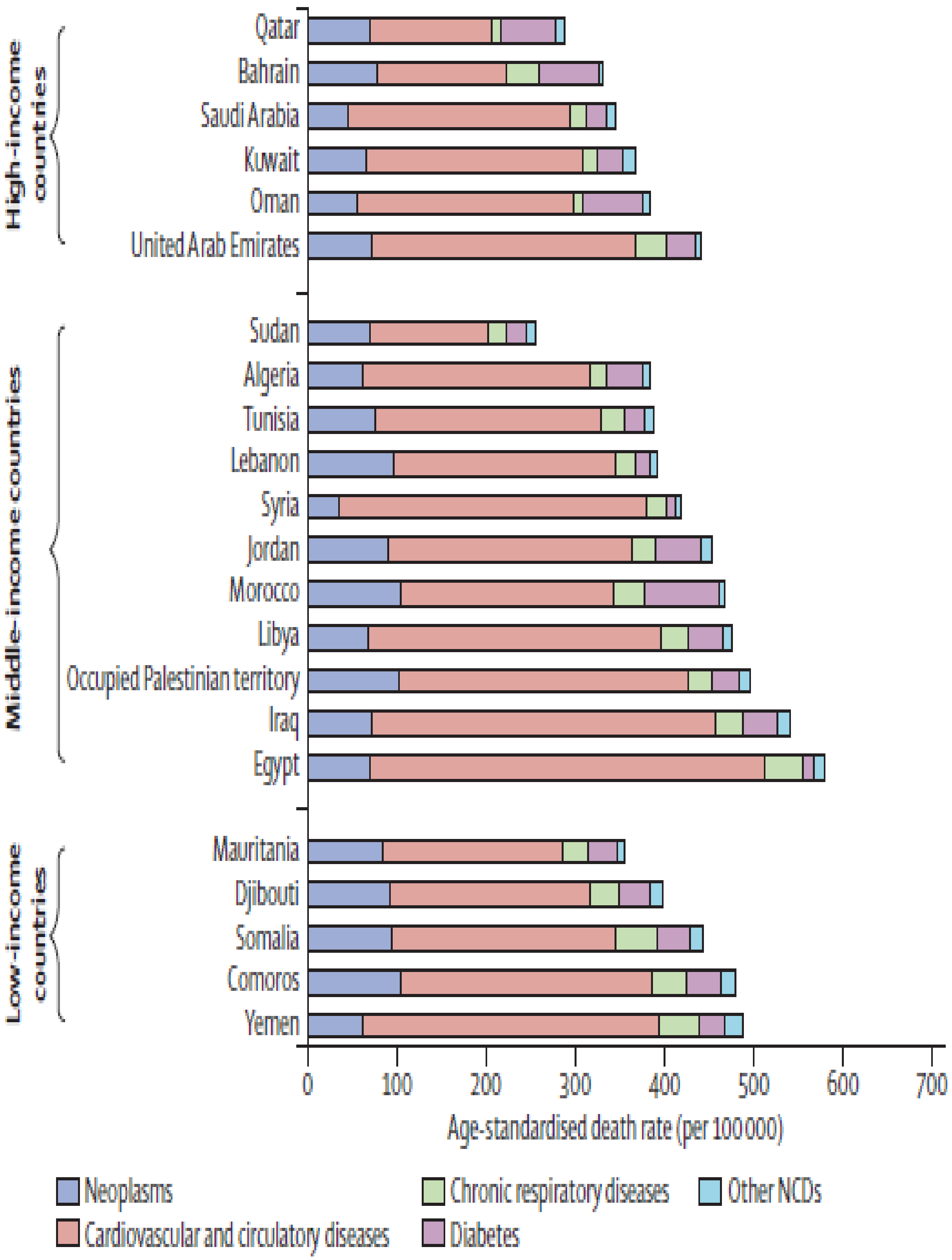


Figure 1.7: Age-standardized death rates from non-communicable diseases (per 100 000 population) in Arab countries, 2010.

Source : Abdul Rahim et al, 2014. Non-communicable diseases in the Arab world (58).

1.6.1 Diet-related chronic diseases

In general, nutritional and health issues in GCC countries can be divided into two types: those associated with lifestyle, such as obesity, CV diseases, diabetes, hypertension, osteoporosis, cancer and dental caries, and those related to nutrition deficiencies, for example iron-deficiency anaemia, undernutrition among preschool children, and deficiencies of calcium and vitamin D. With regard to food consumption patterns in the Gulf region, there have been drastic changes in both the quantity of food consumed and the quality of the diet during the last three to four decades. Meals have shifted towards high-energy-density foods with more saturated fat (mostly from animal origin) and added sugar, as well as a lower intake of complex carbohydrates, dietary fibre, fruits, and vegetables. The average total energy intake in all GCC states exceeds 3000kcal per capita, and fat represents 25-35% of total energy. Intake of animal products has increased steadily to the extent that animal fat represents 40-52% of total per capita fat intake in the region (135). Poultry and eggs are generally more regularly consumed than red meat in the gulf region, and fish intake is low. Data from the Food and Agriculture Organisation (FOA) showed that the daily per capita availability of poultry meat in GCC states ranged from 106-163 grams during the period 2003-2005, compared to 2-73 grams in other Middle East countries. Although fish intake showed a slight increase during the period 1990-2005, in comparison to meat and poultry, the average daily per capita availability of fish was still low (24-52 grams) (135). Musaiger et al (2012) suggest that although the production of milk and dairy products in the Gulf countries has increased during the past decade, the intake per capita is still below the daily requirement (136). During 1990-2005, the daily per capita availability of milk and dairy products decreased in Kuwait and UAE by 20% and 33% respectively but increased by 15% in Saudi Arabia (137). The food groups and suggested daily serving for Arab Gulf populations are listed in (table1.4).

Table 1.4. Food groups and suggested daily servings.

Food Group	Servings	Serving sizes
Cereals and their products	6-11	1slice, ¼ Arabic flat bread, 30g cornflakes, ½ cup cooked cereals (rice, wheat, oat, macaroni), 6 small crackers (use whole meal cereals).
Vegetables	3-5	1 cup raw leafy vegetables or cooked vegetables, ¾ vegetable juice.
Fruits	2-4	1 medium piece of fruits (banana, apple, mango, pear), ½ cup fresh, frozen or canned fruit, ¾ cup fruit juice.
Milk and dairy products	2-3	1 cup of milk, Laban or yoghurt, 43g of cheese, 1 tablespoon cream cheese (use low fat dairy product).
Meat, chicken, fish, eggs, legumes and nuts	2-4	50-80g of meat, chicken or fish, one egg, 2 tablespoons of peanut butter, ½ cup legumes, ⅓ cup nuts, 2 tablespoons of seeds.

Source: Arab Centre for Nutrition

The relationship between dietary fibre and prevention of some chronic disease is well documented. The intake of fruits, vegetables and complex carbohydrates is a good indicator for fibre intake due to the fact that fibre is available only in foods of plant origin. In GCC states, fruit and vegetable consumption is below the recommended intakes. More than 85% of adults in the Gulf region consumed less than five servings of fruits and vegetables per day (138). Furthermore, the consumption of whole grain is decreasing remarkably, with more dependence on refined cereals (139). The potential health problems associated with overconsumption of foods rich in added sugar and salts are well established. The high intake of foods rich in free sugar, particularly among children and adolescents has been reported by many studies in the Gulf region. For instance, in Saudi Arabia, 26% of adolescent's daily fluid consumption come from high-sugar carbonated beverages and 25% come from canned fruit drinks (140). The available data about food composition of meals commonly consumed in the Gulf countries shows high levels of sodium in these meals. Several factors contribute to this high sodium intake, including the excessive use of table salt with the meals, spices, and pickles, in addition to the high salinity of drinking water and the high consumption of fast foods and fries among children and adolescents (140) (141).

In terms of nutrition deficiencies in the Gulf region, undernutrition is considered a problem of concern among children (1-5 years), manifested by wasting, underweight and stunting. The prevalence of underweight in preschool children in the Arab Gulf region ranges from 7% to 23%, whereas stunting ranges from 18% to 22% and wasting ranges from 6% to 13% (141) (142). Despite the high-income level of Arab Gulf countries, anaemia remains an important nutrition problem, particularly iron deficiency anaemia. The prevalence of anaemia among preschool children was 20-60%, and 13-50% among school children and adolescents, as well as 23-54% in women of childbearing age (143). Iron deficiency disorders are prevalent mostly in the mountain areas. The most probable factors that contribute to this are the low intake of dietary iron and foods enhancing iron absorption (144). In most Arab Gulf countries, vitamin A deficiency and iodine deficiency are not a problem of concern. Vitamin A deficiency in 0-72-month-old children was estimated to range between 16-20%. The prevalence of goiter is between 2-10% in the region (142) (145).

Although the environment in the Gulf countries is sunny most of the year, vitamin D deficiency is, however, one of the main public health concerns. For instance, 69% of children below 16 years in Qatar and 28-80% of adults in Saudi Arabia had vitamin D deficiency (146). The main risk factors associated with prevalence of vitamin D deficiency in Gulf region are low exposure to sunlight, low dietary vitamin D and calcium intake and short duration of breastfeeding during the first six months (147).

1.6.2 Morbidity and Mortality associated with NCDs

Due to the changes in lifestyle, dietary habits, and life expectancy in the Gulf region, disease trends have remarkably changed. Diet-related chronic diseases, as in developed countries, have become the major health problem. A systematic review documented that the prevalence of MS ranged 29.6-36.2% in men and 36-46% in women in the GCC countries, which is 10-15% higher than in most developed countries, with generally higher prevalence rates for women (33). Overweight and obesity has increased in all age groups and has become the major cause of morbidity in the region. Zaghloul et al., reported that 12-25% of school children aged 6-11years were overweight or obese in the region. The level increased to 15-45% among adolescents (11-18 years), 30-60% among adult men, and 35-75% in adult women (139). As already discussed, obesity, especially abdominal obesity, is a potent risk factor for T2D, which has a higher prevalence in Arab Gulf countries (12-23%) than in many Western countries. Several studies on the prevalence of overweight and obesity in the Gulf countries have shown that physical inactivity (including long periods of watching television or using internet), high consumption of high-energy-density foods and multiple pregnancies are the main contributing factors to elevated levels of obesity (136). CVDs are the leading cause of death, accounting for 28-30% of deaths in the region (148). Osteoporosis is also an increasing public health problem in the Gulf countries, prominently among women. As already discussed, Vitamin D and calcium deficiencies, together with female sex, age, menopause, and smoking are the main risk factors for prevalence of osteoporosis in the region (149).

1.6.3 Factors Associated with obesity prevalence in GCC countries

Dietary habits and lifestyle of the populations in the gulf region are considerably affected by the nutrition transition (shifts to more Westernised diets, characterised by processed foods high in fat, sugar, and salt) in conjunction with epidemiological transition (rapid population growth due to advances in medicine reducing mortality and improving fertility). Increasing urbanisation, the changes from manual work to office work in labour market as well as the increasing sedentary lifestyle and other sociocultural factors have led to the prevalence of physical inactivity in the Arab Gulf countries (134). Unfortunately, comprehensive and detailed studies relating to factors associated with obesity in EMR including GCC countries are limited. Most of the available studies are cross-sectional and focussed on a limited range of factors (57). In addition, adapting different formats of questionnaires in related studies make the comparisons between countries and the interpretation even more complicated. The WHO has classified the evidence for factors that probably promote or prevent overweight and obesity into four categories, which are; convincing, probable, possible, and insufficient (57).

The most convincing factors related with the prevalence of obesity are energy intake and inactivity. The prominent probable factors for weight gain in the Gulf region include heavy marketing of energy dense foods, home and school environment and unsuitable social and economic environments. The nutrition transition is very obvious in all high income Arab Gulf Countries and available data indicates that most of the changes in dietary habits and food consumption patterns have replicated those occurring in Western Countries over the last four decades (57) (139). Studies show that high consumption of fast foods, especially among children and adolescents, increase the risk of overweight. A limited number of studies have investigated the link between fast food intake and obesity in GCC countries. In Kuwait, the regular consumption of fast foods among university students (mean age 21.1±2.95 years) was the significant predictor of obesity together with other variables (physical activity, sweet consumption, and sedentary lifestyle) (150). However, in the absence of well-designed studies on the role of fast foods in obesity in the Gulf region, it is hard to confirm that Western foods, *per se,* are a significant factor associated with the consumption of a high energy dense diet. In fact, many traditional foods, which form part of Gulf cuisine, contain high levels of fat and energy. In Bahrain, a study was conducted to compare the nutritional profile of Western and local fast foods consumed in the country. The study found that some local fast foods contained higher amounts of fat, salt, and energy than Western alternatives. The finding suggests that the notion that local foods are healthier than Western fast foods is not always true and urged nutrition education programs to focus on the nutritional aspects of both local and Western fast foods (151). Urbanisation is another important factor related to obesity in the region. It potentially means decreased level of physical activity and increased availability of food, and fast foods in particular. In Saudi Arabia, for example, the prevalence of obesity in children living in rural southwestern region is 4% compared to 22% in children living in Riyadh (the capital) (152).

Physical activity in GCC states is considerably lower than the physical activity in many developed countries. Only 30-42% of adult men and 26-29% of adult women met the international standard of physical activity (150min/week) (153). Sedentary lifestyle is increasing in the region, mainly due to increase reliance on mechanised transport, reliance on housemaids in most of the daily house tasks, as well as long duration in watching television and using computers, especially by children, teenagers and young people (136).

Environmental factors, primarily the extreme outdoor temperature, are considered important challenges in combating obesity in GCC countries. In addition, lack of forestation and vegetation, force people to remain indoors and rely on cars to travel even in short distances. Furthermore, socioeconomic factors such income status, marital status, education level may contribute in the prevalence of obesity in the region (152). Culture and traditional customs in the GCC countries have partly been blamed for not achieving the targeted goals in controlling obesity, especially with women. The cultural restrictions and conservative customs towards women, and their lifestyle, translate in very limited access to different physical activities and aerobic exercises. In addition, the availability of migrant labour for household work has resulted in a more sedentary lifestyle for the more affluent members of these societies. Multiparity may be another reason for the prevalence of adiposity among women and due to many combined factors (gestational weight gain, decreased physical activity, increased food intake) it has been suggested that women may gain 4.5 kg or more in one year postpartum (152).

1.7 The sultanate of Oman

The Sultanate of Oman is an Arab country which occupies the south-eastern corner of the Arabian Peninsula and has an area of 309,500 square kilometres. It is bordered by the United Arab Emirates to the northwest, Saudi Arabia to the west, and Yemen to the southwest and also shares marine borders with Iran and Pakistan. The coast is formed by the Arabian Sea on the southeast and the Gulf of Oman on the northeast. The population of the country has increased over 60% in the last 25 years (154), and reached 4,419,193, in 2016, of which Omanis comprise 54.6%, and 45.4% are foreign nationals (155). The Omani population is extremely young, with the median age of 20.9 years in 2012, and 18.2% of the population is between 15-24 years (156) (154). The life expectancy at birth in (2014) was 76.6 years. According to WHO, about 24% of Omani population lives in rural settings, and the rest is distributed in urban areas (figure 1.8) (154). Most of urban dwellers are largely concentrated in a few regions of the country (eg. Muscat and Al-Batinah Governorates) (157). By contrast, some Governorates have only small shares of the country's total population and have very low population densities (eg. Al Wusta and Musandam) (156). The Sultanate of Oman has made remarkable achievements over the last four decades in terms of public health and socioeconomic status. These include a marked reduction in the incidence of infectious diseases and improvements in the health care system, which have resulted in a sharp reduction in mortality indicators and dramatic increases in life expectancy. The crude death rate declined from 13.3 per 1000 population in 1980 to 3.2 in 2012 and life expectancy at birth increased by approximately1.5-fold from 49.3 to 76.2 years during the same period (156). Over the next 25 years, the elderly population of Oman will increase 6-fold, and the urbanisation rate is expected to reach 86%. In addition to the improvement in health indicators of the population, the standards of living have also improved. The relative average household income of the Omani families has significantly increased during the last three decades with the per-capita income now ranked 84 out of 186 countries in human development index (HDI) (158).

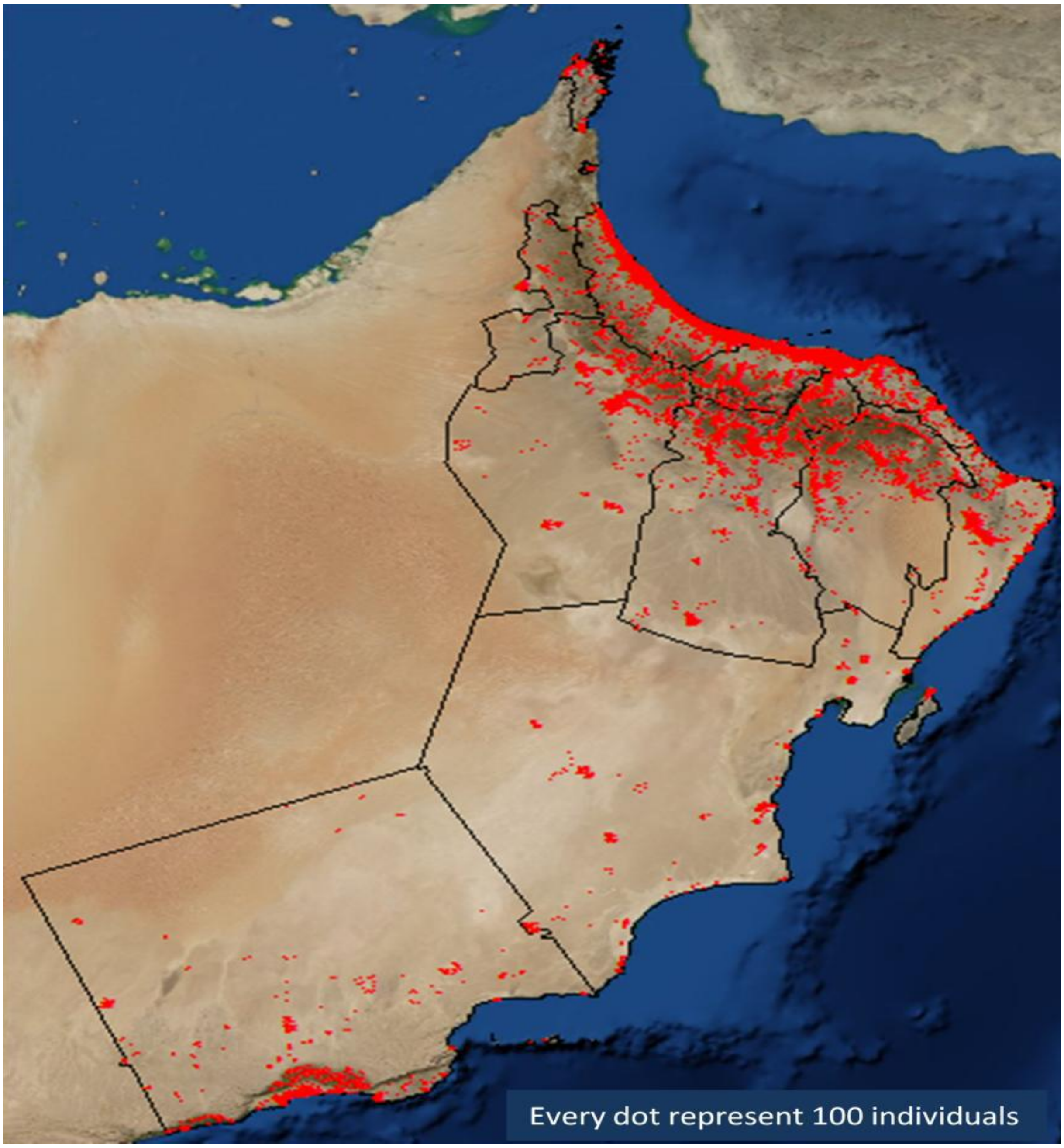


Figure 1.8. Diagrammatic map of Oman showing the scattered population, 2010.
Source: Health Vision 2050, Sultanate of Oman (156).

The new affluence throughout the country and the remarkable advances has not been without price. The advancement in socioeconomic status has contributed to a more sedentary lifestyle. Water scarcity has led to importation of 85% of foods, rendering the country vulnerable to the often-poor quality of commercially processed, energy dense high calorie foods, and to fluctuation in food prices. As a result, overweight and obesity have increased rapidly in adults, and NCDs, particularly type 2 diabetes, kidney and heart diseases, have grown to reach epidemic levels. In 2012, 38.2% of Omani adults were overweight and 33.5% obese (159).

Furthermore, 62.5% of Omani adults had an elevated waist circumference as evidence of MS, with 40% having hypercholesterolemia. Exercise is minimal, with the environment being blamed as not supporting the active living (159). The Ministry of Health has developed a long-term vision for the development of the health system (Health Vision 2050) in Oman. This health vision aims for Omani people to live healthy and productive lives, through the establishment of a well-organized, equitable, efficient and responsive health system, grounded by equity and social justice. It is comprehensive, demonstrates the health system in Oman and reflects the health policy/strategy in the country. It has been designed based on an extensive analysis of political, economic, social, technological, environmental and legal environments. The national nutrition strategy vision, part of health vision 2050, is planned to present an equitable, environmentally sustainable and increasingly self-sufficient Oman, with a population physically fit and well-nourished in all ages groups, committed to an active lifestyle and balanced diet. The targeted goals are included into 3 main domains; health and nutrition, food security and quality, and PA through active living, each of which is linked to the major nutritional problems of the country (e.g. overweight and obesity, stunting, anaemia). In each domain, goals are followed by strategic approaches as followed:

Health and nutrition:

1- Reduce the level of overweight and obesity to <5% of the population through exercise and a balanced diet of fruits and fresh vegetables.
2- Reduce the percentage of stunting to low birth weight to <3% of the population by improving women's health and nutrition before, during and after pregnancy.
3- Increase breastfeeding rates at 6 months to >90% to improve nutritional and cognitive potential of children.
4- Reduce all macronutrient deficiencies including anaemia via consumption of appropriate micronutrient rich foods.

Food security and quality:

1- Reduce importation of cardio-toxic processed, high-density foods to <30% of all intakes through cooperative agreements with regional suppliers, and more hard regulation and increased tariffs on non-healthful foods, in parallel with providing of non-obesogenic diet (such as fresh fruits and vegetables).

2- Increase dietary diversity and self-sufficiency from local food through organically grown fruits and vegetables via introducing high-tech (i.e., nutrient and water efficient) rural and urban gardens in 80% of households.

Physical fitness through active living:

1- Improve physical fitness, at all ages, of the population through measures to increase the active living to 1 hour/day aerobic heart-friendly exercise (i.e., walking, biking, jugging, bicycling, gardening).

2- Provide urban green-spaces and pedestrian transport routs in all cities that are pedestrian friendly and allow for safe exercise and intra-city travel during the day and night.

Lifestyle factors, such as insufficient PA, unhealthy diet and smoking are considered the main risk factors for NCDs in Oman. However, lifestyle behaviour is not the only factor associated with escalating prevalence of NCDs, with individual's awareness about the risk factors of NCDs is considered another challenge. While the prevalence of hypertension in Oman is 40%, about 75% of suffers do not know that they have elevated blood pressure(156). Of those who do know, 17% do not receive treatment and 67% do not control their blood pressure. Similarly, 52% of diabetic patients do not know that they have high blood sugar, and of those who know, 64% do not have their blood sugar controlled (156). All of these factors together with prevalence of overweight and obesity make the control of NCDs more complicated.

The current status of nutritionally related disease and the nutritional intakes in Oman will be discussed in detail in the following Chapter. However, like the rest of the Gulf region Obesity, MS, type 2 diabetes and CVD have all seen marked increases over the last decades. Despite all efforts mentioned before, NCDs are on the rise and pose a threat to the health of Omani population. To date, public health studies in Oman, especially those involving decision makers, have emphasised the need to simultaneously target both dietary habits and sedentary behaviours (160). To our knowledge, few, if any, studies have assessed the individual associations between dietary practices, physical activities and related knowledge and attitudes among adults in Oman. A greater understanding of these relationships is vital to help address the current burden of NCDs in Oman.

1.8 Hypotheses and objectives of the study

The hypothesis and objectives of the current study are the following:

Hypotheses:

- Low levels of physical activity and excessive energy intakes are linked to an increased incidence of obesity in Oman.

- Poor awareness of the impact of physical activity and consuming a healthy diet contribute to the incidence of overweight and obesity in Oman.

- Adoption of Western diets, rich in refined carbohydrates and saturated fat, mean these macronutrients now represent prominent sources of energy in the Omani diet.

- Mobile phone–based technologies represent a valuable tool for changing obesogenic behaviour in the Omani population

Objectives

- To establish baseline information on nutritional status and its association with physical activity for a sample of the adult population in Oman.

- To assess food choices and dietary intake using three-day dietary recall questionnaire.

- To assess the knowledge and attitudes of Omani adults towards food choice and physical activity.

- To compare dietary practices and physical activity levels between males and females and between urban and rural Governorates in Oman.

- To review the currently available mobile phone apps designed to monitor diet and physical activity and conduct a preliminary study to investigate whether these are suitable for use by the Omani population (living in Oman and in the UK).

Chapter 2: Survey of the Current Attitudes and Practices towards Diet and Physical Activity amongst Omani Adults

2.1 Introduction

2.1.1 Epidemiology of NCDs in the Sultanate of Oman

In Oman, although the health status of the population has evolved over the past 4 decades and communicable diseases have been successfully reduced a wide range of NCDs have emerged and now represent the main health concerns in the country. Recent WHO reports described the levels of NCDs in Oman as very worrying with, cardiovascular diseases, diabetes, cancer, chronic respiratory diseases accounting for 68% of all mortality in Oman (figure 2.1) (161). Furthermore, NCDs contribute to 18% of premature deaths (deaths between 30 and70 years) in Oman (161). Like many other GCC countries, prevalence of obesity in Oman is alarming. In 2000, the age adjusted prevalence of obesity in men and women was 16.7% and 23.8% respectively (compared to 10.5% in 1991 25.1% in 1991) (162). More recently, the Oman Medical Journal reported that prevalence of obesity, as assessed by BMI, had reached 24.1% (22% males, 26.1% females) (163). Overweight and obesity were found to be more common in the Southern part of Oman (70%) compared to Northern areas (32-57%) and those living in urban areas were more obese (21.1%) than those living in the rural communities (13.1%) (162). The prevalence of obesity-related conditions including hypertension (40.3%), DM (12.3%), raised total cholesterol (33.6%) have all been shown to be high (163). Table 2.1 shows the prevalence of overweight, obesity, and T2DM among Omani Population, according to the Oman World Health Survey (OWHS).

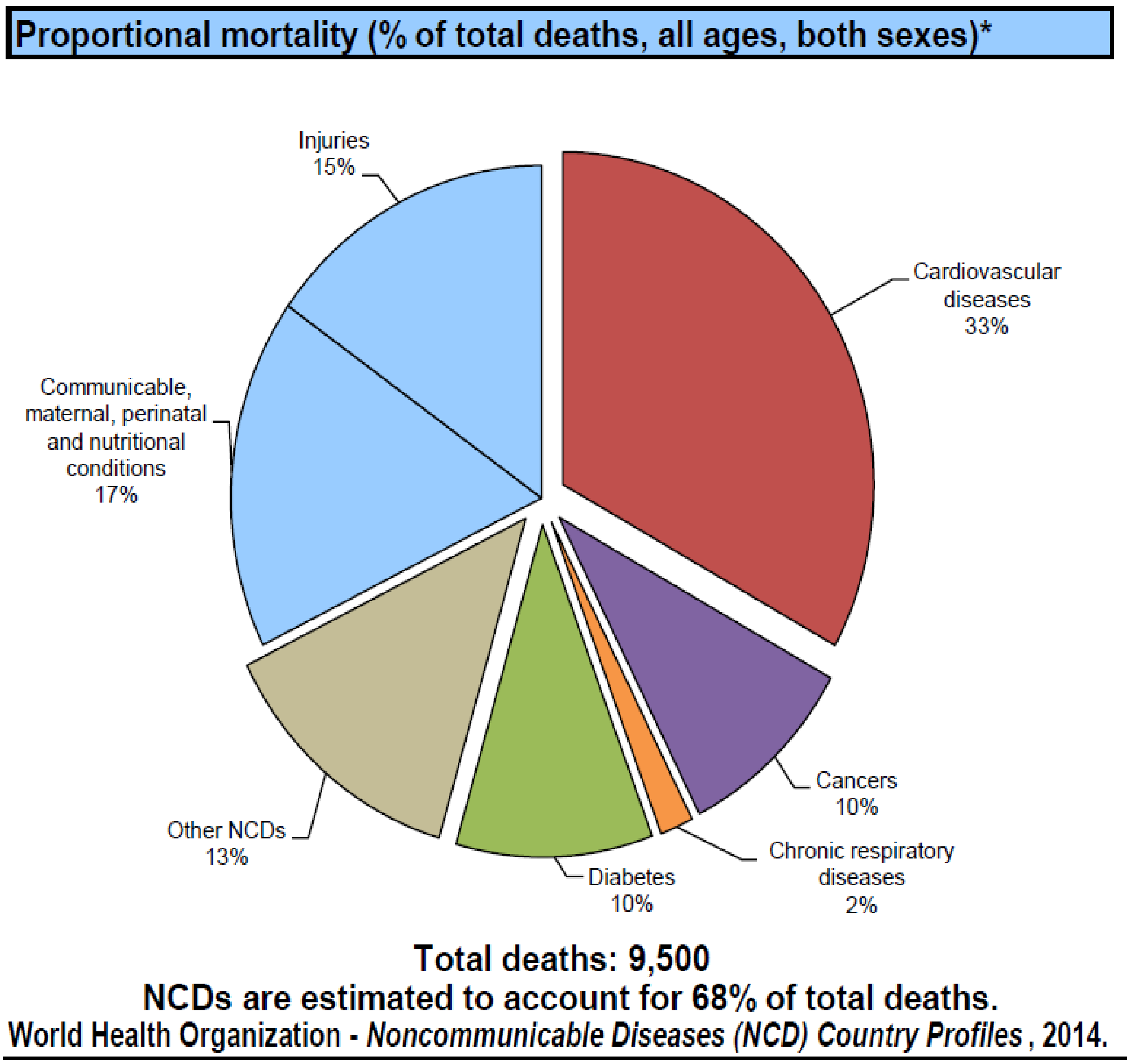


Figure 2.1. Proportional mortality in Oman.

Table 2.1: Percent distribution of body mass index and type 2 diabetes mellitus among Omani Population, according to gender and age group.

Gender characteristic		BMI				T2DM
		Underweight <18.5	Normal 18.5-24.9	Overweight 25-29.9	Obese ≥30	
Male		7.7	39	31.2	22	12.4
Female		10	36	28	26.1	12.1
Age group	18-24	19.4	50.9	17.8	11.9	0.9
	25-34	6.6	34.9	33.4	25.1	3.1
	35-44	2.2	28.5	35	34.3	11
	45-54	5.6	25.8	34.5	34.1	23.6
	55-64	5.8	32	37	25.2	34.9
	65+	20.4	44.3	19	16.3	30.7

Source of the data: OWHS: Part 1(163).

2.1.2 Efforts and initiatives to address the burden of obesity in Oman and GCC countries

Obesity–related NCDs have become a major health concern in Oman, as in other GCC countries. The Food and Agriculture organisation (FAO), and the WHO of the United Nations (UN) have urged individual countries, through international conferences, to develop health plans and strategies based on public health concerns and relevant to people of different ages, lifestyle, and cultures (136). In addition, several meetings and workshops in the GCC countries have emphasised the action needed to promote healthy lifestyle and healthy nutrition. Developing food-based dietary guidelines (FBDG), in 2012, dedicated for GCC countries is one prominent attempt, to prevent and control the main nutrition-related disorders based on the current scientific and health information. The guidelines were developed by the Arab Centre for Nutrition and include food-based advice, taking into account socio-cultural and religious background, lifestyle, and the dietary habits, of population in GCC states. Similar attempts were implemented in Oman in 2009, with the establishment of the Omani guide to heathy eating. However, the Omani guidelines are different in two main issues: (1) they were prepared for health educators and not directed to the public and (2) they focused on the portion size of food items, while the FBDG focused on food-based advice. In Oman, efforts continue to tackle NCDs in collaboration with related UN organisations including WHO, FAO, United Nations Development Programmes (UNDP), United Nations Population Fund (UNFPA), and Unite Nations Children's Fund (UNICEF). The United Nations Interagency Task Force on the Prevention and Control of NCDs carried out a joint mission to Oman in order to support Omani government programmes. Although some recent progress has been made, the joint mission reported that the overwhelming majority of Omani adults have insufficient fruits and vegetables intake, more than 40% of Omani adults still have hypertension and 12% have been diagnosed with diabetes (164). In addition, 40% are physically inactive and one in seven men use tobacco. Thus, while Oman has showed significant commitment to curb the prevalence of NCDs, including the establishment of several national strategies (e.g. health promotion strategy, school health strategy, Oman health vision 2050) overweight, obesity and related NCDs remain a major public health problem.

The current study was designed to investigate dietary habits, lifestyle behaviours and related knowledge and attitudes amongst Omani adults, in order to gain a better understanding of the main factors associated with the increased incidence of obesity in Oman. The study also sought to identify the barriers that restrict people to change their unhealthy habits, and effective intervention need to be undertaken. Hence, the study is different from previous studies through investigating the impact of both dietary intakes and physical activity on nutritional statutes of Omani adults aged (18-60 years) and used a reliable tool for nutrient analysis. Whereas previous surveys collected household data about health and dietary habits of Omani society, and investigated the factors associated with prevalence of some diet-related diseases (such as anaemia) and micronutrient deficiencies (e.g. vitamin A, vitamin D). The current study hypothesised that excessive energy intakes and low levels of PA are responsible for increased incidence of obesity in Oman, worsen by poor awareness of the consequences of such unhealthy lifestyle behaviours. As mentioned in chapter one, the aims and objectives of the study are:

Aims

- To establish baseline information on nutritional intakes, and physical activity and their association with obesity in the adult population in Oman.

Objectives

- To assess the knowledge and attitudes of Omani adults towards food choice and physical activity.
- To assess food choices and dietary intake using food frequency and three-day dietary recall questionnaires.

- To compare dietary practices and physical activity levels between males and females in different age groups in all Governorates in Oman.

2.2 Survey methodology

2.2.1 Design and development of the questionnaire

The Sultanate of Oman is administratively divided into 11 governorates. The governorates are Muscat (capital), Al Batinah north, Al Batinah south, Al Dakhliah, Dhofar, Al Sharqiyah north, Al Sharqiyah south, Al Dhahirah, Al Buraimi, Musandam, and Al Wusta (165). In order to obtain a nationally representative sample of Omani subjects in a practical and organised way, the same area classification was adopted for this survey. The targeted population for this survey were Omani adults aged 18 years and over. The reason of targeting this age group is that they fall in greatest risk age-wise and being more likely to be exposed to diet related diseases. Also, about 66 % of Omani population is above 15 years with the median of 20.9 years (156). The hypothesis of the current study proposed that the excessive energy intakes of unhealthy foods as well as low level of physical activity were responsible for the increased incidences of overweight and obesity in Oman. Yet, testing this hypothesis required recent representative data about health, diet and physical activity of Omani population. The available representative data, before commencing the current study, was quite old (the national nutrition survey in 2004), and many changes could have happened during this period. Hence, it was very important to provide the study with updated representative data. Due to time and resources constraints of this research, it was not possible to conduct face to face survey or interviews for data collection. The most feasible option for collecting the required data from Omani adults living in Oman was using a survey questionnaire.

Questionnaires are one of the most affordable data collection tools that provides many advantages compared to other methods. They are practical and can gather large amounts of information from large number of people (hence good statistical significance) in a short period of time, with relatively low costs. They can be carried out by the researcher or by any number of people with limited affect to its validity and reliability due to standardised questions for all participants. Questionnaires also ensure anonymity, uniformity in responses, and provide freedom to the respondents (166). However, questionnaires have some disadvantages include;

self-reporting based on participants own interpretation, which may have resulted in a level of subjectivity. Another weakness is poor response rate, hence, some results may be inadequate to understand some forms of information which consequently has a negative impact on the validity of generalised statements. Although questionnaires can be used only with educated respondent, however, ambiguous answers and omission of replies to some questions still can occur (166). Thus, the current population survey was cross-sectional, based on a structured questionnaire (Appendix A). The questionnaire started (first page) with the main objective of the survey and the important notes to be considered before starting filling the questionnaire. It included three sections:

Demographic background: this section concerned participants characteristics such as place of living, age, gender, weight, height, educational status, marital status, family members, working status and household income. This section was also aimed to find out the impact of demographic background on the nutritional status of Omani adults.

Health and diet: the aim of this section was to evaluate the knowledge and attitudes of Omani people towards their health and diet, as well as to obtain precise information about the quantity of food consumed per day and their daily dietary habits. Hence, this section included knowledge and attitudes questionnaire, and two different quantitative methods (FFQ, and 3-day dietary assessment).

Self-reported exercise: this section aimed mainly to determine levels of PA of study participants (low, moderate, and high levels) in addition to assessing the sedentary behaviours among study participants. This section also sought to find out the link between PA level with the finding from health and diet section (BMI, body weight, energy intake).

2.2.2 The validation of the survey model

For the purpose of validation and reliability in this current survey, questions in all sections were developed in light of similar questionnaires implemented earlier in the GCC countries, such as (The 2004 National Diet and Nutrition Survey of the Sultanate of Oman) and (The National Nutrition Survey Questionnaire for Adults aged 19 years and above, in Kingdome of Bahrain, 2002) (167) (168). However, there are some differences between the two mentioned questionnaires and the one used in the current study (table 2.2). The table indicates that the nature of the current survey was similar to the one conducted in Bahrain, 2002. Both survey methodologies included socio-economic and lifestyle data, health related indices (smoking and PA behaviour), and food frequency questionnaires (FFQ). However, the difference was that Bahraini study used 24-hour diet recall for dietary assessment, whereas the current study used 3-day diet diaries (two-week days and one during weekend). The reason of using 3-day diet diaries in this study, was due to the fact that using a single 24-hour dietary recall could easily fail to record the consumption of certain food items, which might be important (169). Although, the 2004 National Diet and Nutrition Survey in Oman investigated the dietary habits and nutritional status of the Oman population (as this study did), however, that survey did not investigate PA and lifestyle behaviour. The 24-hour dietary recall data, in both Bahraini and Omani National Nutrition Surveys, were collected by trained dietary interviewers, whereas data in this survey study were collected by self-reported questionnaires completed by study participants. While Bahraini survey (2002) adapted using blood test for measuring haemoglobin level, the current survey was not designed to collect any blood samples from study participants, due to time and resources constraints. Unfortunately, despite careful choice of previously validated questions and piloting of the questionnaires, it subsequently became apparent that some questions were not worded to produce information that could be used as part of the study (for example, in Appendix 1, question 17 in health and diet section the frequency of fast food consumption). This has unfortunately limited the value of some of the data collected.

Table: 2.2 Differences between the questionnaire of the current study and questionnaires of (National nutrition survey in Oman (2004) and Bahrain (2002).

Questionnaire **Characteristic**	**Current study**	**Oman 2004**	**Bahrain 2002**
Targeted population	Adults (18+)	- Children (6 months-5 years) - Adolescent (13-18 years) - Men (19-59 years) - Non- pregnant/non lactating women (19-49)	Adults (19+)
Dietary data collection	- Self-reported diet diaries. - FFQ	- Two 24-hour dietary recall (one in week day and one during weekend) via in depth interview (household visit) by dietary interviewer. - Quantities estimated using standard units of weight and volume.	- 24-hour dietary recall via interview. - FFQ
Measurement: **- Height & weight** **- Blood test**	- Self-reported - Not involved	- Trained surveyors - Not investigated	- Trained surveyors - Survey team nurses
Physical activity	Involved	Not involved	Involved

Before conducting the current survey, the questionnaire was pre-tested in a small pilot study implemented on nine Omani adult students registered in the University of Nottingham (4 males and 5 females), in order to identify the mistakes and undesirable trends that might have crept into the questionnaire. In addition to develop research questions and collecting preliminary data prior to performance of the main survey study, as well as helping in testing the validity and reliability of statistical techniques to be adopted for the data processing and analysis. Mathiyazhagan and Nandan in (2010) illustrated that pilot survey study is considered to be a substantial saver of time and effort, if well done and thoroughly exploit, by helping to avoid erroneous and insignificant hypothesis (166). Minor changes have been made based on the suggestions obtained from the pilot study (most of them related to rephrasing some questions to be culturally more acceptable, such as using the term social type instead of the word sex to determine the gender and deleting some types of exercise such as dancing). However, the changes did not alter the meaning or the number of questions in the questionnaire. Due to the nature of the current study, the questionnaire was developed in English language and translated and administered in Arabic, which was the local language of the targeted study population. The answers then translated back to English language during data entry (as the study was originally in English). The translated questionnaire did not require any changes in either the number or meaning of the questions. The survey was anonymous, and no personal/ private information was collected. The ethical approval of the study was obtained from the Medical School Research Committee of the University of Nottingham (Ref: OVSB14112013 SoBS Nutrit). The researcher was supported by the Oman Cultural Attaché in UK with the implementation of the study in Oman.

2.2.3 Data collection

As shown in figure 2. 2, the survey team was composed of 11 health educators, recruited by the principle researcher, from all governorates in Oman (one from each governorate). They underwent training focused on clarifying the meaning of each questions in each section and the proper answer required. The contact (via phone or email or face to face) between the respondents, team members and the principle investigator, was emphasised during the training. This was to help ensure that as much support as possible, was accessed by the team to support them advising the study participants during the survey. All team members worked in parallel during the same time span (from December 2013 to April 2014) under the supervision of the principle investigator. Information about demographic background, health, diet, and PA were self-reported and collected with the aid of the questionnaire.

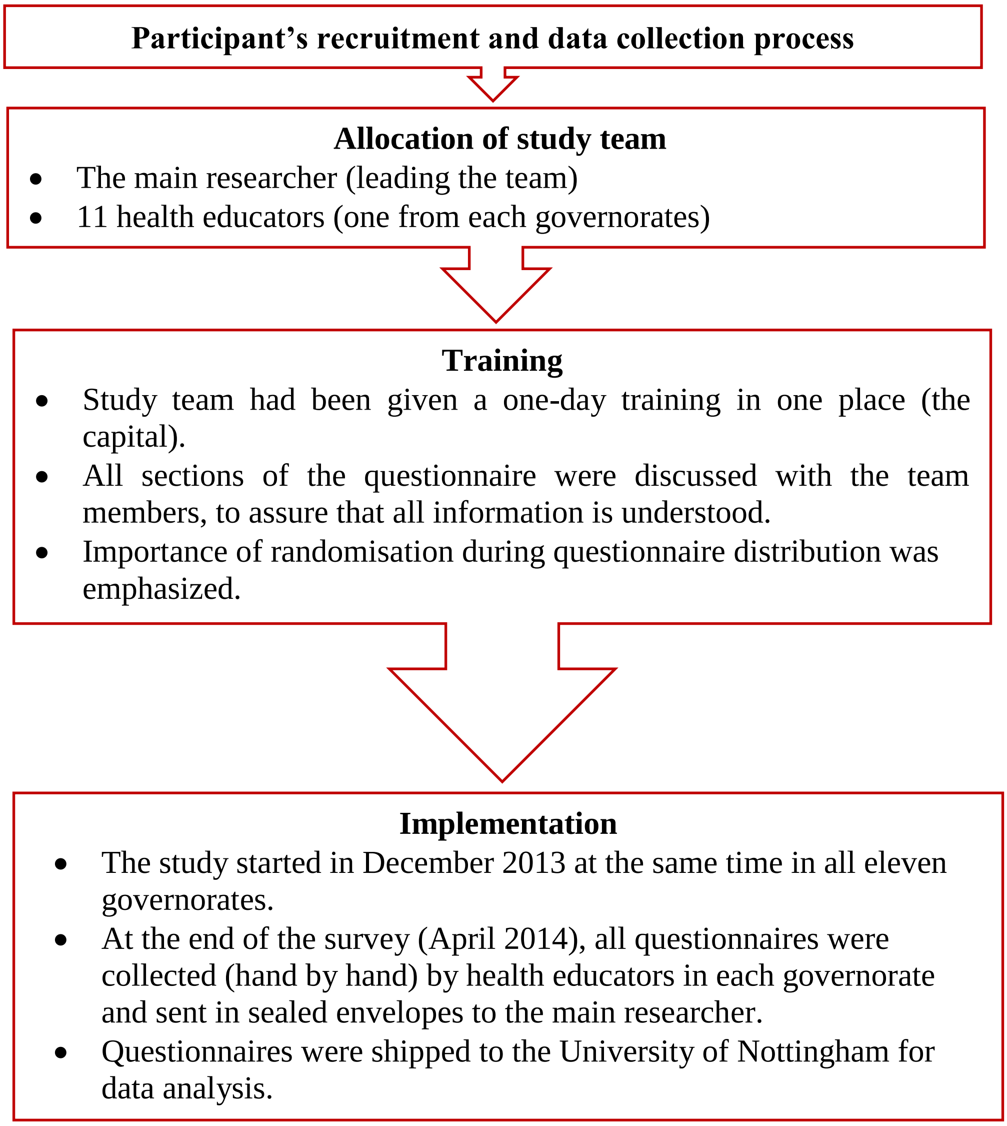


Figure 2.2 Participants' recruitment and data collection flow chart

2.2.4 Study population and sampling method

The survey investigated the current dietary practices and attitudes towards diet and physical activity amongst free living Omani adults aged 18-60 years. According to the National Centre for Statistics and Information in the Sultanate of Oman, the total Omani population in 2012 was (2,092.56), distributed in eleven governorates (170). Using a sample size calculator (http://www.raosoft.com/samplesize.html), adjusted with 5% margin error, 95% confidence level, and 70 % response distribution, and resulted in minimal sample size of 323 subjects. Additional subjects were added, to reach 500 subjects, in order to have sufficient subjects in all age groups in both gender from all governorates. During the survey, a total of seven hundred fifty questionnaires were distributed, equally by gender, to all governorates (urban and rural) in Oman during the period from December 2013 to April 2014. The number of participants in each governorate was allocated and calculated by multiplying the percentage of population density in the governorate with total number of questionnaires required in this study (500). For example, the percentage of population density in Muscat was 20.8%, therefore number of questionnaire required was (0.208*500 questionnaire =104 questionnaire) (table 2.3). However, the actual number of questionnaires distributed to each governorate was more than the number obtained from the calculation, in order to allow for 5% drop-out rate. Potential participants in all governorates were randomly selected and provided with detailed information about the study. Eligible participants were requested to read the instructions in page one of the questionnaire and answer all questions in all sections. Respondents were given sufficient time to complete the questionnaire and return it back to the research team member allocated in their governorate. Then, all completed questionnaires, in each governorate, were collected in closed envelopes and sent to the principle investigator via work mail (Ministry of Education). Upon being received, all questionnaires were reviewed and only those completed were included. Recruitment continued until 500 completed questionnaires had been received. Two hundred and fifty questionnaires were excluded due to incomplete information in the main sections (health and diet, physical activity). The study was concluded at the end of April and all questionnaires were transferred to the University of Nottingham for data analysis.

Table 2.3. Distribution of study questionnaires in urban and rural areas by population density in each governorate in Oman.

Urban governorate	% of Omani Population	No. of Questionnaires (required)	No. of Questionnaires (distributed)	% of questionnaires returned
Muscat	20.8	104	155	67.1
N. Batinah	19.7	98	148	66.2
Al Dakhilyah	13.7	69	103	66.9
S. Batinah	12	60	90	66.7
Dhofar	8.4	42	63	66.7
Al Dhairah	6	30	45	66.7
Rural governorate				
S. Sharqiyah	8	40	60	66.7
N. Sharqiyah	7	35	53	66
Al Buraimi	2.2	11	17	64.7
Musanadam	1.12	6	8	75
Al Wusta	1	5	8	62.5
Total	**100**	**500**	**750**	66.7

2.2.5 Data analysis

Collected questionnaires were coded and prepared for data entry process. Demographic data was statistically analysed using descriptive statistics using the SPSS software package (version 20). Obesity was defined by the WHO-BMI standards mentioned earlier in the introduction. The percentage of study participants in each BMI category was calculated for the total sample and stratified by gender, age group and governorate. Furthermore, the correlation between BMI categories with other lifestyle factors such as energy intake, PA, and demographic characteristics were also investigated. The FFQ assess the level of food consumption in all initial food groups covered in the questionnaire. Five food groups were classified based on the type of food, include; ((fruit, vegetables & legumes), (fish, meet, & egg), (milk & milk products), (grains & pastry), (snacks), and (drink)). Daily food intake details were collected from the completed dietary 72-hour recalls and computerised using Dietplan6 software for nutritional analysis. Dietplan6 is a program that can handle food tables from multiple sources and data from any source can be included in any recipe, menu or personal food diary without restriction. The database is pre-installed with the full set of UK food tables and includes Dietary Reference Values (COMA, 1991), Food Portion Sizes (MAFF 2nd Edition, 1993), Food Labelling Data (EU Regulation 2011) and the Nutritional Standards and Requirements for School Food (HMSO, 2008). Nutrient values are calculated as soon as a food or ingredient is added, making it easy to observe the effects of adding or subtracting any item. Nutrient values, as dependent variables, were analysed using factorial ANOVA. P-value of (<0.05) was considered significant.

2.3 Results

2.3.1 Demographic characteristics

Different countries have varying definitions of rural areas for statistical and administrative purposes. For the purpose of the current study, governorates were classified into urban and rural areas based on the population density and the geographical nature of the region.

Governorates characterised by a desert or agricultural area with relatively low population density, and located outside the cities or towns, were classified as rural. Over 80% of study population were living in urban regions (table 2.3), and most of the populated urban governorates are coastal areas (such as Muscat, Al Batinah north, Al Batinah south, and Dhofar). Governorates (such as Al Wusta, Musandam, and Al Buraimi) represent very low population density areas, and both North Al Sharqiyah and south Al Sharqiyah represent a combination of deserts (in some areas) and agricultural areas. Table (2.3) shows the distribution of study questionnaires in urban and rural governorates by the percentage of population in each governorate. Overall, five hundred participants (279 female and 221 male) completed the survey questionnaires. In spite of a number of limitations which potentially affected response rate of this study (including the limited number of team members (one from each governorate), level of education of the target population, and the diverse geographical nature of Oman), the response rate of the survey was 67% and as such, deemed appropriate for such a study. Table (2.4) shows the demographic and social characteristics of the participants. Overall, more than half of the study subjects lived in Muscat, South Albatinah, and north Albatinah. The table also shows that nearly half of the participants are in age group (31-49), and 43.6% were younger than 30 years. The mean age of study participants was about 33 years, and males higher (35 years) than females (31 years). The mean height of the respondents was 160 cm, and the mean weight was 69.9 kg. As would be expected, males taller (169 cm) and weighed more (77 kg) than females (158 cm, 63.9 kg respectively). Looking at the variations in the educational level, more than half of the study population had attended university. About 67% of the study population were currently married, while 30% had never been married and 2.6 % were widowed or divorced. Almost three quarters of married participants had children. Looking at the current job of the participants, the majority (66%) worked in the governmental sector. The majority of participants (55%) had a household income of between 700-1500 OMR (£1400-3000) per month.

Table 2.4. Demographic and social characteristics of the study subjects.

Characteristics (U) = Urban areas (R) = Rural areas	Male (n=221) n	Female (n=279) n	Total (500)	Percentage (%)
Governorate				
Muscat (U)	65	51	116	23.2
Dhofar (U)	12	16	28	5.6
Al Dakheliah (U)	17	17	34	6.8
Al Buraimi (R)	6	11	17	3.4
Al Batinah South (U)	45	65	110	22
Al Sharqiah South (R)	7	10	17	3.4
Al Wusta (R)	4	4	8	1.6
Musandam (R)	2	13	15	3
Al Batinah North (U)	29	49	78	15.6
Al Sharqiah North (R)	3	9	12	2.4
Al Dhaherah (U)	25	28	53	10.6
No Answer	6	6	12	2.4
Age group				
≤30	82	136	218	43.6
31-49	114	127	241	48.2
≥ 50	25	16	41	8.2
Average				
Age (years)	35	31	32.8	-
Height (meter)	1.69	1.58	1.6	-
Weight (Kilogram)	77.02	63.93	69.9	-
Educational level				
Illiterate	2	6	8	1.6
Read and write	4	4	8	1.6
Primary school	2	1	3	0.6
Elementary school	8	3	11	2.1
Secondary school	41	39	80	15.6
Technical or college school	63	60	123	24
University graduate (4 years)	94	160	254	49.5
Post-graduate studies	11	15	26	5
Marital status				
Married	180	166	346	67.2
Divorced	2	5	7	1.4
Widowed	1	5	6	1.2
Single, never married	42	114	156	30.3
Number of children:				
None			95	26.4
(1-3)			171	47.5
(4-6)			58	16.1
7 or more			36	10
Current job				
Unemployed	5	8	13	2.6
Retired	8	3	11	2.2
Housewife	5	14	19	3.8
Employed in governmental sector	140	193	333	66.6
Employed in private sector				
Manager / professional	29	38	67	13.4
Military sector	6	2	8	1.6
Owen Business	12	0	12	2.4
Student	5	0	5	1
Not working	10	21	31	6.2
	1	0	1	0.2
Household income				
<500 OMR			58	13.4
(500-700) OMR			73	16.9
(701-999) OMR			107	24.7
(1000-1500) OMR			132	30.5
> 1500 OMR			63	14.5

2.3.2 Health and Diet

Results in part two of the questionnaire (knowledge and attitudes towards health and diet) illustrated that the majority (77.4%) rated their health as good. However, over 80% of participants reported that they had not attended a recent medical examination and were therefore unable to specifically state whether they were suffering from Type 2 diabetes, CVD, or hypertension. However, a high prevalence of hypertension (16.7%) was reported. The majority of the study population were non-smokers (97%) with only 17 participants reporting smoking any form of tobacco. Around 56% of the study sample thought that they need to lose weight. Results also showed that 70% of the participants ate 3 meals or more daily and almost 80% of participants consumed an omnivorous diet (animal & vegetable sources). The percentages of participants following a salt, fat, carbohydrate (starch) or calorie restricted diet were 2.8, 9.6, 4.8, and 8.2% respectively. Meat and meat dishes were the most enjoyable food (32.8%), followed by fish and sea food dishes (32.6%). Approximately 18% of study sample enjoyed eating fruit, and 16% enjoyed eating cake, pastries, desserts, and ice-cream. 95% of the participants consumed fast foods frequently, and sandwiches were the most commonly consumed (55.4%). Potato chips, pizza, Burger and kebabs, and fried chicken were 15.2, 14.3, 7.8, and 7.4% respectively. The vast majority of the study sample (94%) did not take any dietary supplements. Table 2.5 shows the food frequency results by portion size per week for all study respondents. Over 10% of the participants did not, or rarely consume fruit and 19.3% did not or rarely consumed vegetables. In addition, 28.6% and 34.6% never or rarely consumed starchy potatoes, and legumes respectively. The majority of the study respondents (37.3%) consumed 3 portions/week of fruits. In addition, over 29% consumed 3 portions of green leafy vegetables or other vegetables (e.g. carrots, tomatoes, cucumber, etc.). With regard to the consumption of fish, meat and eggs, results showed that most participants consume 3 portions / week of fish (56.7%), chicken (61.7%), and eggs (44%). The majority (32.5%) of study participants consumed one portion/week of red meat, and 26.3% consume 3 portions/week.

However, a majority of subjects never, or rarely, consumed meat products (62.2%) or sea food (65.6%). Consumption of milk was generally low with over half of the participants never or rarely drinking milk (either full or fat-reduced varieties). The majority consumed milk products such (cheese, yogurt, milk drink, etc.) in 3 portions/week (33.7%) or 5.5 portions (24.9%). Grains such as (rice, wheats, oats, etc.) were consumed very frequent with almost 74% of study participants consuming grains at least 5 days per week. While bread was regularly consumed by participants, this was much more likely to be white, rather than wholemeal, bread. About 42 % of participants consumed 3 portions, or more, of snacks such as (potato chips, candies, chocolates, ice-cream etc.). In addition, 33.4% ate 3 portions/week or more of cakes and pastries. Surprisingly, over 80% of study participants reported that they rarely eat Omani Halwa (traditional Oman sweets). Furthermore, over 50% never, or rarely consumed nuts (e.g. pistachio, cashew nuts, etc.) and 28.7% consumed only 1-2 portions per week. While the majority (65%) never or rarely consumed soft drinks, 40.6% drank fruit drinks more than 3 times/week or more. More than half of the respondents consumed coffee or tea daily.

Table 2.5. Percentage of food consumption (per week) in study participants.

Type of food / Food Frequency	1	2	3	4	5	6
	never or rarely	1-2 portions	2-4 portions	5-6 portions	or 7 more portions	I don't know
(%) Fruits, vegetables, and legumes						
Fresh fruit (apples, oranges, pears, etc..)	10.2	11.2	37.3	13.4	26.1	1.8
Green leafy vegetables (lettuce, cabbage, endive, spinach, etc...)	10.5	9.1	29.6	23.1	26.1	1.6
Starchy vegetables (potatoes, sweet potatoes, etc. …)	28.6	26.8	26.2	9.4	6.8	2
Other vegetables (carrots, tomatoes, cucumber, etc...)	8.8	5.9	29.8	26.3	28.4	0.8
Legumes (Lentils, beans, peas,...)	34.6	28.6	27.3	4.9	3	1.7
(%) Fish, Meet and Eggs						
Fish	11	18.2	56.7	9.3	4.5	0.2
Sea foods (squid, prawn, shrimps, etc…)	65.6	15.1	13.7	1.7	2.3	1.7
Chicken	6.5	12.1	61.7	13.9	4.8	1
Red meat	34.4	32.5	26.3	2.4	2.4	2
Meat products (sausages, burgers, sandwich,..)	62.2	20.2	12	3	0.9	1.7
Eggs	12.4	21.7	44	14.1	6.7	1.1
(%) Milk and milk products						
Milk, full fat	50	13.6	18.1	6.4	10.4	1.5
Milk, low fat or skimmed	64.3	9.7	15.2	4.4	4.9	1.5
Milk products (cheese, yogurt, milk drinks,..)	8.8	10.3	33.7	24.9	21.1	1.3
(%) Grains and pastry						
Bread, white	8.1	8.5	29.3	25.1	28.6	0.4
Bread, whole meal /brown	59.9	11.2	16.5	7.4	4.4	0.6
Cereals (corn flakes, oatmeal,.)	65	18.8	11.2	2.7	1.9	0.4
Pasta (spaghetti, macaroni, noodles, grits,..)	39.3	39.3	15.7	3.3	1	1.2
Grains (rice, wheat, oats, etc…)	3.2	5.1	17.5	37.3	36.4	0.6

Continue table 2.5

Type of Food \ Food Frequency	1 never or rarely	2 1-2 portions	3 2-4 portions	4 5-6 portions	5 or 7 more portions	6 I don't know
(%) Snacks						
Snack foods (potato chips, candies, chocolates, ice-cream etc..)	34.6	22.5	26.4	9.7	5.6	1.2
Omani halwa	81.1	12.5	3.3	0.6	0.2	2.3
Cakes & Pastries (cakes, biscuits, sweet pies,..)	40.2	25.4	26.5	5.2	1.7	1
Nuts (pistachio, cashew nuts,..)	50.2	28.7	13.2	3.6	2.7	1.7
(%) Drinks						
Soft drinks (cola drinks)	65.3	14.1	8.6	4.3	7	0.6
Fruit Juices	16.5	20.2	36.9	14.9	10	1.4
Fruit drinks	41.6	16.6	24.1	9.8	6.7	1.2
Coffee/tea	12.3	3.9	13.7	18.8	50.8	0.6

2.3.3 Body Mass Index

Study participants were asked to record their height and weight, and this was used to calculate Body Mass Index (BMI). This data was provided by 83.2% of the participants. Overall, average BMI of study respondents was (26.4 ± 5.9). Table 2.6 shows the distribution of study subjects in each BMI category. About 38% of study samples were in normal weight, 33.2% overweigh, 19.7 % obese, and 2.9% were morbidly obese. While study participants, were initially distributed into 5 age groups (in about 9-year intervals), taking the socio-cultural dimensions of Omani population into consideration it was also useful to distribute them into 2 main age groups (18-30, and 31-60 years). The age group (18-30) primarily represents those participants who are students, unemployed/recently employed, and not married, while the age group (31-60) represented participants who are married, employed or retired. Such division helps to further explore the impact of these sociodemographic factors on health and lifestyle behaviour. The body mass index, in both genders, is higher in the age group 31-60 compared to age group 18-30 (figure 2.3). In the younger age group (18-30y) men had a higher BMI than women, but in older individuals there was no significant difference ($p = 0.22$). As shown in (figure 2.4), the prevalence of overweight and obesity was generally increased by increasing age to reach over 70% by the age of 45 years. Figure 2.4 compares the prevalence of overweight and obesity of males and females within the different age groups. The incidence of underweight was generally low (6%) and was most apparent in females between the ages of 16- 35 years. The percentage of study population in each BMI categories by gender and age group in all governorates are presented in (Appendix B). BMI was significantly ($p<0.05$) influenced by age and gender but not by governorates (Urban vs Rural). However, although it is not significant, prevalence overweight and obesity were more obvious in some urban governorates (such as Muscat, North and south Al Batinah). In addition, about 31% of obese females, in age group (18-30y), were from Dhofar (urban region). When dividing the 500 questionnaires and diet diaries into gender and age categories, the number of subjects from the five rural governorates was too low (70 out of 500 subjects) for meaningful statistical analysis. Thus, the data presented in tables (2.7, 2.8, and Appendix D) represent urban governorates only. Total energy, protein, energy from protein, level of cholesterol in the blood, and sodium were significantly ($p<0.05$) influenced by gender, as shown in tables (2.8, Appendix D). Furthermore, total sugar was significantly ($p<0.05$) affected by age group, governorate, and the interaction between the three factors (age group, gender, governorates). Energy from carbohydrates as well as energy from fat were significantly ($p<0.05$) affected by age group and the interaction of gender and age group. No significant ($p<0.05$) difference in level of fat, polyunsaturated fatty acid, and iodine between study subjects. In contrast, monounsaturated fatty acid and Trans fatty acid were significantly ($p<0.05$) affected by the interaction of age group and gender. Potassium was significantly ($p<0.05$) affected by age group and the interaction of age group, gender, and governorate. Vitamin C was significantly ($p<0.05$) affected by governorate, interaction of gender and governorate as well as the interaction of the three factors. Table 2.9 shows the comparison of average nutrient intake in study population with Dietary Reference Values (DRVs) in UK. Generally, total energy and energy from Protein, fat, and carbohydrates were within the health guideline set by UK. Of the micronutrient investigated, it was noted that sodium intake was considerably higher than that recommended in UK (DRV). Furthermore, average level of cholesterol and sodium in both gender, as well as saturated fat intake of males in age groups (18-30y) recorded in this study (table 2.8), was higher than the standard levels defined by many health-related organisations such as WHO, and British Nutrition Foundation.

Table 2.6. Distribution of study subjects in BMI Categories *(Kg/m²)* (WHO, (12)).

BMI categories

		Frequency	Percent	Valid Percent
Valid	**Underweight**	25	5.0	6.0
	Normal	159	31.8	38.2
	Overweight	138	27.6	33.2
	Obese	82	16.4	19.7
	Morbidly Obese	12	2.4	2.9
	Total	416	83.2	100.0
Missing	**System**	84	16.8	
	Total	500	100.0	

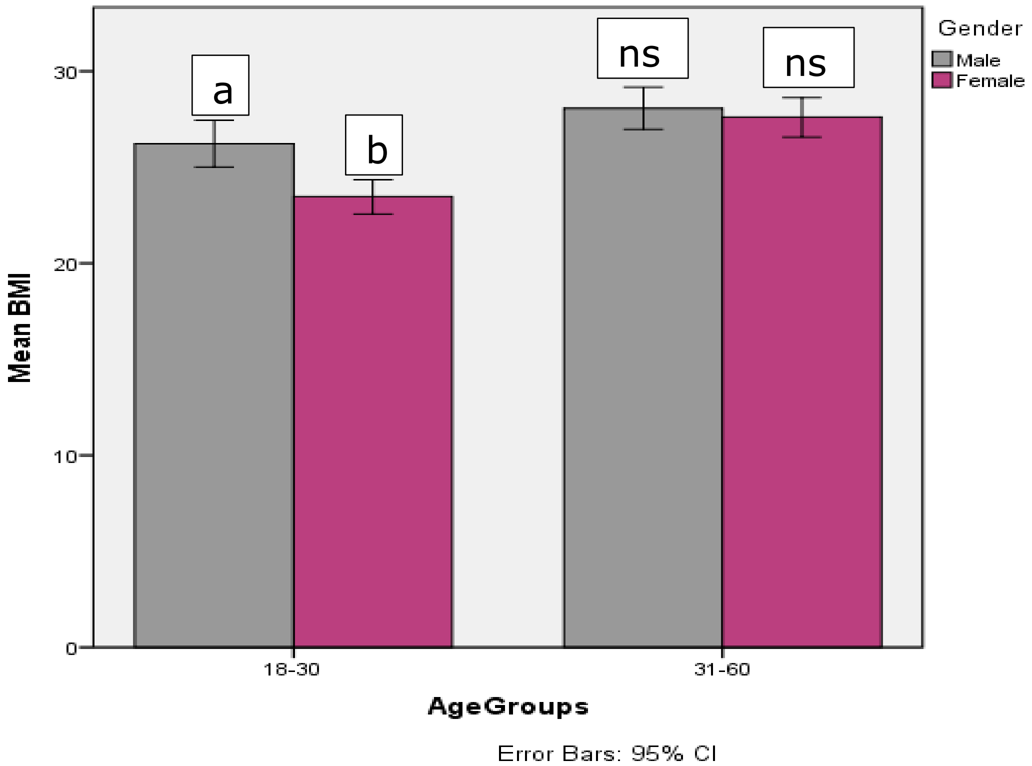


Figure 2.3. Mean (±SD) BMI of study population by age group and gender in all governorates. Values with differing transcripts are significantly different from one another (a>b, P=0.22; ns=non-significant).

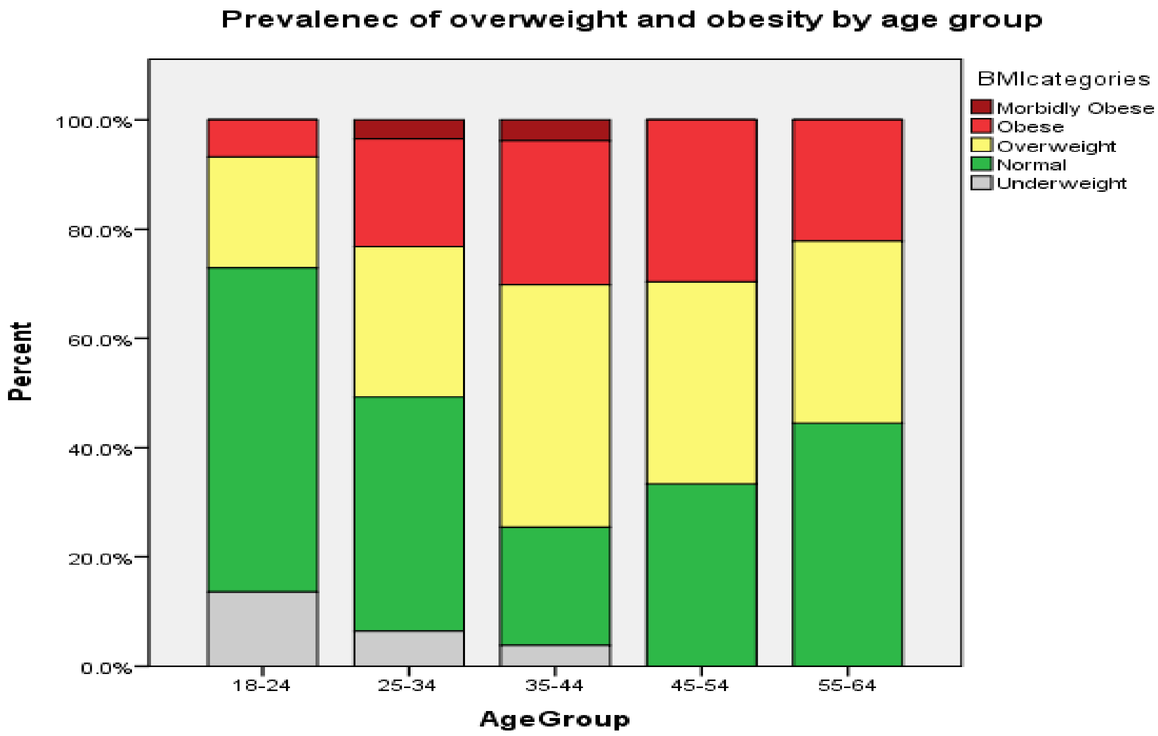


Figure 2.4. The prevalence of overweight and obesity*(kg)* by age group in all governorates.

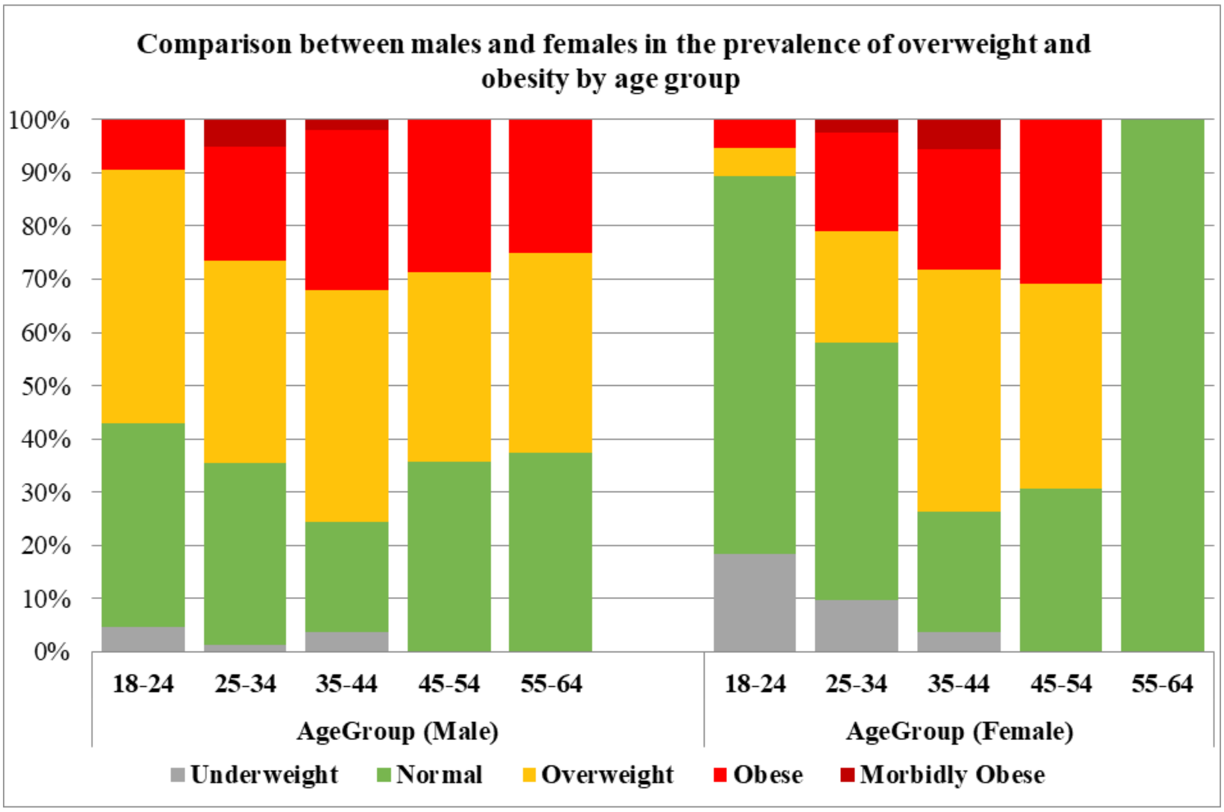


Figure 2.5. Comparison between males and females in the prevalence of overweight and obesity *(kg)* by age group *(years*).

Table 2.7. Distribution of study Participants in governorates (rural Gov. are excluded)

		Gender					
		Male		Female			
		Age Group *(year)*		Age Group *(year)*			
		18-30	31-60	18-30	31-60		
		n	n	n	n	Total	Percentage
Governorate	Muscat	18	46	23	27	114	28
	Dhofar	6	6	9	6	27	7
	Al Dakhliah	3	12	8	9	32	8
	Al Batinah South	20	21	32	28	101	25
	Al Batinah North	17	12	22	25	76	19
	Al Dhahirah	7	18	15	12	52	13
	Total	**71**	**115**	**109**	**107**	**402**	**100**

Table 2.8. Average values of some study variables by gender and age groups (rural Gov. are excluded).

Gender	Male		Female	
Nutrient /Age Group *(year)*	18-30	31-60	18-30	31-60
Carbohydrates *(g/d)* [a,b]	307 ± 94	332± 79	288 ± 74	302 ± 77
Protein *(g/d)* [b]	103 ± 64	97± 61	98 ± 58	96 ± 58
Fat *(g/d)* [NS]	88 ± 29	79± 26	77 ± 27	82 ± 30
Total energy *(kcal/d)* [b]	2353 ± 592	2360 ± 549	2145 ± 516	2188 ± 547
% Energy CHO [a, ab]	49 ± 8	52 ± 7	51 ± 6	51 ± 6
% Energy Protein [b]	16 ± 4	16 ± 3	16 ± 3	15 ± 3
% Energy from Fat [a, ab]	33 ± 7	30 ± 7	32 ± 7	32 ± 7
Sat fats *(g/d)* [c'ab]	24 ± 11	20 ± 9	20 ± 8	20 ± 10
Cholesterol *(mg/d)* [b]	369 ± 193	315 ± 168	270 ± 196	268 ± 147
Sodium *(mg /d)* [b]	2722 ± 1094	2652 ± 1185	2398 ± 1068	2331 ± 899
Potassium *(mg/d)* [a, abc]	2527 ± 757	2772 ± 691	2414 ± 795	2456 ± 691
Vitamin C*(mg/d)* [c, bc, abc]	98 ± 72	107 ± 70	93 ± 63	104 ± 66

(a) Significant between Age Groups

(b) Significant between Gender

(C) Significant between Governorates

(ab) Significant between the interaction of (Age Groups*Gender)

(bc) Significant between the interaction of (Gender *Governorates)

(abc) Significant between the interaction of (Age Groups*Gender* Governorates)

(NS): Non-significant

Table 2.9. Comparison of average nutrient intake in study subjects with UK (Dietary Reference values (DRVs)).

	Study subjects		DRV (UK)	
	Male	Female	Male	Female
Carbohydrate *(g/d)*	323±85	296±77	346	276
Protein *(g/d)*	98±62	95±58	97	78
Fat *(g/d)*	82±27	80±29	101	81
Total energy *(kcal/d)* *	2338±538	2171±533	2594	2070
Energy from CHO (%)	51±7	51±6	50	50
Energy from Protein (%)	16±3	16±3	15	15
Energy from Fat (%)	31±7	32±9	35	35
Iodine *(µg)*	132±56	116±54	140	140
Sodium *(g/d)*	**2.7±1**	**2.4±1**	**1.6**	**1.6**
Potassium *(g/d)*	2.7±1	2.4±1	3.5	3.5
Vitamin C *(mg/d)*	103±70	100±65	40	40

***** EAR for men and women in UK, SACN Report 2011.

Table 2.10 shows effect of different demographic variables on the distribution of study participants in BMI categories. Overall, there was no clear pattern between prevalence of overweight and obesity and the following variables; different educational levels, household income, and living area (urban v rural). However, there were clear effects of age and gender. Figure 2.6 shows the mean energy intake of the study participants by age and BMI category. Overall, energy intake was significantly (P=0.014) affected by BMI category, but not by age, and there was no interaction between the two (table 2.11).

Table 2.10. Percentage distribution of study participants in different BMI categories, according to background characteristics.

Characteristics	Body Mass Index (BMI) *(kg/m²)*				
	Underweight	Normal weight	Overweight	Obese	Morbidly Obese
	<18.5	18.5-24.9	25-29.9	30-39.9	> 40
Gender *(%)*					
Male	2	30	43	22	3
Female	9	45	26	18	3
Age Group *(year)*					
16-24	14	59	20	7	0
25-34	6	43	28	20	3
35-44	4	22	44	26	4
45-54	0	33	37	30	0
55-64	0	44	33	22	0
Education Level					
Illiterate	0	67	0	33	0
Read &Write	0	17	83	0	0
Primary	0	33	33	33	0
Elementary	0	22	44	33	0
Secondary	7	29	46	15	3
Technical or college School	6	35	32	24	4
University graduate (4 years)	7	42	30	19	3
Post-graduate studies	5	50	27	18	0
Household Income					
Q1 (lowest)	9	39	33	15	4
Q2	6	33	42	17	2
Q3	4	34	30	28	4
Q4	5	34	37	21	3
Q5 (Highest)	4	37	35	21	4
Governorate					
Muscat	6	38	33	18	4
Dhofar	0	33	30	33	4
Al Dakheliah	4	44	41	11	0
Al Batinah South	4	42	35	15	3
Al Batinah North	3	32	40	23	2
Al Dhaherah	5	45	23	25	2
Al wusta	12	38	38	12	0
Musandam	15	23	38	15	8
Al Buraimi	29	29	14	29	0
Al Sharqiah North	25	38	12	25	0
Al Sharqiah South	7	40	27	20	7

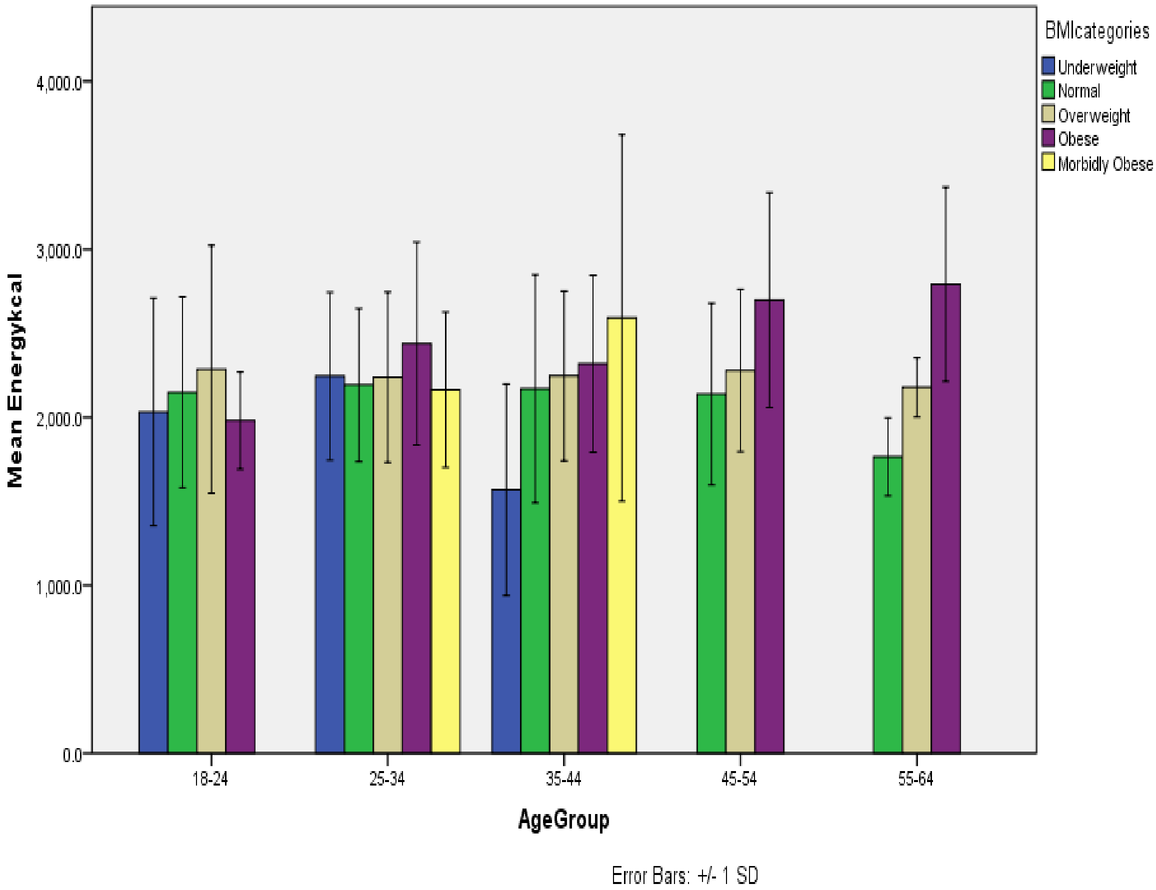


Figure 2.6. Average energy intake (kcal) of study sample by age group in different BMI categories.
* Overall, energy intake was significantly affected by BMI categories (P=0.014).

Table 2.11. Correlations between energy intake as a dependent variable with BMI and age groups.

Tests of Between-Subjects Effects

Dependent Variable: Energy kcal

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.644E6[a]	19	454955	1.5	.067
Intercept	4.795E8	1	4.795E8	1632	.000
BMI categories	3723399	4	930850	3.2	.014*
Age Group	722872	4	180718	0.6	.652
BMI categories * Age Group	4001031	11	363730	1.2	.260
Error	1.128E8	384	293863		
Total	2.146E9	404			
Corrected Total	1.215E8	403			

a. R Squared = .071 (Adjusted R Squared = .025)
* Statistical significant difference (P ≤0.05)

2.3.4 Physical activity (self-reported exercise)

Table 2.12 shows the self-reported exercise of the study population. Non-responding participants are excluded from the table. Overall, about 34% of the study population did not engage in regular walking for at least 10 minutes per a day, and almost same percent (33.7%) engaged for only 1-2days per week. Most of the study population who engaged in daily regular walking were walking in moderate pace. Looking at the differences between males and females in regular daily walking, females were more likely to be inactive than males. Nearly 45% of the participants were using the stairs more than three times per a day, while about 20% never used stairs. More than 80% of the study population were not engaged in either moderate or high intensity sport per week. Clear differences were observed between males and females regarding engagement in moderate and high intensity sports. Only 10.7% of females were engaged in moderate intensity sport compared to 26.8% of males. In addition, about 93% of the population that regularly engaged in high intensity sport were males. Figure 2.7 illustrates that physical activity level decreases by increasing age group. About 62% of study participants in age group between (16-34) years reported that they practiced low PA, and the percentage showed linear increase by increasing age to reach over 80% in age group between (45-64 years). However, the percentage of moderate and high PA were remarkably low (≤20%) compared to low PA and decreased, in general, by increasing age. Similarly, the percentage of high PA level decreased from 18% in age group (16-24 years) to 6% in age group (45-54 years). The BMI pattern with respect to physical activity levels is demonstrated in (figure 2.8). Overall, there was an inverse relationship between body weight (represented in BMI classes) and levels of PA. The majority of study participants, in all BMI classes, recorded that they practiced low PA, particularly those who were normal weight and overweight participants. Although the number of participants in moderate and high intensity PA was relative small, the trend of decreasing PA with increasing body weight was obvious.

Table 2.12. Physical activity levels of study participants (self-reported exercise).

Characteristics		Respondent's Gender				Total (n)	Percentage %
		Male (n)	%	Female (n)	%		
Regularly walking for more than 10 minutes	Never	48	22	120	43.3	168	33.9
	1-2 days	77	35.3	90	32.5	167	33.7
	3-4 days	38	17.4	31	11.2	69	13.9
	5-6 days	19	8.7	10	3.6	29	5.9
	Everyday	36	16.5	26	9.4	62	12.5
	Total	**218**		**277**		**495**	
Pace of your walking	Slow	30	17.4	30	17.5	60	17.5
	Moderate	114	66.3	122	71.3	236	68.8
	Fast	28	16.3	19	11.1	47	13.7
	Total	**172**		**171**		**343**	
Using the stairs (more than 10 steps)	Never	45	20.6	55	19.9	100	20.2
	1-2 times	83	38.1	90	32.6	173	35
	3-5 times	37	17	66	23.9	103	20.9
	More than 5 times	53	24.3	65	23.6	118	23.9
	Total	**218**		**276**		**494**	
The engagement in moderate intensity sports	Never	158	73. 1	243	89.3	401	82.5
	1-2 days	36	16.7	18	7.1	54	11.1
	3-4 days	10	4.6	7	2.5	17	3.5
	5-6 days	7	3.2	1	0.4	8	1.6
	Every day	5	2.3	1	0.7	6	1.2
	Total	**216**		**270**		**486**	
The engagement in high intensity sports	Never	144	68.9	245	98	389	84.7
	1-2 days	33	15.8	4	1.6	37	8.1
	3-4 days	18	8.6	1	0.4	19	4.1
	5-6 days	5	2.4	0	0	5	1.1
	Every day	9	4.3	0	0	9	2
	Total	**209**		**250**		**459**	

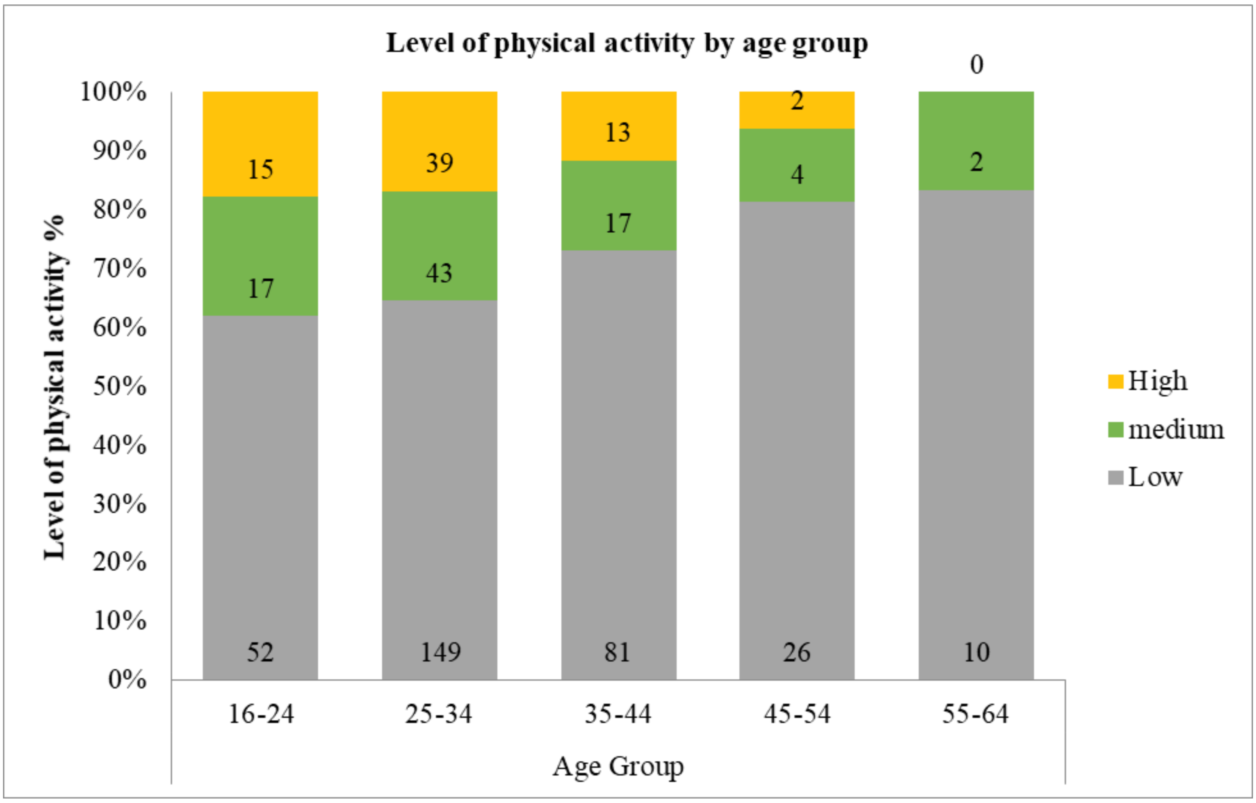


Figure 2.7. Level of physical activity by age group *(year)*

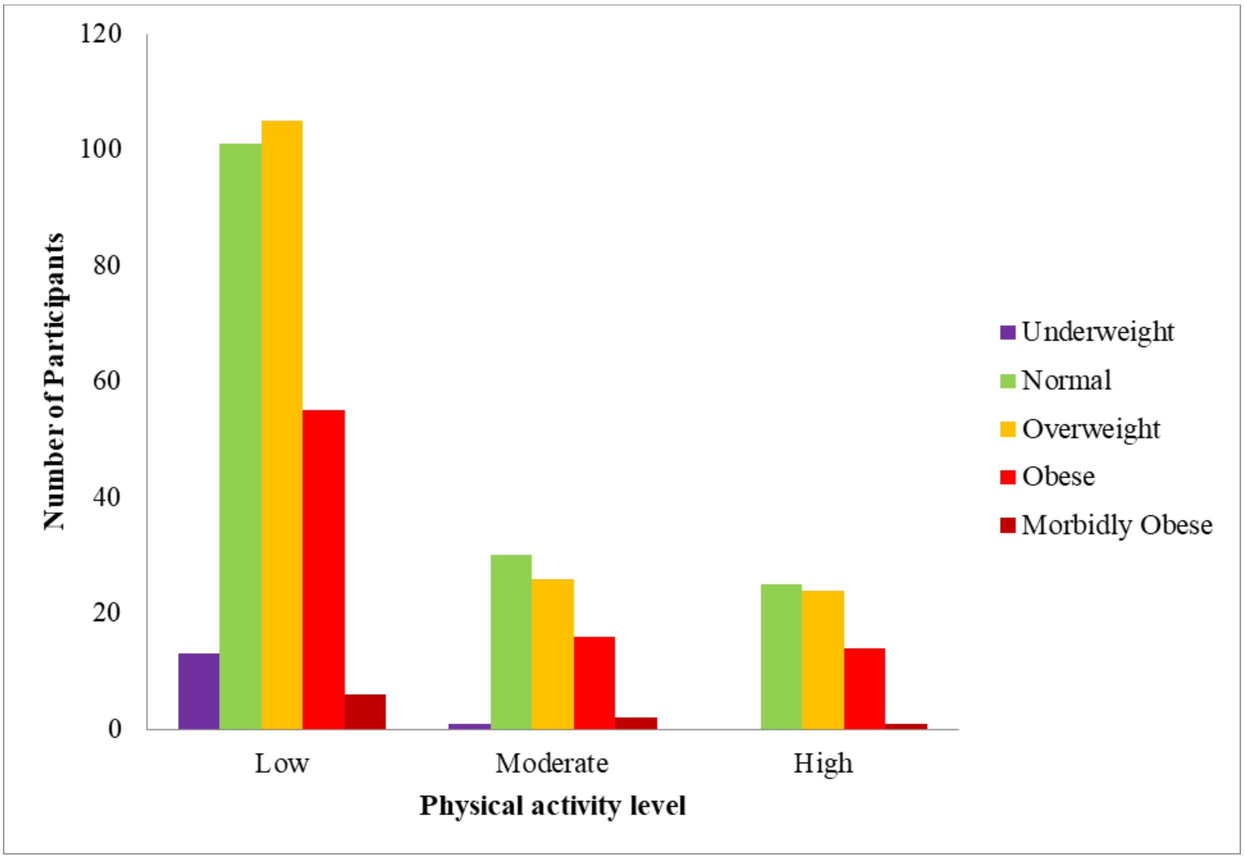


Figure 2.8. Pattern of BMI *(kg/m²)* with respect to level of physical activity of study sample

2.3.5 Sedentary behaviours

Overall, results of the survey study indicated prevalence of sedentary lifestyle among study population (table 2.13). The majority of female population had a maid, and 44% only engaged in the household work for one to two hours or less per week. While the majority of participants (in both genders) watch television for less than 3h/day, 40.6% spend 4h or more per day in using computers, tablets or mobile phones at work, as well as 28.1% of the participants spend four hours or more using the same appliances at home.

Table 2.13. Prevalence of sedentary behaviours in study participants.

Characteristics	Percentage %
Having a maid (Female Only)	
Yes	62.5
No	37.5
The engagement in the household work hour/week (Female Only)	
1-2 hrs	44
3-4 hrs	36.8
5-7 hrs	12
More than 7 hrs	7.2
Hours spent in watching TV and/or DVD/Video per day	
1/2 hour or less	35.9
1 hour	26.3
2 hours	20.1
3 hours	10.9
4 hours	4.7
5 hours or more	2.1
Hours spent in using a computer, tablets or mobile phone at home	
1/2 hour or less	22.8
1 hour	17.1
2 hours	22
3 hours	9.9
4 hours	11.6
5 hours or more	16.5
Hours spent in using a computer, tablets or mobile phone at work	
1/2 hour or less	17.3
1 hour	14.2
2 hours	14.9
3 hours	13
4 hours	16.8
5 hours or more	23.8

2.4 Discussion

The current study aimed to investigate the dietary habits, lifestyle behaviours and related knowledge and attitudes amongst Omani adults, in order to gain a better understanding of the main factors associated with the increased incidence of obesity in Oman.

2.4.1 Demographic data

This survey-based study was conducted on 500 healthy adults, aged (18-60 years), living in Oman. Questionnaires were distributed randomly in all governorates in Oman according to the population density in each governorate. The vast majority of study population were living in urban areas (80.6%). The WHO, in 2014, reported that 73.4 % of Omani population are living in urban areas (161), which is in line with the distribution of study participants in this study and may explain the high percentages of physical inactivity, sedentary time spent, and prevalence of obesity among study population. Furthermore, studies in low and middle-income countries have identified that risk factors for chronic diseases are more prevalent in urban than rural areas (171). Mehana et al (2010) reported that people living in urban areas in Oman are more obese than those living in rural areas and overweight including obese are more prevalent in the southern part of Oman (172). Data from this survey showed that the distribution of study population in age groups was comparable with the age groups of total Omani population reported by OWHS in 2012 (163). Overall, less than 2% of the study population were with no education. Looking at the percentage of illiteracy among study population and correlate it with the high percentages of physical inactivity and obesity in different educational level, yielding to suggest a systematic review of food, health and physical activity strategy in Oman to reduce the prevalence of chronic disease. Results of this study indicated that the percentage of population who are currently married was higher than (67 %) the percentage of population who have never married (30%). This finding was consistent with the findings of Al-Riyami et al (2012) who reported that 67% of the adult respondents (18 years old and a above) were married and 24 % where never married (163). However, the same study showed that 55% of the Omani household population have never been married and 39% are currently married. This discrepancy in results can be attributed to the nature of the targeted study population. Al Riyami study (a community-based household survey) illustrated that 44% of Omani household population were less than 15 years (below the age of marriage), and only 14% were in the age group 30-44 years, which may explain the high percentage of non-married in household population. This explanation was further supported by another finding in the same study about non-Omani household population. The data showed that 42% of non-Omani household were in age group 30-44, and 71% of them were married. Hence, the percentage of non-married participants found in this current study seem to be reasonable, as all study participants were adults with average age of 33 years. Results also showed that the majority of study population have 1-3 children which are slightly lower compared to 10-20 years ago, and this possibly because of the delay in marriage age for both genders as well as the increasing number of working women in last two decades. Most of study population were working in governmental sector which is the favourite sector for most of the Omani people as it provides more desired facilities compared to other sectors. National Centre for Statistics and information (NCSI) in Oman reported that Omanisation in private sector was 13% in 2015, whereas in public civil sector, Omanisation was 85% in the same year (173). Due to renaissance that the sultanate witnessed in all disciplines during the period of His Majesty presidency, level of life was clearly improved and reflected in the life of individuals including monthly salaries of the population. This finding was further supported by NCSI report in (2012), which indicated that Oman's average household income has risen by 83.9% in the period between 2001 and 2011 from OMR 637.5 (£1,654) to OMR 1,172 (£3,044) (174).

2.4.2 Health and Diet

Although the vast majority of the study respondents reported that their health was good, 80% had not undergone a recent medical examination to identify chronic disease status, including T2DM, CHD, a stroke, and hypertension. Of those participants who reported a recent medical examination, 17% had been diagnosed with hypertension. A survey study in Oman documented that the prevalence of hypertension among Omani people is over 40% (163). It is well documented that foods rich in salt is a leading cause to hypertension. The current study indicates high consumption of sodium amongst participants (2550 mg/day) with level of consumption higher than sodium reference value set by many countries including Western countries such as UK (1600 mg/day) (175). In addition to, only 2.8% of the study participants followed salt restriction. The Omani guide to healthy eating (2009) reported that high sodium intake and salted foods are associated with hypertension, stomach cancer and CVDs. The sodium intake in Omani population was estimated to be twice the requirement of which 87% comes from table salt (176). This pattern is seen in neighbouring countries as well. The food-based dietary guidelines for the Arab gulf countries highlighted many factors contributed for high levels of sodium intake in the Gulf countries include; the high use of table salt in the meals, spices, pickles as well as the salinity of water. In addition to, the high consumption of fast foods and fries among children and adolescents (136). The study confirmed results of a recent WHO report (2014) of very low levels of tobacco smoking (3% in this study vs 8% in WHO study) (161). Given that more than half of the study participants were overweight or obese, around 56% thought that they need to lose weight. Results of the study suggested that the culture of following some diet restriction (such as fat, salt, carbohydrate, calories restriction) and dietary supplements was not common among study participants. Unexpectedly, only 16% reported enjoying eating cake, pastries, desert, and ice-cream. This could be explained partially as these food items are considered as snacks, and many of these dishes are presented mainly only occasionally and often associated with specific celebrations. However, the majority of the respondents (95%) reported that they consumed fast foods (which are rich in salt, fats, cholesterol, saturated fats, Trans fats) frequently, especially sandwiches. This finding was supported by Ministry of health report (Health Vision 2050) in 2014, which indicated that about 98% of Omani youth eat fast foods at least once a day (156). Furthermore, the Omani guide to healthy eating (2009) reported that the main sources of fats in Omani diet are mostly from snacks and fast foods (176). The high consumption of foods prepared away from home can be attributed to many factors: youth lack essential nutritional knowledge, as about 30% do not know that saturated fats are unhealthy, and 57% do not realize that unsaturated fats are healthier (177). The second factor is the number of workforce women has increased, and thus less time available for them for food preparation at home. In the current study, 83.5% of Omani women were employed which was in line with Musaiger (2011) (57). Another factor is the increase in household income and the lack of places, for many families, to spend their leisure time resulted in increasing frequency of dinning at restaurants especially during weekends and holidays. Fast food restaurants offer a range of portion size from small to super-size items. Studies about consumption of fast foods and related risk factors in GGC countries are very scarce. Amin et al (2008) noted that in primary school children (6-11 years) in Saudi Arabia, the proportion of obesity among those who ate outside home, more than 5 times per week, increased about 53%, and the association between eating outside home and obesity among those children was highly significant ($P<0.001$) (178). Similarly, in Iran, results of dietary analysis of meals consumed outside home, using 24 hours recall, showed that the mean daily energy intake of adolescents (12-16 years) who ate at least one meal away from home was significantly higher than those who did not eat (179). Eating outside home could be on the account of other healthier foods (such as fruits and vegetables). Many studies reported that eating away from home is more likely to affect fruits and vegetable consumption and associated with lower fruit and vegetable intake (180).

Despite the small sample size of participants from rural areas, comparison between rural and urban areas in terms of consumption of fast foods showed that (91%) of rural participants consumed fast foods frequently compared to (96%) in urban areas, which suggested that rural governorates were influenced by the invasion of fast foods, as their urban counterparts. When comparing consumption of fast foods between males and females, (43%) of participants who consumed fast foods were males and (57%) were females. The consumption of fast foods among women can be linked to high level of employed women (83.5%) recorded in this study, which they may not have time for food preparation at home. The difference between male and females in consumption of fast foods recorded in this study was significant (p=0.003), and this can be attributed to the high number of female participants (56%) compare to males counterparts (44%). The high consumption of fast foods recorded in this study, in general, and in females in particular can be viewed as a warning alarm of more incidences of obesity, hypertension, type 2 diabetes and other NCDs, if no urgent, effective intervention is being seriously adapted.

Food frequency questionnaires (FFQ)

Although Oman imports 85% of necessary foods to satisfy the needs of the population, it is rated as food secure, which means, based on the definition of (World Food Summit, 1996), that all people in Oman at all times have physical and economic access to enough safe and nutritious food to meet their dietary needs and food preference for active and healthy life (159). While Oman is nearly self-sufficient in fruits and vegetables, it can provide only 0.8% of its grain requirements using local production, as well as only 34% in red meat. Hence, dietary habits and food choice of Omani people might be influenced. Therefore, the next two sections sought to find out the dietary habits of study participants and their impact on nutritional status using two different methods (FFQ and 3-day diet diaries).

Food frequency questionnaire is one of the most common tools used in a large-scale population –based studies to assess the habitual food intake and examine the relationship between diet and diseases (181). Despite the easy administration, FFQ data may suffer from random and systematic errors due to estimation, hence, may not represent adequately the dietary habits of study population. Therefore, two dietary assessment methods (FFQ and 3-day diet diaries) were used in the current study, in order to increase the validity and reliability of the data obtained and help in correlate the observed dietary habits among study participants with the corresponding nutritional biomarkers obtained from 3-day diet diaries. Sauvageot et al (2013) stated that the relative validity of FFQs is usually evaluated by comparing their data with those of food records (181). The FFQ implemented in this study designed in light of similar FFQ implemented by Ministry of Health in Bahrain (National Nutrition Survey for Adult Bahrainis, 2002). Standard portion size was used to record the approximation of food consumption of study participants.

Data analysis of fruit consumption showed that the majority of the participants (37%) consumed 2-4 portions per a weak. This finding was supported by the Omani guide for health eating, which stated that the Omani diet contains about 2 servings of fruits, mostly from melon, dates and mango. The guide also emphasised that 3 serving of fruits from average diet of 2000 calories are required, in order to satisfy the nutrient requirement (176). In contrary, the WHO/EMRO in 2011, reported that the consumption of fruit and vegetable in Arab Gulf countries (including Oman) was below the recommended allowances. More than 85% of adults in the Gulf region consumed fruit and vegetables below five servings per day (136) (182). Taking into consideration the high consumption of fast foods recorded in this study, encouraging more fruit consumption is important, in order to replace the high energy dense foods with more healthier choices, and hence help in mitigating the incidences of obesity, hypertension and other NCDs complications. The consumption of fish, meats and eggs was good and Omani healthy plate recommends 1-2 serving per day. Interestingly, red meat was consumed at a moderate level with most of the participants consuming no more than one portion per week. Although the majority of study participants consumed milk products (such as cheese, yoghurt, milk drinks) 3 portions/week, however the consumption of natural milk was still below the recommended portion of milk set by the Omani guide for healthy eating (1 serving/day of milk or milk products). This finding is similar to the finding of Musaiger et al (2012) who indicated that although the production of milk and dairy products in the Gulf countries has increased during the past decade, the intake per capita of milk and dairy products is still below the recommended amount of milk group (a 2000 kcal diet is about 0.5 serving where 1 cup equal 45 g natural cheese (e.g. cheddar) or 60 g processed cheese) (136). Although about two third of the study participants consume grains in at least 5 days per week, and this is in line with Omani healthy plate (recommend 6-11 servings/day) (183), consumption of whole grain cereals (rich in fibre) was very low. More than half of the participants consumed white bread or refined cereals. This finding matches that of Musaiger et al, (2012) who reported that the consumption of whole grain in GCC countries is decreasing remarkably, with more dependence on refined cereals. The majority of the participants indicated they eat snacks between 2-4 times per week. Unexpectedly, Omani halwa, a very famous traditional sweet dish in Oman (served specially in all occasions and considered as a symbol of Omani hospitality), was no longer among the main menu for the vast majority of the participants. Fruit juice was the most frequently consumed beverage, however fruit drinks (rich in free sugar) were also relatively high. The high intake of foods rich in free sugar, particularly among children and adolescents has been reported by many studies in the Gulf region. For instance, in Saudi Arabia, 26% of adolescent's daily fluid consumption come from carbonated beverages and 25% come from canned fruit drinks (136).

Overall, data from FFQ suggested that some dietary habits and food choices, in the daily Omani menu, need to be reviewed and modified. Given that the overwhelming majority of Omani population consume grains in almost daily bases, more focus is required to encourage people to consume more whole grain cereals, rather than relying on refined cereals (source of free sugar) which are linked to many health complications such blood sugar instability and increasing the likelihood of developing type 2 diabetes.

Three-day dietary assessment

Unfortunately, no specific commercially available dietary software is available which is specifically tailored to analyse Omani foods or even foods consumed in GCC countries. It was therefore necessary to rely on software developed for use in the UK (Dietplan 6) (184). Despite the fact that Dietplan6 database was pre-installed with the full set of UK food tables, it is resilient software that allows editing new recipes or entering ingredients of any meal. Nutrient values are calculated as soon as a food or ingredient is added, making it easy to observe the effects of adding or subtracting any item. Nutrient values of three-day dietary assessment presented as a full report includes micronutrients, macronutrients, energy from macronutrient, and total energy.

Results indicated that 38% of the study population were within the normal range of BMI, less than 1 in 10 were underweight, about 33% were overweight, and 22% were obese. Although the prevalence of obesity among Omani males and females was very similar especially in older age group, overweight was significantly higher in males than females. This finding is consistent with the national diet and nutrition survey of the sultanate of Oman in 2004, which indicated that 40% of men and 28% of women were overweight and obesity was 21% and 19% respectively (185). Similarly, study conducted in Bahrain in 2002 found that almost 36% of the population were within the normal range of BMI, and (36.7%) of males were overweight compared to (28.3%) of females which is in line with the findings of this study (168). However, the same Bahraini study indicated that the prevalence of obesity is higher in females than males, which contradict the findings of the current study. Unfortunately, due to time constraints, and large number of study population, it was not possible to measure the prevalence of central obesity (WC) in this study which provide more reliable data about obesity as a risk factor for NCDs. However, previous study reported that Omani females are much more likely to be centrally obese than males (54% to 20% respectively) (163). Moreover, a recent systematic review paper on obesity in Gulf Co-operation Council States which includes 45 studies, reported that the prevalence of overweight and obesity in adults was 25-50% and 13-50% respectively, with a higher prevalence of obesity amongst females (186). The inconsistency between results of this study and other studies in terms of prevalence of obesity between males and females can be attributed to unwilling of some participants, especially females, to answer the question of the weight. Almost 17% of study population did not answer the question of the weight, which might affect the validity of the result. Furthermore, female weight measure can be under reported, especially when recalling the high consumption of fast foods among female participants. There was no significant ($P<0.05$) difference in BMI of those living in urban governorates compared rural residents. This finding is opposite to the findings of Al- Riyami et al (2003) who found that urban residents were more likely to be obese than those living in rural areas for both genders. This could be explained by small number of participation from rural areas in this study. In addition, more than 13 years passed on Al-Riyami's findings and possibly because of economic growth and transport development, some changes maybe occurred in their life style and dietary habits, especially when the comparison of average energy intakes between urban areas (2248±541) and rural areas (2263±581) showed no statistical significant difference ($P=0.3$).

Although, questionnaires and diet diaries were returned by 500 subjects (221 male/279 females), however when divided into gender and age categories the number of subject from rural governorates was frequently too low (only 14% of total population from 5 governorates) for meaningful statistical analysis. Thus, data from; Al Wusta, Musandam, Al Buraimi, Sharqiah North, and Sharqiah South were excluded (table 2.7). Although total energy intake was significantly ($P<0.05$) higher in males than females (table 2.8), total energy intake of the study sample was within the normal range of daily discretionary calories allowance, and consistent with the Omani guide to healthy eating. Table 2.9 compares the average nutrient intake in study subjects with Dietary reference values of UK. The contribution of fat in total energy in this study was (32%), which was consistent with percentage energy from fat recommended for the UK and European countries. The European Food Safety Authority (EFSA) proposed a lower bound of the reference intake range for total fat of 20 energy % (E%) and 35 E% as upper bound (187). In contrast, the Omani guide to healthy eating stated that the intake of fat contributes over 40% of the caloric intake of Omanis. This discrepancy can be partly attributed to under reporting of dietary intake in 3-day food records due to self-estimation, especially when linking the finding with the high consumption of fast food reported by study participants. Moreover, in some Omani communities, the habit of adding ghee or butter on the table still persists (183). Worth noted, despite the absence of agreement for high consumption of fast foods in the comparison with moderate level of total fat obtained from 3-day dietary analysis, some micro nutrient values such as cholesterol levels, saturated fat (in male participants aged (18-30 years), and sodium level, ought to be interpreted with caution. The analysis of the 3-day diet diaries recorded, in general, high levels of sodium intake (mean 2529±1069 mg/day), cholesterol level (mean 301±178 mg/dl) compared to the recommended levels of sodium and cholesterol (1600 mg/day (British Nutrition Foundation) (175), < 240 mg/dl (WHO) (188), respectively. The high level of cholesterol found in this study was further supported by similar finding by Al Riyami et al (2012), who reported that about one third of Omanis had high level of cholesterol. Furthermore, cholesterol level in the current study was significantly influenced by gender. Males showed higher level of cholesterol than females, and no effect of age or geographical was noted. In contrast, Al Riyami et al (2012) found that the high level of cholesterol was the same in both gender, but higher in age groups (55-64) (65%). The inconsistency can be attributed to many reasons including; under-reporting due to self-estimation of study participants, the sample size and the targeted population. Al Riyami covered larger sample size and targeted household population in all governorates in Oman. Moreover, the analysis of micronutrient in this study exclude rural governorates (due to small sample size) whereas Al Riyami included both urban and rural regions. In addition to, Al Riyami used blood sample test to analyse and assess cholesterol level, whereas in the current study, the cholesterol was analysed using Dietplan6 software. Despite the discrepancy, levels of sodium and cholesterol obtained in this study is worrying, and more likely to be associated with the finding of high consumption fast foods (reviled by FFQ) and high incidence of overweight and obesity among study participants.

Nutrient analysis of male participants in age group (18-30 years) also showed relatively higher level of total fat (88±23 g), saturated fat (24±11 g), and cholesterol (369 ± 193), compared to all other groups, although the differences were not significant. This can be linked to the fact that the majority of this particular group were single (average marriage age in males was 37 years) and might be more likely to relay on fast foods and energy dense foods, which are high in total energy, total fat, saturated fat, cholesterol, and sodium. Musaiger (2011) reported that the frequency of eating food prepared outside the home is increasing in East Mediterranean Region (EMR) and is more apparent in GCC countries (57).

The current study found no clear relationship between prevalence of obesity and educational level, and household income. This finding agrees with Al Riyami et al (2012) who found no clear pattern between different educational and household income levels, and overweight and obesity using BMI classification. However, the same study reported that central obesity (waist circumference) in Oman decreases by educational level and illiterate Omani individuals are more likely to be obese than those with a secondary or university education. Results in the current study also showed a significant correlation between BMI categories and energy intake of study sample (table 2.11). This finding is in line with Gilmore et al (2014) (63) and Vandevijvere et al (2015) (64). Although no significant effect of both age group and the interaction between age group and BMI categories on the level of energy intake (table 2.11), clearer pattern was observed between BMI and energy intake in older age groups (>35 years) compared to younger age groups (figure 2.6). This can be partly attributed to the gradual decrease of PA level by increasing age observed among study participants (figure 2.7). Furthermore, most of the participants in age group (>35 years) were married (average marriage age 37 years) which many studies indicated that married individuals are more susceptible to being overweight and obese, as the married couples are less active and tend to eat together, likely reinforcing more food intake (152).

Overall, data analysis of 3-day dietary assessment confirmed that the majority of Omani population from all Omani governorates (urban & rural) were either overweight or obese, particularly those over 30 years of age. High cholesterol and sodium levels recorded in this study, despite the moderate level of fat, suggested high consumption of unhealthy sources of fat, which are more likely to be from fast food recorded in this study. The increase of obesity by increasing age found in this study, and as in many GCC countries, may be linked to some inappropriate socio-cultural background used to frame the dietary practices (e.g. the habit of adding ghee or butter on the table), such norms should be replaced with healthier lifestyle habits in order to reduce the incidences of obesity and NCDs.

2.4.3 Physical activity and sedentary behaviours

Results of self-reported exercise indicated that the study population were generally physically inactive and showed high levels of sedentary behaviour. This could be due to many reasons including lack of availability of sport grounds, parks and facilities suitable to engage in PA, the weather, and time available for exercising. Furthermore, the rapid socio-economic development in Oman, due to oil boom and globalisation, has contributed to rapid urbanisation, motorisation and have had a clear impact on reducing physical activity among study population. In addition, socio-cultural norms may comprise a real challenge restricting PA, particularly outdoor PA of women, among study population. Although evidences and indicators about physical inactivity in GGC countries are very obvious, however, evidence that would help identify the social and cultural contexts that may constraint people's mobility, especially women, is spares. Al Nohair (2014) illustrated that traditional/cultural restrictions in lifestyle of women in GGC countries is one of the main factors that linked to increased rates of obesity and physical inactivity among women (152). The accessibility for females to sports and exercise activity is limited. Mabry et al (2013) reported that socio-cultural restriction in Oman and GGC countries represented mainly in women's PA dressing, and their age (189). A recent qualitative study conducted in Unite Arab Emirates mentioned that women do not have space at home in order to practice indoor exercises and families do not allow them to walk alone (190).

Results about sedentary behaviour found in the current study showed that nearly two third of female population had a maid, and the majority of females engaged household work for only 2 hours per week or less. Furthermore, sedentary behaviour found in this study was clearly influenced by increased reliance on computer and tell communication technologies as well as high availability of satellite TV. The influence of greater use of mechanized appliances, widespread use of computers, TV and electronic gaming devices, on encouraging sedentary lifestyle behaviour were documented by several studies conducted in GCC countries. Al-Nuaim et al (2012) reported that the lifestyle in GCC countries have been dramatically influenced by rapid urbanisation, reliance on auto-mobile for personal travel, easy availability of cheap migrant labour for household work, as well as decreased occupational-work demands (191). These changes in lifestyle have encouraged sedentary behaviour among both young adult people. Males in the current study were more physically active than females. This finding was in line with the findings of Al-Nakeeb et al (2012) (192). However, Mabry et al (2014) showed that physical inactivity in Omani adults occurs in 33% and 41% of men and women respectively, which was less than the level recorded in the current study (76). This discrepancy in physical inactivity levels can be attributed to many reasons include; using self-reported approach for the assessment of PA and sedentary behaviour which depends mainly on the memory of the study participants, the other reason related to the nature of the questions recruited in this survey questionnaire, may have been less sensitive to assess the normal daily PA level recommended for the adults, and may be less sensitive to the different types of PA especially in rural areas. This may involve the use of objective methods of assessing PA, which was hindered by time and resources constraints of the study.

Prevalence of physical inactivity found in this study may be originated since the childhood of the participants. The national strategy for prompting PA in Oman (A call for Action) in 2014 demonstrated that the physical inactivity among secondary school students was high, ranging from (33-61%) in boys and (77-90%) in girls (76). Boys were more active than girls and student living in rural areas were significantly more active than those living in the urban areas, although the data from the Global School-based Health survey (on students at age 13-15 years in Oman) revealed no significant differences between boys and girls in physical activity, but there is a significant difference in dietary behaviors between them (193). Levels of PA reported in this study decreased by increasing age, more clearly over age 35 years (figure 2.7). This finding is strongly related to the earlier finding (the clear pattern between BMI level and energy intake over the age 35 years, figure 2.6), and support each other. Overweight and obese participants over 35 years (majority employed and married) showed gradual increase in energy intake as they become older, simultaneously they tend to be more sedentary by advancing in age. These are the etiology risk factors for many NCDs that many recent studies emphasised, and many health-related organisation repeatedly warning people to avoid. Although the number of study participants who engaged in moderate and high physical activity level was less than those who engaged in low physical activity, pattern of BMI categories was observed in moderate and high physical activity level and it was clearer in moderate intensity sports (figure 2.8). Many factors could be associated with this physical inactivity, include the conservative cultural norms (e.g. restricting women outdoor activities), limited options for entertainment, lack of awareness, motivation and time for some participants, unfavourable weather, ineffective health strategies (76). Comparing PA between urban and rural areas, despite the small study sample size from rural areas, showed that in both geographical areas, the majority practiced low PA, and similar average number of participants in moderate and high intensity sport. It could be possible that type of exercises listed in the questionnaire were less sensitive to assess level of PA, especially in rural areas where many outdoor daily works with animals and farms, unintentionally neglected from PA list.

Overall, the findings demonstrated that factors such as gender, age and BMI seem to influence adults PA levels. Physical activity, in general, appeared to decline gradually with increasing age and body weight, indicating that the older the adults, the less activity they are (sedentary lifestyle) and the more weight they gain. Small contribution of rural areas in this study and the nature of the questionnaire may not be enough to draw a conclusion about the difference in PA level between urban and rural areas. Due to time and resources constraints in this study, as well as the desert nature of some rural areas, participation from rural areas was low compared to the participation from urban areas. Hence, larger sample size (representing rural areas), with more sensitive method, taking into account the different aspects of PA in each area is recommended in future studies.

Study 1 illustrated that the low level of PA as well as lack of health awareness (represented in unhealthy food practices) were the main contributor to the prevalence of overweight and obesity among study subjects. Therefore, for the intervention to be implemented, targeting the unhealthy lifestyle behaviour is essential. Literature recently demonstrated that new web-based technology gained popularity and became more accepted in public health intervention as a useful tools support improving health behaviours. Hence, to keep up with the development, and to overcome a number of limitations recorded in the conventional intervention, the current study represents a pilot-scale intervention aimed to investigate the effectiveness and feasibility of smartphone apps on promoting physical activity and improving dietary intake behaviours in Omani adults. Despite being a pilot scale study, this intervention is considered novel, and to the best of our knowledge, no public health intervention study in Oman have used health smartphone apps, as an investigation tools, to target lifestyle behaviors (PA or dietary practices).

Chapter3: Effectiveness of Health and Fitness Smartphone Applications to Improve Dietary Habits and Promote Physical Activity in Omani Adults

3.1 Introduction

Fitness can be viewed as the state of being physically active and healthy through proper exercise, diet and sleep habits (194). Physical inactivity is considered as the major cause of lack of fitness. The WHO defined physical activity (PA) as any bodily movement produced by skeletal muscles that requires energy expenditure (195). The differences between PA and exercise may be unclear for many people. Exercise is a subcategory of PA that is planned, structured and repetitive, purposefully to improve or maintain one or more components of physical fitness. Physical activity includes exercise, as well as any other activities which involve bodily movement, which are done as part of work, play, active transportation, household chores, or recreational activities (196). According to (WHO) PA guidelines, adults in age group (18-64 years) are recommended to do at least 150 minutes of moderate-intensity aerobic PA during the week, or 75 minutes of vigorous-intensity aerobic PA throughout the week, or an equivalent combination of moderate- and vigorous- intensity activity (196). The aerobic activity should be performed in bouts of at least 10 minutes duration. The guidelines also recommended adults to increase their moderate-intensity aerobic PA to 300 minutes per week, or 150 minutes of vigorous-intensity aerobic PA per week, or an equivalent combination of moderate-and vigorous- intensity activity, in order to get additional health benefits. With regard to muscle-strengthening, activities should be done involving major muscles groups on 2 or more days per week (196).

Levels of physical inactivity are rising in many countries with major implications for the prevalence of NCDs. The WHO reported that, globally about 23% of adults aged (18+) were insufficiently active in 2010 (20% men and 27% women). The highest prevalence of physical inactivity was recorded in The WHO Region of Americas and EMR (32 and 31% respectively), while the lowest prevalence was recorded in the South-East Asia (15%) and African (21%) regions (197). The limited evidence on the prevalence of physical inactivity among Omani adults showed that it occurred in 33% of men and 41% of women (76). However, the prevalence of physical inactivity among males and females' college students was higher at 43% and 57.8% respectively. Furthermore, adolescents, who are recommended to do at least 60 minutes of moderate-intensity PA per day (196), showed a low level of activity, with physical inactivity reaching 70.1% in boys and 84.6% in girls (76). Almost all studies carried out on young people (secondary school students) reported a high prevalence of physical inactivity in this age group, ranging from 33.3-61.2% in boys and 76.9-90.2% in girls (198) (199). Girls were significantly less active than boys and students living in rural areas were significantly more active than their urban counterpart (76). A well-documented study titled "A National Strategy for Promoting Physical Activity in Oman" evaluated PA in Oman in several domains including; leisure-time, work, transportation, household chores, planed exercises, in the context of daily, family and community activities. The study showed that men were more inactive in the work domain compared to women. In contrast, women were more inactive in the transport and leisure domains, a pattern seen in many developing countries. The same study also indicated that the high-risk groups for physical inactivity, included men and women who were unemployed, women aged 40 years and older and men aged 20-29 years, as well as men who were married (200). The unemployed group was the only commonly–identified high-risk sub-group across all PA domains. This group included students, people looking for work, housewives and retirees. Conservative cultural norms and limited options for entertainment and volunteer work were prominent factors associated with the prevalence of physical inactivity among unemployed group (160). The study suggested that establishing women-only exercise locations could reduce leisure inactivity among women and building walker-friendly residential areas could reduce transport inactivity in men (76). Overall, the determinants of physical inactivity in Oman can be categorised into four themes; interpersonal factors (lack of motivation, awareness and time), social factors (low value of PA, customs restricting women's participation in outdoor activity), factors related to policy (ineffective health communication, limited resources) and environmental factors (weather, lack of places suitable for PA).

Public health professionals can play a decisive role in shaping the health policy in the country. In 2011, a qualitative study was conducted on Omani public health managers in order to determine their perceptions about health risk behaviours, the barriers and possible solutions to address physical activity in Oman (201). Recommendations recorded from the public health managers focused on adapting effective, culturally sensitive interventions at the environment level (building sidewalks and exercise facilities) and policy levels (strengthening the existing intervention and coordinating actions with relevant sectors), in order to improve PA levels and mitigate the burden of NCDs in Oman (201). Table 3.1 summarises the results of the semi-structured interview with ten middle-level public health managers. It is worth noting that most of the barriers mentioned in table (3.1) are still considered as potential gaps in public health strategies in Oman and need to be addressed effectively in order to improve general health of Omani people. The current study represents an attempt to target both PA and diet together, as described in chapter 1(aims and objectives).

Table 3.1. Perceptions of public health managers about (barriers and solutions) to address physical inactivity and prolonged sitting in Oman.

Theme	Sub-theme
Barriers to addressing physical inactivity Intrapersonal	Lack of motivation. Lack of awareness. Lack of time.
Social environment	Social restrictions on women. Low value placed on PA. Dependence on motorized transport. Social restrictions for older people. Cultural norm to employ domestic workers. Negative association of public transport/taxis.
Physical environment	Inadequate infrastructure. Limited access to places to be active. Limited access to government sports clubs. Limited access to private sports clubs. Weather. Sedentary work setting.
Public policy environment	Sedentary work setting. Ineffective health communication. Limited resources. Focus on curative. Lack of healthy public policies.
Solutions to address PA Build conducive environment	
Community participation Multisectoral coordination	Build supportive infrastructure. Build culturally appropriate infrastructure. Community participation Identify and work with relevant groups and organisations. Multisectoral coordination Work with other sectors. Advocate for supportive environment. Establish a national health promotion body.

Continue table 3.1

Theme	Sub-theme
Strengthen Ministry of Health policies and programmes	Improve health communication. Use settings approach. Conduct research. Promote PA for staff. Review human resource requirements. Strengthen primary health care. Region-specific action. Establish unit within the Ministry of Health. Address PA and diet together.
Barriers to addressing prolonged sitting Intrapersonal	
Social environment	Lack of awareness. Lack of motivation. Social environment Sedentary culture. Limited culturally appropriate activities for women. Cultural norm to employ domestic workers.
Physical environment	Limited access to non-sedentary activities. Sedentary work setting.
Solutions to address prolonged sitting Community participation Multisectoral coordination	Identify and work with relevant groups and organisations. Advocate for supportive environment for PA. Work with other sectors.
Strengthen Ministry of Health policies and programmes	Raise awareness. Use settings approach. Address PA and sitting time together. Conduct research.

Source of the table: Mabry et al (2013) (201).

3.1.1 Successful initiatives to address physical inactivity in Oman

Evidence from around the world reiterates the importance of taking a comprehensive approach to the promotion of PA. The Toronto Charter for PA is an advocacy tool developed by PA experts and launched at the 3rd International Congress on PA and Public Health held in May 2010, in Toronto, Canada. It summarised the evidence on the benefits of PA and outlined four key action points: (1) implement a national policy and action plan; (2) introduce policies that support PA; (3) reorient services and funding to prioritise PA, and (4) develop partnerships for action (202).

Public health experts in Oman have advocated adopting a coordinated multisector approach to promote PA. The Nizwa Healthy Lifestyle Project (NHLP), a community-based initiative implemented during the period 2004-2009, was considered as one of the most successful innovative interventions in Oman. It was a multifaceted intervention initiated to underpin all efforts and endeavours dedicated to face the rising toll of NCDs and the underlying risk factors in Oman (203). Dr. Jihane Tawilah (WHO Representative in Oman) described this project as a showcase in the East Mediterranean Region of WHO. Its main strategy was adopting comprehensive approach taking into account social, economic, behavioural, and political determinants. This approach successfully challenged some conservative traditional concepts including achieving a good gender balance and engaging women in healthier practices such as increasing their PA and consumption of healthier foods (204). The evaluation of PA in NHLP showed significant improvements in PA level in both genders. Although NHLP recorded remarkable success, 7 years have now passed since it was evaluated (2009-2010) and, to our best knowledge, no similar intervention has been implemented since then in the country. This could be due to a number of limitations including resource intensiveness, requirement for repeated counselling and amount of time required.

3.1.2 Self-monitoring as a behaviour change strategy

Self-monitoring, the systematic observation and recording of target behaviour, has been described as the key component of behavioural treatment for weight loss. In early literature (1985-1990) self-monitoring referred to only monitoring the diet using paper diaries. Subsequently, researchers found a significant relationship between PA and weight loss (205). Today, self-monitoring of both PA and dietary intake are well-established components of the standard behavioural treatment programs. Self-weighing has recently been introduced as another monitoring component (205).

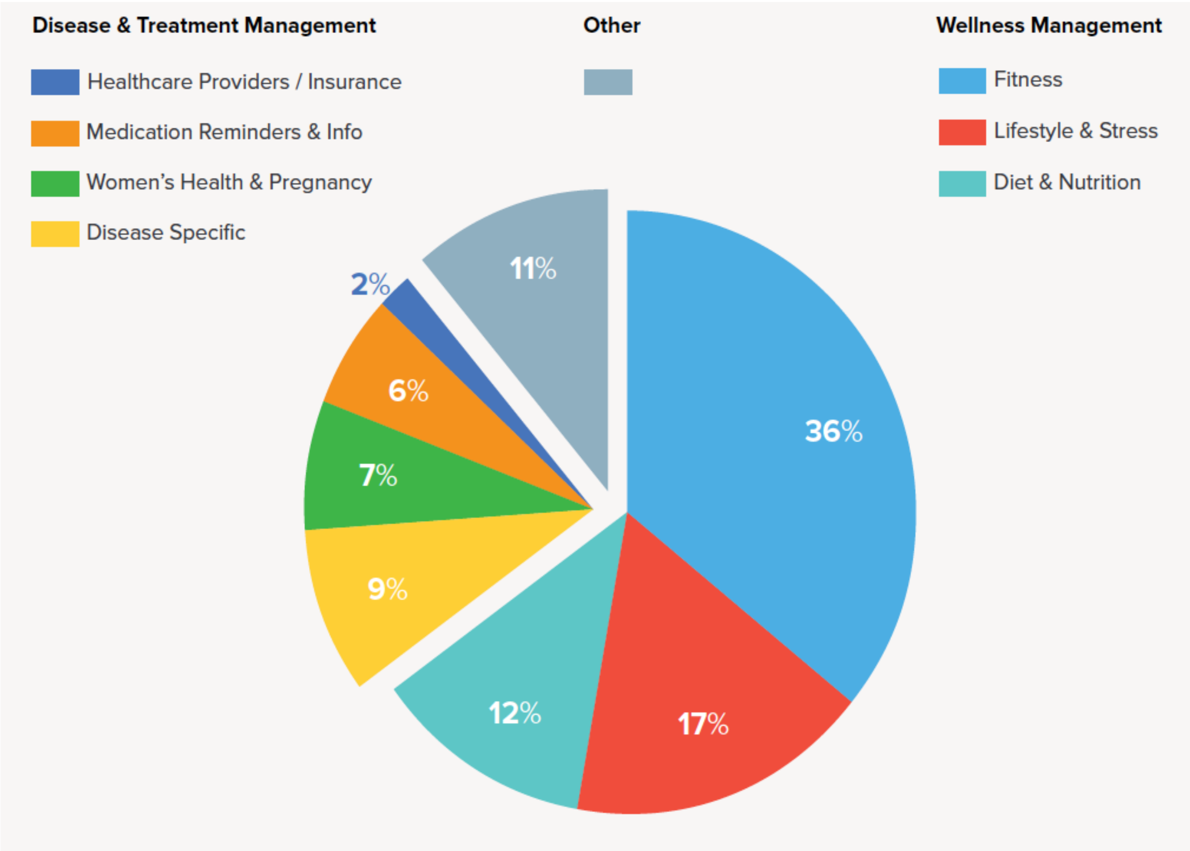
The feature of self-monitoring in behaviour change has a strong theoretical foundation (self-regulation theory). According to this theory, the process of changing habits needs well developed self-regulatory skills include deliberate attention of some aspects of an individual's behaviour and recording some details of that behaviour. In targeting eating behaviour, for example, successful self-regulation depends partly on the truthfulness, consistency and timeliness of self-monitoring in relation to the performance of eating behaviour (205). Studies have shown a consistent relationship between self-monitoring and success in both losing weight and maintain weight loss (206). While several methods have been used to perform self-monitoring, though the most often used is still paper diaries.

The conventional paper-and-pencil diary represents a beneficial, real-time method of self-monitoring if used correctly (207). Adherence to self-monitoring in paper diet diary format can be measured by the number of diaries completed, the frequency of log-ins or reported weight changes. However, this method provides no objective verification of the recording time and reveals many limitations related to the diary not being in the user's immediate possession (retrospective error). Observational evidence suggests that participants often record their dietary intake and exercise long after the event, waiting until their next treatment session, which defeats the main benefit of diaries (to provide accurate real time data) and subjecting the data to the very recall biases, which is expected to be avoided by using a diary method. Moreover, delaying recording of food intake, to the end of an afternoon or whole day, may influence the positive effects of self-monitoring, by reducing the opportunity to correct the action throughout the day if dietary constraints are violated (206). In weight loss behavioural intervention, self-monitoring requires daily recording of dietary intake and its energy content (and sometimes other macronutrients, such as carbohydrate, fats, and protein). In addition, recording of frequency, intensity, time, and type of PA is also required so that individuals are aware of their current behaviours (208). This can be tedious for individuals who often must use a book listing the caloric values of daily foods consumed to assess their daily energy intake. With advances in new technology, many public health studies have started to use electronic devices, such as pedometers, i-watches and mobile devices, to address the limitations in the conventional methods. Such new technology provides automatic calculation of energy intake and energy expenditure, and offers an opportunity for real-time self-monitoring, which are significant challenges in paper recording method. Many studies illustrate that traditional interventions have limited effectiveness to undertake changes in unhealthy behaviours compared to modern, new technology interventions, such as using a pedometer or smartphone application (63). Weight loss programs that use mobile apps for self-monitoring of physical activity and dietary intake have been demonstrated to be associated with significant changes in body weight and BMI (209). Wharton et al (2014) in 8-week weight-loss trial showed that participants, using a commercially available app, more consistently entered complete days of food data, and withdrew from the study less often compared to those using paper and pencil tools (210).

3.1.3 Health-related smartphone applications (Apps)

Technology has been blamed as a contributor to unhealthy lifestyle behaviours, however it has also recently been developed to play a role in health management and provide solutions to many limitations in traditional strategies. Smartphones have gained popularity in recent years. Over 80% of mobile phone users in the world have smartphones (211). In Oman, for example, almost 92% of adults owned a mobile smartphone in 2011, and about 82% of the subscribers indicated that they had intermediate level of skills with mobile technologies (212). Smartphone applications are software designed to run on smartphones. Smartphone apps offer novel, cost-effective opportunities to target users in an interactive and individualised way (213). They can be used outdoors (i.e., part of PA) and provide tracking tools and social connections, which may offer a variety of behaviour change techniques, such as offering immediate feedback to users on their performance based on the available real-time monitoring (214). Smartphone apps, aimed at monitoring and informing lifestyle choices, are becoming increasing common. The IMS (iMedicalApps) institute estimated that 12% of apps accounted for 90% of all downloads, the majority being diet and fitness apps (215). In Germany, for instance, about 21% of smartphone users have installed at least one health app to monitor their health (213). In 2016, the number of health-related apps in the market reached 165,000 and almost two thirds were focused on general health issues such as fitness, lifestyle and diet (figure 3.1).

Gender is an important demographic factor to be considered when designing effective and tailored technology interventions. Despite this need, gender differences are still less considered in the field of technology interventions. Arteaga et al (2012) stated that game-based applications are more relevant for promoting PA in male adolescents (215). The higher interest of men, and their earlier acceptance of technology, has resulted in higher mobile health (mHealth) adoption intentions compared to women (216).



Source: Mevvy.June 2015; IMS Health, AppScript, June 2015; IMS Institute for Healthcare Informatics, August 2015

Figure 3. 1. Mobile health Apps (mHealth) by category in 2015.

Gender differences have also been reported to influence the motivation for engagement in physical activity (217). Klenk et al (2017) reported that the importance of apps' features and functionalities (e.g self-monitoring, games, feedback, and social network features) might vary with gender due to differences in the usage and gratifications between men and women, in addition to the different motives towards PA. Despite the comparable levels of app usage and PA between men and women, results showed that women found enjoyment and goal setting more important than did men when using mobile media for PA. This might suggest higher motivation of women for health-oriented behaviour. However, the study also showed that men were more inclined to use the live tracking function and share their results. Results also showed that companionship was the most relevant facilitator for the usage of social features, which were more frequently used by men (213).

A study by Vehkanen (2015) aimed to investigate gender differences in usage and user experience of a mental wellness app called Oiva. Results showed that both men and women used and experienced the app and its functionalities in similar way, and no significant gender difference in the usage data from the log files or in the online questionnaire answers about the usage and user experience of the App. Results also showed that the positive effect on the participants' mental well-being was similar for men and women (218). Turner-McGrievy et al (2013) reported that no significant differences between male and female app users in reporting self-monitoring of diet or PA (208). The Rock Health Digital Consumer Survey surveyed more than 4000 US adults, in 2015 to assess the adoption rates, attitudes, and preference of digital health technologies. The survey showed no significant demographic differences (including gender) in health app downloaders (219).

The quality of healthcare apps can be measured by three main indicators; safety (security and privacy), effectiveness (using behaviour change techniques (BCTs)), positive experience (star ratings, System Usability Scale) (220) (221). The relationship between the effectiveness of the health-related apps and free/paid apps was inconclusive. Middelweerd et al (2014) found no differences in the number of BCTs between paid and free apps or between the two app stores (iTunes and Google Play) (222). However, Cowan et al (2013) and West et al (2012) reported a significant association between the inclusion of behaviour change theories and the price of the apps (223) (224). SOURCEBITS, a company providing mobile services, reported that the main difference between paid and free apps is that paid apps are straightforward in terms of monetisation, whereas free apps follow different strategies. In free apps, the download is free, yet the developer gets the revenue using other ways, most commonly by advertising (225). However, uncontrolled advertisements may affect the retention of the app. Another marketing strategy is called the freemium model, in which apps have an option of free download and offer limited functionality, and then can be upgraded at a cost (small-in app- purchases) to a fully functional app. Freemium apps accounted for 72% of app downloads on Apple store (224). The pros and cons for both free and paid apps are listed in table 3.2.

Table 3.2. Comparison between free and paid apps: The Pros and cons.

Free Apps	
Pros	**Cons**
More downloads	No guaranteed revenue
Multiple monetisation strategy	Ads distract users
Majority of industry	Requires high engagement to generate revenue
Lower user expectations	Lower user loyalty
Positive reviews more likely	
Paid Apps	
Pros	**Cons**
Every download generates money	Fewer downloads
Free from ads	Limited monetisation options
In-app purchases still possible	Higher user expectations
Higher perceived value	Require higher quality
Users are more loyal	

Source: sourcebits.com (ourcebits.com/app-development-design-blog/free-vs-paid-apps-pros-cons/).

While many recent studies have increasingly emphasised the potential of well-designed, technology-based apps to impact populations, there are increasing demands to regulate this growing market with regard to the claims made about effectiveness. Little or no regulations currently exist to ensure that health apps are accurate in content, evidenced-based, or effective. Moreover, systematic reviews and meta-analysis studies that assess the efficacy of smartphone apps to promote weight loss and improve PA are very scarce. Therefore, studies in this domain suggest seven strategies help to understand the accuracy, evidence base, and efficacy of the apps. The strategies are as follow: Review related scientific literature, Search app clearinghouse websites, Search app stores, Review app (descriptions, users' ratings and reviews), Conduct a social media query of professional and, if available, patient networks, Pilot the apps, and draw out feedback from patients (226).

Recently, Mateo et al (2015) compared the efficacy of mobile phone apps with other approaches to promote weight loss and increase PA in a systematic review and meta-analysis of studies. The study included 12 controlled studies (performed in populations of children and adults) that examined mobile apps interventions with PA outcomes or weight-related health measures (body weight, BMI, or weight circumference). Results showed that body weight and BMI were significantly reduced by 1.04 kg and 0.43 kg/m2 respectively while no significant increase in PA level was seen. The study suggested that mobile phone app-based interventions are likely to be useful tools for weight loss, though it also acknowledged a number of limitations including the small number of related studies, small sample-sizes and short-follow up periods in the included studies (209).

Fitness and weight management apps can be viewed partly as health guides that can help making consumers' health better. Hence, selecting the convenient app is a matter of importance, especially with the availability of huge number of apps, with different levels of functionalities, available. Several systematic reviews on fitness and weight management, rated apps based on number of BCTs available that promote health and fitness. Middelweerd et al, in 2014, analysed BCTs available in free and paid apps (in both iTunes and Google play stores) using the taxonomy created by Abraham and Michi (2008). The study found that apps (free/paid) included an average of 5 common BCTs (range 2-8). The most frequently used techniques were; self-monitoring (keeping record for behaviour), providing feedback on performance, and goal setting (detailed planning). However, techniques such as stress management, motivational interviewing, self-talk, role model, relapse prevention were less used (222).

3.2 Investigation of the use of smart phone apps to monitor the energy intake and physical activity of Omani men and women

Study 1 illustrated that the low level of PA as well as lack of health awareness (represented in unhealthy food practices) were the main contributor to the prevalence of overweight and obesity among study subjects. Therefore, for the intervention to be implemented, targeting the unhealthy lifestyle behavior is essential. Literature recently demonstrated that new web-based technology gained popularity and became more accepted in public health intervention as a useful tools support improving health behaviors. Hence, to keep up with the development, and to overcome a number of limitations recorded in the conventional intervention, the current study represents a pilot-scale intervention aimed to investigate the effectiveness and feasibility of smartphone apps on promoting physical activity and improving dietary intake behaviours in Omani adults. Despite being a pilot scale study, this intervention is considered novel, and to the best of our knowledge, no public health intervention study in Oman have used health smartphone apps, as an investigation tools, to target lifestyle behaviors (PA or dietary practices). It is intended that the data could inform the use of such apps in a larger intervention trial aimed at encouraging weight loss through a combination of dietary and physical activity interventions. The study was implemented on 63 Omani healthy adults (16 males and 47 females) in two phases, conducted separately. Phase 1 was initially planned to be implemented on Omani adults living in Oman. However, delays in ethical approval meant that there was limited time to perform the study before the onset of Ramadhan (the fasting month of Muslims) and as such, it was no longer possible to conduct the study in Oman. It was therefore decided to conduct the study on Omani adults living in Nottingham, UK. Taking into account the results of this study a further intervention, undertaken in collaboration with Nahla Al Anqoodi (an MSc student in University of Nottingham), was performed on 42 Omani female adults living in Oman. In general, both studies can be viewed as feasibility studies aimed to inform future preventative interventions in Oman. Therefore, both studies are presented in this chapter as phase 1 and phase 2 respectively.

3.2.1 Choice of Mobile Phones Applications

Many freemium apps, especially those high in usability scale, provided the most BCTs. Hence, three highly ranked freemium apps (Lose it (121), MapMyFitness (227) and Pacer (228), available in both iTunes and Google Play, were used in these studies. Lose it, is a comprehensive app-based weight loss program providing smart, personal and convenient ways to help people lose weight and improve their health. It is a very popular app with more than 24 million users. The app is powered by proven nutrition science and robust behaviour change techniques including, monitoring daily energy intake and energy expenditure, customising weight lose plan (goal setting), tracking nutrients intake (macro and micro nutrients), social support (connecting to friends and family) and offer challenges (head-to-head, team and group-based challenges). It is also providing a comprehensive meal plan database and allows integration with health and fitness brands such as Fitbit, Nike, Withings, Apple Health, RunKeeper, and MapMyFitness.

MapMyFitness is a fitness tracking application that enables consumers to use the built-in GPS of a mobile device to track all their fitness activity. It provides workout details, including duration, distance, pace, speed, elevation and calories burned as well as route traveled on an interactive map. Over 15 million users are recorded in the MapMyFitness member list.

Pacer app is a free app which serves as a digital pedometer, designed to record your steps, distance, calories burned, and active time. It can help in weight management by tracking weight and BMI using trends pages. It is simple, offers social support, is easy to use, gives a detailed information on users' progress and can connect to other health apps such as Myfitnesspal. Both PA apps (MapMyFitness and Pacer) were implemented on two different groups in this study. The main difference is that MapMyFitness tracks the daily step counts using Global Positioning System (GPS) to detect and record the route of walking or running, whereas Pacer app depends on sensors, provided within the smartphone, to record the daily step counts (without navigation). All three apps include the main BCTs (self-monitoring, feedback on performance, goal setting, as well as social support).

3.2.2 Phase 1: Evaluation of effectiveness of Mobile Phone Applications in improving physical activity and dietary intakes on Omani nationals living in Nottingham, UK

Hypothesis:

1. Health and fitness smartphone apps that include behaviour change techniques (self-monitoring, individualised feedback, specific goal setting, and prompt review behavioural goals techniques) provide better outcomes in terms of physical activity and energy intakes.

Objectives:

- To assess the effectiveness of two smartphone apps (Lose it) and (Map My Fitness) to improve physical activity level and energy intakes of Omani male and female adults living in Nottingham.
- To measure the difference in weight, BMI, mean daily calorie intake and the mean daily step counts between baseline and the end of the study (primary outcomes).
- To measure the difference in percentage of nutrients (Carbohydrate, Fat, Protein) between baseline and end of the intervention (secondary outcomes).
- To assess participant's satisfaction about the effectiveness of both apps in improving their dietary and physical activity behaviours.

3.2.3 Methodology

Phase 1 adopted a mixed-method evaluation approach including a pilot-scale apps study, a short evaluation questionnaire and focus group interviews using recruits from Omani adults living in Nottingham.

3.2.3.1 Participant's recruitment

Over thirty potential participants (males and females) were invited through a face-to-face meeting or via email sent out to Omani adults living in Nottingham, most of them registered in the Omani society enrolled in the student Union (University of Nottingham). Enrolment into the study commenced on 1 May 2016 and all final outcome assessments were completed by 5 June 2016 (duration of 5 weeks in total). Potential participants were given explanations about the study and their required engagement. Twenty-eight potential participants (18 males, 10 females) agreed to participate in the study (figure 3.2).

3.2.3.2 Inclusion and exclusion criteria

Participants were eligible if they:

- had a willingness to take part in the study
- were active smartphone user, were over the age of 18 years
- had a BMI between 18.5-32
- were capable of undertaking moderate physical activity
- had not been diagnosed with any chronic diseases (including hypertension, cardiovascular disease, diabetes)

Participants were excluded for the following reasons:

- not smartphone users
- pregnant
- diagnosed with any chronic disease
- could not undertake moderate exercise (for any reason including being overweight)
- any conditions that could influence his/her daily dietary energy intake.

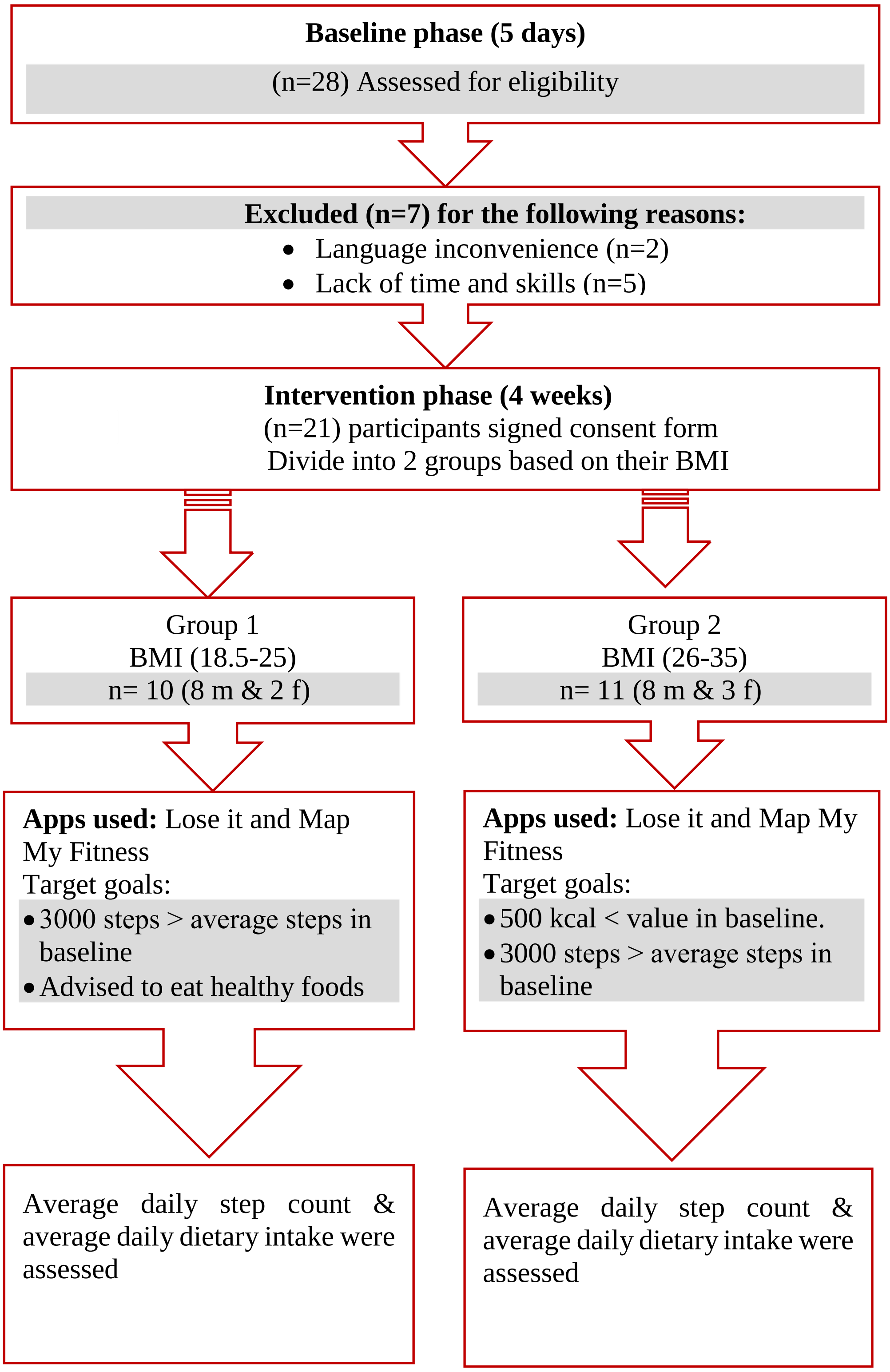


Figure 3.2. Participants' recruitment and follow up (Phase 1).

3.2.3.3 Intervention (study protocol)

Two smartphone apps (Lose it and Map My Fitness) were selected as study tools to measure the outcomes, due to their high rating, using already-established desired criteria for smartphone apps promoting weight loss and physical activity (see section 3.2.1). Lose it app was used to track the daily dietary intake and (Map My Fitness) was used to track daily step count. Both apps provide robust food (Lose it) and exercise (Map My Fitness) databases and easy-to-use interfaces for logging food and exercise. In the Lose it app, users entered their current weight, goal weight, and the goal rate of weight loss. The app then showed the users their daily, individualized calories goal. The app provides immediate feedback in the form of daily calorie gauge graphic that increases in real-time as food is entered into the app. Furthermore, it generates real-time reports showing the users their weight trend, caloric intake in the past week and nutritional summaries of their diet (e.g. fats, carbohydrates, protein, etc.). In addition, it includes a barcode scanner for branded foods, as well as social networking feature that enables users to contact their friends and share their progress. In the Map My Fitness app users enter their weight, height, and the goal of daily step count. The app uses the GPS navigation technique to provide automatic feedback and tracking of the step count and calories burned. The app also provides a visually appealing display of step count history and goal achievement.

To preserve subjects' confidentiality individual subject data was sent only to the principal investigator, who allocated a subject number so that the data was completely anonymised prior to any analysis. The background data collected by the two apps was outside of the researcher control and, as a precaution, subjects were advised to decline any notifications (including advertisements) that might 'pop up' on their smart phones during installation of the apps.

At the base line phase, subjects were asked to download the two apps onto their smartphones. Participants were given enough information (Appendix C) and training on how to use both apps, creating account, entering their demographic data (age, gender, weight, and height), recording their daily food intake and step count, and sending reports using "share data" function or via email option available in the apps. Participants were requested to practice their normal daily dietary intake and physical activity level and not to use either of the two apps features during this baseline phase. Two days after starting the baseline phase, potential participants were asked to send their data to the researcher to be reviewed and checked. All participants were further requested to send all their data at the end of the baseline phase (five respective days). The collected baseline data were saved and analysed, and then participants were assessed for eligibility before starting the intervention. Seven participants withdrew from the study during the baseline phase (2 males and 5 females). Twenty-one participants (16 males and 5 females) were eligible and agreed to take part in this study. Due to small sample size, the upper limit of BMI in the exclusion and inclusion criteria was changed from 32 to 35. Participants were divided, based on their BMI, into two groups (group 1, normal weight (BMI 18.5-24.9) and group 2, overweight and obese (BMI 25-35)) (figure 3.2). Upon completion of the consent form (Appendix E), eligible participants were requested to start the intervention phase. Participants were given sufficient training to enable them to activate the app's features such as setting goals, monitoring their daily calories intake, recording daily step counts, synchronising the data from both apps, saving and sending the data, and to set a reminder to log their food. They were also encouraged to use the social networking with friends, creating groups, sharing their data with their friends, creating challenges etc. In addition, they were provided with a link to an instructional video developed by apps producers, in order to allow for better understanding of apps' functionalities. Participants in group 1 were individually requested to increase their daily step count by 3000 steps/day (based upon recorded daily step count in baseline phase), as a goal setting, and not to change their daily dietary intake (advised to eat healthy food). Similarly, in group 2 participants were individually requested to increase their goal setting, in PA app, by 3000 steps/day, as well as reducing their daily dietary intake by 500 kcal (based on the average value recorded in the baseline phase) and record it in goal setting plan in the Lost it app. All participants were encouraged to use features of both apps' that may help them achieving their particular goals.

3.2.3.4 Data collection

All daily recorded data, in both apps, were automatically saved in both apps (once recorded). Study participants were requested to send their energy intake reports to the investigator at the end of every week, via email. Data of each session of PA (including the route maps) were instantly sent to the investigator via the share data function, after saving the workout in the app.

3.2.3.5 Focus-group interviews and Apps evaluation (short questionnaire).

Focus groups, according to Thomas et al (1995), is a technique involving the use of in-depth group interviews in which participants are selected because they are a purposive, although not necessarily representative, sampling of specific population, and the group is being focused on a given topic (229). Thus, the criteria for selecting the participants, in this type of research, is basically that they would have something to say on the topic and would be comfortable talking to each other and to the interviewer (230). Recently, focus-group interviews, as tools for qualitative data collection, have gained popularity in health research, investigating human behaviours, feeling and attitudes. They play a role in involving users in care management and strategy development, as well as assessing health promotion and nutrition intervention programmes (231). Focus-group interviews are basically aimed to understand and explain the meanings, beliefs and cultures that influence the feeling, attitudes and behaviours of individuals. Hence, it is a very useful tool for exploring the complexity surrounding food choice, dietary and other lifestyle behaviours, in ways that encourage the participants to engage positively with the research. Focus-group interview has many distinct features including the generation of a rich source of qualitative data that excludes misinformed or extreme views which records a relatively collective view of participants while saving time and expense (232) (233). The social interaction of the group (group dynamics) offers deeper and richer data than those from one to one interviews (229) and the findings can be used to precede quantitative procedures. Moreover, it can generate information about a range of ideas and feelings that individuals have about certain issues and clarify the differences in perspective between groups of individuals. Although for some individuals self-disclosure is natural and comfortable, for others it requires more trust and efforts and may pose a challenge in this model of research. Many studies in this field suggest that selecting the members of focus-group, to obtain rich data, depends on the topic under investigation. Krueger et al (1994) suggested that participants should share similar characteristics (e.g. gender, age group, ethnic and social class background) (234). However, most research recommends that participants should not know each other, in order to encourage more honest and spontaneous expression of views and a wider range of responses (231).

The outcomes obtained from the apps study could be challenged due to the small sample size and the fact the volunteers were living in the UK rather than Oman. It was hoped that conducting focus groups would provide a greater insight into the suitability of the interventions for this cultural group. Focus group interviews, including 5 male participants, were held on Sunday 5 June 2016. As mentioned earlier, many factors have hindered recruiting larger number of participants and involving both genders including; the limited resource constraint and the conservative culture of Omani community that restricted the engagement of females with male group. Hence, it was not possible to get female participants involved in the focus group interview or create 2 focus groups interview.

Timing was arranged and agreed (12:00 noon) with the participants for convenience and to improve attendance resulting in only one absence. Participants sat around a central table and the room was set up to provide an informal environment where they were free to talk and socialise. The focus group included participants from different BMI categories (including normal weight, overweight and obese individuals) and followed a semi-structured discussion, using open questions, of effectiveness of health and fitness apps in improving diet and PA behaviours in Omani people. The focus group was moderated by the principle investigator. Consent was obtained through the allocation and signing of a consent form. At the beginning participants were requested to speak one at a time for transcription purposes. Discussions were recorded via an audio recording device. The data was securely stored on the University website and external hard disk. All details of the interview listed in (Appendix F).

It is essential to assess participants' satisfaction with the smartphone apps, as acceptability is related to intervention effectiveness (235). Hence, at the end of the current intervention, participant's satisfaction was evaluated via two questionnaires (one for each app, presented electronically using Google Forms) and sent by email to all study participants who completed the intervention. Each questionnaire included 7 straightforward short answer questions. All completed answers were sent to the investigator (via email), by clicking on send icon available in the questionnaire form. Data collection and descriptive data analysis was sorted automatically by Google Drive software. Details of both questionnaires and their results are presented in (Appendices E and F).

3.2.3.6 Data analysis

The data collected from this study were statistically analysed by IBM SPSS Statistics 22 using descriptive statistics to illustrate the baseline characteristics of study participants, paired sample t-test to compare the differences in primary and secondary outcomes before and after the intervention, one-way analysis of variance (ANOVA) to evaluate the effect of BMI categories on average daily step counts and average daily energy intake.

3.2.3.7 Ethical consideration

The study was approved by the Medical School Research Committee of the University of Nottingham (Ref: SBREC150124A).

3.4 Results

3.4.1 Participants' recruitment and baseline characteristics

A total of 28 potential participants volunteered to participate in the study (18 males and 10 females). Of these, 7 (25%) participants withdrew from the study due to a variety of reasons including, lack of skills or interest in using new technology (especially women), language inconvenience and lack of time. As a result, 21 were eligible and agreed to participate in the study (16 males and 5 females). Eligible participants had a mean (± SD) age of 34±3.9 years, a mean (± SD) BMI of 26.3±3.7, and 16 (76%) were male. Other baseline characteristics are outlined in table 3.3. Based on BMI classification, 10 participants (47.6%) were normal weight, 8 (38.1%) were overweight and 3 (14.3%) were obese (table 3.4). Half of the male participants were either overweight (38%) or obese (12%). Out of five female participants, two were overweight and one was obese. As illustrated in table 3.5, the average (± SD) daily dietary intake (Kcal/day) and step count (Steps/day) in the baseline phase were 1462 ± 638, and 2491 ± 2556 respectively.

3.4.2 Primary and secondary outcomes

The comparison of different study variables before and after the intervention, in all study subjects is illustrated in (Appendix I). Results showed no significant changes in primary and secondary outcomes by gender, by the end of the study except for the step counts in male subjects (P=0.02) (table 3.6). However, in the group as a whole, significant changes were observed in the body weight, BMI and daily step counts of study participants by the end of the intervention. No changes were noted in daily energy intake, percentage of carbohydrates, fats, and proteins. Intervention measures of weight, BMI, energy intake, daily step counts, and macronutrients did not change in group 1, whereas in group2 average daily step counts was significantly increased by the end of the study (P=0.009) (table 3.7). Results in the same table also show a trend to increased daily step count in group 1, although it was not significant (P=0.09). Using One-Way Analysis of variance, results showed no significant effect of BMI category on daily energy intake or daily step counts of study participants before or after the intervention (table 3.8).

Descriptive results

Table 3.3. General characteristics of study participants in the baseline phase.

	Male (n=16)	Female (n=5)	Total (n=21)
	Mean ± SD	Mean ± SD	Average
Age *(year)*	35 ± 4	34 ± 4	34±3.9
Height *(m)*	1.74 ±.05	1.56 ± .05	1.7±0.1
Weight *(kg)*	77.2 ± 10.8	66.6 ± 14.3	74.7±12.2
BMI *(kg/m²)*	26.0 ± 3.5	27.2 ± 4.5	26.3±3.7
Energy intake *(kcal/d)*	1525.9 ± 697.8	1258.0 ± 377.9	1462±638
Step count *(steps/d)*	3112.9 ± 2606.8	500.4 ± 832.4	2491±2556

Values are means ± standard deviation (SD)

Table 3.4. Distribution of study participants based on BMI *(kg/m^2)* category.

	Male (n=16) n (%)	Female (n=5) n (%)	Total (n=21) n (%)
Normal Weight	8 (50)	2 (40)	10 (47.6)
Overweight	6 (38)	2 (40)	8 (38.1)
Obese	2 (12)	1 (20)	3 (14.3)

Table 3.5. Average daily (dietary intakes, step counts) before and after study.

	Male (n=16)	Female (n=5)	Total (n=21)
	Mean (±SD)	Mean (±SD)	Mean (±SD)
Energy Baseline *(kcal/d)*	1525.9 ± 697.8	1258.0 ± 377.9	1462.1 ± 638.3
Energy End *(kcal/d)*	1622.4±631.5	991.5±172.6	1472.2 ± 617.1
Step Count Baseline *(steps/d)*	3613.5 ± 2569	625.5 ± 905.3	2490.9 ± 2556.4
Step counts End *(steps/d)*	7395.8±4899	2992±780.6	6359.6 ± 4671.5

Inferential statistics

Table 3.6. Changes over time of primary and secondary outcomes in male and female participant (using dependent samples Paired t-test).

	Male			Female			Total		
Variables	**Baseline**	**End**	**Sig. (2-tailed)**	**Baseline**	**End**	**Sig. (2-tailed)**	**Baseline**	**End**	**Sig. (2-tailed)**
Weight *(kg)*	77.6 ± 11.4	76.6±11.3	0.09	66.6 ± 14.3	65.4±13.7	0.08	74.7±12.8	73.6±12.6	0.023*
BMI *(kg/m²)*	26.3 ± 3.6	26 ±3.5	0.08	27.2 ± 4.5	26.7±4.2	0.08	26.6±3.7	26.2 ± 3.6	0.017*
Energy intake *(kcal/d)*	1525.9 ± 697.8	1622 ±632	0.43	1258 ± 378	991.5±173	0.07	1462±638	1472 ± 617	0.919
Step count *(steps/d)*	3613.5 ± 2569	7396±4899	0.02*	625.5 ± 905	2992±781	0.06	2491± 2556	6360± 4672	0.004*
Carbohydrates *(g)*	61.3±6.1	61.5±5.7	0.94	61±8.6	60.7±7.3	0.8	61.3± 6.6	61.3±5.9	0.982
Fats *(g)*	18±4.2	17.3±4	0.58	19.3±4.2	17.5±3.8	0.39	18.3± 4.1	17.3±3.9	0.345
Proteins *(g)*	20.6±5.1	21.3±4.2	0.61	19.7±7.5	21.5±4.0	0.37	20.4± 5.6	21.3±4.0	0.373

Values are means ± standard deviation (SD)
* Statistical significant difference (P ≤0.05)

Table 3.7. Changes over time of primary and secondary outcomes in normal weight and overweight/obese participants.

Characteristics	**Normal weight (BMI: 18.5-24.9 *kg/m²*)**			**Overweight/Obese (BMI: 25-35 *kg/m²*)**		
	Baseline Phase	End of the study	Sig. (2-tailed)	Baseline Phase	End of the study	Sig. (2-tailed)
Weight *(kg)*	64.9±9.8	64.3±9.8	0.13	81.8±9.8	80.5±9.9	0.08
BMI *(kg/m²)*	23.3± 1.4	23± 1.4	0.131	28.9±3	28.4± 2.8	0.06
Energy intake *(kcal/d)*	1414 ± 727	1548.9 ± 727	0.3	1505.8 ± 578	1402.4 ± 524	0.5
Step counts *(steps/d)*	2678.8 ± 2248.4	6763.9 ± 5584	0.09	3116±3016	6000±4007	0.009*
Carbohydrates *(%)*	61.9±4.2	61.8±5.6	0.9	60.7±8.3	60.9±6.4	0.9
Fats *(%)*	17.8±3.6	17.7±3.3	0.8	18.7±4.7	17±4.5	0.4
Proteins *(%)*	20.3±5	20.5±4.4	0.8	20.5±6.3	22.1±3.8	0.4

* Statistical significant difference *($P \leq 0.05$)*

Table 3.8. Impact of body weight (BMI categories) on the mean daily energy intake and daily step count.

BMI *(kg/m²)* **categories** **Characteristics**	**Normal** **(18.5-24.9)**	**Overweight** **(25-29.9)**	**Obese** **(over 30)**	**One-way** **ANOVA (Sig.)**
Ave. Daily energy intake *(kcal/d)* **baseline**	1414±727	1568±586	1340±643	0.839
Ave. Daily step count *(steps/d)* **baseline**	2143±2282	2754±2751	2948±3771	0.847
Ave. Daily energy intake *(kcal/d)* **(end of study)**	1549±727	1460±572	1249±425	0.778
Ave. Daily step count*(steps/d)* **(end of study)**	6764±5584	5914±3067	6173±6374	0.949

3.4.3 Apps evaluation (Focus groups interview & short questionnaire)

Five participants were interviewed in a focus-group interview to find out their impression, views and opinions about both apps. The answers of all interviewees were summarised after each question (Appendix F). In general, most of the interviewees indicated that the dramatic increase in NCDs and the existence of chronic diseases in their family history were the main motivators about the quality of their general health. Most of them have never used health and fitness apps before. All interviewees were satisfied with both apps and many of them reached at least part of their goals. Features, such as creating groups, sharing data and challenges with friends were very helpful in achieving goals. However, they suggested that customising some app features (meal plan, language) to be culturally sensitive would be more effective.

Participants were requested to complete satisfaction questionnaires relating to both apps.18 participants (85%) out of 21 have completed the Lose it app questionnaire, and 19 (90.5%) participants responded to Map My Fitness app questionnaire. All female participants responded and completed both questionnaires. Most study participants reported high satisfaction for both apps, despite the drop-in app usage (especially Map My Fitness app) during the study (Appendix G & H). About 90% (n=17) of the participants had never tried using such apps before. With regard to the Lose it app, approximately 55% of the participants stated that recording daily dietary intake was easy or very easy and almost 67% partly reached their goals. Over 90% (n=17) of study participants indicated that both apps were effective, and they would recommend them to friends. Over 68% of the participants stated that the Map my Fitness app was easy or very easy to use, 53% of them partly reached their goals, and over 30% reached most or all of their goals. In both apps, responses to the question about the most helpful features, reiterated the following features; self-monitoring of energy intake (number of calories consumed with respect to target amount, macronutrients %, healthy foods), feedback about the performance (diagrams, charts, reports), and social networking feature (interaction with users, creating groups, sharing information and making challenges).

3.5 Phase 2: Feasibility of Smartphone Application to Promote Physical Activity in Healthy Omani Female Adults

Despite the generally positive findings observed in phase 1, the study was limited by its small sample size (especially female participants), lack of a control group, low level of female PA recorded in baseline phase (500± 832), short-term follow up and a non-representative study environment. Participants in the study were all living and working/studying in the UK and as such were not directly affected by cultural and environmental conditions that may be prevalent in Oman. Furthermore, it was not possible to specifically assess the role of the apps in improving the lifestyle choices of the subjects as no control group was included. Hence, phase 2 evaluated the effectiveness of health and fitness apps, compared to conventional lifestyle advice, on a larger sample size of (female adults) living in Oman (representative). Both the survey study and the initial app trial suggested that PA, rather than energy intake, may represent a significant problem among Omani adults. Hence, the aim of this study was to specifically determine the feasibility of a smartphone app to increase PA in healthy Omani female adults living in their home country. As such, this was not a continuation of the phase one study and required new Ethical Approval from the Research Committee in University of Nottingham.

Hypothesis: It was hypothesised is that the use of a smart phone app would significantly increase the activity of female subjects living in Oman. However, the null hypothesis was that there would be no difference in activity between the app group and a control group.

Objectives of the study

- To determine the PA of the study population
- To assess the effectiveness of a smartphone app in promoting and improving PA
- To compare PA level before and after the intervention in app and non-app (control) users.

- To compare the changes in dietary intake between the first week at baseline and the fifth week at follow up.

To the best of our knowledge, this is the first study to use a smartphone app with Omani women living in Oman.

3.5.1 Methodology

3.5.1.1 Participant recruitment

The current study was a randomised controlled trial aimed to investigate the feasibility of a smartphone app to promote PA in Omani female adults living in Oman with duration of five weeks in total, including a baseline week. Potential participants were invited through a multi-strategy approach using personal networking, and a flyer (Appendix K). Personal networking is often adequate for recruiting participants in small studies (236). Potential participants were informed about the study contact details and university email address through which the project information sheet can be requested (Appendix L).

3.5.1.2 Inclusion and exclusion criteria

Participants were eligible if they were:

- Omani female adults aged 18–55 years living in Oman.
- Android or iPhone smartphone users, English-language literate
- Capable of undertaking PA.

Participants were excluded for the following reasons:

- Not smartphone users
- Underweight
- Pregnancy

- Medical history of NCDs including hypertension, diabetes, CVD and obesity (BMI>30kg/m2)

All potential participants were contacted by the investigator on the 7th of November 2016, and all final outcome data were collected by the 19th of December 2016.

3.5.1.3 Ethical approval and consents

The study was approved by the Sutton Bonington Research Committee of the University of Nottingham (No: SBREC160105A). Consent forms and all information materials are listed in (Appendix M), were available in Arabic and English languages, to ensure that it was culturally appropriate, and the participants comprehended the information. Completed consent forms were obtained from all study participants.

3.5.1.4 Randomisation and intervention

Participants were provided with all information about the study via e-mail or WhatsApp. A preliminary electronic questionnaire (Appendix N) was used to collect the demographic and anthropometric information of study participants and assessed their eligibility. Eligible participants were assigned a code after completing their consent form.

Using a research randomiser computer software program (http://www. Randomizer.org/form.htm), participants were randomly allocated to one of two groups; the non-app (control) group (n=21) or the app group (n=21). Due to the nature of the intervention, blinding of the participants and researcher was not possible.

The app group was requested to download the mobile app (Pacer), a pedometer, onto their phones. Participants were provided with detailed information and steps for downloading the app and sending the data via data export function available in the app. Those who needed further assistance were advised to contact the researcher. They were also asked to keep a PA log during the baseline week. A three-day food diary data was collected at the baseline and at the fourth week of the intervention. During the baseline period all subjects were requested to continue with their normal daily routine of PA. App group subjects were asked to carry their phones during waking hours.

After data collection on the baseline week was completed, participants assigned to the app group were trained on how to use the smartphone app (Pacer) and encouraged to increase their PA gradually, taking into account that the current guidance is 10,000 steps per day. Participants were contacted by phone and given further information on how to incorporate the additional daily steps into their normal daily life such as taking the longest route to the office, taking the stairs instead of the elevator, walking in the mall during hot weather etc. They were requested to send the step count data at the end of every week, using the 'data export' feature in the application. With regard to control group, once the data collection of the baseline week was completed, they were contacted again by phone and given general information about PA. They were also asked to send written PA logs weekly.

3.5.1.5 Study measures

Age, height and weight were self-reported, body mass index (BMI) was calculated (at the baseline and the end of the intervention). As in Phase 1 normal weight was defined as BMI 18.5- 24.9, overweight as BMI 25–29.9 and obese as BMI ≥ 30. For those in the app group, daily PA, total step count and active time was assessed and recorded by the Pacer app. In the control group, daily PA logs were used to record the active time. Three-day diaries were used to assess the dietary food intake of study subjects in both groups at the baseline phase and the end of the intervention. The name of the app (Pacer) was made available to the control group at the end of the study, and all participants received feedback on their activity and dietary intake upon request.

3.5.1.6 Outcome

The primary outcome measure was PA level (active time) of study participants in both app group and control group. Secondary outcomes were the impact of changes over time of PA level on food choices between the baseline and intervention, and participant satisfaction.

3.5.1.7 Smartphone app and its selection process

In phase 1, 50% of female potential participants (5 female) withdrew from the study during the baseline phase, most of them due to lack of time and skills. Although improvement in PA was noted among study participants by the end of the study, some subjects found the nature of data entry in the fitness app (Map My Fitness) rather tiresome. A possible reason for this was the commitment required to practice PA in regular basis. An additional factor may be the burdensome steps required in activating some functionalities (e.g. setting up data sharing functionality required some skills in sending/accepting invitation via email between the participants and the investigator). Furthermore, using the navigation system in each workout undertaken may have increased the burden. These technology-based setting steps are possible reasons behind the withdrawal of many female participants during the baseline phase. Therefore, in order to ease the burden on study participants, different app was used in phase 2 (Pacer), which included more user-friendly features that replaced the most challenging steps observed in Map My Fitness app used in phase 1. Examples of these features are; continuous automatic tracking of step counts participants were carrying the phone, working without using navigation system and using the ordinary email for sending data.

3.5.1.8 Data handling and statistical analysis

Data was handled, and subject confidentiality maintained as detailed in the phase 1 trial. Statistical analysis was performed using SPSS software (version 20) as described for phase 1. Age and BMI sections were analysed using descriptive statistics (mean ± SD). A chi-squared test was used to compare categorical variables such as demographics. Independent and paired T-tests were used to compare PA levels (active time and step count) and food intake between and within groups. Dietary intake of study subjects was analysed using the dietplan6 software. Data were presented as means, standard deviation or percentages. A P-value ($P \leq 0.05$) was used for the level of significance. Participants' satisfaction and effectiveness of the apps used in improving PA behaviour was assessed using a questionnaire and presented as percentages (HO).

3.6 Results

3.6.1 Participants' recruitment and baseline characteristics

A total of 82 potential participants completed the initial questionnaire. Of these, 40 were excluded from the study due to a variety of reasons including, being diagnosed with chronic diseases, underweight, and being outside the country during the course of the intervention (figure 3.3). Only 42 participants were eligible and were randomised. However, 38 (90.4%) completed the study with three further participants dropping out during the baseline period (3 from the app group and one control. Reasons for drop out included pregnancy, time constraints or lack of response.

Participants who completed the study had a mean age of 34 ± 5.1 years, a mean BMI of 23.5 ± 3.1 kg/m^2, and average energy intake of 1258±369 (kcal/day) at baseline phase (table 3.9). The mean active time was (31.2±23.6 minutes/ day). As shown in (table 3.10), no significant differences were seen between control and app group in educational level, employment status, and marital status (P= 0.2, 0.34, 0.16 respectively). Based on BMI classification, 24 (63%) participants were normal weight and 14 (37%) were overweight (table 3.11). six members of control group were overweight, while 8 in app group were overweight.

3.6.2 Primary and secondary outcomes

In the group as a whole, results showed no significant difference in the mean body weight, mean BMI, average energy intake, and macronutrient values (carbohydrates, fats, and proteins) before or after the intervention (table 3.12). However, a significant increase (P=0.004) was observed in the duration of active time by the end of the intervention. No significant changes were noted in active time of the control group before and after the intervention (P=0.16). In contrast, the active time was significantly increased (P=0.006) in the app group from mean 32.7 ± 21.3 minutes/day in the baseline to mean 48.3 ± 25.1 minutes/day at the end of the intervention. The app group also showed a significant increase (P=0.001) in average step count from mean 3740 ± 2656 steps/day to 4986 ± 3009 steps/day.

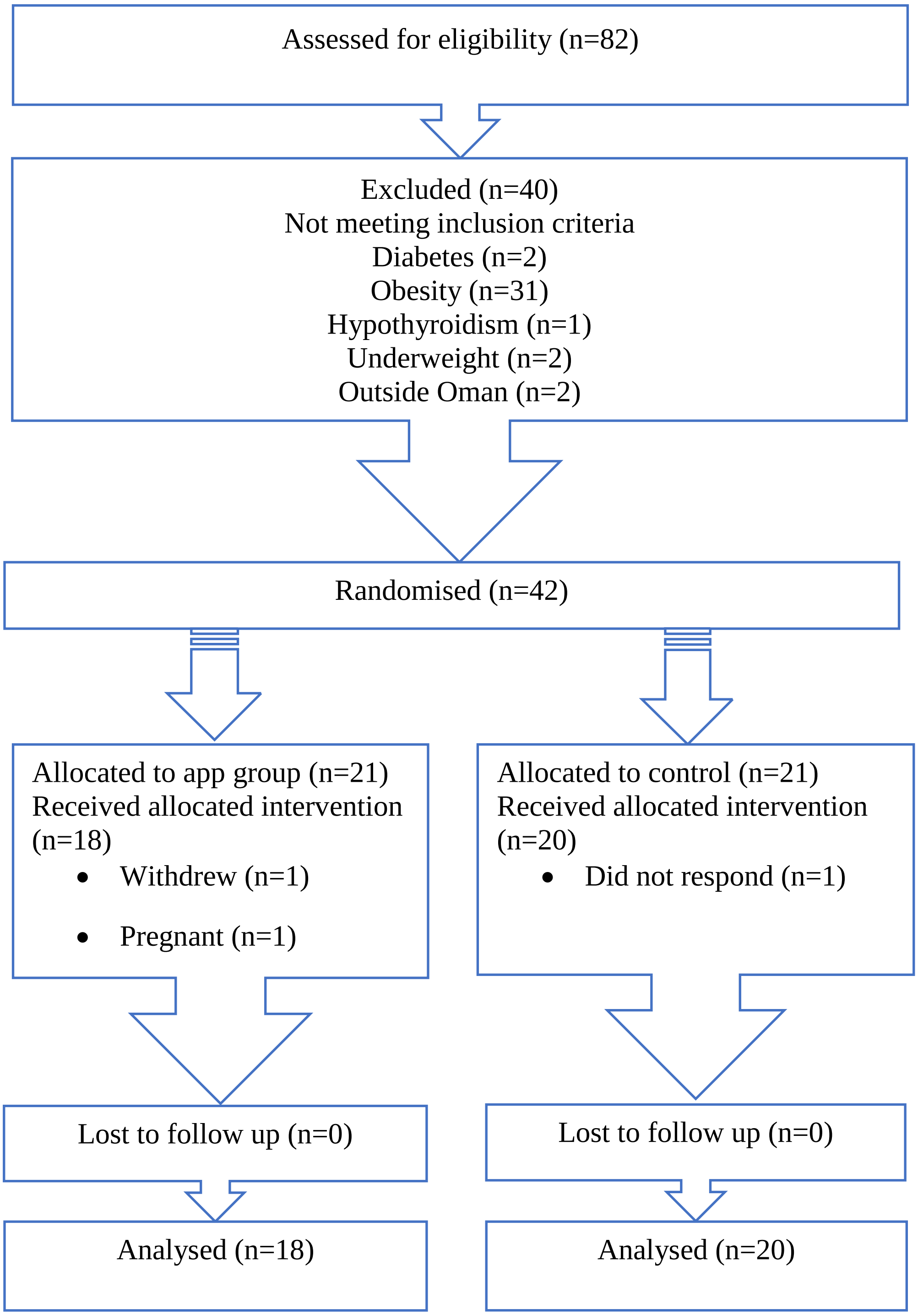


Figure 3.3: Participants' recruitment and follow up (Phase 2).

As illustrated in table 3.13, the treatment effect was evident in the app group, with the increase of 22% of active participants by the end of the intervention compared to a 5% increase in the control group. Table 3.14 shows the differences between control and app groups in primary and secondary outcomes before and after the intervention. No significant difference was observed in the active time between control and app group in baseline (P=0.69) and after the intervention (P=0.133). Similarly, no significant differences between groups in regard to energy intake and macronutrients (carbohydrate-sugar and fibre- and fat) at baseline phase except for the percentage of energy from protein (P=0.007). However, a significant decrease in energy intake (P=0.04) was observed in the app group at intervention. In addition, carbohydrates were significantly lower in the app group (P=0.009) and the percentage of energy from protein continued to be significant (P=0.04).

Table 3.9. General characteristics of study participants in the baseline phase (phase2).

	Control	App	All	P- value
	Mean ± SD	Mean ± SD	Average	
Age *(Year)*	33.85 ± 5.7	34.17 ± 4.5	34 ± 5.1	0.34
Height *(m)*	156.5±6.7	157.8±6.3	157±6.4	0.90
Weight *(kg)*	58.5±10.7	58.5±9.8	58.5±10.1	0.88
BMI *(kg/m^2)*	23.8 ± 3.5	23.3 ± 2.7	23.5 ± 3.1	0.12
Energy intake *(kcal/d)*	1373 ± 494	1142.4 ± 242.5	1258±369	0.09
Active Time *(Minutes/d)*	29.68 ± 25.9	32.7 ± 21.3	31.2±23.6	0.95

Data are presented as mean ± SD (standard deviation); P-value (≤0.05) was determined by independent t-test.
BMI is ‘body mass index’; kcals is ‘kilo calories’.

Table 3.10. Baseline demographics.

Demographic	Control Group (n=20)	App Group (n=18)	P-value
Education Level n (%)			
High School	1(5)	1(5.6)	0.20
Degree	17(85)	11(61.1)	
Postgraduate	2(10)	6(33.3)	
Employment Status n (%)			
Employed	17(85)	17(94.4)	0.34
Unemployed	3(15)	1(5.6)	
Marital Status n (%)			
Single	8(40)	11(61.1)	0.16
Married	12(60)	7(38.9)	

Data are presented as percentages. P-value (≤0.05) was determined by chi-square test.

Table 3.11. Distribution of study participants based on BMI category*(kg/m^2)*.

	Control	App	All
	n (%)	n (%)	n (%)
Normal Weight	12 (66.7)	12 (60)	24 (63.2)
Overweight	6 (33.3)	8 (40)	14 (36.8)

Table 3.12. Changes over time of primary and secondary outcomes in control and App group (using dependent samples Paired t-test).

	Control			App			All		
Variables	**Baseline**	**End**	**Sig. (2-tailed)**	**Baseline**	**End**	**Sig. (2-tailed)**	**Baseline**	**End**	**Sig. (2-tailed)**
Weight *(Kg)*	58.5±10.7	58.5±10.4	0.98	58.5±9.7	58.3±9.7	0.997	58.5±10.1	58.4±9.9	0.796
BMI *(Kg/m²)*	23.8 ± 3.5	23.8 ± 3.5	0.98	23.4 ± 2.7	23.3 ± 2.7	0.994	23.6 ±3.1	23.6 ±3.0	0.834
Energy intake *(kcal/d)*	1373 ± 494	1349 ±467.9	0.66	1142 ± 242.5	1069± 293.5	0.37	1263.8±407	1216±415	0.321
Active time *(Minutes/d)*	29.6±25.97	35.8 ± 24.7	0.16	32.7 ± 21.3	48.3 ± 25.1	0.006*	31.2±23.6	39.6±23.4	0.004*
Step count *(Steps/d)*	-	-	-	3740±2656	4986±3009	0.001*	-	-	-
Carbohydrates *(g/d)*	178.9 ± 72	175.4± 66.4	0.75	143.7 ± 44	126.9 ± 35.5	0.16	162.3±62	152.5±59	0.232
Fats *(g/d)*	55.4 ± 22.5	53 ± 24.5	0.51	44 ± 16	43.9 ± 17	0.92	50.2±20	48.9±22	0.636
Proteins *(g/d)*	50.7 ± 17	52.6 ± 14.5	0.46	50.9 ± 14.9	49.8 ± 14.6	0.76	50.8±16	51.3±14	0.820

Values are means ± standard deviation (SD)

* Statistical significant difference (P ≤0.05)

Table 3.13. Physical activity level changes between baseline and intervention for both groups.

Physical Activity Level	**Control Group (n=20)**		**App Group (n=18)**	
Active Time	**Baseline n (%)**	**Intervention n (%)**	**Baseline n (%)**	**Intervention n (%)**
Active >30 (*Minutes/d)*	9(45)	10(50)	8(44.4)	12(66.7)
Inactive ≤ 30 (*Minutes/d)*	11(55)	10(50)	10(55.6)	6(33.3)
Step count				
Active > 5,000 (*Steps/d)*	-	-	5(27.7)	7 (38.9)
Inactive ≤ 5,000 (*Steps/d)*	-	-	13(72.3)	11(61.1)

Table 3.14. Mean difference for outcomes in control and app groups at baseline and intervention.

	Outcome	**App Group** (n=18) **Mean ± SD**	**Control Group** (n=20) **Mean ± SD**	**P-Value**
Baseline	**Active Time** *(minutes/d)*	32.7 (21.3)	29.68 (25.96)	0.69
	Dietary Energy *(Kcals/d)*	1,142.4 (242.5)	1,373 (494)	0.08
	Carbohydrate *(g/d)*	143.7 (44)	178.9 (72)	0.07
	% Energy CHO	47.3 (9.9)	48.2 (7.7)	0.75
	Protein *(g/d)*	50.9 (14.8)	50.7 (17)	0.96
	% Energy Protein	17.9 (3.4)	15 (2.7)	0.007∗
	Fat *(g/d)*	44 (16)	55.4 (22.5)	0.09
	%Energy Fat	34.8 (8.7)	36.6 (7.3)	0.49
	Total Sugar *(g/d)*	48 (24)	55.8 (26.5)	0.35
	Total Dietary Fibre *(g/d)*	9.5 (4)	9.5 (3)	0.16
Intervention	**Active Time** *(minutes/d)*	48.3 (25.1)	35.89 (24.7)	0.133
	Dietary Energy (*Kcals/d)*	1,068.6 (293.5)	1,348.8 (467.9)	0.04∗
	Carbohydrate *(g/d)*	126.9 (35.5)	175.4 (66)	0.009*
	% Energy CHO	45.2 (7.8)	48.6 (8.6)	0.22
	Protein *(g)*	49.8 (14.6)	52.6 (14.5)	0.56
	% Energy Protein	18.6 (3.4)	16.2 (3.4)	0.04∗
	Fat *(g)*	43.9 (17)	53 (24.5)	0.18
	% Energy Fat	36.1 (7.2)	35.1 (7.3)	0.68
	Total Sugar *(g/d)*	40.7 (17.6)	52.5 (20.9)	0.07
	Total Dietary Fibre *(g/d)*	8.7 (4)	10.5 (3.9)	0.18

∗ Represents significance. P-values (≤ 0.05) were determined by independent t-test; CHO (carbohydrate); SD (Standard Deviation).

3.6.3 Participants' satisfaction with the app

All 18 participants in the app group completed a satisfaction questionnaire (figure 3.4) (Appendix O & Appendix P). 89% of the participants found the app to be effective, easy to use and indicated that they would continue using it after the study. 94% found the app motivated them to do PA, while 89% thought that combining the app with a wearable device would be beneficial.

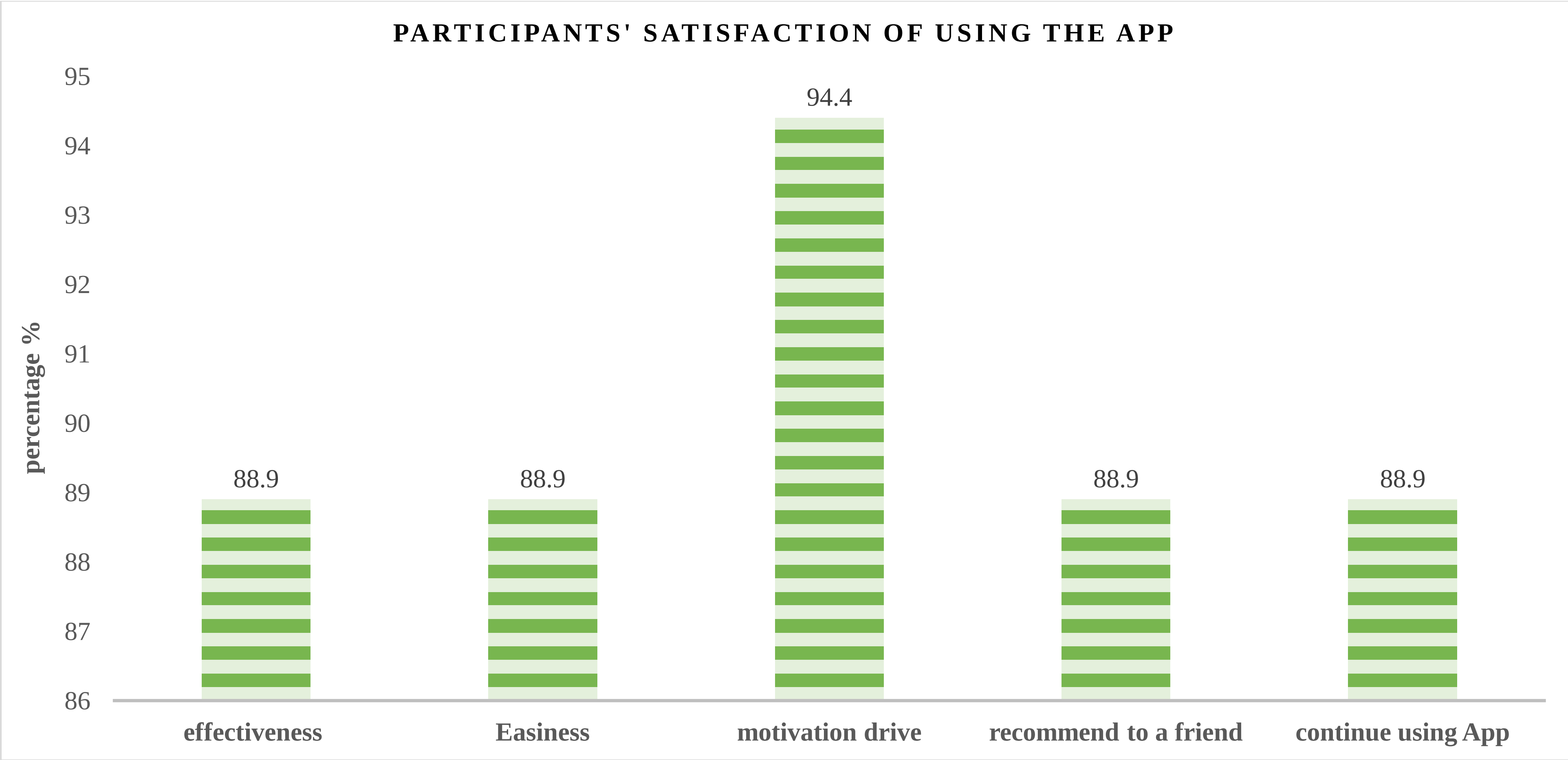


Figure 3.4. Participants' satisfaction is presented in percentages *(n=18)*.

3.7 Discussion (Phase 1)

Phase 1 aimed to investigate the effectiveness of two smartphone apps (Lose it and Map My Fitness), available free in both Android and Apple stores, to improve physical activity and dietary intake in Omani male and female adults living in Nottingham. Twenty-eight participants were recruited in this study which represents approximate 28% of the estimated 100 Omani nationals living in the Nottingham area. Connelly (2008) suggested that a pilot sample should be 10% of the sample projected for the larger study, although it is not a straight forward for some studies, which are influenced by many factors (237). Furthermore, Hill in (1998) suggested 10-30 participants for pilots in survey research (238).

To our knowledge, neither apps have been assessed in prior studies. Due to time and population size constraints, it was not possible to implement a randomised trial to evaluate the validity of both apps. However, the two apps were chosen due to their high rating using already-established criteria for smartphone apps. The desired criteria included; tracking (monitoring) of step count, energy intake, energy expenditure, automated feedback, providing visually appealing graphic display, as well as goal setting functionality and goal achievement feedback. The rating also depended on the number of users registered with the app's company, the number of reviewers in the app stores (number of stars achieved out of 5) and number of "likes" in social media such as Facebook. For example, Lose it app was selected as a finalist in the 2015 Annual MITX Awards for most innovative Mobile App and best consumer Tech that make life easier categories (239). However, there are many other free available apps with similar popularity. Both apps included many features and techniques that promote behaviour changes, such as self-monitoring, feedback on performance, and goal setting. Webb et al (2010) reported in his systematic review that interventions that included larger number of behaviour changes techniques are more likely to be effective (240).

3.7.1 Demographic data

Results of the current study showed that more than half of the participants were either overweight or obese. The mean (± SD) daily energy intake of study participants at the baseline phase was 1462.1 ± 638.3. According to the Food and Agriculture Organisation of the united nation (FAO), this value was below the average minimum energy requirement per person per day (1,800kcal) (241). As none of the subject reported actively trying to lose weight, it appears that this must be an underestimation that could be attributed to a number of reasons. Firstly, as in many such studies, the actual energy intake could be subjected to underestimation due to self-reporting method. Secondly, the investigation tool (Lose it app) was presented in the English language to non-native English speakers. Even though most of the participants were students (undergraduate or postgraduate) who had a relatively high standard of English, this may have impacted on accurate use of the app. Furthermore, most of the recipes and food items available in the app were Western foods and very few Middle East and Gulf States meals available, which may have affected the accuracy of recording the daily dietary intake. According to the focus group interview report (Appendix F), 99% of the study participants had not used such apps before and thus, lack of skills and experience may have affected the accuracy of data entry with some participants. The reason of choosing the app in English language was the limited number of weight loss apps that based on evidence-informed practices, available to Arab populations. Furthermore, although Arabic weight-loss apps available, most of their content has been taken from existing English apps and does not take into account the social norms prevalent in the Arab culture (242).

The difference in the average daily energy intake found in this study and the one reported in study 1 (2252kcal/day, using traditional method/paper diary) further supported the previous explanation of underreporting of energy intake. Participants' awareness of the impact of overweight and obesity, on risk of developing NCDs, despite the relatively high educational

level of UK cohort, in conjunction with possible underestimation of the effectiveness of such tools to achieve tangible improvement may influence the outcome as well. Mabry et al (2014) reported that lack of awareness and low social values of PA were important determinants of physical inactivity in Oman (243). The average BMI of study participants in the current study was 26.3±3.7 which compares well with the results of survey study 1, which found the average BMI of 500 Omani participants to be 26.4 ± 5.9. The mean (± SD) steps/day at the baseline phase was 2,491±2,556, which suggested that many of our study participants fall well below the guideline (30 minutes of moderate-to-vigorous walking for at least five days). Simon et al (2009) reported that moderate-intensity walking equals about 100 steps per minute, and individuals encouraged to walk minimum of 3000 steps in 30 minutes for 5 days/week in order to meet the current guidelines (244). Tudor-Locke et al (2013) stated that individuals achieving above 5,000 steps/day are considered active, and those achieving below 5,000 steps/day are considered sedentary (245), and associated with many risk factors, including obesity (85).
This finding was consistent with the findings obtained in study 1, which suggested a clear association between physical inactivity and prevalence of overweight and obesity, despite the normal energy intake value.

3.7.2 Primary and Secondary outcomes

Data analysis of the primary outcomes in the current study showed that body weight, BMI and average daily step count were significantly changed by the end of the intervention. Body weight, in the group as a whole, has decreased by 1.5% and average daily step counts increased by 2.5-fold (P<0.01) (table 3.6). However, participants categorised as overweight and obese at the start of the trial remained in the same BMI category at the end of the trial (table 3.7). With regards to PA, the treatment effect was evident and represented in changing PA level, of the group as a whole, from sedentary (2491± 2556) to active level (6360± 4672). Although female participants showed a trend to increase PA, however, partly due to small sample size, the increase was not significant (P=0.06). In contrast, PA level of male participants was significantly increased by the end of the study (P=0.02).

While the changes in BMI in this trial were very small, this was to be expected due to the short duration of the study. These data suggest that prolonged use of these apps for dietary and PA tracking might be a useful tool to support weight management and improving fitness. The magnitude of change in daily step counts (over 3869 per day or approximately 1.8 mile) was clinically meaningful and if continued would expected to result in long-term health benefits. The body weight in the current study is predicted to decrease by 18% in one year, if the daily step count of (1.8 mile/day) is maintained and no changes in the average energy. Dallinga et al (2015) indicated that mobile apps have positive impact in the preparation of running events, as it promotes health and PA (84). The finding is further supported in a study by Glynn et al (2014), who reported that use of a simple smartphone app significantly increased physical activity of primary care population over 8 weeks (83). By contrast, Laing et al (2014) found no significant effect of smartphone apps on weight loss compared to usual care in overweight primary care patients, and he suggested that apps may be useful for individuals who are ready to self-monitor energy intake (246). Wharton et al (2014) compared effect of dietary self-monitoring using mobile app (Lose It) with a traditional paper and pencil method. Results showed that although app group showed more compliance in recording dietary data compared to paper-pencil group, however, both groups lost weight over the course of the study, and no difference in weight loss was noted between groups (210).

No significant changes were observed in the average daily dietary intake during the intervention. This finding was not in line with Turner-McGrievy et al (2013) who suggested that the use of mobile methods for tracking PA and diet is associated with decreased energy intake, as well as increased energy expenditure, in individuals who are trying to lose weight (208).

Several studies have shown a distinct relationship between steps/day and body composition variables. Pillay et al (2015) suggested that individuals with values less than 5,000 steps/day are more frequently classified as obese, and those meeting the 10,000 steps/day target are more likely classified as normal weight (85), which was inconsistent with the findings in the present study. Results in this study suggested no direct and independent association between body weight and either physical activity level or energy intake (table 3.8). However, this finding disagrees with results in study 1 (the survey study), which showed a significant correlation between BMI categories and energy intake of study sample (table 2.11), as well as clear patterns of BMI categories with physical activity level (figure 2.8). This discrepancy may be attributed to the small sample size, the short-term follow up and the non-representative study environment. With regard to the secondary outcomes investigated in this study, analysis showed no significant changes on the macronutrient intake (carbohydrates, fats, and proteins), which equates with the fact that no change in energy intake was observed by the end of the study.

Data analysis between the two study groups showed no significant changes in primary outcomes in group 1 (normal weight), despite the increase trend in average daily step counts. This can be partly explained by the small sample size and large variations of PA levels among the participants (represented in the high standard deviation, table 3.7). However, physical activity of overweight and obese participants (group 2) was significantly increased 2-fold ($P<0.01$) and was associated with a trend to decrease weight ($p=0.08$). This finding ultimately suggests a clear association between physical inactivity behaviour and BMI in the overweight/obesity group. The energy intake and macronutrient values before and after the intervention, remained the same in both groups.

3.7.3 Participants' satisfaction

Participants' satisfaction about the effectiveness of the two apps used in this study was encouraging and represented in high study retention rate (100%). All 7 withdrawals occurred in the baseline phase (2 males and 5 females), which could be attributed to a combination of language inconvenience, low levels of skills, and lack of time (as many of participants were students). Klenk et al. (2017) indicated that gender differences can influence engagement in PA (213). He also reported that men have higher interest in technology compared to women, which may be one potential reason for more drop out in female participants in this study. Over 90% of study participants indicated that both apps were effective, and they would recommend them to friends. This may relate to the interactive platform and the features and functionalities provided in these apps. Klenk et al (2017) conducted an online survey to explore the relationship between expected gratifications and fitness app use. Results revealed that enjoyment, achieving goals, and social media were the most important gratifications met by using the app.

Success of smartphone apps for improving dietary and lifestyle behaviours depends in part on the extent to which they facilitate more consistent data entry, which may be important for increased commitment to dietary and PA behaviour changes. In this study, participants more consistently entered dietary data compared to PA data in Map My Fitness (Appendix J). This might be related to the nature of both apps, the dietary app provided a less burdensome method for tracking the data comparing to PA app. Similarly, Wharton et al (2014) reported that Lose it app recorded higher compliance in dietary self-monitoring compared to both the memo feature on a smartphone and a traditional paper-pencil method (210). Self-monitoring of energy intake, energy expenditure and daily step counts were the most helpful features towards achieving the targeted goals in this trial. This finding was further supported by Burke et al

(2012) who found significant positive relationship between self-monitoring diet, PA or weight with successful outcomes related to weight management (247).

Responses from the focus group interview were very positive. Improving the quality of life, prevention from chronic disease (recorded in their family history), and aging were the prominent motivators of the quality of their diet and PA. Although two interviewees had used similar health and fitness apps before, the previous duration was for a very short period of time, which is in line with many studies that consider sustainability among the main challenging issues in health and PA promotion strategies. All interviewees found both apps helpful and indicated they will continue using them in future, especially Lose it app, which helped them to monitor their daily energy intake and select healthier food choices. One of the advantages that interviewees emphasised was the positive role of the challenge group (a feature provided in fitness app) which encouraged them to increase their daily step count on quite regular basis, especially after recording low level of PA in the baseline phase. Based on their active participation, interviewees suggested some issues that may help in achieving better results in future including; designing a multi-cultural app to be appropriate to several cultures, warranting data protection and consumer privacy, globalising the list of meals to include as many food items as possible (such as the Middle East and Arabic foods). In addition, it was suggested they could be improved by providing professional individualised feedback feature (providing individuals with certain types of physical activity suitable for their age, weight and climate they live in). In general, all interviewees supported using smartphone apps to improve dietary habits and physical activity in Oman, especially in the technology-skilled generation and the exponential rise in global smartphone use. However, some had reservations about the sustainability of using such apps in the conservative Omani society. Research recently suggested that individuals, especially younger generations, preferred the use of mobile phones for dietary and weight loss interventions compared with other web-based tools (210). Finally, interviewees urged health-related authorities in Oman to exert more collaborative efforts to improve health and lifestyle behaviours in Oman.

3.8 Discussion (Phase 2)

Phase 1 attempted to investigate the impact of both PA and dietary-based apps in Omani men and women. A high drop-out rate in the baseline period meant that very few females completed the study. As discussed above, although the diet app was generally well received, no significant changes in energy or macronutrient intake were seen and the app referenced a limited range on 'non-Western' foods. On the other hand, while changes in physical activity were demonstrated, subjects found the nature of entry of PA data rather cumbersome. In addition, the nature of the population studied (predominantly students) and the Western environment they were living in may well have influenced the outcome of the study. To address some of these issues it was decided, to design another study aimed specifically at the viability of using a smart phone app to increase the physical activity in Omani women living in their home country. It was hoped that by focussing on PA and not expecting participants to use a separate app to monitor food intake, participation may be increased and drop-out minimized. It was also decided to use a different PA app to minimise the burden noted in using MapMyFitness app in phase 1. As discussed, many potential barriers exist which restrict PA in Omani females and hinder intervention strategies. As far as we are aware, this is the first study which has actually considered the use of Smart Phone Apps to increase the PA of females in Oman. The study shows that even amongst this relatively 'conservative' group the use of such technology is acceptable and achievable. The results of the study are encouraging and support the development of larger and longer trials to confirm the efficacy of such interventions in improving the metabolic health of this population group.

3.8.1 Demographic data

The majority of study participants were from the capital area (Muscat) which might be due to the recruitment method used in the study. Overall, the study population had mean age (34 ± 5.1 years) and classified as having normal BMI (23.5 ± 3.1 kg/m²). This may not be fully representative of this area as Mehena and Al-Kilani (2010) stated that people in the urban area are more likely to be obese (248). Furthermore, the average BMI found in this study is lower than the one recorded in study 1 (26.4 ± 5.9). However, the study was specifically designed to only include normal and over-weight individuals and as such the inclusion criteria was restricted to those with BMIs <29.9 kg/m^2. Moreover, the majority of the study population was highly educated with only 5% with only high school level. Al-Riyami et al (2012) indicated that only 7% of the Omani household population completed university or higher again indicating that the cohort studied was not representative of the overall population (163). Furthermore, demographic data in this study indicate an equal percentage between those who are married and unmarried and only 10.5% of the sample was unemployed. The higher percentage of employment may impact on ability to perform PA as reported in a cross-sectional study on Saudi women working in office-based jobs suggested a high risk of physical inactivity (249).

3.8.2 Primary and Secondary outcomes

Data analysis of the primary outcomes in the current study showed no significant changes in body weight, BMI between baseline and the end of the study. By contrast, phase 1 recorded a significant decrease in body weight and BMI by the end of the study. This may be attributed to the differences in the protocol and dietary assessment methods used in phase 1 and phase 2. While phase1 aimed to assess both daily dietary intake (using Lose it app) and PA (using MapMyFitness app), phase 2 focused on assessing PA (using Pacer app), and food intake was assessed only twice (using 3-day diet diary, at baseline and the end of the intervention).

However, by the end of the study, macronutrients intake in all study groups remained the same in both phases. On the other hand, both phase 1 and phase 2 (app group) showed significant improvement in average step count by the end of the study (P= 0.004, P=0.001 respectively), which ultimately support the suggestion of the effectiveness of treatment method (smartphone apps) used in both phases.

The American College of Sports Medicine (1998) recommended that at least 30 minutes of daily PA is necessary for adults to maintain physical fitness (249). In the current study, only about 45% of the studied sample met this recommendation in the baseline phase (table 3.13). This is of a similar in magnitude to the study conducted by Mabry et al (2016) on the PA of Omani adults, which revealed that 41.6% of women were physically active with a higher rate among the younger population (250). However, the World Health Survey in Oman (2012) revealed that 59% of Omani women were getting sufficient exercise (163). In contrast, A-Habsi and Al-Kilani (2015) assessed the PA and sedentary behaviour of Omani women who wore an accelerometer; 62% of Omani women spent their time in sedentary behaviour and 38% in PA (250).While 55% of the participants in this study were classified physically inactive (active time < 30 minutes/day) at baseline phase, all 5 female participants in phase 1 were classified inactive (sedentary), as their step count was below 5000 steps/day, before and after the intervention (251) (245). Moreover, women living in Muscat who participated in the survey study (study 1) showed high level of physical inactivity. Out of 51 female adults who participated, over 80% were never engaged in moderate or high intensity sports, and 50% were engaged in low intensity sport. The findings from the survey study also suggested that factors such as gender, age and BMI may influence adults PA levels. In general, physical activity in Oman is influenced by cultural, social, behavioural, and physiological factors. Al-Sinani (2014) reported that physical inactivity could be due to lack of awareness of the importance of physical activity, social values that could restrict women's participation in outdoor activities, lack of public places allocated for physical activities, and sedentary life styles (252). Similar barriers were reported by Mabry et al (2013) (253). This may explain the higher percentage of physical inactivity noted in this study.

Subjects allocated to the app group significantly increased overall activity time by approximately 50% (table 3.14). By contrast there was a non-significant increase in activity time in the control group of approximately 20%. As a result, the difference between the control and app group at the end of the study failed to reach statistical significance.

Step count of the app group had a significant increase between baseline and intervention, from a mean of 3740± 2656 to 4986± 3009 steps per day. The compliance to carrying smartphone during waking hours was not assessed which may be one factor associated with the overall low step count. However, the magnitude of change over 1246 steps per day (≈1 kilometre) is considered meaningful, and if continued, it may result in long-term health benefits. This finding is in line with the finding of Glynn et al (2014) in which an increase of over 1,000 steps was achieved in eight-weeks period when a smartphone app was used to improve PA in primary care (83). Fukuoka et al (2010) studied the effectiveness of a pedometer and app-based diary on a sedentary lifestyle behaviour on 42 women using a pre-post design. Results showed an increase of 20% in steps by the end of the two-week intervention. As the period prolonged for four weeks, steps increased by 33% compared to the previous two weeks (254). Coughlin et al (2016) stated that a smartphone app has the potential to promote PA, although the magnitude of the impact is modest (255). Moreover, the changes in the mean daily step count recorded in this study indicated that the app population was able to move from a sedentary category of 3740± 2656 -steps/day to a low active category of 4986 ± 3009 steps/day in four weeks using the smartphone app.

3.8.3 Dietary intake of participants

The mean energy intake of participants was considerably lower than that reported in Study 1 (survey study), although similar assessment method was used (3-day food diary). The average energy intake of female participants in study 1, in general was 2173±533, and in Muscat females was 2080±460, whereas the mean energy intake of female participants in phase 1 and phase 2 of the intervention trials were the same (1258 ± 377.9 and 1258±369 respectively). Possible reasons for the disparity in energy intake between study 1 and phase 1 of study 2 have already been discussed in section 3.7.1 and related primarily to the use of the app to record food intake. The relatively low intake in phase 2 is harder to explain as food intake was measure by 3-day dietary intake (as in study 1). It appears most likely that, the demographic of this particular cohort has led to a high level of under-reporting.

During the course of the intervention, the app group showed a significant decrease in energy intake (P=0.04) which might be related to the significant decrease of carbohydrate intake (P=0.009). The app group also showed a trend towards a lower sugar intake compared to the control, although not quite significant (P=0.07), which might explain the significant decline in carbohydrate intake. In addition, the three-day food diary could have acted as a self-monitoring tool, where participants made dietary changes accordingly. This finding was consistent with a study by Burke et al. (2011) which reported reduced sugar intake when self-monitoring in the group using personal digital assistant (PDA) (256). A study conducted by Santos et al (2016) to investigate eating behaviour in physically active individuals, indicated that PA may contribute to changes in eating behaviour. The study concluded that although no significant differences were noted in energy and macronutrient consumption between active and non-active participants, however, PA in regular basis is associated with better eating behaviour (257).

3.8.4 Participants' satisfaction to smartphone app

In this study, 94% of study participants (app group) found the app to be a motivator to do PA, probably due to fact that smartphone app is a new assessment method and includes several encouraging features and appealing functionalities including their ability to track their PA performance (self-monitoring) in terms of step count and active time.

Mathews et al (2016), in a systematic review, indicated that self-monitoring is the most common feature in persuasive design, which is implemented in the form of the automatic tracking of active time or sedentary time, step counts, and distance travelled (258).

While about 89% of the participants found the app to be effective and easy to use, and they will continue using it after the study, equal number of study participants suggested that combining the app with a wearable device is important, especially when practicing PA in place where they cannot carry their smartphones. This suggestion is supported by Choi et al (2016) who noted more increase in daily step count in physically inactive pregnant women, who used an app and Fitbit (a wearable device), compared to those who wore Fitbit only for 12 weeks (259). Hence, the app group in the current study could have recorded higher number of steps and active time than that reported if the app were incorporated with a wearable device.

3.8.5 Rate of retention

The study had a high retention rate of 90.5%, and the vast majority found the app helpful and they will continue using such apps in future, which represents an opportunity to improve participant engagement in future innovations.

3.8.6 A Comparison of the Outcomes of Phase 1 and Phase 2

Despite the differences in the environment, gender of study groups, type of smartphone app used and sample size between phase1 and phase 2, overall findings from both studies were comparable. Table 3.15 illustrates similarities and differences between phase 1 and phase 2.

The main differences between the two phases were that phase 2 were implemented in Oman and recruited larger number (42) of female participants, whereas phase 1 implemented on 21, predominantly male Omani adults living in Nottingham, UK. Moreover, phase 2 used one smartphone app (Pacer) to assess physical activity and 3- day diet diaries to assess dietary intake behaviour. Phase 1 used two apps to assess PA and dietary intakes separately. Apart from gender, similar inclusion and exclusion criteria were used in both studies except for the upper inclusion limit of BMI. The inclusion criteria in phase 1 was expanded, due to small number of available subjects, to include participants with BM≤35, whereas the upper limit in phase 2 was BMI≤30. Overall, primary and secondary outcomes obtained in phase 1 and phase 2 (app group), were consistent. Both studies showed significant increases in average daily step counts by the end of the intervention, comparing to data recorded in baseline phase. This supports the hypotheses of these studies about the effectiveness of such smartphone apps to improve physical activity in inactive societies. Furthermore, phase 1 and phase 2 (app group) reported no significant changes in both energy intake and macronutrient values (carbohydrates, fats, and proteins) before and after intervention. However, by the end of phase 2, energy intake and carbohydrate level in the app group were significantly decreased compared to the control group (P-value = 0.04 and 0.009 respectively).

In summary, the baseline data in study 2 (phase 1 and phase 2) emphasised the prevalence of physical inactivity and sedentary lifestyle (recorded in study 1) among the project's study population. The outcomes from the intervention in both phases suggested that novel web-based technologies, such as (smartphone apps) have the potential to become an important option, as a driver for the behavioural-change process in Oman. The impact of long-term app use for dietary and PA tracking, in large randomised control trial with longer follow up, remains to be addressed. While the use of the Apps for monitoring PA appeared relatively robust, their suitability for determining dietary intake is less clear. However, new developments in dietary tracking (e.g. use of photographs to estimate portion sizes) and inclusion of a population specific food database may also improve their value in estimating dietary intakes and suggesting appropriate changes (126) (127).

Table 3.15. Similarities and differences between phase 1 and phase 2.

Intervention study	Phase 1	Phase 2
Apps	- Lose it! Allocated to track dietary intake. - Map My Fitness, allocated to track physical activity.	- Pacer, allocated to track physical activity of Omani female adults. - 3-day diet diary to assess dietary intake
Participants Number groups	- Both males and females - 21 (16 m) and (5 females) - One group	- Females Only - 42 females - Two (control & intervention)
Average age (*year*)	- 34±3.9	- 34 ± 5.1
Average BMI (*kg/m*$^{2.}$)	- 26.3±3.7 - Recorded in baseline & end of study	- 23.5 ± 3.1 - Recorded in baseline to test legibility & end of study
BMI (inclusion criteria)	- BM≤35	- BMI≤29.9
Data entry method	- Self-reported	- Self-reported
Control group	- No control group	- Control group
Active time (*minute*)	- Not measured	- Measured
The place of the study	- Nottingham, UK	- Oman
Change in daily step counts *(Steps/d)*	- 2490.9 ± 2556.4 to 6359.6 ± 4671.5 **(P=.004)**	- 3,739.9 ± 2,655.9 to 4,985.5 ± 3,008.7 **(P=0.001)**
Changes in energy intake *(kcal/d)*	- 1462.1 ± 638.3 to 1472.2 ± 617.1 **(P=.919)**	- 1,142.4 ± 242.5 to 1,068.6 ± 293.5 **(P=0.37)**
% Energy Carbohydrate	- 61.3±6.6 to 61.3 ± 5.9 **(P=0.982)**	- 47.3 ± 9.9 to 45.2 ± 7.8 **(P=0.32)**
% Energy Protein	- 20.4±5.6 to 21.3±4.0 **(P=0.373)**	- 17.9 ± 3.4 to 18.6 ± 3.4 **(P=0.34)**
% Energy Fat	- 18.3±4.1 to 17.3±3.9 **(P=0.345)**	- 34.8 ± 8.7 to 36.1 ± 7.2 **(P=0.52)**

CHAPTER 4

Conclusion

The aim of the present study was to inform future health promotion interventions in Oman and contribute to better understanding of the importance of appropriate dietary practices and physical activities for the general health.

Findings from the survey study confirmed that a high proportion of the Omani population are either overweight or obese. While it was previously shown that residential area (Urban v Rural) significantly impacted on the prevalence of obesity (Al- Riyami et al (2003)), the present study failed to find any significant effect. This suggests that the problems of overweight and obesity are spreading throughout the country and might forecast more burdens on health care system in the future if no effective intervention is undertaken.

This study also highlighted a disturbing lack of awareness of the potential risks of developing NCDs in the Omani population, with 80% of those surveyed never having had a medical check-up for NCDs or their risk factors. This suggests an urgent need to improve the population's awareness of the impact of lifestyle on risk of the development of NCDs, through better education and media campaigns.

The high consumption of fast foods, salt and refined cereals found in this study suggest a prevalence of unhealthy dietary habits among Omani people, which are likely to be associated with metabolic risk factors including, high cholesterol level, obesity and hypertension. Hence, more restricted regulations are required to control the prevalence of fast foods (such as increasing taxation). Simultaneously, intensifying the awareness about healthy food choices available in the local markets (such as consuming more whole grains, fruits and vegetables) is crucial to improve the dietary habits of the population and reducing the burden of NCDs.

The moderate daily mean energy intakes of the study participants compared to their BMI, even taking into account potential under-reporting, suggests that low levels of energy expenditure represent a significant problem amongst Omani male and female adults. Hence, more deliberate public health response and culturally appropriate interventions (involving concerted intersectoral action) is urgently needed to address physical inactivity in Oman.

The prevalence of overweight and obesity amongst adults, particularly those over 30y, and the corresponding prevalence of sedentary lifestyle noted in this study, support the view of adopting preventative and intervention strategies, targeting unhealthy eating behaviours and physical inactivity starting from school age onwards, in order to reduce high prevalence of diet-related chronic disease in Oman. High educational level of study population (more than half of the participants completed an undergraduate degree or higher) suggests that the problems of physical inactivity and obesity are not restricted to those members of the population of lower educational status, indicating that preventative intervention programs need to be targeted at all sections of the Omani population. Hence, it is important for health strategies in Oman to be updated with new health and awareness programs suitable for the current (technology-skilled) generation, in order to enable them for better understanding of healthy food choices as well as supporting them to confront all unhealthy dietary and lifestyle practices. Nevertheless, support from society, social media, and non-governmental organisations (NGOs) is crucial to improve health and lifestyle behaviours among Omani population.

Recent technologies (such as smartphone apps, pedometers) provide a platform for a range of behaviour change tools which have the potential to improve health and lifestyle behaviours. While these have rapidly grown in popularity across much of the developed world, little work has been performed to explore their appropriateness and effectiveness within Middle-Eastern populations. Study 2 was designed as a pilot study aimed at assessing the efficacy of smartphone apps on improving physical activity and dietary intake behaviours amongst Omani adults. Despite a number of limitations, the outcomes of both phases suggest that existing web-based technology, such as (smartphone apps), can be successfully used by Omani adults to improve lifestyle factors associated with the high prevalence of diet-related chronic disease in this population. However, the feedback from study participants suggests the need for designing more culturally sensitive apps in future interventions, which take into account unique needs of the individuals and address population-specific barriers (such as those associated with performing PA, particularly amongst women) in order to increase participants' engagement and motivation. Further research with larger sample sizes and longer follow-up is required to investigate the impact of using such apps.

It is well recognised that studies of lifestyle behaviours, such as (diet and PA) are vulnerable to misreporting. In study 1 (survey study), the potential under reporting of body weight, energy intake and PA (due to self-reporting), was the main challenge that may have lowered the validity of the results. Hence, despite the consistency of many of findings in this study with those of similar studies conducted in Oman or GCC, generalised statements must be treated with caution. Specifically, the potential underreporting of dietary intake, means that too much emphasis is given to the impact of low PA on obesity. Similarly, in study 2, results obtained from the dietary monitoring app may well be subject to underreporting of energy intake (as the average was <1500 kcal/day), as well as inaccuracies in self-recording of body weight before and after the intervention. More details about study limitations are provided in the following section (strength and limitations).

4.1 Behaviour change model (Stages of changes)

Adopting a healthy diet and increasing physical activity, the 2 cornerstones for the treatment of many NCDs are often limited by difficulties in implementing the required lifestyle changes (260). While it is well documented that diet and PA promote weight loss, many randomised control trials have shown that more benefits are gained when behaviour therapy is applied to the subjects studied, especially with motivated subjects (260). The trans-theoretical model (TTM) is one of the most popular stage models in health psychology, and is linked to wide varieties of successful interventions either in adoption of healthy behaviours (e.g. weight control, exercise acquisition) or cessation of unhealthy ones (e.g. smoking cessation, quitting cocaine (Prochaska, et al.,

1994) (261). Behaviour changes, according to the (TTM), move through a defined series of five qualitative stages: (1) pre-contemplation (not thinking about changing the behaviour of the problem within the next 6 months); (2) contemplation (intending to change in the next 6 months, but unwilling to start); (3) determination (planning to change in the next month, mostly having already tried unsuccessfully to change, at least one time in the past year; (4) action (making health related changes in the behaviour for as little as one day or as long as 6 months); (5) maintenance (keeping the behavioural changes for longer than 6 months). These stages of changes have been theorised to predict the efficacy and sustainability of the improvement, as well as to predict the treatment participation to programs and dropout. Skipping this stage directly into the action, may have a negative impact on the targeted behaviour, because individuals have not adequately reached or accepted the consequences to make this major lifestyle change (261). In order for the approaches to be effective, an individual's specific stage of change (readiness to change) needs to be matched. When applying the stages of behaviour changes theory on the respondents (in study one and two) in this current research, theoretically, they appeared to be matching stage 3, as more than half of the participants (study 1) acknowledged that there is a problem (reflected by the statement “I need to lose weight”), and their voluntary participation in the study (one and two) indicated their determination (the willing to change). This stage is very important, as people try to collect information and details about what they will need to do and what it is going to take to make this lifestyle change.

4.2 Strength and limitations

The strengths in study 1 include recruitment of a representative sample size (500 male and female subjects form all governorates in Oman), taking into account effect of demographic factors (level of education, household income, marital status etc.). Questionnaires were randomly and equally distributed between Omani males and females. Therefore, outcomes of this study provide updated data in nutritional status, and its association with physical activity, for adult population in Oman. Furthermore, most previous survey studies in Oman focused on gathering comprehensive information on general health, investigating nutritional status prevalence, food habits, knowledge and physical activity of Omani population. This study was different as it focused on investigating the impact of both dietary practices and physical activity on nutritional status in Omani adults and to the best of our knowledge, no such study has been conducted before. Furthermore, the current study has used reliable software (DietPlan6) to analyse the dietary intake of study participants. The dietary analysis by this software covered a wide range of parameters include micronutrients, macronutrients, energy from macronutrient, and total energy.

However, this study has a number of limitations including; the study is based on cross-sectional data, which means it is only capture data at a specific time and does not show the dynamics with respect to age, period and birth cohort. Study 1 was cross-sectional targeted individual level data through self-reported questionnaires, which could be subjected to some bias. Also, the questionnaires were quite long (10 pages) and detailed which could have been tedious for the participants and hence may affect their responses. The sample size in rural areas was small and not enough for inferential statistics, therefore data from rural areas were not included in some phases of data analysis.

Study 2 piloted the use of smartphone apps by Omani nationals living in both the UK and Oman. While the intention of phase 1 (UK residents) was to recruit both males and females, the study group was very clearly male dominated. Hence, phase 2 was specifically targeted at females living in Oman. This phase also allowed us to assess the impact of environmental and cultural factors on use of the technology which would inevitably are significantly different to the UK. Taken together the two phases provide valuable pilot data to suggest that these novel, inexpensive, accessible, and user-friendly interventions, have the potential to improve lifestyle factors associated with metabolic disease in the Omani population. Overall, the subjects embraced the use of such technology and, while the studies were too short to demonstrate clear changes in risk factors, such as body weight, they did indicate that the apps were effective at increasing physical activity. If this were maintained over a prolonged period of time it would be expected to result in significant improvements in metabolic health.

One of the main limitations of Study 2 was the factor that the subjects were not necessarily representative of the Omani population as a whole. Inevitably, those who took part in phase 1 were primarily those undertaking further education in the UK and, as such, more likely to higher educational and economic status than the general population. Furthermore, all but one of the females studied in phase 2 were educated to graduate or postgraduate level. Thus, caution should be used when applying the results to the overall population.

The sample size in phase 1 was limited by the size of Omani population available in the UK. As such it was decided not to include a control group and to make all comparisons to baseline activity and food intake. Inevitably, this means that no account could be made for any ‘placebo effect’ which might occur as a result of participants simply being more aware of their dietary intakes and physical activity. However, the nature of the study group did allow for a comparison of behaviours of those who were overweight with those of normal weight. Furthermore, phase 1 was conducted in a time not suitable for many participants (students), as they were preparing for end term exams, and some of them leaving the country.

Phase 2 was specifically designed to address the barriers that females living in Oman might face in using App technology. Again, the study group was relatively small and consisted largely of highly educated individuals, but it did have the advantage of including a control group. While clear differences in physical activity were evident between the App and control group, the study period was insufficient to demonstrate whether these would lead to changes in body weight and other metabolic parameters. However, overall the two phases clearly demonstrated that the use of mobile phone Apps has potential to improve physical activity in the Omani population and a larger and longer intervention trial with specific outcomes related to metabolic health is warranted. As the results of such a trial are positive then, the use of such technologies should be embedded in public health policy to address the urgent need to improve the metabolic health of the Omani population as a whole.

4.3 Future use of self-monitoring technologies to promote metabolic health in Oman

High prevalence of overweight and obesity recorded in this study was clearly associated with high prevalence of physical inactivity and sedentary behaviour amongst Omani adults. Both overweight/obesity and PA gradually increased with advancing age, and more clearly in age groups over 30 years. This would suggest implementing an effective intervention targeting both young people, particularly those in age group (18-25 years, to try to prevent weight gain that is apparent in older age groups,30+y), as well as those who are currently overweight or obese, in order to help them to improve their health and weight management. As the young people (18-25 years) represents mostly adults not presently in employment (college/ university students), it would be indeed a good opportunity to implement a preventative intervention targeting this group of adults, to curb the prevalence of NCDs and their risk factors in Oman in future. However, studies showed that it is difficult to reduce the excessive weight once it become established (262). Hence, children population should be given more focus on preventative intervention strategies. Prevention may be achieved through a well organised large scale public health campaign targeting diet, PA, and built environment. The campaign would be implemented on preschool institutes, schools and after school and involve a survey on both school children and teachers to identify the appropriate tools to improve healthy and dietary behaviours in different age groups.

Although evidence from the pilot scale study (study 2) showed that the smartphone app-based intervention had the potential to promote lifestyle changes such as PA and weight management. However, sample size was relatively small and not representative, and the intervention tools used in the study were not ideal for the Omani/GCC culture and environment. Underreporting of dietary intake also comprised a real challenge of the study outcomes, especially in study 2 (both phases). Yet smartphone apps recently have been developed and provided with many novel techniques to improve dietary pattern and the quality of dietary intake data. Example of such features, includes the digital capture of dietary intake, in which participants are instructed via SMS to provide text description of amount and type of food consumed, as well as to capture before and after images of all foods and beverages consumed. If this technique had been used in the current study, it potentially would have minimised the chances of under-reporting of dietary intake. Therefore, implementing more controlled studies with larger sample of Omani population using high ranked novel free health and fitness apps (provided with new techniques e.g. digitally capture dietary intake) would be helpful to identify the problems and to look at the cost-effectiveness, financial and technical feasibility in implementing such intervention. However, it would be more important to examine the feasibility and the efficacy of culturally and environmentally customised smartphone apps targeting PA and weight management in Omani people, which has not been investigated in this study due to time and resources constraints. In order for such intervention to be successfully implemented in public health level in Oman, intensive human and financial resources are inevitable. Hence, it would be pertinent to examine decision makers and stakeholder’s perceptions on the feasibility of investing in developing such population specific apps. Positive outcomes from this intervention would encourage public health policy makers in Oman to prioritise such novel technologies in future public health strategy to address public health issues in Omani population.

References:

1. Zuhaibi K Al, McCullough F, Salter AM. Impact of dietary practices on metabolic health in Omani adults. [cited 2017 Jul 2]; Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/FC79577CE1354A208E1F8A98BE170781/S0029665115003900a.pdf/impact_of_dietary_practices_on_metabolic_health_in_omani_adults.pdf
2. Seidell JC, Halberstadt J. The global burden of obesity and the challenges of prevention. Ann Nutr Metab. 2015;66:7–12.
3. Public Health England. Adult Obesity International Comparisons Data Factsheet. 2016;
4. Hruby A, Hu FB. The Epidemiology of Obesity: A Big Picture. Vol. 33, PharmacoEconomics. 2015. p. 673–89.
5. Alhyas L, McKay A, Balasanthiran A, Majeed A. Prevalences of overweight, obesity, hyperglycaemia, hypertension and dyslipidaemia in the Gulf: systematic review. JRSM Short Rep [Internet]. 2011;2(7):55. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21847437%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3147233
6. WHO. WHO | Obesity. WHO [Internet]. 2014 [cited 2017 Jun 1]; Available from: http://www.who.int/gho/ncd/risk_factors/obesity_text/en/
7. Alhyas L, McKay A, Majeed A. Prevalence of type 2 diabetes in the states of the co-operation council for the Arab states of the Gulf: A systematic review. PLoS One. 2012;7(8).
8. The Economist Intelligence Unit. Global food security index 2014: an annual measure of the state of global food security. Econ [Internet]. 2014;70. Available from: http://foodsecurityindex.eiu.com/Home/DownloadIndex
9. Zayed KN, Waly MI, Haddabi B Al, Al-Busafi MS, Al-Rawahi N, Al-Tauqi M, et al. Obesity, Eating Habits and Sedentary Behaviour of Omani Young Adolescents: A Cross-Sectional Study. EC Nutr. 2017;71:3–10.
10. WHO | Obesity [Internet]. WHO. World Health Organization; 2014 [cited 2017 Jun 1]. Available from: http://www.who.int/topics/obesity/en/
11. Of S, Of E, Circumference W, Blood ON, In P, Year F, et al. STUDY OF EFFECT OF BMI AND WAIST CIRCUMFERENCE ON BLOOD Blood pressure. 2015;21. Of

S,(12):1776–82.
12. Shiwaku K, Anuurad E, Enkhmaa B, Kitajima K, Yamane Y. Appropriate BMI for Asian populations. Lancet [Internet]. 2004 Mar 27 [cited 2017 May 8];363(9414):1077. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15051297
13. Yusuf PS, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): Case-control study. Lancet [Internet]. 2004 [cited 2017 May 27];364(9438):937–52. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15364185
14. Ibrahim MM. Subcutaneous and visceral adipose tissue: Structural and functional differences. Vol. 11, Obesity Reviews. 2010. p. 11–8.
15. AIDSinfo. AIDSinfo Glossary of HIV/AIDS-Related Terms [Internet]. 2015. 1 p. Available from: https://aidsinfo.nih.gov/contentfiles/glossaryhivrelatedterms_english.pdf
16. Wajchenberg BL. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. Endocr Rev [Internet]. 2000;21(6):697–738. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11133069
17. Oliveira AL, Azevedo DC, Bredella MA, Stanley TL, Torriani M. Visceral and subcutaneous adipose tissue FDG uptake by PET/CT in metabolically healthy obese subjects. Obesity [Internet]. 2015 Feb [cited 2017 May 28];23(2):286–9. Available from: http://doi.wiley.com/10.1002/oby.20957
18. Scheuer SH, Færch K, Philipsen A, Jørgensen ME, Johansen NB, Carstensen B, et al. Abdominal Fat Distribution and Cardiovascular Risk in Men and Women With Different Levels of Glucose Tolerance. J Clin Endocrinol Metab [Internet]. 2015 [cited 2017 May 27];100(9):3340–7. Available from: http://press.endocrine.org/doi/pdf/10.1210/JC.2014-4479
19. Fabbrini E, Magkos F, Mohammed BS, Pietka T, Abumrad NA, Patterson BW, et al. Intrahepatic fat, not visceral fat, is linked with metabolic complications of obesity. Proc Natl Acad Sci [Internet]. 2009 [cited 2017 May 28];106(36):15430–5. Available from: http://www.pnas.org/content/106/36/15430.full.pdf
20. Bertoli S, Leone A, Vignati L, Spadafranca A, Bedogni G, Vanzulli A, et al. Metabolic correlates of subcutaneous and visceral abdominal fat measured by ultrasonography: a

comparison with waist circumference. Nutr J [Internet]. 2015 [cited 2017 May 28];15(1):2. Available from: http://download.springer.com/static/pdf/524/art%253A10.1186%252Fs12937-015-0120-2.pdf?originUrl=http%3A%2F%2Fnutritionj.biomedcentral.com%2Farticle%2F10.1186%2Fs12937-015-0120-2&token2=exp=1495987101~acl=%2Fstatic%2Fpdf%2F524%2Fart%25253A10.1186%25252Fs12

21. Vasiljevic I, Gardasevic J, Kezunovic M, Bojanic D. Waist Circumference as an Indicator Abdominal Obesity in Middle Age. Sport Mont [Internet]. 2017 [cited 2017 May 27];15015325(1):21–2. Available from: http://www.sportmont.ucg.ac.me/clanci/SM_februar_2017_Vasiljevic.pdf
22. World Health Organization. Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation [Internet]. World Health Organization. 2008 [cited 2017 May 27]. Available from: http://apps.who.int/iris/bitstream/10665/44583/1/9789241501491_eng.pdf
23. Mongraw-Chaffin ML, Anderson CAM, Allison MA, Ouyang P, Szklo M, Vaidya D, et al. Association between sex hormones and adiposity: Qualitative differences in women and men in the multi-ethnic study of atherosclerosis. J Clin Endocrinol Metab [Internet]. 2015 [cited 2017 May 28];100(4):E596–600. Available from: https://oup.silverchair-cdn.com/oup/backfile/Content_public/Journal/jcem/100/4/10.1210_jc.2014-2934/1/jcemE596.pdf?Expires=1496063535&Signature=HnMeTxzqINmRVzJGEiABGiA6kd8CFh8~LDKlfJv-opqaV0E4Fx0P0pan-dE~NOAr-Y4zzsVjzk1Qmupbe7OVFjTGnVbsWagyC4LyApDp5sShI1f
24. Nielsen TL, Hagen C, Wraae K, Brixen K, Petersen PH, Haug E, et al. Visceral and subcutaneous adipose tissue assessed by magnetic resonance imaging in relation to circulating androgens, sex hormone-binding globulin, and luteinizing hormone in young men. J Clin Endocrinol Metab. 2007;92(7):2696–705.
25. Allan C a, McLachlan RI. Androgens and obesity. Curr Opin Endocrinol Diabetes Obes. 2010;17(Table 1):224–32.
26. Nedungadi TP, Clegg DJ. Sexual dimorphism in body fat distribution and risk for cardiovascular diseases. J Cardiovasc Transl Res. 2009;2(3):321–7.

27. Vitale C, Fini M, Speziale G, Chierchia S. Gender differences in the cardiovascular effects of sex hormones. Fundam Clin Pharmacol. 2010;24(6):675–85.
28. Choo J, Jeon S, Lee J. Gender differences in health-related quality of life associated with abdominal obesity in a Korean population. BMJ Open [Internet]. 2014;4(1):e003954. Available from: http://bmjopen.bmj.com/lookup/doi/10.1136/bmjopen-2013-003954
29. Difference between Visceral fat and Subcutaneous fat? | Karima Hirani MD MPH - Holistic Doctor - Los Angeles - Alternative and Functional Medicine [Internet]. [cited 2017 May 27]. Available from: http://www.drhirani.com/diabetes/difference-visceral-fat-subcutaneous-fat/
30. van Vliet-Ostaptchouk J V, Nuotio M-L, Slagter SN, Doiron D, Fischer K, Foco L, et al. The prevalence of metabolic syndrome and metabolically healthy obesity in Europe: a collaborative analysis of ten large cohort studies. BMC Endocr Disord [Internet]. 2014;14(1):9. Available from: http://www.biomedcentral.com/1472-6823/14/9
31. Katzmarzyk PT, Church TS, Janssen I, Ross R, Blair SN. Metabolic syndrome, obesity, and mortality: Impact of cardiorespiratory fitness. Diabetes Care. 2005;28(2):391–7.
32. Imes C, Burke L. The Obesity Epidemic: The USA as a Cautionary Tale for the Rest of the World. Cardiovasc Dis [Internet]. 2014;1:82–8. Available from: http://www.pophealthmetrics.com/content/10/1/22
33. Sliem HA, Ahmed S, Nemr N, El-Sherif I. Metabolic syndrome in the Middle East. Indian J Endocrinol Metab. 2012;16(1):67–71.
34. Kassi E, Pervanidou P, Kaltsas G, Chrousos G. Metabolic syndrome: definitions and controversies. BMC Med [Internet]. 2011;9(1):48. Available from: http://www.biomedcentral.com/1741-7015/9/48%5Cnhttp://www.ncbi.nlm.nih.gov/pubmed/21542944%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3115896
35. Stern MP, Williams K, Gonzalez-Villalpando C, Hunt KJ, Haffner SM. Does the Metabolic Syndrome Improve Identification of Individuals at Risk of Type 2 Diabetes and / or Cardiovascular Disease? Diabetes Care. 2004;27(11):2676–81.
36. Ali A, Al-zuhaibi KM, Waly MI, Sankar D, Johnson EH, Sciences V, et al. Growth Performance , Fasting Plasma Glucose and Lipid Profile of Sprague-Dawley Rats Fed

Different Levels of Omani Halwa. Pakistan J Nutr. 2015;14(8):503–10.

37. Wildman RP, Muntner P, Reynolds K, Mcginn AP. The Obese Without Cardiometabolic Risk Factor Clustering and the Normal Weight With Cardiometabolic Risk Factor Clustering. Arch Intern Med. 2008;168(15):1617–24.

38. Lavie CJ, McAuley PA, Church TS, Milani R V., Blair SN. Obesity and cardiovascular diseases: Implications regarding fitness, fatness, and severity in the obesity paradox. Vol. 63, Journal of the American College of Cardiology. 2014. p. 1345–54.

39. England TN. Journal Medicine ©. October. 2003;337(5):1–7.

40. Klautzer L, Becker J, Mattke S. The curse of wealth - Middle Eastern countries need to address the rapidly rising burden of diabetes. Int J Heal policy Manag [Internet]. 2014;2(3):109–14. Available from: http://ijhpm.com

41. SA SA, N R. Obesity and Type 2 Diabetes Mellitus. Intern Med Open Access [Internet]. 2014;1(s6). Available from: http://dx.doi.org/10.4172/2165-8048.S6-002

42. Nguyen NT, Nguyen X-MT, Lane J, Wang P. Relationship between obesity and diabetes in a US adult population: findings from the National Health and Nutrition Examination Survey, 1999-2006. Obes Surg [Internet]. 2011;21(3):351–5. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3040808&tool=pmcentrez&rendertype=abstract

43. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Vol. 87, Diabetes Research and Clinical Practice. 2010. p. 4–14.

44. Pi-Sunyer X, Blackburn G, FL B, GA B, Bright R, JM C, et al. Reduction in weight and cardiovascular disease risk factors in individuals with type 2 diabetes: one-year results of the look AHEAD trial. Diabetes Care [Internet]. 2007;30(6):1374–83. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=105833951&site=ehost-live

45. Vaněčková I, Maletínská L, Behuliak M, Nagelová V, Zicha J, Kuneš J. Obesity-related hypertension: Possible pathophysiological mechanisms. J Endocrinol. 2014;223(3):R63–78.

46. Landsberg L, Aronne LJ, Beilin LJ, Burke V, Igel LI, Lloyd-Jones D, et al. Obesity-related hypertension: Pathogenesis, cardiovascular risk, and treatment-a position paper

of the the obesity society and the American society of hypertension. Vol. 21, Obesity. 2013. p. 8–24.

47. DeMarco VG, Aroor AR, Sowers JR. The pathophysiology of hypertension in patients with obesity. Nat Rev Endocrinol [Internet]. 2014;10(6):364–76. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24732974

48. Cook NR, Cutler JA, Obarzanek E, Buring JE, Rexrode KM, Kumanyika SK, et al. Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP). BMJ [Internet]. 2007;334(7599):885–8. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1857760&tool=pmcentrez&rendertype=abstract

49. He FJ, Pombo-Rodrigues S, MacGregor GA. Salt reduction in England from 2003 to 2011: its relationship to blood pressure, stroke and ischaemic heart disease mortality. Available from: http://dx.doi.org/10.1136/

50. Dobbins M, Decorby K, Choi BCK. The Association between Obesity and Cancer Risk: A Meta-Analysis of Observational Studies from 1985 to 2011. ISRN Prev Med [Internet]. 2013;2013(16):680536. Available from: http://dx.doi.org/10.5402/2013/680536

51. De Pergola G, Silvestris F. Obesity as a major risk factor for cancer. Vol. 2013, Journal of Obesity. 2013.

52. Jaggers JR, Sui X, Hooker SP, LaMonte MJ, Matthews CE, Hand GA, et al. Metabolic syndrome and risk of cancer mortality in men. Eur J Cancer [Internet]. 2009;45(10):1831–8. Available from: http://dx.doi.org/10.1016/j.ejca.2009.01.031

53. Griggs JJ, Sorbero ME, Lyman GH. Undertreatment of obese women receiving breast cancer chemotherapy. ArchInternMed. 2005;165(0003–9926 (Print)):1267–73.

54. WHO (World Health Organization). WHO obesity and overweight fact sheet no 311. Obes Oveweight Fact Sheet. 2013;(March):4–7.

55. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766–81.

56. Flegal K, Bk K, Orpana H, Graubard B. Association of All-Cause Mortality With Overweight and Obesity Using Standard Body Mass Index Categories: A Systematic

Review and Meta-analysis. JAMA [Internet]. 2013;309(1):71–82. Available from: http://jama.jamanetwork.com/article.aspx?articleid=1555137

57. Musaiger AO. Overweight and obesity in Eastern Mediterranean Region: Prevalence and possible causes. Vol. 2011, Journal of Obesity. 2011.

58. Abdul Rahim HF, Sibai A, Khader Y, Hwalla N, Fadhil I, Alsiyabi H, et al. Non-communicable diseases in the Arab world. Vol. 383, The Lancet. 2014. p. 356–67.

59. Gostin LO, Abou-Taleb H, Roache SA, Alwan A. Legal priorities for prevention of non-communicable diseases: innovations from WHO's Eastern Mediterranean region [Internet]. Vol. 144, Public Health. 2017 [cited 2017 Jun 3]. p. 4–12. Available from: http://www.publichealthjrnl.com/article/S0033-3506(16)30381-X/pdf

60. CONFRONTING OBESITY IN THE MIDDLE EAST Cultural, social and policy challenges. [cited 2017 Jun 3]; Available from: http://www.janssen-emea.com/sites/default/files/health-policy-centre/ConfrontingobesityintheMiddleEast.pdf

61. The World Bank. Disease and mortality in sub-Saharan Africa [Internet]. 2006. Available from: http://books.google.com/books?hl=en&lr=&id=2u8m7pPQ_WwC&oi=fnd&pg=PR13&dq=Disease+and+Mortality+in+Sub-Saharan+Africa&ots=pHZKEAad12&sig=cyhm5UIVCYWGgkJ-SyB_cx8ID_0%5Cnhttp://books.google.com/books?hl=en&lr=&id=2u8m7pPQ

62. Millard-Stafford M, Becasen JS, Beets MW, Nihiser AJ, Lee SM, Fulton JE. Is Physical Fitness Associated with Health in Overweight and Obese Youth? A Systematic Review. Kinesiol Rev [Internet]. 2013;2(4):233–47. Available from: http://journals.humankinetics.com/doi/10.1123/krj.2.4.233

63. Gilmore LA, Duhé AF, Frost EA, Redman LM. The technology boom: a new era in obesity management. J Diabetes Sci Technol [Internet]. 2014;8(3):596–608. Available from: http://dst.sagepub.com/content/8/3/596.full

64. Vandevijvere S, Chow CC, Hall KD, Swinburn BA. 3. Increased food energy supply as a major driver of the obesity epidemic : a global analysis. Bull World Heal Organ [Internet]. 2015;93(November 2014):446–56. Available from: http://dx.doi.org/10.2471/BLT.14.150565

65. Naja F, Nasreddine L, Itani L, Adra N, Sibai AM, Hwalla N. Association between

dietary patterns and the risk of metabolic syndrome among Lebanese adults. Eur J Nutr. 2013;52(1):97–105.

66. Bankoski a., Harris TB, McClain JJ, Brychta RJ, Caserotti P, Chen KY, et al. Sedentary Activity Associated With Metabolic Syndrome Independent of Physical Activity. Diabetes Care. 2011;34(2):497–503.

67. Anderssen SA, Carroll S, Urdal P, Holme I. Combined diet and exercise intervention reverses the metabolic syndrome in middle-aged males: Results from the Oslo Diet and Exercise Study. Scand J Med Sci Sport. 2007;17(6):687–95.

68. Okura T, Nakata Y, Ohkawara K, Numao S, Katayama Y, Matsuo T, et al. Effects of Aerobic Exercise on Metabolic Syndrome Improvement in Response to Weight Reduction. Obesity. 2007;15(10):2478–84.

69. Farrell SW, Cheng YJ, Blair SN. Prevalence of the Metabolic Syndrome across Cardiorespiratory Fitness Levels in Women. Obes Res. 2004;12(5):824–30.

70. Church TS, Finley CE, Earnest CP, Kampert JB, Gibbons LW, Blair SN. Relative associations of fitness and fatness to fibrinogen, white blood cell count, uric acid and metabolic syndrome. Int J Obes Relat Metab Disord. 2002;26(6):805–13.

71. Ross R, Katzmarzyk PT. Cardiorespiratory fitness is associated with diminished total and abdominal obesity independent of body mass index. Int J Obes Relat Metab Disord. 2003;27(2):204–10.

72. Wong SL, Katzmarzyk P, Nichaman MZ, Church TS, Blair SN, Ross R. Cardiorespiratory fitness is associated with lower abdominal fat independent of body mass index. Med Sci Sports Exerc. 2004;36(2):286–91.

73. Janssen I, Katzmarzyk PT, Ross R, Leon AS, Skinner JS, Rao DC, et al. Fitness alters the associations of BMI and waist circumference with total and abdominal fat. Obes Res. 2004;12(3):525–37.

74. Wei M, Kampert JB, Barlow CE, Nichaman MZ, Gibbons LW, Paffenbarger RS, et al. Relationship between low cardiorespiratory fitness and mortality in normal-weight, overweight, and obese men. JAMA. 1999;282(16):1547–53.

75. Who WHO. Global status report on noncommunicable diseases 2010 [Internet]. World Health Organization. World Health Organization; 2011 [cited 2017 Jul 2]. 176 p. Available from: http://www.who.int/nmh/publications/ncd_report2010/en/

76. Mabry R, Owen N, Eakin E. A national strategy for promoting physical activity in Oman: A call for action. Sultan Qaboos Univ Med J. 2014;14(2).

77. Steele RM, Brage S, Corder K, Wareham NJ, Ekelund U. Physical activity, cardiorespiratory fitness, and the metabolic syndrome in youth. J Appl Physiol. 2008;105(1):342–51.
78. Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: Systematic review and meta-analysis. Diabetologia. 2012;55(11):2895–905.
79. Bankoski a, Harris T, McClain J, Brychta R, Caserotti P, Chen K, et al. Sedentary activity associated with metabolic syndrome independent of physical activity. Diabetes Care. 2011;34(2):497–503.
80. Pearson TA, Blair SN, Daniels SR, Eckel RH, Fair JM, Fortmann SP, et al. AHA Guidelines for Primary Prevention of Cardiovascular Disease and Stroke: 2002 Update: Consensus panel guide to comprehensive risk reduction for adult patients without coronary or other atherosclerotic vascular diseases. Circulation. 2002;106(3):388–91.
81. Wang F, McDonald T, Champagne LJ, Edington DW. Relationship of body mass index and physical activity to health care costs among employees. J Occup Environ Med. 2004;46(5):428–36.
82. Alberti KGMM, Zimmet P, Shaw J. The metabolic syndrome - A new worldwide definition. Vol. 366, Lancet. 2005. p. 1059–62.
83. Glynn LG, Hayes PS, Casey M, Glynn F, Alvarez-Iglesias A, Newell J, et al. Effectiveness of a smartphone application to promote physical activity in primary care: The SMART MOVE randomised controlled trial. Br J Gen Pract. 2014;64(624).
84. Dallinga JM, Mennes M, Alpay L, Bijwaard H, Baart de la Faille-Deutekom M. App use, physical activity and healthy lifestyle: a cross sectional study. BMC Public Health [Internet]. 2015;15(1):833. Available from: http://www.scopus.com/inward/record.url?eid=2-s2.0-84940105009&partnerID=tZOtx3y1
85. Pillay JD, Van der Ploeg HP, Kolbe-Alexander TL, Proper KI, van Stralen M, Tomaz S a, et al. The association between daily steps and health, and the mediating role of body composition: a pedometer-based, cross-sectional study in an employed South African population. BMC Public Health [Internet]. 2015;15(1):174. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4344772&tool=pmcentrez&rendertype=abstract

86. Barichella M, Malavazos AE, Fatati G, Cereda E. Awareness and knowledge about weight status and management: results from the 1 d sensitization campaign "Obesity Day" in northern Italy. Public Health Nutr [Internet]. 2011 [cited 2017 Jun 3];14(10):1813–22. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/12E9C0D1EECC616999DFD237FF4BB42A/S136898001100005Xa.pdf/awareness_and_knowledge_about_weight_status_and_management_results_from_the_1_d_sensitization_campaign_obesity_day_in_northern_
87. Harnack L, Lytle L, Himes JH, Story M, Taylor G, Bishop D. Low awareness of overweight status among parents of preschool-aged children, Minnesota, 2004-2005. Prev Chronic Dis [Internet]. 2009;6(2):A47. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2687853&tool=pmcentrez&rendertype=abstract
88. Mozaffarian D, Afshin A, Benowitz NL, Bittner V, Daniels SR, Franch HA, et al. Population approaches to improve diet, physical activity, and smoking habits: A scientific statement from the American heart association. Circulation [Internet]. 2012;126(12):1514–63. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=108076026&site=ehost-live
89. Dixon H, Borland R, Segan C, Stafford H, Sindall C. Public Reaction to Victoria's "2 Fruit 'n' 5 Veg Every Day" Campaign and Reported Consumption of Fruit and Vegetables. Prev Med (Baltim). 1998;27(4):572–82.
90. NISHTAR S, MIRZA YA, JEHAN S, HADI Y, BADAR A, YUSUF S, et al. Newspaper Articles as a Tool for Cardiovascular Prevention Programs in a Developing Country. J Health Commun [Internet]. 2004 Jul [cited 2017 Jul 2];9(4):355–69. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15371087
91. Sanigorski AM, Bell AC, Kremer PJ, Cuttler R, Swinburn BA. Reducing unhealthy weight gain in children through community capacity-building: results of a quasi-experimental intervention program, Be Active Eat Well. Int J Obes. 2008;32(7):1060–7.
92. Farquhar JW, Fortmann SP, Flora JA, Taylor CB, Haskell WL, Williams PT, et al. Effects of communitywide education on cardiovascular disease risk factors. The Stanford Five-City Project 87. J Am Med Assoc. 1990;264(3):359–65.

93. Wardle J, Rapoport L, Miles A, Afuape T, Duman M. Mass education for obesity prevention: the penetration of the BBC's "Fighting Fat, Fighting Fit" campaign. Heal Educ Res Theory Pract Pages. 2001;16(3):343–55.
94. Beaudoin CE, Fernandez C, Wall JL, Farley TA. Promoting healthy eating and physical activity short-term effects of a mass media campaign. Am J Prev Med. 2007;32:217–23.
95. Dunt D, Day N, Pirkis J. Evaluation of a community-based health promotion program supporting public policy initiatives for a healthy diet. Heal Promot Int. 1999;14:317–27.
96. Miles A, Rapoport L, Wardle J, Afuape T, Duman M. Using the mass-media to target obesity: an analysis of the characteristics and reported behaviour change of participants in the BBC's "Fighting Fat, Fighting Fit" campaign. Heal Educ Res Theory Pract Pages. 2001;16(3):357–72.
97. Lutz SF, Ammerman AS, Atwood JR, Campbell MK, DeVellis RF, Rosamond WD. Innovative newsletter interventions improve fruit and vegetable consumption in healthy adults. J Am Diet Assoc. 1999;99(6):705–9.
98. Pekka P, Pirjo P, Ulla U. Influencing public nutrition for non-communicable disease prevention: from community intervention to national programme--experiences from Finland. Public Health Nutr. 2002;5(1A):245–51.
99. Puska P, Ståhl T. Health in All Policies—The Finnish Initiative: Background, Principles, and Current Issues. Annu Rev Public Health. 2010;31(1):315–28.
100. Dowse GK, Gareeboo H, Alberti KGMM, Zimmet P, Tuomilehto J, Purran A, et al. Changes in population cholesterol concentrations and other cardiovascular risk factor levels after five years of the non-communicable disease intervention programme. Soc Sci. 1995;1259:1255–9.
101. V. B, C.W. F, S.K. C. Changes in the levels of major cardiovascular risk factors in the multi-ethnic population in Singapore after 12 years of a national non-communicable disease intervention programme. Vol. 47, Singapore Medical Journal. 2006. p. 841–50.
102. Wadden TA, West DS, Delahanty L, Jakicic J, Rejeski J, Williamson D, et al. The Look AHEAD study: a description of the lifestyle intervention and the evidence supporting it. Obesity (Silver Spring). 2006;14(5):737–52.
103. Reyes NR, Oliver TL, Klotz AA, LaGrotte CA, Vander Veur SS, Virus A, et al. Similarities and Differences between Weight Loss Maintainers and Regainers: A

Qualitative Analysis. J Acad Nutr Diet. 2012;112(4):499–505.

104. Jeffery RW, Sherwood NE, Brelje K, Pronk NP, Boyle R, Boucher JL, et al. Mail and phone interventions for weight loss in a outcomes. Int J Obes. 2003;27(March):1584–92.

105. Linde J a, Jeffery RW, French SA, Pronk NP, Boyle RG. Self-weighing in weight gain prevention and weight loss trials. Ann Behav Med. 2005;30(3):210–6.

106. Butryn ML, Phelan S, Hill JO, Wing RR. Consistent Self-monitoring of Weight: A Key Component of Successful Weight Loss Maintenance**. Obesity. 2007;15(12):3091–6.

107. Boutelle KN, Kirschenbaum DS. Further support for consistent self-monitoring as a vital component of successful weight control. Obes Res. 1998;6(3):219–24.

108. Conroy MB, Yang K, Elci OU, Gabriel KP, Styn MA, Wang J, et al. Physical activity self-monitoring and weight loss: 6-month results of the SMART trial. Vol. 43, Medicine and Science in Sports and Exercise. 2011. p. 1568–74.

109. COI. CHANGE4LIFE MARKETING STRATEGY. 2009;25. Available from: http://www.nhs.uk/Change4Life/supporter-resources/downloads/Change4Life_Marketing Strategy_April09.pdf

110. http://www.nhs.uk/Change4Life/Pages/breakfast4life-supporter-resources.aspx.

111. http://www.nhs.uk/Change4Life/Pages/bike4life-supporter-resources.aspx.

112. Tudor-Locke C, Craig CL, Thyfault JP, Spence JC. A step-defined sedentary lifestyle index: <5000 steps/day. Appl Physiol Nutr Metab [Internet]. 2013;38(4):100–14. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=104240339&site=ehost-live

113. Bennett GG, Herring SJ, Puleo E, Stein EK, Emmons KM, Gillman MW. Web-based weight loss in primary care: a randomized controlled trial. Obesity (Silver Spring) [Internet]. 2010;18(2):308–13. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3710670&tool=pmcentrez&rendertype=abstract

114. Tate DF, Wing RR, Winett R a. Using Internet technology to deliver a behavioral weight loss program. JAMA. 2001;285(9):1172–7.

115. Woolford SJ, Clark SJ, Strecher VJ, Resnicow K. Tailored mobile phone text messages as an adjunct to obesity treatment for adolescents. J Telemed Telecare.

2010;16(8):458–61.

116. Pew Research Center. Mobile Device Ownership and Adoption in the United States [Internet]. Pew Research Centre. 2017 [cited 2017 May 30]. p. 1. Available from: http://www.pewinternet.org/fact-sheet/mobile/

117. Change4Life. Be Food Smart [Internet]. 2016 [cited 2017 Jun 1]. Available from: https://www.nhs.uk/change4life-beta/be-food-smart#VvQWqXiz0s3ZFX49.97

118. Sugar - Change4Life [Internet]. [cited 2017 Jun 1]. Available from: https://www.nhs.uk/change4life-beta/sugar#IKK3zqJiY1xS0m5J.97

119. Recipes - Change4Life [Internet]. [cited 2017 Jun 1]. Available from: https://www.nhs.uk/change4life-beta/recipes#UkJmV3EVElblyegA.97

120. Map Fitness Training and Track Fitness Workouts | MapMyFitness [Internet]. [cited 2017 May 24]. Available from: http://www.mapmyfitness.com/

121. Lose It! - Weight Loss That Fits [Internet]. [cited 2017 May 24]. Available from: http://loseit.com/

122. FatSecret United Kingdom - Calorie Counter and Diet Tracker for Weight Loss [Internet]. [cited 2017 May 24]. Available from: https://www.fatsecret.co.uk/

123. Free Diet Plans at SparkPeople [Internet]. [cited 2017 May 24]. Available from: http://www.sparkpeople.com/

124. Fooducate. Lose weight & improve your health with a real food diet | Fooducate [Internet]. 2014 [cited 2017 May 24]. Available from: http://www.fooducate.com/

125. Carter MC, Burley VJ, Nykjaer C, Cade JE. Adherence to a smartphone application for weight loss compared to website and paper diary: pilot randomized controlled trial. J Med Internet Res. 2013;15(4):1–17.

126. Zhu F, Bosch M, Woo I, Kim S, Boushey CJ, Ebert DS, et al. The use of mobile devices in aiding dietary assessment and evaluation. IEEE J Sel Top Sig Proc. 2010;4(4):756–66.

127. Martin CK, Correa JB, Han H, Allen HR, Rood JC, Champagne CM, et al. Validity of the Remote Food Photography Method (RFPM) for estimating energy and nutrient intake in near real-time. Obesity (Silver Spring). 2012;20 VN-r(4):891–9.

128. World Health Organization. WHO | Obesity and overweight [Internet]. World Health Organisation Media Centre Fact Sheet No. 311. World Health Organization; 2012 [cited 2017 Jun 5]. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/

129. World Health Organization. Global Health Observatory (GHO) Overweight. http://www.who.int/gho/ncd/risk_factors/overweight_text/en/index.html 1 sur. 2012. p. 1–2.

130. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in Obesity Among Adults in the United States, 2005 to 2014. Jama [Internet]. 2016;315(21):2284. Available from: http://jama.jamanetwork.com/article.aspx?doi=10.1001/jama.2016.6458

131. Ogden CL, Carroll MD, Fryar CD, Flegal KM. Prevalence of Obesity Among Adults and Youth: United States, 2011-2014. NCHS Data Brief [Internet]. 2015;(219):1–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26633046

132. Rokholm B, Baker JL, Sørensen TIA. The levelling off of the obesity epidemic since the year 1999 - a review of evidence and perspectives [Internet]. Vol. 11, Obesity Reviews. 2010 [cited 2017 Jun 1]. p. 835–46. Available from: http://www.paniconaplate.com/images/uploads/j.1467-789X.2010.00810.x.pdf

133. Bull F, Dvorak J. Tackling chronic disease through increased physical activity in the Arab World and the Middle East: challenge and opportunity. Br J Sports Med [Internet]. 2013;47(10):600–2. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=sph&AN=88182274&site=ehost-live

134. Kilpi F, Webber L, Musaigner A, Aitsi-Selmi A, Marsh T, Rtveladze K, et al. Alarming predictions for obesity and non-communicable diseases in the Middle East. Public Health Nutr [Internet]. 2014;17(5):1078–86. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23642403

135. FAO, “Food Balance Sheet,” FOODSTAT, 2009.

136. Musaiger AO, Takruri HR, Hassan AS, Abu-Tarboush H. Food-based dietary guidelines for the arab gulf countries. Vol. 2012, Journal of Nutrition and Metabolism. 2012.

137. A. O. Musaiger, “Food Consumption Patterns in the East- ern Mediterranean Countries,” Arab Center for Nutrition, Bahrain, 2011.

138. WHO/EMRO, “Regional Data on Non-Communicable Dis- eases,” Cairo, Egypt, 2011, http://www.emro.who.int/ncd/. [12].

139. Ng SW, Zaghloul S, Ali HI, Harrison G, Popkin BM. The prevalence and trends of overweight, obesity and nutrition-related non-communicable diseases in the Arabian

Gulf States. Vol. 12, Obesity Reviews. 2011. p. 1–13.
140. L. L. Bello and N. Al-Hammad, "Pattern of fluid consumption in a sample of Saudi Arabian adolescents aged 12-13 years," International Journal of Paediatric Dentistry,vol. 16, no.3,pp. 168–173, 2006. [22].
141. J. Schmiduber and P. Shetty, "Nutrition transition, obesity and non-communicable diseases: drivers, outlook and concerns," SCN News, vol. 29, pp. 13–19, 2005.
142. UNICEF, "The State of World's Children," New York, NY, USA, 2009.
143. Musaiger AO. Iron deficiency anaemia among children and pregnant women in the Arab Gulf countries: the need for action. Nutr Heal (Berkhamsted, Hertfordshire). 2002;16(3):161–71.
144. B. Abalkhail and S. Shawky, "Prevalence of daily breakfast intake, iron deficiency anaemia and awareness of being anaemic among Saudi school students," International Journal of Food Sciences and Nutrition, vol. 53, no. 6, pp. 519–528, 2002.
145. J. Mason, J. Rivers, C. Helwig et al., "Recent trends in mal- nutrition in developing regions: vitamin A deficiency, anemia, iodine deficiency, and child underweight," Food and Nutrition Bulletin, vol. 26, no. 1, pp. 57–108, 2005.
146. Z. Naeem, "Vitamin D deficiency—an ignored epidemic," International Journal of Health Science, vol. 4, pp. 5–6, 2010.
147. M. A-A. High prevalence of vitamin D deficiency in young children in a highly sunny humid country: A global health problem Bener A. Vol. 61, Minerva Pediatrica. 2009. p. 15–22.
148. No. 14," Riyadh, Saudi Arabia 2008. Executive Board of Health Ministers Council for GCC states, "Health Indicators for the Cooperation states. 2008;NO.14(Riyadh, Saudi Arabia).
149. Bener A, Rizk DE, Shaheen H, Micallef R, Osman N, Dunn E V. Measurement-specific quality-of-life satisfaction during the menopause in an Arabian Gulf country. Climacteric. 2000;3(1):43–9.
150. S. El-Ghazali,J.M.Ibrahim,B.M.Kanari andN. AI. The relationship between lifestyle and body mass index among university students in Kuwait. Egypt J CommunityMedicine. 2010;28:69–76.
151. Musaiger AO, D'Souza R. Nutritional profile of local and western fast foods consumed in Bahrain. Ecol Food Nutr. 2007;46(2):143–61.
152. ALNohair S. Obesity in gulf countries. Int J Health Sci (Qassim) [Internet].

2014;8(1):79–83. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4039587&tool=pmcentrez &rendertype=abstract

153. Mabry RM, Reeves MM, Eakin EG, Owen N. Gender differences in prevalence of the metabolic syndrome in Gulf Cooperation Council Countries: a systematic review. Diabet Med [Internet]. 2010;27(5):593–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20536958

154. World Health Organization Regional Office for the Eastern Mediterranean. Health Profiel 2015: Oman [Internet]. Vol. 6, Health Promotion. 2016 [cited 2017 Jun 5]. Available from: http://applications.emro.who.int/dsaf/EMROPUB_2016_EN_19273.pdf

155. Gulf Labour Markets and Migration. GCC: Total population and percentage of nationals and non-nationals in GCC countries (latest national statistics, 2010-2014) [Internet]. 2014 [cited 2017 May 30]. Available from: http://gulfmigration.eu/gcc-total-population-percentage-nationals-foreign-nationals-gcc-countries-national-statistics-2010-2016-numbers/?print=pdf

156. Affairs undersecretariat for planning. Health Vision 2050 (the main document). 2014;(First Edition).

157. NCSI. National Centre for Statistics & Information: National Accounts [Internet]. Vol. 2014. 2012 [cited 2017 Jun 6]. Available from: https://www.ncsi.gov.om/Elibrary/LibraryContentDoc/bar_pouplation 2106_dc567dc4-84d0-41de-9cb4-e65ed5ab0388.pdf

158. World Health Organization, 2012. Health system profile-Oman. Regional Health Systems Observatory- EMRO. 21. 4 http://gis.emro.who.int/HealthSystemObservatory/PDF/Oman/Health%20system%20organization.pdf.

159. Department of Nutrition, Ministry of Health S of O. OMN 2014 National Nutrition Startegy. 2014;

160. Mabry RM, Al-Busaidi ZQ, Reeves MM, Owen N, Eakin EG. Addressing physical inactivity in Omani adults: Perceptions of public health managers. Public Health Nutr 2013; 17:674–81. doi:10.1017/S1368980012005678. 18.

161. WHO. Nonconmmunicable Diseases (NCD) Country Profile. 2014;2014. Available from: http://www.who.int/nmh/countries/omn_en.pdf?ua=1

162. Al-Lawati JA, Jousilahti PJ. Prevalence and 10-year secular trend of obesity in Oman. Saudi Med J. 2004;25(3):346–51.

163. Al Riyami A, Abd Elaty MA, Morsi M, Al Kharusi H, Al Shukaily W, Jaju S. Oman World Health Survey: Part 1 - methodology, sociodemographic profile and epidemiology of non-communicable diseases in Oman. Oman Med J. 2012;27(5):425–43.

164. NCDs | UN Interagency Task Force on NCDs supports Oman to tackle noncommunicable diseases. WHO [Internet]. 2016 [cited 2017 Jun 12]; Available from: http://www.who.int/ncds/un-task-force/oman-mission-april-2016/en/

165. National Centre for Statistics and Information. Sultanate of Oman, National Centre for Statistics and Information [Internet]. 2017 [cited 2017 Jun 12]. Available from: https://www.ncsi.gov.om/Pages/NCSI.aspx

166. Babbie ER. Survey research method. Media Mimansa. 1990. 34-82 p.

167. Ministry of Health O. The 2004 national diet and nutrition survey of the sultanate of Oman. 2009; Available from: http://s3.amazonaws.com/zanran_storage/www.moh.gov.om/ContentPages/47491409.pdf

168. Wahab AWMA, Manal M, Sairafi A, Moosa K, Gharib MN, Ghada M, et al. NATIONAL NUTRITION SURVEY FOR ADULT BAHRAINIS AGED 19 YEARS AND ABOVE [Internet]. 2002. Available from: http://www.moh.gov.bh/pdf/survey/nut_survey1.pdf

169. Faber M, Jogessar V, Benadé A. Nutritional status and dietary intakes of children aged 2–5 years and their caregivers in a rural South African community. Int J Food Sci Nutr. 2001;52(5):401–11.

170. National centre for statistics and information, Sultanate of Oman. Household income and expenditure features pattern, 2012. https://www.ncsi.gov.om/Elibrary/Pages/LibraryContentDetails.aspx?ItemID=W4jjVW4cFuf1I4APdPcJcQ%3d%3d.

171. Abdul-Rahim HF, Husseini A, Bjertness E, Giacaman R, Gordon NH, Jervell J. The metabolic syndrome in the West Bank population: An urban-rural comparison. Diabetes Care. 2001;24(2):275–9.

172. Mehana M, Kilani H. Enhancing Physical Education in Omani Basic Education Curriculum: Rationale and Implications.

173. National centre for statistics and information, Sultanate of Oman. Development Indicators, 2015. https://www.ncsi.gov.om/Pages/KeyIndicators.aspx.
174. National Centre for Statistics and Information (NSCI). Available from: http://gulfbusiness.com/omans-household-income-rises-83-9-in-a-decade/
175. Nutrition Requirements_ British Nutrition foundation. In: World Crop Pests: Fruit Flies Their Biology, Natural Enemies and Control [Internet]. 2016 [cited 2017 Jun 13]. p. 103–19. Available from: https://www.nutrition.org.uk/attachments/article/234/Nutrition Requirements_Revised Oct 2016.pdf
176. Ministry of Health Sultanate of Oman. The Omani Guide to Healthy Eating. 2009.
177. Abdou, SAH and ElSayed, MK. A KAPB Survey on Lifestyle among Students in Universities, Colleges and other Higher Education Institutes. Muscat, Sultanate of Oman : Ministry of Health, World Helth Organization, 2008. Survey Report.
178. Amin TT, Al-Sultan AI, Ali A. Overweight and obesity and their relation to dietary habits and socio-demographic characteristics among male primary school children in Al-Hassa, Kingdom of Saudi Arabia. Eur J Nutr. 2008;47(6):310–8.
179. Hejazi N, Mazloom Z. Socioeconomic status, youth's eating patterns and meals consumed away from home. Pakistan J Biol Sci. 2009;12(9):730–3.
180. Landais E. Fruit and vegetable consumption and its determinants amongs Morrocan women, in the context of nutrition transition [Internet]. 2012 [cited 2017 Jun 13]. Available from: https://core.ac.uk/download/pdf/42499019.pdf
181. Sauvageot N, Alkerwi A, Albert A, Guillaume M. Use of food frequency questionnaire to assess relationships between dietary habits and cardiovascular risk factors in NESCAV study: validation with biomarkers. Nutr J [Internet]. 2013;12(1):143. Available from: http://nutritionj.biomedcentral.com/articles/10.1186/1475-2891-12-143
182. WHO/EMRO. Noncommunicable diseases in the Eastern Mediterranean Region EMRO Technical Publications Series. 2011 [cited 2017 Jun 3]; Available from: http://applications.emro.who.int/dsaf/EMROPUB_2016_EN_18977.pdf?ua=1
183. Ministry N, Oman H. The Omani Guide to Healthy Eating. 2009;
184. DietPlan 6 [Internet]. [cited 2017 Jun 13]. Available from: https://softwarelibrary.nottingham.ac.uk/moreinfo.aspx?application_id=634#
185. Ministry of Health O. The 2004 National Diet and Nutrition Survey of the Sultanate of

Oman. 2009;
186. Alhyas L, Mckay A, Balasanthiran A, Majeed A. Prevalences of overweight, obesity, hyperglycaemia, hypertension and dyslipidaemia in the Gulf: systematic review. JRSM Short Rep [Internet]. 2011;2(7):1–16. Available from: http://journals.sagepub.com/doi/10.1258/shorts.2011.011019
187. European Food Safety Authority. Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol. EFSA J [Internet]. 2010;8(3):1461. Available from: http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/1461.pdf
188. Roth GA, Fihn SD, Mokdad AH, Aekplakorn W, Hasegawa T, Lim SS. High total serum cholesterol, medication coverage and therapeutic control: an analysis of national health examination survey data from eight countries. Bull World Health Organ [Internet]. 2011 [cited 2017 Jun 13];89(2):92–101. Available from: http://www.who.int/bulletin/volumes/89/2/10-079947/en/
189. Mabry RM, Al-Busaidi ZQ, Reeves MM, Owen N, Eakin EG. Addressing physical inactivity in Omani adults: perceptions of public health managers. Public Health Nutr [Internet]. 2013;17(3):674–81. Available from: http://www.journals.cambridge.org/abstract_S1368980012005678
190. H.I. A, L.M. B, Ali H, PhD RD, Baynouna L, ABFM P, et al. Barriers and facilitators of weight management: perspectives of Arab women at risk for type 2 diabetes. Health Soc Care Community. 2010;18(2):219–28.
191. Al-Nuaim AA, Al-Nakeeb Y, Lyons M, Al-Hazzaa HM, Nevill A, Collins P, et al. The prevalence of physical activity and sedentary behaviours relative to obesity among adolescents from Al-ahsa, Saudi Arabia: Rural versus urban variations. J Nutr Metab. 2012;2012.
192. Al-Nakeeb Y, Lyons M, Collins P, Al-Nuaim A, Al-Hazzaa H, Duncan MJ, et al. Obesity, physical activity and sedentary behavior amongst British and Saudi youth: A cross-cultural study. Int J Environ Res Public Health. 2012;9(4):1490–506.
193. Ministry of Education. Global School- based student Health Survey, 2009 Maldives. 2009;34–6.
194. Higgins JP. Smartphone Applications for Patients' Health and Fitness [Internet]. Vol.

129, The American journal of medicine. 2016 [cited 2017 Jun 14]. p. 11–9. Available from: http://dx.doi.org/10.1016/j.amjmed.2015.05.038

195. Wolrd Health Organization. WHO | Global Strategy on Diet, Physical Activity and Health_Physical activity. WHO [Internet]. 2017 [cited 2017 Jun 14]; Available from: http://www.who.int/dietphysicalactivity/pa/en/

196. Wolrd Health Organization. WHO | Physical activity_Fact sheet,Media centre. WHO [Internet]. 2017 [cited 2017 Jun 14]; Available from: http://www.who.int/mediacentre/factsheets/fs385/en/

197. WHO | Prevalence of insufficient physical activity. WHO [Internet]. 2015 [cited 2017 Jun 14]; Available from: http://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/

198. Kilani H, Al-Hazzaa H, Waly MI, Musaiger A. Lifestyle habits: Diet, physical activity and sleep duration among Omani adolescents. Sultan Qaboos Univ Med J 2013; 13:510–19. 13.

199. Youssef RM, Al Shafie K, Al-Mukhaini M, Al-Balushi H. Physical activity and perceived barriers among high-school students in Muscat, Oman. East Mediterr Health J 2013; 19:759–68.

200. Mabry RM, Reeves MM, Eakin EG, Owen N. Gender differences in prevalence of the metabolic syndrome in Gulf Cooperation Council Countries: A systematic review. Diabet Med 2010; 27:593–7. doi: 10.1111/j.1464-5491.2010.02998.x. 17.

201. Mabry RM, Al-Busaidi ZQ, Reeves MM, Owen N, Eakin EG. Addressing physical inactivity in Omani adults: perceptions of public health managers. Public Health Nutr [Internet]. 2014;17(3):674–81. Available from: http://www.journals.cambridge.org/abstract_S1368980012005678

202. Bull FC. Global advocacy for physical activity—Development and progress of the Toronto Charter for Physical Activity: A global call for action. Res Exerc Epidemiol 2011; 13:1–10.

203. Ministry of Health Oman. Nizwa Healthy Lifestyle Evaluation Report. Muscat, Oman: Ministry of Health, 2012. 24.

204. Huda A-S, Zahir A-A, Halima A-H, Al-Hinai S. Nizwa Healthy Lifestyle Project Evaluation Report. [cited 2017 Jun 14]; Available from: https://websites.godaddy.com/blob/4d341e25-cb38-423e-bd8d-4b620b6008fe/downloads/NHLP_evaluation_Report.21.5.pdf?49804f1d

205. Burke LE, Wang J, Sevick MA. Self-Monitoring in Weight Loss: A Systematic Review of the Literature. J Am Diet Assoc. 2011;111(1):92–102.
206. Burke LE, Sereika SM, Music E, Warziski M, Styn MA, Stone A. Using Instrumented Paper Diaries to Document Self-Monitoring Patterns in Weight-Loss. [cited 2017 Jun 14]; Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2435095/pdf/nihms41891.pdf
207. Glanz K, Murphy S, Moylan J, Evensen D, Curb J. Improving dietary self-monitoring and adherence with hand-held computers: A pilot study. American Journal of Health Promotion 2006;20:165–170. [PubMed: 16422134].
208. Turner-McGrievy GM, Beets MW, Moore JB, Kaczynski AT, Barr-Anderson DJ, Tate DF. Comparison of traditional versus mobile app self-monitoring of physical activity and dietary intake among overweight adults participating in an mHealth weight loss program. J Am Med Inform Assoc [Internet]. 2013;20(3):513–8. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3628067&tool=pmcentrez&rendertype=abstract
209. Mateo GF, Granado-Font E, Ferré-Grau C, Montaña-Carreras X. Mobile phone apps to promote weight loss and increase physical activity: A systematic review and meta-analysis. Vol. 17, Journal of Medical Internet Research. 2015.
210. Wharton CM, Johnston CS, Cunningham BK, Sterner D. 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 [Internet]. 2014 Sep [cited 2017 Jun 14];46(5):440–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25220777
211. Granado-Font E, Flores-Mateo G, Sorlí-Aguilar M, Montaña-Carreras X, Ferre-Grau C, Barrera-Uriarte M-L, et al. Effectiveness of a Smartphone application and wearable device for weight loss in overweight or obese primary care patients: protocol for a randomised controlled trial. BMC Public Health [Internet]. 2015;15(1):531. Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-015-1845-8
212. Safety on the Line. Exposing the myth of mobile communication security_Sultanate of Oman. [cited 2017 Jun 14]; Available from: http://www.refworld.org/pdfid/502a0c500.pdf
213. Klenk S, Reifegerste D, Renatus R. Gender differences in gratifications from fitness app use and implications for health interventions. Mob Media Commun [Internet]. 2017;205015791769155. Available from:

http://journals.sagepub.com/doi/10.1177/2050157917691557

214. Liu, X., & Wei, R. (2014). Maintaining social connectedness in a fast-changing world: Examining the effects of mobile phone uses on loneliness among teens in Tibet. Mobile Media & Communication, 2(3),318–334. doi:10.1177/2050157914535390.

215. Satish Misra M. IMS Institute for Healthcare Informatics. IMS Health [Internet]. 2015 [cited 2017 Jun 14]. Available from: https://www.imedicalapps.com/2015/09/ims-health-apps-report/

216. Zhang, X., Guo, X., Lai, K., Guo, F., & Li, C. (2014). Understanding gender differences in m- health adoption: A modified theory of reasoned action model. Telemedicine and E-Health, 20(1), 39-46. doi:http://dx.doi.org.ezproxy.jyu.fi/10.1089/tmj.2013.0092.

217. Lauderdale, M. E., Yli-Piipari, S., Irwin, C. C., & Layne, T. E. (2015). Gender differences regard- ing motivation for physical activity among college students: A self-determination approach. Physical Educator, 72, 153–172.

218. Vehkanen L. Gender differences in usage and user experience of Oiva App. 2015;

219. Digital Health Consumer Adoption, 2015. [Internet]. [cited 2017 Jun 14]. Available from: https://rockhealth.com/reports/digital-health-consumer-adoption-2015/

220. Nasser F BinDhim,1 2 Lyndal Trevena. Health-related smartphone apps: regulations, safety, privacy and quality. BMJ Innov 2015;143–45 [Internet]. 2015 [cited 2017 Jun 15];1(doi:10.1136/bmjinnov-2014-000019):43–45. Available from: http://innovations.bmj.com/content/bmjinnov/1/2/43.full.pdf

221. Higgins JP. Smartphone Applications for Patients' Health and Fitness [Internet]. Vol. 129, The American journal of medicine. 2016 [cited 2017 Jun 15]. p. 11–9. Available from: http://dx.doi.org/10.1016/j.amjmed.2015.05.038

222. Middelweerd A, Mollee JS, van der Wal C, Brug J, Te Velde SJ. Apps to promote physical activity among adults: a review and content analysis. Int J Behav Nutr Phys Act [Internet]. 2014;11:97. Available from: http://www.ijbnpa.org/content/11/1/97

223. Cowan LT, Van Wagenen SA, Brown BA, Hedin RJ, Seino-Stephan Y, Hall PC, West JH: Apps of steel: are exercise apps providing consumers with realistic expectations? a content analysis of exercise apps for presence of behavior change theory. Health Educ Beha.

224. West JH, Hall PC, Hanson CL, Barnes MD, Giraud-Carrier C, Barrett J: There's an app for that: content analysis of paid health and fitness apps. J Med Internet Res 2012,

14:e72.

225. SOURCEBITS. Free vs. Paid Apps: The Pros & Cons [Internet]. App Institute. 2016 [cited 2017 Jun 15]. Available from: http://sourcebits.com/app-development-design-blog/free-vs-paid-apps-pros-cons/

226. Boudreaux ED, Waring ME, Hayes RB, Sadasivam RS, Mullen S, Pagoto S. Evaluating and selecting mobile health apps: strategies for healthcare providers and healthcare organizations. Vol. 4, Translational Behavioral Medicine. 2014. p. 363–71.

227. Map Fitness Training and Track Fitness Workouts | MapMyFitness [Internet]. [cited 2017 Jun 15]. Available from: http://www.mapmyfitness.com/

228. CrunchBase Inc. Pacer Health [Internet]. 2016 [cited 2017 Jun 15]. Available from: https://www.pacer.cc/

229. Thomas L, MacMillan J, McColl E, Hale C & Bond S (1995) Comparison of focus group and individual interview methodology in examining patient satisfaction with nursing care. Social Sciences in Health 1, 206–219.

230. Richardson CA & Rabiee F (2001) “A Question of Access” – an exploration of the factors influencing the health of young males aged 15–19 living in Corby and their use of health care services. Health Education Journal 60, 3–6.

231. Rabiee F. Focus-group interview and data analysis. Proc Nutr Soc [Internet]. 2004 [cited 2017 Jun 15];63(4):655–60. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/S0029665104000874

232. Rana Muhammad Dilshad. Focus Group Interview as a Tool for Qualitative Research: An Analysis. Pakistan J Soc Sci [Internet]. 2013 [cited 2017 Jun 15];33(1):191–8. Available from: http://www.bzu.edu.pk/PJSS/Vol33No12013/PJSS-Vol33-No1-16.pdf

233. An evaluation toolkit, for e-library developments. Focus groups [Internet]. 2017 [cited 2017 Jun 15]. Available from: http://www.evalued.bcu.ac.uk/tutorial/4b.htm

234. Krueger RA (1994) Focus Groups: A Practical Guide for Applied Research. Thousand Oaks, CA: Sage Publications.

235. Muller, A. Alley, S. Schoeppe, S. and Vandelanotte, C. (2016) The effectiveness of e- & mHealth interventions to promote physical activity and healthy diets in developing countries: A systematic review. International Journal of Behavioral Nutrition and Phy.

236. Kris-Etherton, P. Mustad, V. Lichenstein, A. (1999) Recruitment and screening of study participants. in: Well-Controlled Diet Studies in Humans A Practical Guide to

Design and Management. American Dietetic Association, 76–96. https://www.icts.uiowa.edu/Nu.

237. Connelly, Lynne M. “Pilot studies.” MedSurg Nursing, Dec. 2008, p. 411+. Academic OneFile, Accessed 15 June 2017.

238. Hill, R. (1998). What sample size is “enough” in internet survey research? Interpersonal Computing and Technology: An Electronic Journal for the 21st Century, 6(3-4). How to figure out an appropriate sample for the pilot study?. Available from: https://ww.

239. Lose It! Selected as 2015 MITX Awards Finalist. MITX Awards Finalist. 2015.

240. Webb TL, Joseph J, Yardley L, Michie S. Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. J Med Internet Res [Internet]. 2010 Feb 17 [cited 2017 Jun 16];12(1):e4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20164043

241. Gibson M. The feeding of nations : redefining food security for the 21st century [Internet]. CRC Press; 2012 [cited 2017 Jun 16]. 640 p. Available from: https://books.google.co.uk/books?id=9KfMBQAAQBAJ&pg=PA40&lpg=PA40&dq=the+average+minimum+energy+requirement+per+person+per+day+(1,800kcal).&source=bl&ots=pqEIsRdA-a&sig=d8nrmdcRa-fCV8Juu8jplLOnSZQ&hl=en&sa=X&ved=0ahUKEwjFsNTeg8LUAhVIVRoKHXiTCnEQ6AEIRjAF#v=onepage&q=the average minimum energy requirement per person per day (1%2C800kcal).&f=false

242. Alnasser AA, Amalraj RE, Sathiaseelan A, Al-Khalifa AS, Marais D. Do Arabic weight-loss apps adhere to evidence-informed practices? Transl Behav Med. 2016;6(3):396–402.

243. Mabry R, Owen N, Eakin E. A national strategy for promoting physical activity in Oman: A call for action. Sultan Qaboos Univ Med J. 2014;14(2):170–5.

244. Marshall SJ, Levy SS, Tudor-Locke CE, Kolkhorst FW, Wooten KM, Ji M, et al. Translating Physical Activity Recommendations into a Pedometer-Based Step Goal. 3000 Steps in 30 Minutes. Am J Prev Med [Internet]. 2009;36(5):410–5. Available from: http://dx.doi.org/10.1016/j.amepre.2009.01.021

245. Tudor-Locke C, Craig CL, Thyfault JP, Spence JC. A step-defined sedentary lifestyle index: <5000 steps/day. Appl Physiol Nutr Metab [Internet]. 2013 Feb [cited 2017 Jun

17];38(2):100–14. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23438219

246. Laing BY, Mangione CM, Tseng CH, Leng M, Vaisberg E, Mahida M, et al. Effectiveness of a smartphone application for weight loss compared with usual care in overweight primary care patients. Ann Intern Med. 2014;161:S5–12.

247. Burke LE, Styn MA, Sereika SM, Conroy MB, Ye L, Glanz K, et al. Using mHealth technology to enhance self-monitoring for weight loss: A randomized trial. Am J Prev Med [Internet]. 2012 [cited 2017 Jun 16];43(1):20–6. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3563396/pdf/nihms378784.pdf

248. Mehena, M. And Al-Kilani, H. (2010) Enhancing Physical Education in Omani Basic Education Curriculum: Rationale and Implications. International Journal for Cross-Disciplinary Subjects in Education (IJCDSE), 1 (2), 99-104.

249. Albawardi, N. Jaradi, H, and Al-Hazzaa, H. Levels and correlates of physical activity, inactivity and body mass index among Saudi women working in office jobs in Riyadh city. BMC Women's Health. 2016; 16(33). DOI 10.1186/s12905-016-0312-8.

250. Mabry. R, Morsi, M. Al-Lawati, J. and Owen, N. Descriptive epidemiology of physical activity among Omani adults: the Oman World Health Survey . Eastern Mediterranean Health Journal. 2016; 22 (2), 103-115.

251. Tudor-Locke C, Bassett DR. How Many Steps/Day Are Enough? Preliminary Pedometer Indices for Public Health [Internet]. Vol. 34, Sports Medicine. 2004 [cited 2017 Jun 17]. p. 1–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14715035

252. Public Health England (2016) https://www.gov.uk/government/publications/health-matters-getting-every-adult-active-every-day/health-matters-getting-every-adult-active-every-day/ accessed 20th January 2017.

253. Mabry RM, Al-Busaidi ZQ, Reeves MM, Owen N, Eakin EG. Addressing physical inactivity in Omani adults: perceptions of public health managers. Public Health Nutr [Internet]. 2014 [cited 2017 Jun 17];17(3):674–81. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/0B71CCDD11D14EEA08D7CF075847626B/S1368980012005678a.pdf/addressing_physical_inactivity_in_omani_adults_perceptions_of_public_health_managers.pdf

254. Fukuoka Y, Vittinghoff E, Jong SS, Haskell W. Innovation to motivation-pilot study of a mobile phone intervention to increase physical activity among sedentary women. Prev Med (Baltim) [Internet]. 2010 [cited 2017 Jun 17];51(3–4):287–9. Available

from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2939294/pdf/nihms-223014.pdf
255. Coughlin SS, Whitehead M, Sheats JQ, Mastrominico J, Smith S. A review of smartphone applications for promoting physical activity. Jacobs J Community Med [Internet]. 2016 [cited 2017 Jun 17];2(1):1–14. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4811195/pdf/nihms759489.pdf
256. Burke LE, Conroy MB, Sereika SM, Elci OU, Styn MA, Acharya SD, et al. The Effect of Electronic Self-Monitoring on Weight Loss and Dietary Intake: A Randomized Behavioral Weight Loss Trial. Obesity [Internet]. 2011 [cited 2017 Jun 17];19(2):338–44. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3268702/pdf/nihms-280975.pdf
257. Dos Santos MVL, De Melo CM, Rosa JPP, Da Silva EVA, Lima GHO, Del Re MP, et al. Emotional eating is related to carbohydrate intake in active women. Motriz Rev Educ Fis [Internet]. 2016 [cited 2017 Jun 17];22(4):346–52. Available from: http://dx.doi.org/10.1590/S1980-6574201600040020
258. Matthews J, Win KT, Oinas-Kukkonen H, Freeman M. Persuasive Technology in Mobile Applications Promoting Physical Activity: a Systematic Review. J Med Syst [Internet]. 2016 Mar 9 [cited 2017 Jun 17];40(3):1–13. Available from: http://link.springer.com/10.1007/s10916-015-0425-x
259. Choi J, Lee J hyeon, Vittinghoff E, Fukuoka Y. mHealth Physical Activity Intervention: A Randomized Pilot Study in Physically Inactive Pregnant Women. Matern Child Health J [Internet]. 2016 [cited 2017 Jun 17];20(5):1091–101. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4826820/pdf/nihms743852.pdf
260. Centis E, Moscatiello S, Bugianesi E, Bellentani S, Fracanzani AL, Calugi S, et al. Stage of change and motivation to healthier lifestyle in non-alcoholic fatty liver disease. J Hepatol. 2013;58(4):771–7.
261. Horwath. The stages of change. Eff Clin Pract. 1999;1–7.
262. Dehghan M, Akhtar-Danesh N, Merchant AT. Childhood obesity, prevalence and prevention. NutrJ. 2005;4(1475–2891 (Electronic)):24.

APPENDICES

Appendix A (OVSB14112013 SoBS Nutrit)

Survey on Current Dietary Practices and Attitudes towards Diet and Physical Activity Amongst Omani Adults

Dear participant,

The purpose of this survey is to study the dietary practices for Omani adults as well as their knowledge and attitudes toward the physical activity. Therefore, we would like you to answer the following questions as accurately as possible by choosing the answer that represents your choice. We also need you to complete the daily food dairy tables. All information provided will be treated with strict confidentiality and use only for research purposes.

Notes:

- Please answer all questions in questionnaire and 72 hrs daily intake
- Some questions are determined for females ONLY
- It is recommended that Daily food tables filled in the following respective days (Wednesday, Thursday, and Friday), and if not possible, you can fill them in any two respective week days in addition one weekend day.
- Daily food tables are expected to be filled with details by referring to the example day given to you or you can contact the researcher for more help.
- Those who wish to participate in this study are advised not to change their dietary system, because that will affect the validity of the results.

Part 1: Demographics Questions

1- From which Governorate you are (circle the appropriate number):

1. Muscat 5. Al Batinah South 9. Al Batinah North
2. Dhofar 6.Al Sharqiah South 10. Al Sharqiah North
3. Al Dakheliah 7. Al wusta 11. Al Dhaherah
4. Al Buraimi 8. Musandam

2- **What Age you are? .... (Date of birth is preferred)**

3- **Social type:** 1. Male ☐ 2. Female ☐

4- What is your weight? (1).................. (Kg) and your height? (2)……………(m)

5 - What is the highest grade of school you completed?

1. Illiterate ☐ 2. Read and write ☐
3. Primary school ☐ 4. Elementary school ☐
5. Secondary school ☐ 6. Technical or college school ☐
7. University graduate (4 years) ☐ 8. Post-graduate studies ☐

6- What is your marital status?
1. Currently married ☐ 2. Divorced ☐
3. Widowed ☐ 4. Single, never married ☐

7 - If you married, how many children do you have?
1. None ☐ 2. 1-3 ☐
3. 4-6 ☐ 4. 7 or more ☐

8 -Current situation:

1. Unemployed ☐ 2. Retired ☐ 3. Housewife (Women only) ☐
4. Employed in governmental sector ☐ 5. Employed in private sector ☐ 6. Manager / professional ☐ 7. Military sector ☐ 8. Owen Business ☐
9. Student ☐ 10. Not working ☐

9 - For statistical purposes, what is your monthly household income?
(Please leave blank if you do not wish to answer this question)

1. < OMR 500 ☐ 2. OMR 500-700 ☐
3.OMR 701- 999 ☐ 4. OMR 1000-1500 ☐
5. OMR >1500 ☐

Part 2: Health and Diet

10- How do you rate your health?

1. Good ☐
2. Fair ☐
3. Poor ☐
4. Very Poor ☐

11-Have you been diagnosed with any of the following diseases:

1. Type 2 diabetes (which does not required insulin injections) ☐
2. Coronary heart disease ☐
3. A stroke ☐
4. Hypertension ☐
5. I do not know because I did not underwent a medical test ☐

Please, list any other conditions you are suffering from:………………………........................
……………………………………………………………………………………………..

12- Do you smoke? Yes ☐ No ☐

If **Yes**, what type do you smoke?

1. Cigarettes ☐
2. Pipe ☐
3. Cigars ☐
4. Nargila (Shisha) ☐
5. Others ☐
   Specify...
   ....

13- Do you think you need to lose weight?

1. Yes ☐ 2. No ☐

14- How many meals do you eat daily?

1. One meal ☐ 2. Two meals ☐ 3. Three meals ☐ 4. More than 3 meals ☐

15- Please tick those boxes that relate to your present diet:

1. Mixed food diet (animal and vegetable sources) ☐
2. Vegetarian ☐
3. Salt restriction ☐
4. Fat restriction ☐
5. Starch/carbohydrate restriction ☐

6. Calorie restriction ☐

7. Other dietary plans, please ☐

detail:
………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

16 - Which particular food you enjoy the most?

1. Meat and meat dishes. ☐
2. Fish and sea food dishes ☐
3. Cake, Pastries, desserts, ice-cream ☐
4. Fruits and vegetables ☐

17- Tick from the list of fast foods (which are prepared outside house) which you consume frequently.

1. Potato chips ☐
2. Burger & kebabs ☐
3. Sandwiches ☐
4. Pizza ☐
5. Fried chicken ☐

18- Do you take any dietary supplements*?

1. Yes ☐ 2. No ☐

If you yes, what are these supplements?..
....
....
....

*Dietary supplements are vitamins, minerals, herbs, and many other products. They can come as pills, capsules, powders, drinks, and energy bars. Some supplements may help to assure that you get an adequate dietary intake of essential nutrients.

19- How often do you eat the following foods (weekly)?

Type of food **Food Frequency**	1	2	3	4	5	6
	never or rarely	1-2 portions	2-4 portions	5-6 portions	or 7 more portions	I don't know
(%) Fruits, vegetables, and legumes						
Fresh fruit (apples, oranges, pears, etc..)						
Green leafy vegetables (lettuce, cabbage, endive, spinach, etc...)						
Starchy vegetables (potatoes, sweet potatoes, etc. …)						
Other vegetables (carrots, tomatoes, cucumber, etc...)						
Legumes (Lentils, beans, peas,...)						
(%) Fish, Meet and Eggs						
Fish						
Sea foods (squid, prawn, shrimps, etc…)						
Chicken						
Red meat						
Meat products (sausages, burgers, sandwich,..)						
Eggs						
(%) Milk and milk products						
Milk, full fat						
Milk, low fat or skimmed						
Milk products (cheese, yogurt, milk drinks,..)						
(%) Grains and pastry						
Bread, white						
Bread, whole meal /brown						
Cereals (corn flakes, oatmeal,.)						
Pasta (spaghetti, macaroni, noodles, grits,..)						
Grains (rice, wheat, oats, etc…)						

Food Frequency **Type of Food**	1 never or rarely	2 1-2 portions	3 2-4 portions	4 5-6 portions	5 or 7 more portions	6 I don't know
(%) Snacks						
Snack foods (potato chips, candies, chocolates, ice-cream etc..)						
Omani halwa						
Cakes & Pastries (cakes, biscuits, sweet pies,..)						
Nuts (pistachio, cashew nuts,..)						
(%) Drinks						
Soft drinks (cola drinks)						
Fruit Juices						
Fruit drinks						
Coffee/tea						

<u>Part 3: Physical Activity questions</u>

20- On average, how many days per week do you regularly walk for more than 10 minutes?

1. Never ☐ 2. 1-2 days ☐ 3. 3-4 days ☐
4.5-6 days ☐ 5. Everyday ☐

21-If you regularly walk, what is the pace of your walk?

1. Slow ☐ 2. Moderate ☐ 3.Fast ☐

22- If you regularly walk, on average, how many minutes do you walk each day?

Number of minutes: ……….…………………………………..

23-On average, how many times per DAY do you use the stairs (more than 10 steps) at work, home, or elsewhere? (One floor claiming counts as 1 time)

1. Never ☐ 2. 1-2 times ☐ 3. 3-5 times ☐
4. 5 times or more ☐ 4. Every Day ☐

24- On average, how many days per week do you regularly engage in moderate intensity sports (e.g. volleyball, table tennis, bowling, physical education)?

1. Never ☐ 2. 1-2 ☐ 3. 3-4 ☐
4. 5-6 ☐ 5. Every day ☐

25- If you regularly play moderate intensity sports how many minutes do you play each time?

Number of minuets: ……………………………..

26-How many days per week do you regularly play high intensity sports (e.g. soccer, swimming, hockey, netball, basketball, handball, athletics, tennis squash, etc.)?

1. Never ☐ 2. 1-2 ☐ 3. 3-4 ☐ 4. 5-6 ☐ 5. Every day ☐

27- If you regularly play high intensity sports how many minutes do you play each time?

Number of minuets: …………………………

28- Do you have a maid (only women)?

1. Yes ☐ 2. No ☐

29- If you do your own household work, how many hours per week do you engage in these activities (e.g. gardening, vacuuming, washing, and cleaning) (only women)?

Never ☐1. 1-2 ☐ 2. 3-4 ☐
3. 5-7 ☐ 4. More than 7 ☐

30- On average, how long do you watch TV and/or DVD/Video per day?

1. 1/2 hour or less ☐ 2. 1 hour ☐ 3. 2 hours ☐
4. 3 hours ☐ 5. 4 hours ☐ 6. 5 hours or more ☐

31- On average, how long do you spend using a computer, tablets or mobile phone?

- **At home**

1. 1/2 hour or less ☐ 2. 1 hour ☐ 3. 2 hours ☐
4. 3 hours ☐ 5. 4 hours ☐ 6. 5 hours or more ☐

- **At work (if applicable)**

1. 1/2 hour or less ☐ 2. 1 hour ☐ 3. 2 hours ☐
hours ☐ 5. 4 hours ☐ 6. 5 hours or more ☐ 3 .4

Part 4: Three day diet dairy:

Example Day
Daily food Dairy ***Date (day/month/year) 11/01/2014***
Day of week Saturday
Day 1

Food	Portion	Cooking method	Time
Breakfast - White Lebanon bread - Cheese - Egg - Tea with milk,	- 2 medium slices - 2 pieces of cheese(small triangle shape from the market) - one egg - One medium cup	- backed - Not cooked (from the market) - Boiled - Cooked (2 tea spoon sugars +evaporated milk ≈50ml)	10:00 am
Mid-morning - Black coffee only - Omani dates-	- 3 small cups - 7 pieces of dates	- Not cooked - Not cooked	11:30
Lunch - Rice - Broth with red meat - Salad	- Medium dish of rice - Medium container≈ 500ml - Medium dish of salad includes (1) tomato, lettuce(2 leafs), (1) medium size cucumber, (1) onion, ½ lemon, ½ tea spoon salt	- Rice is boiled with water and ½ tea spoon salt. - Meat is cooked with vegetables ((2)tomatoes, (2)potatoes,(1) onion, (3) segments of garlics, ½ tea spoon Indian spices,(1) piece of carrot) - Not cooked	1:30
Mid-afternoon - Fruits (Banana ,peach, Apricot) - Biscuits with dates - Kit kat	- 1 each - Small packet (3 pieces) - 1(50g) bar	- Not cooked - Not cooked - Not cooked	4:30
Evening Meal - White bred - Grilled lamb - Grilled chicken - Fried chips - Diet Coke	- 2 slices - 2 steaks - 2 steaks - 1 cup - 1	- Baked - Roasted - Roasted - Fried - N/A	7:00
Any other snacks/drinks Omani coffee	- 3 small cups	- N/A - N/A	9:30

Daily Food Diary

_______ ***Date (day/month/year) __/___/___*** ***Day of week***

Day 1

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks/drinks			

Daily Food Diary

_____ ***Date (day/month/year)*** ***__/___/___***   ***Day of week***

Day 2

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks/drinks			

Daily Food Diary

______ ***Date (day/month/year)*** __/___/___   ***Day of week***

Day 3

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks/drinks			

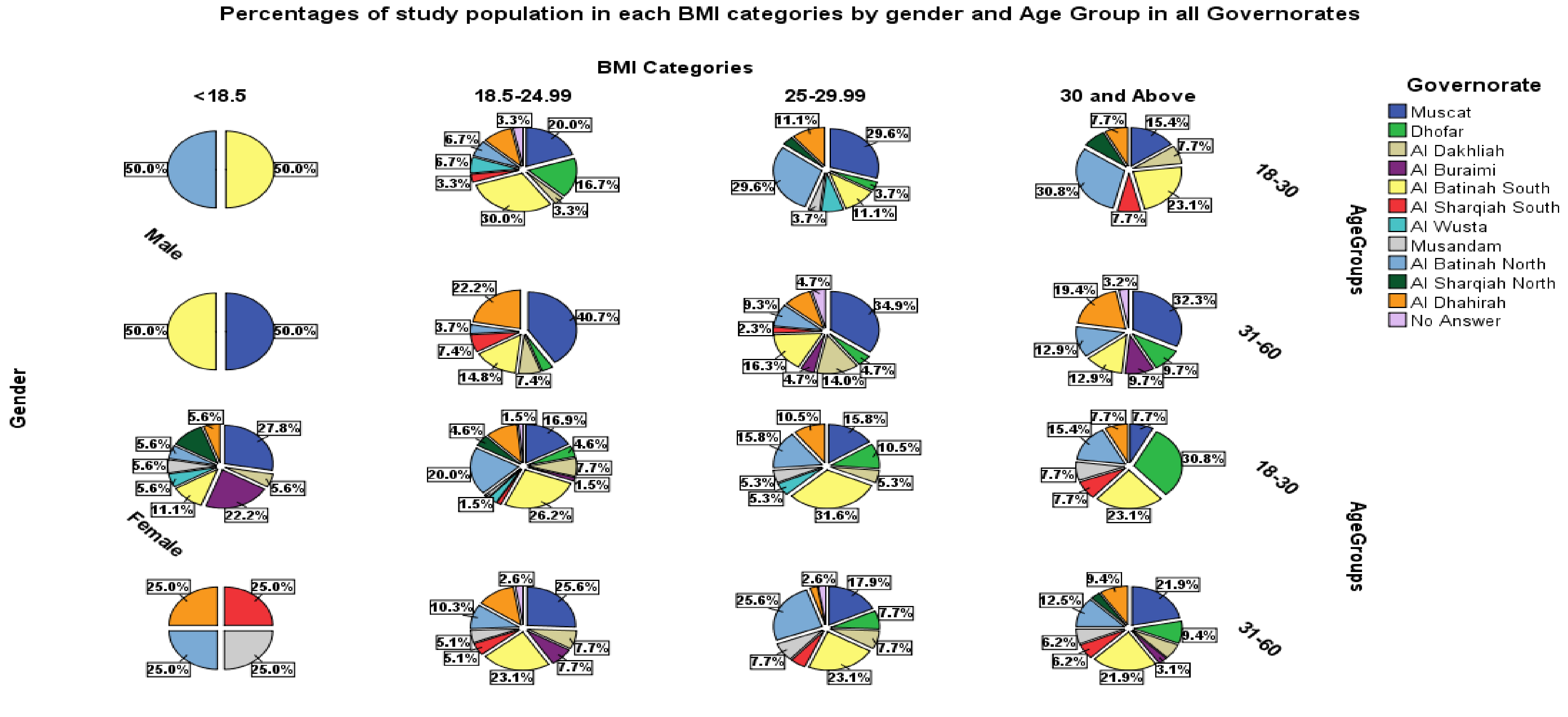
.Thank you for participating in this study
For further details, and/or to participate, please contact
:Khalid Al Zuhaibi at

- Gsm:+968 99445879
- **Email: sbxka3@nottingham.ac.uk**

If you would like a summary of the outcome of this study, please write your email :address below

……………………………………………………………………………………………
……………………………………………………………………………………..…………
..………………………………………………………………………………………………

Appendix B. Percentages of study population in each BMI categories by gender and Age Group in all Governorates



* BMI is significantly (P<0.05) affected by Gender and Age group (all Governorates are included)

** No significant (P<0.05) effect of governorates (Urban vs Rural) on BMI of study samples.

*** Rural governorates are: Musandam, Al Wusta, Al Buraimi, Sharqiyah south, Sharqiyah south

Appendix D. Average values of some study variables by Governorates, Age group and Gender (rural Gov. excluded).

Governorates	**Muscat**				**Dhofar**			
Gender	**Male**		**Female**		**Male**		**Female**	
Age Group	18-30	31-60	18-30	31-60	18-30	31-60	18-30	31-60
Protein (g) b	130 ±70	86±51	98±56	100±56	111±58	123±62	128±60	108±65
Fat (g) NS	80 ± 23	80±21	75±21	83±25	70±15	92±31	88±42	86±35
CHO (g) a'b	322 ± 91	329±76	259±72	294±73	229±58	326±54	286±70	302±71
Total Sugar a'c'abc	95 ± 40	90±37	77±34	85±30	61±27	64±16	69±21	80±33
Iodine (ug) NS	138± 45	136±47	90±61	111±40	113±51	110±24	93±39	110±38
Saturated fats (g) c'ab	21 ±6	20±7	20±9	19±8	20±8	16±3	22±10	23±9
MonoUfats (g)ab	28 ±10	25±11	22±11	26±11	26±6	29±12	29±16	29±9
PolyUfats (g) NS	18 ± 6	16±6	12±4	17±8	16±3	20±8	18±9	18±9
Transfats (g)ab	1 ± 1	1±1	1±1	1.1±0.9	1±1	1±1	1±1	2±1
Cholesterol (mg) b	417 ± 265	296±125	234±126	243±122	399±111	306±138	239±106	253±81
Potassium(mg)a'abc	2680 ± 931	2643±647	2212±492	2494±581	1821±565	2454±453	2274±1041	2419±915
Sodium (mg) b	2535±1379	2443±844	2566±950	2504±903	1951±449	2808±1322	2122±953	2153±464
Calcium(mg) a	692 ± 223	692±196	652±227	640±164	547±226	695±207	674±261	755±142
VitaminC(mg) c'bc'abc	138± 85	104±72	65±41	100±70	48±21	28±5	52±36	93±82

Continue Appendix D

Governorates	Al Dakhliah				Al Batinah South			
Gender	**Male**		**Female**		**Male**		**Female**	
Age Group	18-30	31-60	18-30	31-60	18-30	31-60	18-30	31-60
Protein (g) b	67±30	82±47	72±43	80±48	80±64	113±68	97±54	93±61
Fat (g) NS	98±35	83±30	66±27	99±38	91±27	77±28	70±19	83±29
CHO (g) a'b	338±32	331±64	262±73	339±67	336±94	332±95	297±64	293±85
Total Sugar a'c'abc	110±26	108±34	76±25	113±35	84±31	94±35	78±30	82±32
Iodine (ug) NS	77±30	126±68	88±40	129±58	128±47	148±72	128±63	114±44
Saturated fats (g) c'ab	24±13	22±14	16±8	23±12	23±10	18±9	17±6	17±10
MonoUfats (g)ab	29±17	24±12	19±11	31±15	29±13	22±11	21±8	32±45
PolyUfats (g) NS	16±5	14±5	13±5	20±8	18±8	15±7	12±5	22±34
Transfats (g)ab	2±1	1±1	1±1	1±1	1±1	1±1	1±1	2±4
Cholesterol (mg) b	268±224	260±120	197±159	284±191	359±147	356±231	311±278	242±147
Potassium(mg)a'abc	2948±323	2887±439	2212±694	2899±734	2728±632	2932±702	2445±580	2254±801
Sodium (mg) b	3416±639	2404±647	1963±768	2552±535	3009±937	2731±995	2430±933	2205±1180
Calcium(mg) a	607±69	711±256	539±178	754±139	792±238	810±297	702±165	664±213
VitaminC(mg) c'bc'abc	75±37	105±46	81±35	122±61	95.4±58	107±58	97±66	104±70

Continue Appendix D

Governorates	Al Batinah North				Al Dhahirah			
Gender	**Male**		**Female**		**Male**		**Female**	
Age Group	**18-30**	**31-60**	**18-30**	**31-60**	**18-30**	**31-60**	**18-30**	**31-60**
Protein (g) b	93±57	95±67	94±63	81±49	133±50	111±77	106±69	136±64
Fat (g) NS	100±38	79±24	83±33	76±25	82±30	70±31	82±32	73±39
CHO (g) a'b	307±104	348±70	315±92	324±64	245±75	333±97	292±66	266±91
Total Sugar a'c'abc	86±39	92±15	88±29	90±34	69±34	116±36	100±33	75±23
Iodine (ug) NS	135±68	132±65	123±62	127±50	119±51	134±64	114±56	120±42
Saturated fats (g) c'ab	29±15	19±10	21±7	20±8	26±8	22±12	25±11	23±15
MonoUfats (g)ab	35±16	25±10	28±17	23±10	30±13	23±13	27±15	25±15
PolyUfats (g) NS	21±9	16±6	17±11	15±6	15±8	13±5	16±7	13±5
Transfats (g)ab	2±1	1±1	1±1	1±1	2±1	2±1	2±1	2±2
Cholesterol (mg) b	388±180	319±138	260±154	288±158	248±150	352±178	312±180	341±163
Potassium(mg)a'abc	2485±715	2634±576	2559±676	2547±490	2083±522	3032±955	2636±1418	2335±789
Sodium (mg) b	2993±984	2978±1406	2242±827	2383±773	2090±522	2990±1981	2700±1809	2052±759
Calcium(mg) a	773±233	703±261	709±265	724±177	588±1002	809±235	656±202	666±237
VitaminC(mg) c'bc'abc	82±77	108±63	130±75	114±64	95±69	140±88	106±66	83±54

(a) Significant between Age Groups
(b) Significant between Gender
(C) Significant between Governorates
(ab) Significant between the interaction of (Age Groups*Gender)
(bc) Significant between the interaction of (Gender *Governorates)
(abc) Significant between the interaction of (Age Groups*Gender* Governorates)

Appendix C: Participants information sheet

Effectiveness of health and fitness smartphone applications to improve dietary habits and promote physical activity in Omani adults

You are being invited to participate in a research study. When considering whether or not to participate in this study, it is important that you understand why this research is being done and what it will involve. Please ask the researcher any questions or queries you might have. Thank you for your interest in this study.

Background

Information about the health of Omani people indicates a high prevalence of overweight and obesity in both males and females. Results from a survey in 2014 showed that 55% of participants were either overweight or obese, and the majority of them are physically inactive. Regular, ongoing support with information about making healthier lifestyle choices is motivating for many individuals. The current study, aims to explore the usefulness of smart phone apps in supporting overweight and obese Omani adults to improve their diet and level of physical activity. Smartphone applications are increasingly popular and are convenient since subjects can access information daily and at a time suitable for them.

What does the study involve?

This study is an intervention trial involve recruiting 30 Omani healthy adults (15 males & 15 females) fall in age group (18-55) years, living in Nottingham. Volunteers will randomly (using a computer software) be divided into two groups. Group 1 will be asked to only modify their daily exercise. Group 2 will be asked to modify both their daily dietary intake and exercise (as measured by daily step counts). All participants will be given detailed information about the intervention and how to participate in this study. They will be asked to use the allocated smartphone app /apps to track their daily calories intakes and/or daily step counts during all period of the trial (4 weeks) and send the collected data to the researcher at the end of every week.

Why have you been chosen to take part?

All Omani healthy adults aged (18-55 years) living in Nottingham will be invited to be screened to investigate whether they are eligible to participate in this study.

Do you have to take part?

It is up to you to decide whether or not to take part. If you do decide to participate, please keep this information sheet and complete the consent form. You are still free to withdraw at any time and without giving a reason.

What if something goes wrong?

If you have reason to complain about this study, complaints should be addressed in the first instance to Prof. Andrew Salter (tel. 0115 9516120, email Sczams@exmail.nottingham.ac.uk) or Dr Fiona McCullough (tel. 0115 9516121, email sbzfswm@exmail.nottingham.ac.uk). Address: School of Bioscience, The University of Nottingham, Sutton Bonington Campus, Leicestershire, LE12 5RD). If this does not resolve the matter to your satisfaction then please contact the School of Bioscience's Research Ethics Officer, Dr Kate Millar (tel. 0115 951 6303, email Kate.Millar@nottingham.ac.uk), address as above.

Will my taking part in this study be kept confidential?

The results of this study will be kept strictly confidential. Any information about the research participants that leaves the research unit will have names and addresses removed so that you cannot be recognised from it.

What will happen to the results of this study?

The results of this study will be reported in postgraduate research project thesis and may also be written up and submitted for publication in a peer review journal. You are invited to contact the researcher to request a summary of the results once they are available.

Who has reviewed the study?

The School of Biosciences Research Ethics Committee.

Thank you for considering participating in this research.

Investigators:

Khalid Al Zuhaibi (sbxka3@nottingham.ac.uk, +447917914898)

Research Supervisors: Professor Andrew Salter, Dr. Fiona Mccullough

School of Biosciences, University of Nottingham

Appendix E: Consent Form

School of Biosciences **SBREC150124A**

University of Nottingham

Participant Consent Form

Effectiveness of health and fitness smartphone applications to improve dietary habits and promote physical activity in Omani adults

In signing this consent form, I confirm that:

I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me.	Yes	☐	No	☐
I have had the opportunity to ask questions.	Yes	☐	No	☐
I understand the purpose of the research project and my involvement in it.	Yes	☐	No	☐
I understand that my participation is voluntary, and I may withdraw from the research project at any stage, without having to give any reason and withdrawing will not penalise or disadvantaged me in any way.	Yes	☐	No	☐
I understand that while information gained during the study may be published, any information I provide is confidential (with one exception – see below), and that no information that could lead to the identification of any individual will be	Yes	☐	No	☐

disclosed in any reports on the project, or to any other party. No identifiable personal data will be published.

I understand that the researcher may be required to report to the authorities any significant harm to a child/young person (up to the age of 18 years) that he/she becomes aware of during the research. I agree that such harm may violate the principle of confidentiality.	Yes	☐	No	☐
I understand that data will be securely stored	Yes	☐	No	☐
I understand that I may contact the researcher *[*or *supervisor]* if I require further information about the research, and that I may contact the Research Ethics Officer of the School of Biosciences, University of Nottingham, if I wish to make a complaint relating to my involvement in the research.	Yes	☐	No	☐
I agree to take part in the above research project.	Yes	☐	No	☐

Participant's name (BLOCK CAPITAL)	Participant's signature	Date

Researcher's name (BLOCK CAPITAL)	Researcher's signature	Date

Appendix F- Investigator's Script

Focus groups interview: Could health and fitness apps be effective in improving diet and physical activity behaviours in Omani People?

Introduction

I want to thank you all for coming to our focus group today (5th June 2016). It is a great privilege for us gets to talk with you about your participation in our intervention study. The study which aimed to investigate the effectiveness of two health and fitness smartphone applications (Apps), to improve dietary habits and promote physical activity in Omani adults living in Nottingham. The two Apps are (lose it) which is used to track the daily food intake, and Mapmyfitness used to track daily step counts. It is really interesting and will be very helpful to us to have your ideas, views and opinions about using these two Apps.

So, I am going to ask you some questions I am already prepared, and there are no right or wrong answers to those questions. It is perfectly alright for you to disagree with someone else in the group. In fact, that actually may be helpful to us, so please feel free to say whatever you would like to say about the topic. In terms of ground rules, and because we are limited in the amount of time we have, I would ask you to try to be concise in your comments, and be clear and direct, try to let people finish their thoughts before you share yours, **but** feel free to share what you feel is important. Any questions before we start?

Before starting the interview, the five participants identified themselves (Fore recording purposes). The answers of all participants will be summarised after each question.

1. Would you like to tell me what motivates you about the quality of your diet, general health, and physical activity?

- To improve the quality of life
- Our family history with some chronic disease (e.g. Diabetes, Blood pressure, cardiovascular diseases...).
- To increase our knowledge about the food we eat (how healthy it is, how much we should eat, the concept of calories…)
- We are aging and most of us close (if not entered) from the age 40. More care is needed to our health and fitness.

2. Have you heard of or tried to use any health and fitness smartphone Apps before this study?

- 3 answered **No**, This is our first time.
- 2 answered **Yes,** they have tried to use similar Apps before, but unlike using the 2 Apps in this study, they only used them for a short period of time.

3. Did you find the applications helpful?

- All of them answered yes, both Apps are very helpful, one participant mentioned that he found Lose it App is very helpful and interesting specially in controlling the amount of food (especially dinner) in each meal to not exceed the allocated budget.

4. To what extent have you reached your goals?

- Increased our daily step counts in **a regular basis**, especially when we created a challenge group (one of the effective App features). Monitoring our daily workout encourage us to do more physical activity.
- The feedback after the baseline phase motivated us to increase our daily step counts.
- **Partially reached some of the goals**, because we are student and we do not have enough time to exercise and to achieve all or goals.
- One participant mentioned that in the first 2 weeks he focused more in Lose it App, because it is easier to him to control his food than to walk, eating is a daily habit but exercise is a new habit to him (need to change my routine).

5. What are the App's features that helped you most to achieve your goals?

- The easy use of both apps, effective log dashboard (using food pictures and the calories in each portion size were very helpful especially in making a decision of what and how much food to eat).
- The synchronisation between food intake calories and calories expenditure via physical activity.
- The barcode scan in Lose it App (especially when we do not know the name of a particular food in English).
- The challenge Feature in MapMyFitness App (encourage Participants to walk more)
- Friendship feature in MapMyFitness App & calories budget in Lose it App.

6. What features do you think need to be added or improved in order to obtain better results in future?

- Automatic detection and adjustment between walking and running,
- Increase the number of food items included in (Lose it App) especially food from Arab and The Middle East countries.
- Need to improve the accuracy of MapMyFitness App, because sometimes if you walk to the same distance every day, it gives you different step counts, and when an individual stop walking, it continues counting the calories.

7. How likely are you to continue to use these (or other apps) to monitor your diet and physical activity?

- We will continue to use these apps and encourage our friends to use like these apps especially we are getting old (entering 40 years).
- In addition to using health and fitness apps, some participants go further and thinking seriously to buy fitness band and other fitness tools.

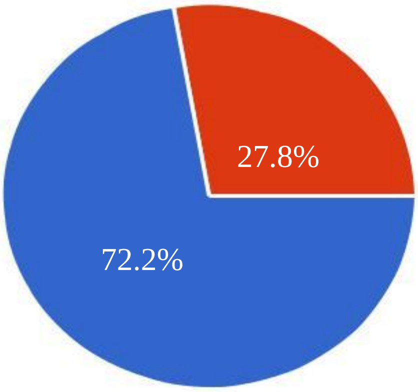
8. In general, do you support using smartphone Apps to improve dietary habits and physical activity? How likely will it be effective if it is applied on Omani people in Oman?

- All said **Yes** we support using smartphone apps.
- New generation are more likely to use these types of technology, they are always using there smartphone, so they have the sense of using such apps.
- Sustainability needs more efforts from health and fitness authority in Oman, initiatives alone is not enough, especially when taking into account the customs in Oman as a challenge.
- The weather in Oman is not encouraging using physical activity, therefore the use of smartphones may be not as expected.
- The changes in lifestyle in Oman, urges us to strongly encourage all tools and means that help to improve our general health and fitness, including these smartphone Apps.
- These apps could be effective, especially if they are designed to be culturally appropriate.

9. Are there any other aspects of the study you would like to discuss?

- It will be more helpful to provide individuals with more deep health messages as a feedback of their daily dietary intake and physical activity (e.g. if you carry on with this level of physical activity and this balance of calories and macronutrient, you will end up with less chance of getting certain types of diseases).
- If such apps modified to be appropriate of certain culture, they will be more effective.
- Adding a recommendation or suggestion features to the fitness app in a way that enables it to provide individuals with certain types of physical activity suitable for their age, weight and climate they live in.
- Privacy is very important and could stop some people from using such apps. Sorting out this issue is crucial.

Appendix G: Participants evaluation of Loss it! App



Gender		
Male	13	72.2%
Female	5	27.8%

1. Had you tried using this App before or was being part of the study the first time?

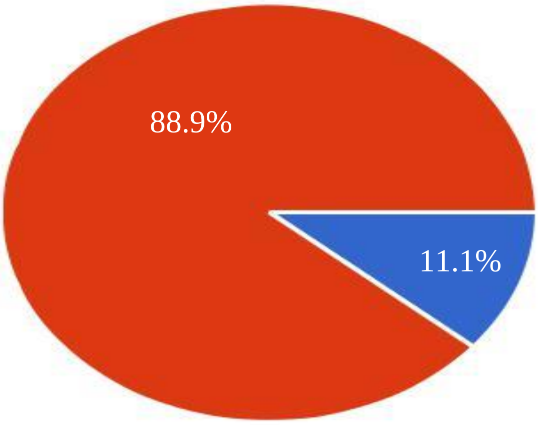


Figure 2:

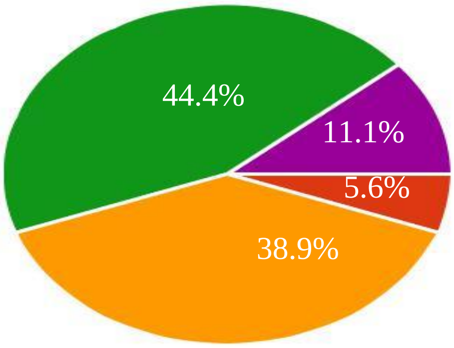
Yes, I have tried this App before	2	11.1%
No, this is my first time	16	88.9%

2. What is the most helpful in this App?

- Monitoring your daily calories intake.
- Calorie count.
- Knowing the calories in each food.
- Easy access to most food a person eats with very specific details of ingredients.
- Sample
- Easy to use

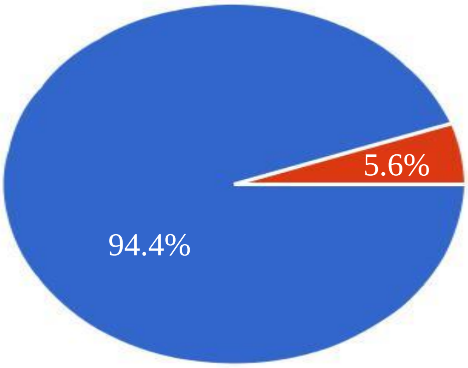
- Get idea about the calories in the meals and how much is in each meal.
- Knowing the nutrition, you had.
- The recording of food and what it includes and how we control it.
- Knowing nutrients.
- Knowing the calories.
- Organized my daily food and know the calories of each meal.
- Measure the calories every day which help me to compare it with the other days.
- Knowing the calories of food.
- Knowing my food calories.
- It is accurate.
- Monitor and improve food and nutrition intake.
- Knowing your daily calories budget

3. How easy to record your daily dietary intake?



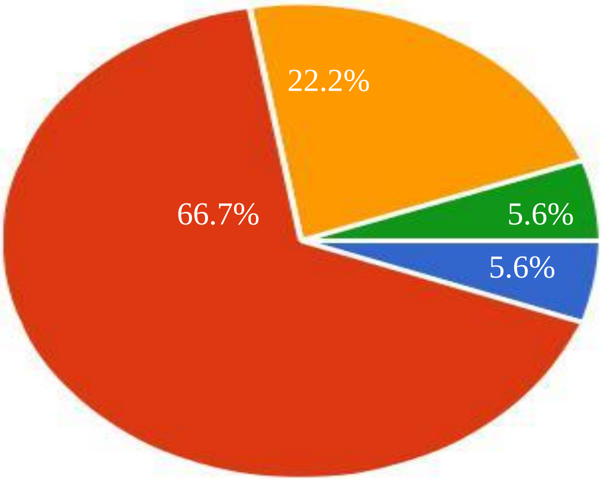
A. Very difficult	0	0%
B. Difficult	1	5.6%
C. Medium	7	38.9%
D. Easy	8	44.4%
E. Very Easy	2	11.1%

4. How effective this App is for you to lose weight?



A. Effective	17	94.4%
B. Not effective	1	5.6%

5. To what extent you have reached your goals?



A. Not reached at all	1	5.6%
B. Partly reached	12	66.7%
C. Mainly reached	4	22.2%
D. Completely reached	1	5.6%

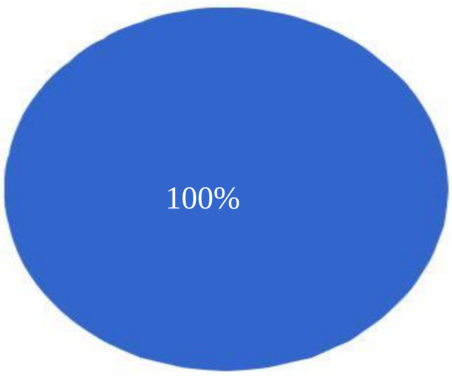
6. What App's features helped you more in achieving your results?

- Knowing the calories

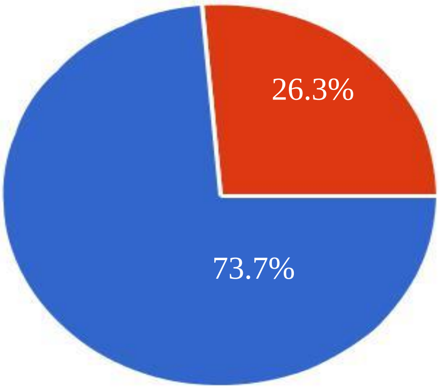
- Goal setting
- Nutrient count
- The calories' details for each single food
- Lost it
- Calories info.
- knowing the calories in the meals to minimise and avoid it
- Calories burning
- The circle of your daily food and Calories.
- knowing the nutrients
- Calories circle
- Enter the meals every day.
- calculating food Calories
- Weekly report.
- It is fast
- Nutrition summary and setting the weight loss goal.
- Knowing the calories in some types of food that i started to avoid

7. Would you recommend this App for your friends?

Yes	18	100%
No	0	0%

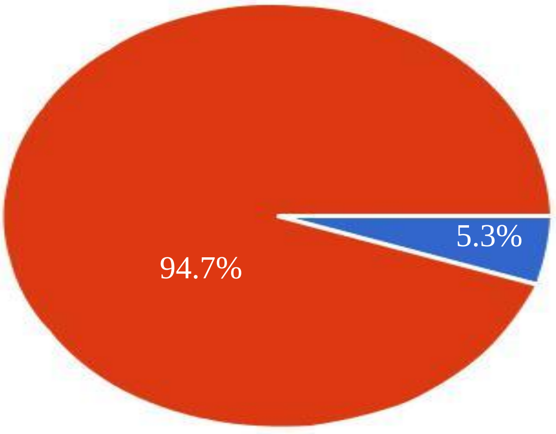


Appendix H: Participants evaluation of Map My Fitness App



Gender		
Male	14	73.7%
Female	5	26.3%

1. Had you tried using this App before or was being part of the study the first time?



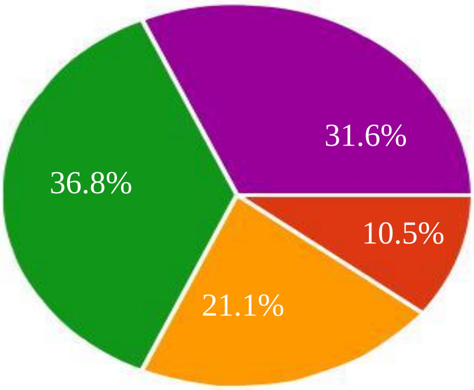
Yes, I have tried this App before	1	5.3%
No, this is my first time	18	94.7%

2. What is the most helpful in this App?

- Distance count.
- Knowing the calories that I can burn by doing exercises.
- It's easy to use and calculate the distance you walked.
- Measuring the distance you walk accurately.
- Very simple and easy to use it.
- Simple
- Easy to use
- knowing how much calories can burn as every time i walked

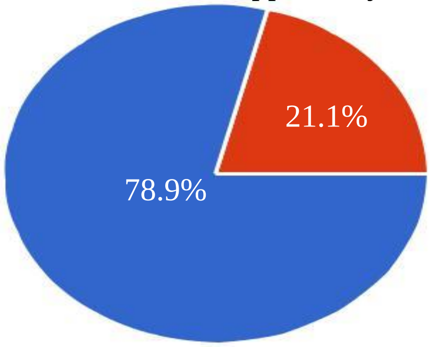
- Flexibility in choosing the type of exercise
- This app helped us to know the importance of sport and it also encourages us to control our fitness.
- knowing distance
- Helped me to walk more.
- To map my fitness and showing me the importance of sport.
- Can be used without Internet.
- Recording my daily activities.
- It is accurate.
- Exercises.
- Tracking your walking.
- Step count

3. How easy to record your daily step counts?



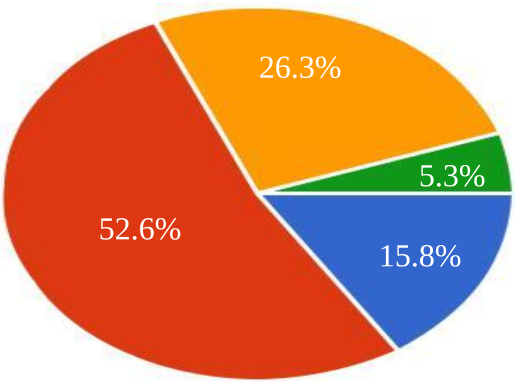
A. Very difficult	0	0%
B. Difficult	2	10.5%
C. Medium	4	21.1%
D. Easy	7	36.8%
E. Very Easy	6	31.6%

4. How effective this App is for you to lose weight?



A. Effective	15	78.9%
B. Not effective	4	21.1%

7. To what extent you have reached your goals?



A. Not reached at all	3	15.8%
B. Partly reached	10	52.6%
C. Mainly reached	5	26.3%
D. Completely reached	1	5.3%

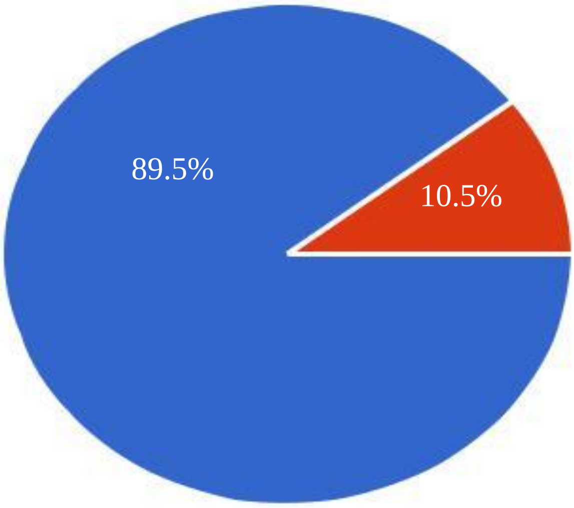
6. What App's features helped you more in achieving your results?

- Sharing data.
- Connections with friends.
- The good thing is that you can challenge your friends which give a sense of motivation.
- Self –monitoring.
- History of foods.
- Lose it.
- Recording my daily exercise.
- Challenges and calories calculated.
- N/A
- Knowing the calories, we lost.

- Knowing the distance.
- Walk more
- The challenges between friends.
- Making challenges with my friends.
- Auto tracking.
- It is fast.
- Walking workout
- Health
- Linkage with loose it app
    -

7. Would you recommend this App for your friends?

Yes	17	89.5%
No	2	10.5%



Appendix I. Comparison of study variables before and after the intervention, in all study samples.

Baseline phase											End of the intervention						
No	Age	Weight kg	Height (m)	Height (m^2)	BMI	Energy (kCal)	Daily steps	CHO g	Fat g	Protein g	Weight kg	BMI	Energy (kCal)	Daily steps	CHO g	Fats g	Proteins g
1	34	103.5	1.7	3.0	34.6	2068.4	963.8	61.0	24.0	15.0	102.0	34.1	1716.2	2470.4	68.1	11.8	20.2
2	40	64	1.7	2.8	22.7	1069.4	6607.0	58.4	14.8	26.8	64.0	22.7	1213.8	6005.5	68.6	13.4	18.0
3	37	76.5	1.7	2.8	27.4	1939.6	8416.8	58.7	16.8	24.4	75.3	27.0	1269.5	8802.0	58.9	17.9	23.2
4	31	64	1.7	2.8	22.7	1226.6	0.0	63.7	23.9	12.3	62.0	22.0	1205.3	-	59.6	23.6	16.7
5	38	73	1.8	3.1	23.8	2957.8	3733.8	70.0	15.0	15.0	74.4	24.3	3436.9	3858.9	70.8	15.5	13.8
6	32	78.7	1.8	3.2	24.6	729.2	3781.0	63.0	20.0	17.0	-	-	1333.4	19185.5	64.1	17.9	18.0
7	30	70	1.7	2.9	24.2	1280.0	-	67.4	16.9	15.7	69.0	23.9	1359.6	10147.6	65.3	17.3	17.5
8	36	86	1.8	3.2	26.5	2521.2	1606.0	65.9	11.3	22.7	86.0	26.5	2760.2	3787.7	67.7	10.3	22.1
9	40	80	1.7	3.0	26.4	921.3	1565.8	71.8	12.2	16.0	75.0	24.8	1662.3	7307.6	55.4	22.6	22.1
10	31	96	1.7	2.9	33.2	1099.6	7297.2	61.0	19.0	20.0	92.0	31.8	1146.0	13533.4	56.5	13.1	30.5
11	-	70	1.8	3.1	22.9	859.7	0.0	56.9	23.5	19.6	-	-	1595.2	-	53.3	23.1	23.6
12	42	72.3	1.7	2.7	26.6	1765.0	4440.4	58.0	18.0	23.0	71.0	26.1	1478.6	9607.1	65.3	15.6	19.2
13	31	76.4	1.8	3.1	24.4	1268.7	3856.4	61.5	15.5	23.0	75.4	24.1	1578.8	3553.6	61.6	16.8	21.6
14	32	83	1.8	3.1	26.8	686.2	3175.3	45.3	24.1	30.7	87.0	28.1	1266.9	2128.8	55.7	21.0	23.3
15	30	68	1.7	3.0	23.0	2517.9	1532.6	60.7	14.0	25.3	66.7	22.5	1881.2	5757.6	55.8	16.6	27.6
16	35	74	1.7	2.8	26.2	1503.5	2830.0	58.1	18.4	23.5	72.3	25.6	1054.4	-	56.8	20.3	22.9
17	38	45	1.5	2.2	20.5	1042.4	1919.5	59.5	15.9	24.6	45.0	20.5	820.0	2172.3	61.2	15.1	23.6
18	34	75	1.6	2.6	29.3	1844.0	-	69.7	15.0	15.3	75.0	29.3	1255.2	3850.6	65.4	17.6	17.0
19	34	59	1.5	2.4	24.9	1188.6	-	58.0	18.6	23.4	57.7	24.3	1065.2	3429.8	57.4	17.7	24.9
20	35	78	1.6	2.6	29.7	1363.6	-	69.0	22.4	8.6	77.0	29.3	931.7	-	69.2	13.5	17.4
21	28	76	1.6	2.4	31.6	851.6	582.5	48.9	24.7	26.4	73.0	30.4	885.6	2515.4	50.4	23.5	24.7

Appendix J: Compliance in data entry of energy intake and PA.

No	Lose it			MapMyFitness		
	No. Days Completed	**Missing**	**Total**	**No. Days Completed**	**Missing**	**Total**
1	29.0	2.0	31.0	18.0	13.0	31.0
2	31.0	0.0	31.0	20.0	11.0	31.0
3	31.0	0.0	31.0	26.0	5.0	31.0
4	24.0	7.0	31.0	0.0	31.0	31.0
5	31.0	0.0	31.0	26.0	5.0	31.0
6	30.0	1.0	31.0	11.0	20.0	31.0
7	24.0	0.0	24.0	11.0	13.0	24.0
8	31.0	0.0	31.0	11.0	20.0	31.0
9	23.0	0.0	23.0	16.0	7.0	23.0
10	30.0	0.0	30.0	28.0	2.0	30.0
11	19.0	11.0	30.0	0.0	30.0	30.0
12	0.0	30.0	30.0	0.0	30.0	30.0
13	30.0	0.0	30.0	29.0	1.0	30.0
14	31.0	0.0	31.0	18.0	13.0	31.0
15	27.0	0.0	27.0	4.0	23.0	27.0
16	23.0	0.0	23.0	14.0	9.0	23.0
17	15.0	0.0	15.0	0.0	15.0	15.0
Total	**429.0**	**51.0**	**480.0**	**232.0**	**248.0**	**480.0**

Appendix K: Research Flyer

Omani Ladies Join Our Research to Improve Your

It is Your Chance to get Fit!

Aim: To improve physical activity using mobile application.

What to do:

Increase physical activity either by step counting or more active time

Interested please contact us at:

Nahla Al-Anqodi (MSc Advanced Dietetic Practice)

stxnsal@nottingham.ac.uk

+968-97702626

Appendix L: Information sheet

School of Biosciences,

University of Nottingham

Information for Participants

Feasibility of Smartphone application to promote physical activity in healthy Omani female adults

Investigator: Nahla Al-Anqodi (stxnsal@nottingham.ac.uk) +447774992476

Supervisors:

Professor Andrew Salter, Dr. Fiona McCullough

School of Biosciences, University of Nottingham

You are being invited to participate in a research study. When considering whether or not to participate in this study, it is important that you understand why this research is being done and what it will involve. Please ask the researcher any questions or queries you might have. Thank you for your interest in this study.

Background:

Data available about the health of the Omani adults shows a high prevalence of overweight and obesity. In a recent survey on Omani adults in 2015 it reported that 55% of the studies sample were either overweight or obese and suggested that it was due to them being physically inactive. The current study, aims to examine the feasibility of smart phone apps in supporting normal, overweight and obese Omani female adults to improve their level of physical activity. Smartphone applications are increasingly popular and are convenient as participants can monitor their physical activity progress anywhere and anytime.

What does the study involve?

This study is a feasibility study involves recruiting 40 Omani female healthy adults (18-55 years). Participants will randomly be divided into two groups using computer software.

Group 1 will be asked to modify their physical activity level (as measured by daily step counts). Group 2 will be asked to continue with their daily physical activity. All participants will be given detailed information about the intervention and how to participate in this study. Group 1 will asked to use the allocated smartphone app for physical activity and to keep three days food diary (at baseline and last week of the intervention) and track daily step counts during all period of the study (5 weeks). Group 2 will be asked to keep a record of their physical activity

Using an electronic physical activity questionnaire. Participants will be directed to send the collected data to the researcher at the end of every week via email.

Participants who feel unwell during the study are advised to will be advised to stop all physical activity immediately and consult their GP immediately.

Participants who are pregnant, cannot undertake physical activity, have a medical history of NCD – hypertension, diabetes, CVD, obesity (BMI>30kg/m2) and non-Android or IPhone smartphone users are excluded from the study.

Participants will be guided on how to download the app and advised decline any notifications that may pop during the installation of the APP. All food diaries and physical activity diary/log will be provided by the researcher (added at the end of the document). Further information on physical activity is provided through the link below.

http://www.nhs.uk/Livewell/getting-started-guides/Pages/getting-started-walking.aspx

Why have you been chosen to take part?

All Omani female healthy adults aged (18-55 years) living in Oman will be invited to participate. A screening will be done to investigate eligibility to participate in this study.

Do you have to take part?

It is up to you to decide whether or not to take part. If you do decide to participate, please keep this information sheet and complete the consent form. You are still free to withdraw at any time and without giving a reason.

What if something goes wrong?

If you have reason to complain about this study, complaints should be addressed in the first instance to Prof. Andrew Salter (tel. 0115 9516120, email Sczams@exmail.nottingham.ac.uk) or Dr Fiona McCullough (tel. 0115 9516121, email sbzfswm@exmail.nottingham.ac.uk). Address: School of Bioscience, The University of Nottingham, Sutton Bonington Campus, Leicestershire, LE12 5RD). If this does not resolve the matter to your satisfaction then please contact the School of Bioscience's Research Ethics Officer, Dr Kate Millar (tel. 0115 951 6303, email Kate.Millar@nottingham.ac.uk), address as above.

Will my taking part in this study be kept confidential?

The results of this study will be kept strictly confidential. Any information about the research participants that leaves the research unit will have names and addresses removed so that you cannot be recognised from it.

What will happen to the results of this study?

The results of this study will be reported in postgraduate research project thesis and may also be written up and submitted for publication in a peer review journal. You are invited to contact the researcher to request a summary of the results once they are available.

Who has reviewed the study?

The School of Biosciences Research Ethics Committee.

Thank you for considering participating in this research.

Appendix M : Participants Consent Form

School of Biosciences

University of Nottingham

Participant Consent Form

<u>"Feasibility of Smartphone application to promote physical activity in Omani female adults"</u>

Gender: Female

Nationality: Omani

Location:……..

In signing this consent form I confirm that:

I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me.	Yes	☐	No	☐
I have had the opportunity to ask questions.	Yes	☐	No	☐
I understand the purpose of the research project and my involvement in it.	Yes	☐	No	☐
I am above 18 years	Yes	☐	No	☐
I understand that my participation is voluntary, and I may withdraw from the research project at any stage, without	Yes	☐	No	☐

having to give any reason and withdrawing will not penalise or disadvantaged me in any way.

I understand that while information gained during the study may be published, any information I provide is confidential (with one exception – see below), and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party. No identifiable personal data will be published. *[If other arrangements have been agreed in relation to identification of research participants (e.g. in a focus group) this point will require amendment to accurately reflect those arrangements]*	Yes	☐	No	☐
I understand that the researcher may be required to report to the authorities any significant harm to a child/young person (up to the age of 18 years) that he/she becomes aware of during the research. I agree that such harm may violate the principle of confidentiality.	Yes	☐	No	☐
I agree that extracts from the interview may be anonymously quoted in any report or publication arising from the research *[Omit if quotes not being used]*	Yes	☐	No	☐
I understand that the interview will be recorded using audiotape/electronic voice recorder/video recorder *[Amend/delete as applicable]*	Yes	☐	No	☐
I understand that data will be securely stored	Yes	☐	No	☐
I understand that the information provided can be used in other research projects which have ethics approval, but that my name and contact information will be removed	Yes	☐	No	☐

before it is made available to other researchers. *[Omit if data will not be used in this way]*

I understand that I may contact the researcher *[*or *supervisor]* if I require further information about the research, and that I may contact the Research Ethics Officer of the School of Biosciences, University of Nottingham, if I wish to make a complaint relating to my involvement in the research. Yes ☐ No ☐

I agree to take part in the above research project. Yes ☐ No ☐

I have no medical history of NCD-Diabetes, Hypertension, Cardiovascular disease. Yes ☐ No ☐

______________________	______________________	____________
Participant's name (BLOCK CAPITAL)	Participant's signature	Date

______________________	______________________	____________
Researcher's name (BLOCK CAPITAL)	Researcher's signature	Date

Appendix N : Participants Preliminary Questionnaire :

Name: **Email:**

<u>"Feasibility of Smartphone application to promote physical activity in Omani female adults"</u>

Participants will be randomly divided into two groups. Group 1 will be asked to download a physical activity application into their mobile and send the step count data from the application to the researcher's email. Group 2 will record their physical activity in a diary and this will be emailed to the researcher. Both groups will keep a food diary for 3 days at the beginning of the study and at the last week of the study, these will be emailed as well. The study is for 5 weeks.

<u>Demographics</u>

Age:

A. 18-29
B. 30-44
C. 45-55

Weight (kg):…………….
Height (cm):…………………..
Education:

A. Elementary school
B. High school graduate
C. Technical or vocational school
D. College graduate
E. Post-graduate studies

<u>Marital Status:</u>

A. Married
B. Single

Employment

A. Unemployed
B. Home duty
C. Retired
D. Manager/ professional
E. Student
F. Self employed
G. Employed

The End of Questionnaire thank you for your participation

Appendix O : Participants Satisfaction Questionnaire

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Evaluation Questionnaire for Pacer App users

1. **Have you used this App before?** *
   - Yes, used this App before
   - No, this is my first time
2. **How easy to see your daily step count?** *
   - very difficult
   - difficult
   - Medium
   - Easy
   - Very easy
3. **How effective this App for you to do physical activity?** *
   - Effective
   - Not effective
4. **Did the App motivate you to increase physical activity?** *
   - Yes
   - No
5. **Do you think combining the App with a wearable device is necessary?** *
   - Yes
   - No
6. **Do you see yourself continuing to use this App or any other App?** *
   - Yes
   - No
7. **Would you recommend using App to a friend?** *
   - Yes
   - No
8. **What was the most helpful feature in this App?** *

....

9. **Do you have any comments?** *

....

Thank you

SUBMIT

Appendix P : Satisfaction questionnaire results

Qyestions	Percentage (%) n=18		
1. Effectiveness of the App	88.9%		11.1%
2. Easiness	83.3% very easy,	5.6% easy	11.1% medium
3.App motivation to do physical activity	94.4% motivated		5.6% not motivated
4. Continuing using the App	88.9% yes		11.1% No
5.Necessity of combining the App with wearable device	88.9 Yes		11.1 No
6. Recommending the App to a friend	88.9% Yes		11.1% No

Answers for questions 1-6

Answers to Q7:

- Step counting
- Can get the data easily
- Providing accurate data
- Easy to add in physical activity
- Saves daily steps and can be found easily by date.
- The dashboard and database of exercise.

Answers to Q8:

- Technical problems
- Add other features such as heart rate.
- Problem arise when not enough battery available on the phone.
- Very useful to those who are carrying their mobile phones.
- Prefer wearable and now using fitbit watch which comes with the App but found pacer easier.