IMPACT OF PHYSICAL ACTIVITY AND DIETARY PROGRAMME ON METABOLIC SYNDROME RISK FACTORS IN SAUDI WOMEN

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ABSTRACT

This thesis explores the impact of lifestyle factors on the development of metabolic syndrome (MS) in Saudi Arabian women. A survey of a snowball sample was used to recruit 258 female and explored factors influencing physical activity (PA) and food intake and their effects on BMI in women living in the KSA and the UK. Participants completed a self-reporting questionnaire relating to knowledge, attitudes, barriers and levels of PA, sedentary activity and eating habits. Excessive energy intake, physical inactivity and sedentary lifestyle were all prevalent in Saudi women, resulting in 80%, over the age of 35y, being overweight or obese. BMI was associated with both energy intake and PA, though the relationship with the former was stronger. The most common barriers to regular exercise were transportation and lack of time. Findings were generally similar between women living in Saudi Arabia and the UK. The efficacy of reducing energy intake, with or without increased PA, on risk factors associated with MS in overweight Saudi women was investigated in a pilot study. After a four-week programme, incorporating dietary modification alone (D) or in combination with regular vigorous aerobic exercise (D+E), improvements were seen in body composition and a range of metabolic risk factors. Both groups lost weight, but, paradoxically, those in D lost significantly more than those in D+E (5.3 vs. 3.3%, p=0.016). Moreover, significant reductions were also found in blood pressure, plasma triacylglycerol, insulin, total and LDL cholesterol, with no significant differences between the two groups. Plasma glucose and HDL cholesterol remained unaltered. Overall, these changes led to a decline in prevalence of MS from 20% to 5% and 21% to 7% for the D and D+E groups, respectively. Thus, reducing energy intake appears, at least in the short term, more important than increasing PA in reducing body weight and associated metabolic risk factors.

These studies confirm that excessive dietary intake and physical inactivity both contribute to overweight and obesity in Saudi Arabian women. With appropriate support, it is possible to both reduce energy intake and increase PA, although, in the short -term, the former appears to be most important. It remains to be established whether longer term improvements in PA would further improve metabolic health.

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ABBREVIATIONS

BMI: Body Mass Index

BP: Blood Pressure

CVD: Cardiovascular Diseases

D: Diet

DASH diet: Dietary Approach to Stop Hypertension

DBP: Diastolic Blood Pressure

DE: Diet plus Exercise

DRVs: Dietary Reference Values

EAR: Estimated Average Requirement

EMR: Eastern Mediterranean Region

FBG: Fasting Blood Glucose

FFA: Free Fatty Acid

HDL: High Density Lipoprotein

HOMA-IR: Homeostatic Model of Insulin Resistance

IDF: International Diabetes Federation

IR: Insulin Resistance

KSA: Kingdom of Saudi Arabia

LDL: low Density Lipoprotein

MS: Metabolic Syndrome

PA: Physical Activity

RNI: Reference Nutrient Intake

SBP: Systolic Blood Pressure

TAG: Triacylglycerol

T2D: Type 2 Diabetes

TC: Total Cholesterol

UAE: United Arab Emirates

VAT: Visceral Adipose Tissue

WC: Waist Circumference

WHO: World Health Organization

W-SA: Women Living in Saudi Arabia

W-UK: Women Living in the UK

CHAPTER ONE

METABOLIC SYNDROME HEALTH CONSEQUENCES AND TREATMENT

1.1. Obesity prevalence and burden of related diseases

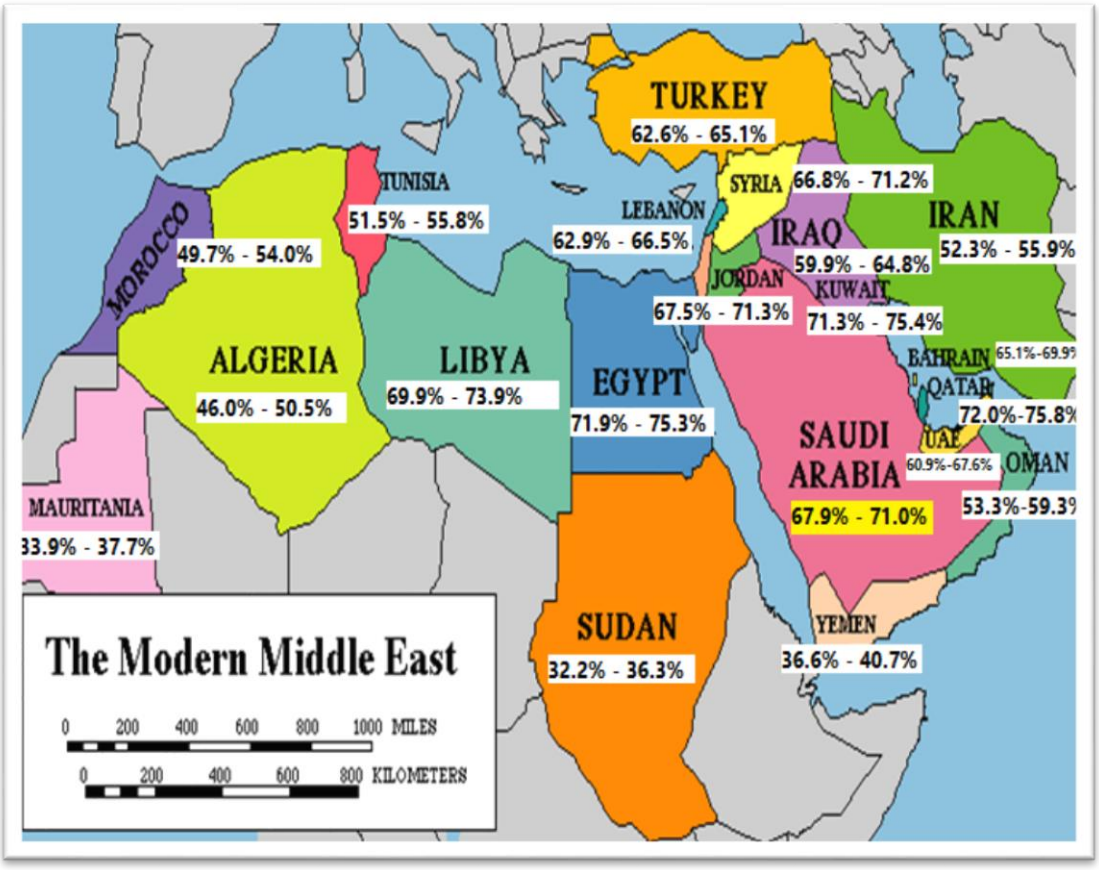
Globesity is a blend of the expression 'global obesity' and was coined by the WHO to emphasise that obesity is considered a worldwide phenomenon occurring throughout both developed and developing countries (WHO, 2015a). The worldwide spread of obesity has reached pandemic proportions; 39% of the global population (38% of males and 40% of females) is overweight and 13% (11% of males and 15% of females) are obese. Although obesity can be prevented, the rates of obesity continue to escalate, with the worldwide prevalence of obesity more than doubling between 1980 and 2014 (WHO, 2015b). It is expected that almost half of the world's adult population will be overweight or obese by 2030 (Heasman, 2014). The consequences of obesity include an increased incidence of metabolic syndrome (MS), type 2 diabetes (T2D) and hypertension and it is considered an independent risk factor for coronary artery disease (CAD) (WHO, 2015c). Cardiovascular diseases (CVD) are the number one cause of death globally, accounting for 17.3 million deaths per capita, a number that is projected to grow to more than 23.6 million by 2030 (Mozaffarian et al., 2015; WHO, 2015c). Additionally, the total number of the population with diabetes is expected to increase from 425 million in 2017 to 629 million in 2045 (IDF, 2017).

The Middle East, including the Arabian Peninsula, Eastern Mediterranean, Turkey and Iran, and North Africa, has seen the highest rates of overweight and obesity (see Figure 1.1), where more than 58% of males and 65% of females were found to be either overweight or obese (IDF, 2013a). Cardiovascular events are also on the rise among the Arab Middle East population, causing 45% of early deaths in the Gulf region (European Society of Cardiology, 2013). There were 38.7 million adults with diabetes in the Middle East and North Africa (MENA) in 2017 and, by 2040, this is predicted to double to 72.1 million (IDF, 2017).

Similarly, Kingdom of Saudi Arabia (KSA) has one of the highest rates of obesity in the

world, particularly in women (see Table 1.1). Findings from national surveys conducted between 1996 and 2011 showed that, over a period of ten years, the prevalence of obesity in women increased from 23.6% to 44.0% (AlQuaiz et al., 2014). The KSA is also facing an epidemic of CVD, causing 46% of early deaths (WHO, 2014). According to IDF, the KSA was among the top 10 countries globally with the highest projected prevalence of diabetes in 2011 (16.2%) and 2030 (20.8%) (Al-Quwaidhi et al., 2014).

Figure 1.1: Overweight and obesity prevalence (BMI≥25) in Middle East for adult males and females, respectively (20+), in 2013



(Vizhub.healthdata.org, 2013)

Table 1.1: Global Obesity Rates

Economist.com rankings

Highest obesity*

	Men, % of total population		Women, % of total population	
1	Lebanon	36.3	Qatar	45.3
2	Qatar	34.6	Saudi Arabia	44.0
3	Kuwait	32.8	West Bank and Gaza	42.5
4	Panama	27.9	Lebanon	38.3
5	United States	27.7	Panama	36.1
6	Cyprus	26.6	Albania	35.6
7	Saudi Arabia	26.4	Bahrain	34.1
8	West Bank and Gaza	23.9	United States	34.0
9	Bahrain	23.3	Egypt	32.4
10	Albania	22.8	United Arab Emirates	31.4
11	England	22.7	Iran	30.0
12	Germany	22.5	Kuwait	29.9
13	Scotland	22.3	Turkey	29.4
14	Ireland	20.1	Mexico	29.0
15	Israel	19.9	Scotland	26.0
16	Mexico	19.4	Israel	25.7
17	Australia	19.3	Mongolia	24.6
18	United Arab Emirates	17.1	Jamaica	23.9
19	Wales	17.0	England	23.8
20	Oman	16.7	Cyprus	23.7
21	Slovenia	16.5	Germany	23.3
	Turkey	16.5	22 Oman	23.1
23	Lithuania	16.2	23 Peru	23.0
24	Canada	16.0	24 Australia	22.2
	Peru	16.0	25 Morocco	21.7
26	Luxembourg	15.3	26 Russia	21.6
27	Sweden	14.8	27 Trinidad & Tobago	21.1
28	Portugal	14.5	28 Fiji	19.3
29	Switzerland	14.1	29 Mauritania	19.2
30	Mongolia	13.8	30 Wales	18.0

* Data for these health rankings refer to the latest year available, 1999-2003. Obesity is defined as body-mass index of 30 or more

Source: "Pocket World in Figures", based on data from the World Health Organisation

(The Economist, 2007)

1.2. Metabolic Syndrome in the KSA

As already indicated, MS is a common consequence of obesity. Epidemiological and pathological data indicate that MS is associated with increased risk for CVD and T2D (Shin et al., 2013; Gosadi, 2016). MS is of great importance, as it commonly precedes the development of T2D by many years and the risk factors that constitute this syndrome contribute independently to CVD risk. Therefore, MS is a useful practical tool to predict these two major metabolic disorders (Shin et al., 2013).

MS is identified as a constellation of metabolic risk factors that are associated with increased risk for developing CVD and T2D (Sayon-Orea et al., 2014). The principal cause of MS is central obesity, being overweight with adipose tissue accumulation mainly around the waist. This results in the development of a range of risk factors for CVD/T2D including: impaired fasting glucose, insulin resistance (IR), elevated triacylglycerol (TAG) level, high blood pressure (BP) and decreased high density lipoprotein cholesterol (HDL) (IDF, 2006).

The prevalence of MS has dramatically increased over the last few decades and has become a worldwide pandemic. It is estimated that about 20%-25% of the world's adult population has MS (Stern et al., 2004). People with MS are three times as likely to have a heart attack or stroke, and are twice as likely to die from these conditions compared with people without the syndrome. Additionally, people with MS have a fivefold greater risk of developing T2D (Stern et al., 2004). The prediction that the incidence of diabetes will double by 2025 seems likely to parallel the rise in cardiovascular-related diseases and death (IDF, 2013b).

MS is an important and increasingly common public health problem in the Middle East. It affects about one in four people and prevalence increases with age (Sliem et al., 2012). A systematic review study, documenting the prevalence of MS among males and females in some of the Arabian Gulf countries (Saudi Arabia, Bahrain, Kuwait, Qatar, Oman and the United Arab Emirates), reported that, for females, the prevalence of MS was 32.1%-42.7%, as defined by the Adult Treatment Panel (ATP) III, and 36.1% -45.9% based on the IDF definition. For males, it was 20.7%-37.2%, based on the ATPIII definition, and from 29.6%-36.2% according to the IDF definition (Mabry

et al., 2010b). It is also pointed out that the prevalence of MS in these countries is about 10%–15% higher than in most developed countries, with a higher prevalence among females (Musaiger et al., 2012).

Epidemiological studies in the KSA have also suggested an increased prevalence of MS for adults. According to the National Epidemiological Health Survey, the prevalence of MS among the Saudi population has been reported to be approximately 40%, with higher prevalence in females compared to males (42% vs. 37.2%) (Al-Nozha et al., 2005), and studies predict a sharp increase in the prevalence rates of the syndrome among Saudi females during the next few years (Al-Qahtani et al., 2006).

1.3. Pathogenesis of the Metabolic Syndrome

The pathogenesis of the MS is not yet fully understood. It is believed that obesity and IR are the two key players in the pathophysiology of MS (Cornier et al., 2008; Stuckey et al., 2015). Obesity is considered the main determinant of IR (Chiarelli and Marcovecchio, 2008). Body fat distribution is recognised as an important predictor of the adverse health consequences of obesity, with growing evidence that abdominal visceral fat plays a more important role in the development of IR than overall body fatness (Caprio et al., 1995). Guilherme et al. (2008) demonstrated that the amount of visceral fat was directly correlated with basal and glucose-stimulated insulin levels and inversely correlated with insulin sensitivity and the rate of glucose uptake. Conversely, little correlation was observed between abdominal subcutaneous fat and the same metabolic indices (Boulton et al., 1995).

According to the 'portal theory', these results could be related to a higher lipolytic activity of visceral fat adipocytes compared with subcutaneous fat cells, resulting in a higher turnover rate of free fatty acids (FFA) and glycerol delivered directly to the liver (Cornier et al., 2008). Ectopic deposition of fat in the liver or muscle can also lead to IR in obese individuals (Weiss and Kaufman, 2008). In muscle, increased plasma FFA disrupts the glucose-fatty acid cycle and has an inhibitory influence on insulin-mediated glucose transport (Cornier et al., 2008). Moreover, increased FFA plasma levels have been shown to impair hepatic insulin action, increasing glucose output and the synthesis of proinflammatory cytokines, as well as altering lipoprotein metabolism

(Cornier et al., 2008). The accumulation of fat deposits in the liver and muscle impairs insulin signalling, with reduced glucose uptake in the muscle and decreased insulin-mediated suppression of hepatic glucose production (Weiss and Kaufman, 2008). In addition to abdominal visceral obesity and IR, other factors have been identified as potential contributors to the pathophysiology of the MS, including maternal obesity, gestational diabetes, ethnicity, birth weight and family history of diabetes, as well as genetic factors (Cornier et al., 2008).

1.4. The role of diet and exercise in the treatment of the metabolic syndrome

1.4.1. Effects of exercise and diet on weight reduction

The cornerstone of therapeutic interventions to treat or prevent MS is weight loss via lifestyle modification, including hypocaloric diet and/or increased physical activity (PA), along with behavioural techniques to support these changes (Foster-Schubert et al., 2012). Epidemiological prospective studies and clinical trials have shown that even a modest weight reduction of 5%-10% is associated with preferential mobilisation of visceral adipose tissue (VAT), leading to simultaneous improvement in all metabolic markers of coronary heart disease risk. Thus, simultaneous metabolic improvements associated with mobilisation of VAT may contribute substantially to reduced risk of acute coronary event in high risk patients (Despres et al., 2001; Rappou et al., 2016). In a short-term randomised controlled trial, for each 1kg of weight lost, the likelihood of MS was reduced by 8% in obese males and females (Phelan et al., 2007).

Numerous studies have confirmed that achieving changes in people's patterns of PA and diet remains the central goal of all treatment programmes, due to the salutary effects of moderate activity and a varied, balanced diet on health and longevity (Kaur, 2014). The UK Department of Health (Miles, 2007), the US health organisations (Haskell et al., 2007) and the World Health Organisation (WHO, 2010) advocate 45–60 minutes of moderate intensity PA a day to prevent obesity, and at least 30 minutes of moderate intensity PA on most days of the week to reduce the risk of CVD, diabetes and breast and colon cancer.

In meta-analysis, increasing the amount of exercise to about 30 minutes per day contributed to approximately 2kg weight loss after one year (Franz et al., 2007). Despite only a small effect on body weight loss per se, PA has other well-established health benefits. Physically active women and men of all ages have a lower mortality rate compared to inactive individuals (Pedersen, 2007). Moreover, exercise alone, or in combination with weight loss and dietary interventions, has been shown to reduce the incidence of T2D and improve the metabolic risk factors associated with MS (Kaur, 2014; Blackford et al., 2015). In addition, studies have consistently shown that subjects participating in high levels of PA have improved weight loss maintenance compared to subjects with lower levels of PA (Jakicic et al., 2008; Lin et al., 2015). Aerobic exercise improves CVD risk markers and body composition independent of weight reduction in overweight or obese subjects (Wiklund et al., 2014). Resistance training on its own is beneficial for improving sensitivity to insulin as well as increasing the amount of lean body mass, thereby increasing the basal metabolic rate (Caponi et al., 2013). The combination of aerobic and resistance exercise training reportedly has a synergistic impact on improving metabolic components, IR, reproductive functionality and reducing abdominal fat in obese people (Wiklund et al., 2014; Matsuo et al., 2015).

Dietary change seems to play a larger role in the achievement of initial weight loss than PA. Meta-analyses showed that randomised controlled trials comparing dietary counselling-based weight loss programmes with usual care interventions produced a mean net weight loss of approximately 5kg after one year, of which about half was maintained after three years (Dansinger et al., 2007; Franz et al., 2007). The optimal dietary macronutrient composition for weight loss purposes has not been clearly demonstrated (Franz et al., 2007). Studies comparing various dietary compositions for the purpose of weight loss have given divergent results (Dansinger et al., 2005; Gardner et al., 2007). Some authors found that dietary composition did not seem to influence weight loss (Dansinger et al., 2005), while others have reported superior effects of a low carbohydrate diet during one year of treatment (Gardner et al., 2007). A meta-analysis showed that carbohydrate-reduced diets achieved greater initial

weight losses, but no difference between diets could be demonstrated after one year (Nordmann et al., 2006).

While lowering the glycaemic index and load of the diet has received much recent attention as an approach to weight loss, conflicting reports have appeared (Thomas et al., 2007; Aston et al., 2008) as to its efficacy. Meta-analysis has shown that diets emphasising carbohydrates with a low glycaemic index improved weight loss by about 1kg compared to higher glycaemic carbohydrates (Thomas et al., 2007). On the other hand, a well-controlled study, in which most foods were provided to participants, found no advantage of a diet with a low glycaemic index on weight loss, dietary intake or appetite ratings (Aston et al., 2008). Evidence does exist indicating that short-term weight loss and maintenance are improved when low fat, high protein sources of energy replace carbohydrates (Paddon-Jones et al., 2008). For improved long-term weight maintenance, a reduction in fat intake has been shown to be effective in a number of studies (Howard et al., 2006; Phelan et al., 2006; Jakicic et al., 2008). However, in a well-controlled dietary intervention study, a low-carbohydrate diet and a Mediterranean diet were superior to a low fat diet after two years (Shai et al., 2008). In this regard, it has to be noted that the low carbohydrate diet was not energy-restricted, while the two other diets were.

The debate about whether PA or diet modification is more efficient in combating obesity and MS has become a controversial issue. Comparison studies between exercise, diet intervention and controlling MS conditions reported that exercise plus diet had more success in the treatment of MS than exercise or diet alone (Anderssen et al., 2007; Okura et al., 2007). Studies have indicated that obese adults can decrease their chance of developing MS by losing weight through dieting alone, but adding physical exercise to a weight loss programme has much more benefit. According to *Exercise with diet improves insulin sensitivity much more than diet alone*, a report by the Endocrine Society, a combination of diet-induced weight loss and regular exercise almost doubled the improvement in insulin sensitivity compared to dieting alone (LifeExtension, 2012), while, according to Casazza et al. (2009), diet composition was more closely related to MS components than physical exercise and carbohydrate consumption was adversely related to waist circumference (WC), TAG and glucose

levels. Another study found that the insulin sensitivity index improved in 70% of individuals in the diet group and in 86% of those in the diet plus exercise group, but improvements were not seen in the exercise only or control groups (Nancy, 2012). On the other hand, a study by Alshehri (2010) reported that walking or light jogging for an hour every day can produce significant loss of abdominal fat without caloric restriction.

Dietitians play a key role in the prevention and management of obesity and nutrition-related disease. Studies have demonstrated that registered dietitians' education and counselling on diet-related patient outcomes were more effective than general education provided by the cardiac rehabilitation staff. The results showed significant ($p<0.05$) improvements in the dietitian group, compared with the general education group, in BMI, WC, low density lipoprotein cholesterol (LDL), TAG and total cholesterol (TC) (Holmes et al., 2005; Agostini et al., 2016). Studies have also shown that dietary advice given by a dietitian plays an important role in modifying dietary behaviour and individuals' health. Metaanalyses have shown that randomised controlled trials comparing weight loss programmes based on dietary counselling with usual care interventions produced a mean net weight loss of about 5kg after one year, of which about half was maintained after three years (Dansinger et al., 2007; Franz et al., 2007). It has been reported that subjects receiving advice from dietitians experienced a greater reduction in blood cholesterol than those receiving advice only from doctors (-0.25 mmol/L [95% CI, -0.37, -0.12 mmol/L]) (Thompson et al., 2003; Agostini et al., 2016). The evidence suggests that more specific dietary advice to modify intake of fat sources, particularly dietary saturated fat, and increased consumption of fruit and vegetables is probably necessary for combating chronic disease risk (Ammerman et al., 2002; Spyreli, 2015).

A randomised clinical trial found that women given dietary advice to reduce fat and increase intake of vegetables and fruit lost 1.5kg more weight and reported fewer feelings of hunger compared to women that were given advice to eat a low fat diet without increasing intake of vegetables and fruit (Ello-Martin et al., 2007). It has been suggested that diets which include at least five servings of fruit and vegetables daily and having an average negative energy balance of 500 calories per day resulted in

weight loss of 7%-10% and were sufficient to have a significant impact on the components of MS and prevent the development of diabetes (Bednarzyk, 2009).

Other studies have proved that patients with MS who were advised to undertake the DASH (Dietary Approaches to Stop Hypertension) diet were able to raise their HDL cholesterol and experienced a significant reduction in BP, lowered their blood sugar and TAG levels, and even lost weight, after six weeks. The DASH diet includes a variety of vegetables and fruit, whole grains, poultry, fish and nuts while avoiding foods and drinks that are high in added sugars, saturated fats and red meat, as well as the choice and preparation of foods with less sodium (salt) (Azadbakht et al., 2005; Soltani et al., 2016).

It is also proved that participants who followed the Mediterranean diet pattern showed a reduction in blood sugar levels and abdominal obesity, in addition to 28.2% of the participants with MS on the diet who no longer met the criteria at the end of the study (Babio et al., 2014). Another study also reported that adherence to healthy lifestyle practices, such as a Mediterranean style diet, was associated with about 70% decrease in chronic disease (Knoops et al., 2004; Salas-Salvado et al., 2016). The Mediterranean diet is naturally low in saturated fat, such as that found in meat and butter, high in fruit, vegetables, whole grains and legumes, and has an emphasis on monounsaturated fat (olive oil, nuts, avocado, etc.) and seafood rich in Omega-3 fatty acids (American Heart Association, 2014; Salas-Salvado et al., 2016). The success of these trials appears dependent on the availability of intensive counselling and adherence to the intervention. In that regard, adherence remains an issue of concern when treatment involves diet and/or PA, with greater adherence being associated with greater improvement in the MS components (Fappa et al., 2008). It has also been shown that level of adherence to nutritional advice, rather than type of diet, was the main determinant of greater weight loss and CVD risk factors reduction (Desroches et al., 2013).

A number of studies have recently investigated the use of new technologies, (frequently involving Internet use) in delivering nutritional advice. A systematic review aimed to compare the effects of such interventions for enhancing adherence to dietary advice for the prevention of chronic diseases in adults. Some interventions,

such as telephone follow-up, video, contacts, feedback and nutritional tools, demonstrated a mixed effect on diet adherence, as it was found that some diet adherence outcomes favoured the intervention group compared to the control group (Desroches et al., 2013). By the same token, a study by Brandt et al. (2011) investigated the effect of advice from an intensive online dietitian, combined with a community intervention, in promoting weight loss and optimising healthy behaviours and found a reduction in the mean weight loss among obese people from a baseline of 7.0kg after a mean maintenance period of 20 months. More recently, Jacobs et al. (2016) found that use of a Smartphone app, 'Noom' (a Smartphone-based behavioural weight loss programme), was linked to significant short-term weight loss and improved adherence to the dietary regime. An average 1.92 BMI points were lost after three months of using Noom and, for every 10% increase in adherence, there was a decrease of 2.59 BMI points. A pilot study showed that, at six months of the intervention, mean weight change was significantly greater in the Smartphone app 'My Meal Mate' group (–4.6kg) as compared to the slimming website Weight Loss Resources group (–1.3kg) and to the paper diary group (–2.9kg) ($p=0.004$) (Carter et al., 2013). Sherrington et al. (2016) suggest that personalised feedback may be an important behaviour change technique to incorporate within Internet-delivered weight loss interventions. Participants who received personalised feedback via Internet-delivered interventions had 2.13kg mean difference greater weight loss in comparison with control groups providing no personalised feedback. This was also true for results at three and six-month time points, but not for studies where interventions lasted ≥12 months (Sherrington et al., 2016). Evidence suggests that, over a period of six months, lifestyle counselling by phone was more effective than e-mail for weight management in overweight employees. Body weight reduced 1.5kg in the phone group and 0.6kg in the Internet group, compared with control group (usual care group in the form of lifestyle brochures). Furthermore, counselling by phone was effective for reducing fat intake and increasing PA (Van Wier et al., 2009; Sherrington et al., 2016).

1.4.1.1. Effects of exercise and diet on waist circumference, visceral and subcutaneous adipose tissue

Central obesity is a key feature of MS, reflecting the fact that the prevalence of MS is driven by the strong relationship between WC and increased adiposity (Shah et al., 2014). Many studies have shown that WC is a better predictor of total abdominal fat than the Waist to Hip Ratio (Wang et al., 2005) since it was found to be more strongly correlated with visceral fat (Kawada et al., 2016). Total abdominal fat has been described as the sum of the fat or adipose tissue present in three compartments of the body's abdominal region: subcutaneous, visceral and retroperitoneal. Analytical studies on the relationship of external to internal adipose tissue have shown that each kilogram of subcutaneous adipose tissue is associated with approximately 200 grams of internal adipose tissue and that skinfolds are significantly correlated with total adiposity. Due to differences in body composition between men and women, the age-related increase in body fat mass, the decrease in fat-free mass (Lee and Nieman, 2013; Chamieh, 2013) and the relationship between body fat percentage and BMI are sex- and age-dependent (Lee and Nieman, 2013). In adult males with an average weight, the percentage of body fat is in the order of 15%-20%, whereas, in females, this percentage is higher and in the range of 25%-30% (Lee and Nieman, 2013; Chamieh, 2013). Reference cut-off points of body fat percentage greater or equal to 25% in males and greater or equal to 32% in females are considered unhealthy (Lee and Nieman, 2013; Chamieh, 2013).

In men and women, WC levels equal to or greater than 94cm and 80cm, respectively, indicate increased risk and levels at 102cm and 88cm indicate greatly increased risk (WHO, 2003a). Abdominal adiposity is strongly associated with IR and creates an atherogenic inflammatory milieu. High levels of these biomarkers correlate with increased risk of T2D and CVD. A slight decline in body weight can significantly decrease abdominal adipose tissue, IR, LDL and TAG and reduce cardiometabolic risk (Shah et al., 2014)

Numerous studies have shown that the risk of various metabolic disorders, as well as death, is increased in people with abdominal obesity, even when BMI is not markedly increased (Despres, 2012; Popa et al., 2016). A recent study reported that patients

with visceral obesity had higher prevalence of MS (81.6% vs. 54.6%; p=0.004) and higher prevalence of high BP (68.8% vs. 31.3%; p=0.002) and T2D (42.9% vs. 16.7%; p=0.19). Patients with visceral obesity also had higher total abdominal adiposity (884 vs. 765 cm^2; p<0.001) and higher VAT/total adipose tissue ratio (32% vs. 20%; p<0.001) (Faria et al., 2015).

The recent finding that adipose tissue is an 'active' tissue that exclusively secretes a number of proteins, the so-called adipocytokines, has provided a new hypothesis on the pathophysiology of T2D (Coelho et al., 2013). Adipose-derived proteins, such as adiponectin and leptin, have been shown to contribute to a number of metabolic defects, such as hyperinsulinaemia, IR, hyperglycaemia and dyslipidaemia, when their concentrations are out of their 'normal' range (elevated concentrations for leptin and decreased concentrations for adiponectin) (Coelho et al., 2013). In healthy individuals, it appears that diet and/or exercise-induced weight loss results in reductions in leptin levels and increases in adiponectin levels (Rolland et al., 2011; Golbidi and Laher, 2014). Elevated levels of C-reactive protein, tumour necrosis factor-a (TNF-a) and interleukin 6(IL-6), prominent markers of chronic low- grade inflammation in the human body, have been associated with obesity, T2D and CVD by epidemiological studies, and have been posited to provide the 'common link' between these closely connected chronic diseases. Individuals with elevated levels of these cytokines have been shown to have an increased future risk as well as an increased incidence of T2D (Rolland et al., 2011; Golbidi and Laher, 2014). Diet and/or exercise appears to lower the elevated levels of plasma C-reactive protein, tumour necrosis factor-alpha (TNF-alpha) and interleukin-6 (IL-6) in healthy individuals. Further, the low-grade inflammation has adverse effects on the metabolic control (Rolland et al., 2011; Coelho et al., 2013; Golbidi and Laher, 2014).

Several studies have examined the relationship between lifestyle factors, including dietary quality and PA, on body composition and central obesity (Rolland et al., 2011; Shah et al., 2014; Faria et al., 2015). More recent studies have reported that decreased carbohydrate intake was significantly associated with VAT loss in men with T2D (Gepner et al., 2016). Findings from a large population-based cohort of males and females free of CVD showed that a diet consistent with recommended dietary

guidelines and enhanced PA was associated with lower volumes of subcutaneous and VAT in both sexes (Molenaar et al., 2009; Golbidi and Laher, 2014). These findings are comparable to those from other large and cross-sectional studies that demonstrated a considerable decrease in WC occurring with changes in a combination of lifestyle factors (Rolland et al., 2011; Golbidi and Laher, 2014). Researchers have also shown that cardiorespiratory fitness, accomplished through regular exercise, is associated with a reduction in abdominal obesity, in particular visceral fat, independent of any change in BMI, in both males and females (Rolland et al., 2011; Coelho et al., 2013; Golbidi and Laher, 2014).

Diet and exercise, both individually and combined, are considered the two major cornerstones for both prevention and treatment of T2D in obese individuals (Rolland et al., 2011; Blackford et al., 2015). Weight loss studies in healthy obese young individuals have demonstrated reductions in abdominal fat distribution, particularly in the VAT depot (Coelho et al., 2013; Golbidi and Laher, 2014). These changes in abdominal fat have also been associated with improvements in insulin sensitivity (Rolland et al., 2011; Golbidi and Laher, 2014). In addition, exercise without weight loss has been shown to alter abdominal fat (Shah et al., 2014; Faria et al., 2015). Unlike healthy obese individuals, obese T2D individuals have higher levels of subcutaneous adipose tissue (Rolland et al., 2011; Coelho et al., 2013) and this may potentially influence the pattern of abdominal fat loss with diet and/or exercise (Coelho et al., 2013).

A systematic literature search which included studies using CT or MRI imaging to assess VAT reported that moderate or high intensity aerobic training has the highest potential to reduce VAT in overweight men and women. These results suggested that an aerobic exercise programme, without hypocaloric diet, can show beneficial effects to reduce VAT with more than 30cm² (on CT analysis) in females and more than 40cm² in males after 12 weeks (Vissers et al., 2013).

1.4.2. Effects of diet and exercise on metabolic syndrome components

1.4.2.1. Effects of exercise and diet on insulin resistance

Insulin resistance plays a key role in the pathophysiology of MS and the alternative term of 'insulin resistance syndrome' has been used by some experts (Sharma et al., 2014). Individuals with IR are at greatly increased risk of developing heart disease, T2D, high BP, stroke, non-alcoholic fatty liver disease, polycystic ovary syndrome and certain forms of cancer (Baldani et al., 2015; Stuckey et el., 2015).

While there is no drug treatment that directly treats the underlying IR in MS, diet modification and exercise have been advocated as ways of improving insulin sensitivity (Roberts et al., 2013). Some studies suggest that a diet high in total saturated and trans fatty acids might promote IR (Morio et al., 2016). Research has also indicated that replacing saturated fatty acids with monounsaturated or polyunsaturated fatty acids can improve insulin sensitivity, but only if total fat intake is also controlled (Rubin, 2013). In the SLIM study, *Lifestyle Intervention on Postprandial Glucose Metabolism*, researchers demonstrated improved glucose tolerance and insulin sensitivity among subjects who reduced their intake of both saturated and total fats (Corpeleijn et al., 2006). The benefits of decreased saturated fatty acids intake were noted only in those with a total fat intake of less than 35% of calories (Corpeleijn et al., 2006; Rubin, 2013).

Interestingly, some research suggests that caloric restriction, rather than amount and type of fat, is more important in promoting visceral fat loss and alleviating IR. A randomised controlled study compared the effects of a low-fat diet (60% of energy from carbohydrate and 20% of energy from fat) with a low-carbohydrate diet (20% of energy from carbohydrate and 60% of energy from fat) on weight reduction and IR in overweight/obese adults (Bradley et al., 2009). Diets were designed on an individual basis to facilitate a weekly 0.5-kg weight loss. At the end of eight -weeks, both groups had lost an average of 7% of their initial body weight and demonstrated similar reductions in both WC and body fat proportion. Both groups experienced comparable improvements in IR, which was attributed to weight loss per se, rather than the specific macronutrient makeup of the diets. Thus, questions remain regarding the

relative contributions of individual macronutrients and weight loss to the reversal of IR (Bradley et al., 2009; Rubin, 2013). Choosing carbohydrate-dense foods that are low on the glycaemic index may also have beneficial effects, particularly when combined with a reduction in calories and regular PA. Kirwan et al. (2009) proved that combining a low-glycaemic diet with PA resulted in a greater decrease in IR in older obese adults than did PA and calorie reduction without regard to glycaemic index (Kirwan et al., 2009).

There is substantial literature showing improved insulin sensitivity after PA, both with and independent of body weight loss (Yassine et al., 2009). There is debate about the best PA prescription to maximise insulin sensitivity in different populations, but both regular aerobic exercise and resistance training have been suggested to confer beneficial results (Rubin, 2013). Heijden et al. (2010) showed that a 12-week period of moderate aerobic exercise training (two days/week, 30 minutes/session, ≥70% of VO2 peak) resulted in decreased IR in post-pubertal obese subjects. In fact, the decreased fasting insulin was significantly associated with decreased visceral adiposity. Evidence found that a regular moderate to vigorous exercise programme (a 40-minute workout at up to 75% maximum heart rate, 4-6 times/week for 16-weeks) enhanced not only insulin sensitivity, but also the capacity of obese middle-aged participants to burn fat, especially in those who also lost weight (Rubin, 2013). In addition, Finucane et al. (2010) found that aerobic exercise intervention significantly increased aerobic fitness and weight loss, reduced WC and saw a 68% reduction in prevalence of abnormal glucose metabolism.

A regular exercise programme conducted three to five times a week for 30 to 60 minutes at lower intensity than is typical for cardiovascular fitness has shown metabolic benefits (Carroll and Dudfield, 2004). Aerobic exercise and dietary studies found that PA lowers BP and improves fasting blood glucose (FBG) in obese, sedentary IR subjects. This intervention produced a 9% overall reduction in weight and reduced body fat by 21% (Carroll and Dudfield, 2004). In sedentary overweight European and South Asian men and women, exercise training consisting of 45 minutes sessions of walking or jogging and one supervised aerobic circuit training session produced no body weight change, but insulin sensitivity was improved by 40% (Carroll and Dudfield,

2004). Another study found that nine months of exercise training alone increased maximal aerobic capacity by 14% in obese middle-aged and older men without a significant change in body weight, oral glucose tolerance response, lipids, or BP. Hypocaloric diets and weight loss also improve IR. When dietary changes or exercise induce an 8% weight reduction, insulin sensitivity improves up to 60% (Carroll and Dudfield, 2004).

1.4.2.2. Effects of exercise and diet on dyslipidaemia

It has long been established that amount and type of dietary fat has an impact on plasma total and LDL cholesterol. In general, saturated fatty acids increase LDL cholesterol while unsaturated, particularly polyunsaturated fatty acids, reduce it (Siri-Tarino et al., 2015). However, dietary fat may also impact on the dyslipidaemia-associated MS, namely high plasma TAG and low HDL-C (Finelli et al., 2016; Sonestedt et al.,2016). A recent systematic review of the effects of Mediterranean diet on diabetes control and CVD risk modification showed an improvement in SBP, HDL-C, ratio of TC to HDL, and TAG level in diabetics, as well as a significant weight loss, when compared to a control diet (Sleiman et al., 2015). Estruch et al. (2006) demonstrated similar results relating to SBP and cholesterol/HDL ratio after three months of randomising 772 asymptomatic patients, of which 50% were diabetics, to either Mediterranean or low-fat diet.

Despite diet being the first line of treatment, some studies have investigated the independent influence of exercise on blood lipids (Zapata-Lamana et al., 2015). Available evidence indicates that approximately 60 minutes of moderate intensity endurance exercise on most days of the week can produce 5% increase in HDL cholesterol and 15% decrease in TAG levels, a beneficial shift in the distribution of LDL size and a 4mmHg reduction in both systolic and diastolic BP (International Chair on Cardiometabolic Risk, 2014). Another study found an increase in HDL-C concentration (+17.2%, $p<0.01$) and a decrease in TAG concentration (-11.6%, $p<0.05$) after an eight-week aerobic exercise intervention compared to the control group (Frappier, 2015). This specific exercise programme consisted of four weekly 90-minute sessions of running, jumping and playing ball at an intensity of about 66% of VO2peak (Frappier, 2015). Similarly, a further study showed that five weekly 40-minute sessions, for a

period of six weeks, significantly decreased TAG concentrations (1.6 ± 0.2mmol/l to 0.8 ± 0.1mmol/l; $p<0.05$) compared to pre-training concentrations. However, no changes in TC or HDL-C concentrations were observed (Kim et al.,2007).

Likewise, Greenwood et al. (2016) reported that, in comparison with moderate exercisers and inactive women, vigorous exercisers had lower BMI and lower HOMA-IR, higher levels of HDL-C and a reduced prevalence of MS. The effects of exercise training on blood lipids and lipoproteins appear even after one acute bout of exercise, which increases hydrolysis of triacylglycerol (lipolysis) in the adipose tissue and oxidation of lipids in the skeletal muscle (Fogelholm et al., 2006; Lakka and Laaksonen, 2007; Kauko, 2010). An acute bout, as well as regular aerobic exercise, affects blood lipid concentration by increasing HDL by about 5% from the starting-point and decreasing LDL by 5% and TAG by 4%. These impacts are individual, depending on genes and the body's response to exercise. These impacts might be the mechanism by which exercise decreases the risk of CVD (Fogelholm et al., 2006; Lakka and Laaksonen, 2007; Kauko, 2010). The impact of exercise training on blood lipids and lipoproteins may be associated with the elevated energy intake of muscles during, and the body's elevated basal metabolism after, exercise (Fogelholm et al., 2006; Kauko, 2010).

1.4.2.3. Effects of exercise and diet on hypertension

Hypertension is a well established metabolic disorder presented in more than half of those with MS and, in the setting of IR, high BP is shown to be an important risk factor (Mastidia, 2011). About 25% to 33% of normal weight hypertensive individuals also suffer from IR. A 3% to 9% loss in weight is correlated with a mean reduction of SBP and DBP of about 3.0mmHg (Kirby, 2009). It is estimated that 5mmHg reduction of SBP across the general population would result in overall reductions of 9% in coronary heart disease mortality, 14% in stroke mortality and 7% in all-cause mortality (Kaur, 2014).

Mild elevations of BP often can be effectively controlled by lifestyle therapies. Studies in adults have often demonstrated the lowering effect of regular exercise on SBP and DBP. Meyer et al. (2006) found a significant decrease in SBP (117.0 ± 7.1mmHg to 113.1 ± 7.7mmHg; $p<0.05$) compared with a non-exercising control group (121.0 ±

9.4mmHg to 121.0 ± 8.6mmHg) after a six-month intervention in 47 boys and 49 girls. In another study, compared to a control group, Ben Ounis et al. (2010) showed a significant reduction in SBP and DBP (-7.6% and -10.9%, respectively; $p<0.01$) after an eight-week aerobic intervention (four sessions/week, 90minute/session) at an intensity of 66% of VO2peak. Mean SBP baseline values were >130mmHg for both groups, suggesting that hypertension in youth can be prevented/treated with aerobic exercise training.

However, not all studies have demonstrated positive effects of exercise on BP. After an eight-week aerobic training programme, Kelly et al. (2004) found no significant differences in SBP and DBP without weight loss in young obese subjects. Similar results were observed after a six-week jump rope intervention among obese Korean participants (Kim et al., 2007). Limiting factors, such as short studies and normal mean baseline BP values, may explain these lack of effects.

The potential of dietary changes to lower BP was clearly demonstrated in 'the DASH study' (Soltani et al., 2016). A low fat diet with increased consumption of vegetables and fruit, whole grain and low fat dairy products substantially decreased SBP and DBP compared with a control diet (Gulseth et al., 2010; Soltani et al., 2016). Another study found that patients with MS who were advised to undertake the DASH diet were able to significantly reduce their BP after six weeks (Azadbakht et al., 2005). In a subgroup analysis of the DASH trial to examine the impact of study diets on BP in subjects with and without MS, subjects were randomised to receive a control diet, a diet rich in fruit and vegetables, or the DASH diet. The results showed that the DASH diet, compared with the control diet, reduced SBP by 4.9mmHg ($p=0.006$) and DBP by 1.9mmHg ($p=0.15$). In the non-MS subgroup, corresponding net BP reductions were 5.2mmHg ($p<0.001$) and 2.9mmHg ($p<0.001$), respectively. The DASH diet reduced BP in 75% of hypertensive subjects with MS (Hikmat and Appel, 2014).

1.5. Conclusions

The evidence reviewed clearly demonstrates the impact of lifestyle factors on the development of MS and its components. The global rise in the prevalence of MS is clearly associated with the increased prevalence of obesity. It is also clear that

interventions designed to reduce body fat, particularly visceral fat, can alleviate many of the components of MS, including IR, dyslipidaemia and hypertension. While both dietary and PA interventions have yielded beneficial results, the optimal lifestyle changes required to alleviate MS remain to be firmly established

While MS represents a global problem, growing evidence suggests that different geographical, gender and ethnic populations may have different levels of susceptibility. The following chapter will specifically address the incidence of, and causal factors associated with, MS in Saudi Arabian women.

CHAPTER TWO

REVIEW OF THE FACTORS INFLUENCING DIET, EXERCISE AND HEALTH IN KSA WOMEN

The research programmed described in this thesis was based on experience of working as a health professional (as a dietitian) in Saudi Arabia and experiencing that obesity and physical inactivity are leading to a range of health problems, particularly in women who face many barriers and challenges to adopting a more healthy lifestyle. The impact of culture and religion has been sparsely reported in the literature; hence, the researcher started the project by reviewing the information currently available.

2.1. Nutritional and lifestyle habits in the KSA

The KSA has been undergoing a rapid urbanisation and this has had a direct influence on its people's dietary habits and lifestyles. Many factors have contributed to these changes, including lifestyle transition, urbanisation, income, demographic and food cost changes. In addition, developments in food manufacturing, the food subsidy system, immigration and influence of the mass media have all impacted on dietary and lifestyle choices (Musaiger and Zagzoog, 2013).

Dietary intake habits have changed significantly in the Middle East countries over the last three decades. During the period 1970-2005, a rise in the consumption of animal products and a reduction in the consumption of vegetables, fruit and complex carbohydrates has been documented (Musaiger, 2011a). As a consequence, the consumption of fat, especially saturated fatty acids and simple sugar, has risen, while, at the same time, the consumption of dietary fibre has declined, resulting in increased risk factors for diet-related chronic diseases, particularly obesity, CVD, diabetes mellitus and cancer (Musaiger, 2011a).

Statistics indicate that Arab country populations, including the KSA, suffer from paradoxical nutritional problems: those correlated with unhealthy food patterns and nutrient deficiencies, such as vitamin D and calcium, iron deficiency anaemia and underweight, and those correlated with over-nutrition and changes in lifestyle, such as obesity, diabetes and hypertension (Musaiger et al., 2011a;b). This position has

generated a great challenge for the Saudi Health Authority to address. National studies in the KSA have shown an increase in skipping meals and replacing them with a large number of snacks throughout the day, with most of these snacks being high in calories and low in nutrients (Al-Khateeb and Al-Gelban, 2008; Amin et al., 2008). It is evident that skipping breakfast is correlated with high risk of obesity (Maddah, 2009) and poor cardiometabolic health status (Smith et al., 2010). The consumption of whole grains in the KSA has decreased over recent times. Saudi women have been reported to be less partial to the taste of whole grains and tend to consume more refined cereals (Bakhotmah, 2012).

The recent influence of a Western lifestyle on the Saudi culture is considered responsible for the increased consumption of fat and 'junk' food in the KSA (Winter et al., 2011; Alfawaz, 2012). Also, sugar-sweetened soft drinks are consumed widely in the KSA (Midhet et al., 2010; Mohieldein et al., 2011). Several countries in the Arab region have a high dependence on street food, with subsequent exposure to the risk of consuming contaminated food. Arab countries still face many deficiencies in their food safety systems. The lack of local food composition data is one of the major reasons for the insufficiency of measuring nutrients consumption. Establishing food-based nutritional guidelines for the country will help consumers to choose healthy and proper food (Musaiger, 2011a). Changes in lifestyle and socioeconomic status in this region have also had a significant impact on PA.

The rapid economic growth has brought notable prosperity and easier lifestyle in terms of transportation and access to cheap migrant labour, accompanied by new technologies that promote sedentary lifestyles (Al-Hazzaa, 2004b), including televisions, mobile telephones and tablet devices, computer and gaming systems and other household appliances. In the Arabian Gulf states, simple observation shows that leisure activities have changed from outdoor play to indoor entertainment and that there has been a great shift from manual work to office work. People have shifted from fishing and pearl diving, farming, animal husbandry, ploughing, planting and harvesting to less physically demanding office work, such as teaching, management, banking, selling, accounting and other administrative work, while manual work in this region has been delegated to migrant labour (Musaiger and Zagzoog, 2013). This has

all led to a more inactive lifestyle and decreased energy expenditure in most Eastern Mediterranean countries.

Previous studies have shown that physical inactivity is extremely prevalent among both sexes and all age groups of the Saudi population (Al-Hazzaa, 2004b). There were, however, significantly more inactive females (98.1%) than males (93.9%) (Al-Nozha et al., 2007). This high prevalence of physical inactivity in Saudi society has emerged as a serious threat to public health, as evidenced by the high risk of metabolic disease in the Saudi population, compared with the populations of the UK and US (Al-Hazzaa, 2004a). A review of the prevalence of MS and its components in the Middle East reported that females were less active compared with males in certain areas, which could be the reason for the high rates of obesity (Sliem et al., 2012).

Saudi women have limited access to sport and this might be aggravated due to the easy access to cheap migrant labour for domestic chores. For instance, most Saudi Arabian and Kuwaiti families usually employ maids and chefs, adding to a sedentary lifestyle in indigenous women (Badran and Laher, 2011). This is in addition to the role of multi-pregnancy, which is considered another important factor for the high rate of obesity in women in the Arabic countries. It is estimated that about 25% of women experience a weight gain of 4.55kg, or more, one year postpartum, which is likely to be due to a combination of factors such as gestational weight gain, decreased PA and increased food consumption (Badran and Laher, 2011).

2.2. The position of girls' and women's sport participation in the KSA

It has been a matter of common observation, particularly in the Muslim world, that sport is generally considered as a male-oriented and male dominated activity, whereas women are confronted with a number of constraints and hurdles to overcome in order to participate in sport (Marwat et al., 2014). The position of Muslim women in an Islamic society context is a greatly discussed issue, especially in the contemporary world. Some people have argued that women have inferior rank in relation to men, while others provide evidence indicating the existence of a fair balance between females and males. Indeed, Islam advocates in favour of good health and sound physique. There is nothing in the Quran (the Islamic sacred book) that forbids Muslim

women from exercising, but Islam imposes some specific rules, which are not only required for females, but also their male counterparts (Shilpi, 2012). '*Al sharia*' (the Islamic code of life) provides some Islamic principles with reference to women's participation in sport, including the maintenance of '*Al hijab*' (covering of the hair and other secret parts of the body), obeying a dress code, avoidance of the mixing of men and women while playing, avoidance of gambling and paying due attention to '*Arcan*'(obligatory religious practices, such as five times daily prayer, fasting in the month of Ramadan, Al-hajj, etc.) (Marwat et al., 2014).

On the other hand, a number of clerics have argued that the role of the Muslim female was thought to be based at home performing household work, while males were responsible for all other kinds of issues (Shilpi, 2012). On account of dress codes and the open mixing of males and females in non-Islamic sporting activities, many clerics dislike the arrangements and methods of participation of Muslim females in sport, so they strongly criticise their taking part (Di-Capua, 2005; Marwat et al., 2014).

In Saudi Arabia, key aspects of gender roles and relations in Saudi society are governed by the religious law (Al sharia) and include gender-segregation and limits on the social and spatial mobility of women (Alyaemni et al., 2013). Gender segregation is strictly enforced, and almost all women wear a veil with loose clothing which covers certain precise parts of their body when they enter the public domain (Mobaraki and Soderfeldt, 2010). The country's religious scholars have also issued religious rulings against women's participation in sports, often subjecting women to harassment and punishment if they break any of these laws. In 2009, one of the officials of the Supreme Council of Clerics objected to girls' sport, saying that the 'jumping and movement' needed in basketball and football might cause girls to lose their virginity (Khalaf, 2014).

The lives of Saudi women are constrained in many ways because of their gender; they cannot vote, they cannot drive, and they have restrictions on movement outside their homes and limited opportunities to attend health centres (Hakobyan, 2008). The male is the dominant member of a Saudi family, so women must also have the permission of a male (guardian), typically the closest male relative, to work, travel or have elective surgery. Hence, the male and cultural view of feminism in the KSA will form a key aspect in relation to increasing or controlling a female family member's participation

in sports. Traditional Saudi society lays out a specific role for women, and employment opportunities outside the home are limited (Hakobyan, 2008; Shilpi, 2012). According to the latest official figures, 49.9% of the Saudi population is female (Mobaraki and Soderfeldt, 2010), but barely 21% contribute to social development, because it is socially unacceptable for women to work in fields other than teaching and medicine (Vidyasagar and Rea, 2004; Khalaf, 2014). Apparently, a high dependence on automobiles, the hot climate and the employment of domestic helpers contribute to the low levels of PA in Saudi women's daily life (Mabry, 2010a). This, in addition to many other factors, hinders their participation in sport and their access to healthcare (see Figure 2.1), which will be discussed in detail in another part of the thesis.

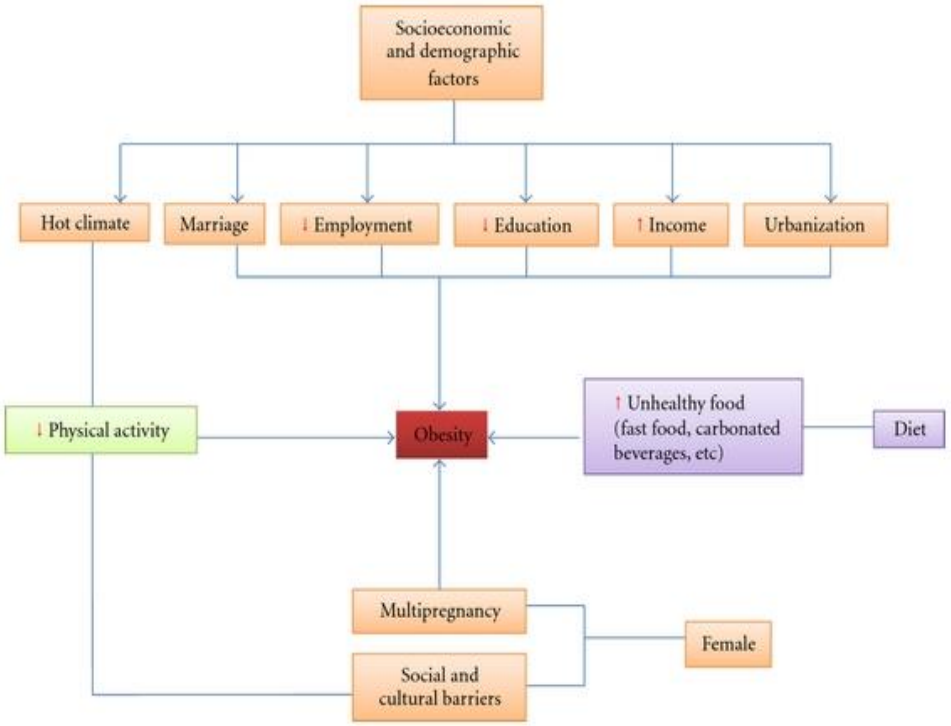
Under the Saudis' strict Islamic legal system, the KSA is the only country in the world that generally forbids women from competitive sports (Al-Eisa and Alsobayel, 2012), except for 2012, when it sent two female athletes in judo and track and field to the London Olympics, which was a major step to reforming its view on women and sports (HRW, 2013; Khalaf, 2014). According to Wilcke (2012), there is no sports education for girls in public schools, although it is available in private schools, which are often very expensive to attend. Recreation facilities for women are limited to very expensive commercial health clubs and private sports clubs.

In 2009, the government actually shut down a large number of what it called 'unlicensed' health sports clubs for women and a spokesperson for the local municipality in Jeddah stated that "the government is not issuing permission for women-only sports clubs" (Carroll, 2013, p. 26). Not until 2013 did the Saudi Arabian government license women's sports clubs for the first time, and, until recently, girls' public schools did not have sports classes, despite promises from the authorities to introduce physical education classes into them (Ministry of Health Saudi Arabia, 2014). Wilcke (2012) found that it is impossible for women to have access to team sports, such as football, unless at an enclosed, private and, basically, illegal club for women. There is also no provision for competitive sports or elite level athletes. There are some Saudi females competing at a high level in sports, such as equestrian. But they are based outside of the region and are not able to represent their country due to not being recognised by the government (Carroll, 2013).These factors, together with

religious laws and cultural environment, effectively limit females to a sedentary lifestyle, which has contributed to increasing the obesity rate among women (Wilcke, 2012).

A published report by Human Rights Watch (HRW) called *Steps of the Devil* has drawn attention to the denial of girls' and women's rights in sport in the KSA, the systematic discrimination against women in sport in the KSA and the influence it has had on the obesity and diabetes rates, particularly among women and girls (HRW, 2013). Although the KSA has signed treaties that acknowledge the rights of girls and women to physical education, such as the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination Against Women, HRW showed that, in practice, women are systematically excluded from sport and exercise (Shilpi, 2012; HRW, 2013). The report concluded that, while there are plans to develop access to sport in girls' schools, there are few choices for staying fit for women. The few health clubs that have sports or fitness equipment could be prohibitively expensive, while team sports for women are almost non-existent (HRW, 2013).

Figure 2.1: Factors contributing to obesity in the Arabic-speaking countries



(Badran and Laher, 2011)

2.3. The impact of KSA culture on women's health behaviour

Culture is defined as "the day-to-day activities and practices of given community members as they develop their interpretation of different issues in their lives, including health and illness" (Dutta, 2008). Culture, in that sense, influences how people think about and understand their health.

Saudi Arabia's cultural roots lie deep in an antiquity that has been shaped by its Islamic heritage, its historical role as an ancient trade centre and many other elements that are vital to the human condition (North and Tripp, 2009). The cultural setting in the KSA is deeply religious, conservative, traditional and family-oriented. Many attitudes and traditions are centuries-old, derived from Arab civilisation. However, its culture has also been influenced by a rapid change, as the country was transformed from an impoverished nomadic community into a rich commodity producer in just a few years during the 1970s (North and Tripp, 2009).

There is no doubt that individual factors such as age, gender, level of education, personality, experience and occupation might come into play and impact people's health behaviour, but socio-cultural and religious factors have the greatest role (see Figure 2.2) (Shuval et al., 2008; Draper et al., 2015).

In the current study, it was important to clarify how the KSA culture influences individuals' perceptions and interpretations of their health condition and how it influences the choices they make. The main paradigms influencing peoples' perceptions of health are the role of religion and the role of social norms. The following sections describe the impact of these two paradigms on women's health behaviour.

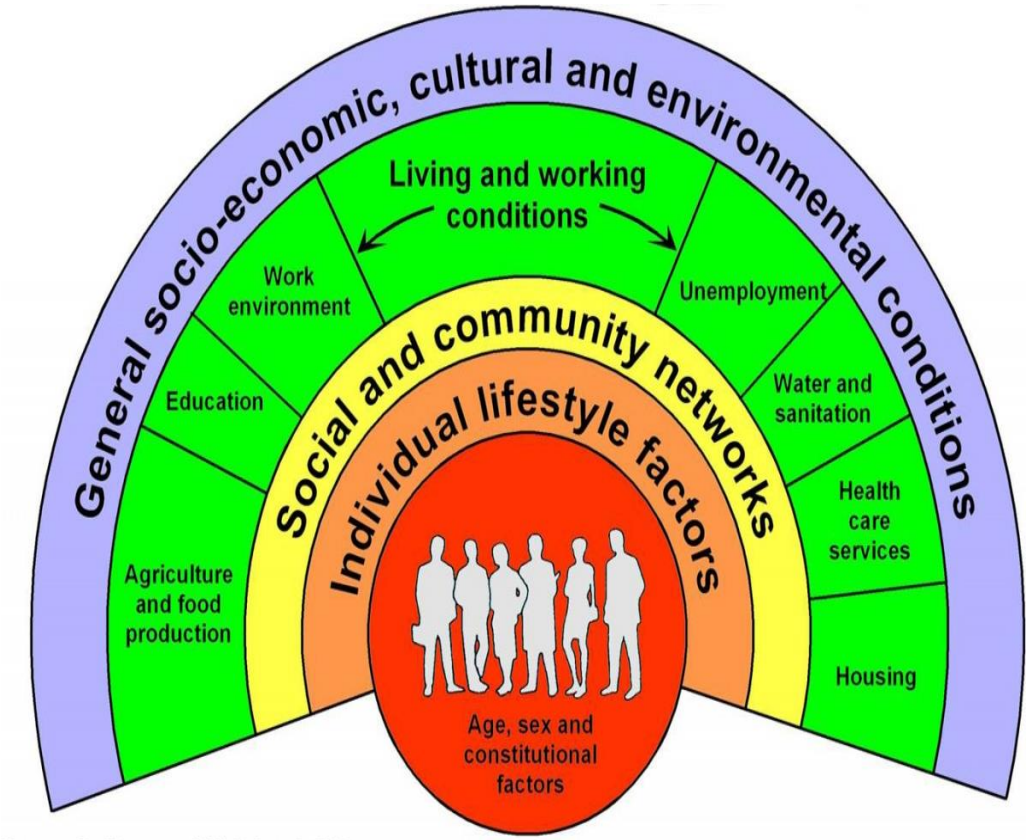
2.3.1. The role of religion

Saudi Arabia is the birthplace of Islam and is governed by a strict interpretation of Sharia (Islamic law). This governs virtually all facets of life, with customs and traditions in Saudi based on the tenets mentioned in the Quran (Country Stats - Saudi Arabia - Culture, 2016). Saudi is one of the few countries to have religious police (Mutaween), who have the power to enforce people in acting in line with Saudi Arabia's strict moral

codes in a manner respectful of the traditions and laws of the region, so as to avoid being punished. This involves enforcing dress codes, strict separation of males and females, attendance at prayer (*Al salat*) five times each day, the ban on alcohol and pork, and other aspects of Sharia or behaviour it believes to be commanded by Islam (North and Tripp, 2009; Country Stats - Saudi Arabia - Culture, 2016).

Saudi Islamic culture imposes distinct community roles based on gender and women may struggle to adapt to what they perceive to be misogynistic regulations that, for instance, deny them the right to drive an automobile or use public transport and taxis on their own, insist on traditional dress and also prohibit them from socialising in public with male strangers. Such rules are actively and aggressively enforced by the religious police (Al-Solaim and Loewenthal, 2011).

Figure 2.2: Social Determinants of Health



Source: Dahlgren and Whitehead, 1991

Family honour, based on Islamic teachings, is one of the most important characteristics in the Arab family. According to Nydell (2012), social exchanges between men and women very seldom happen outside of the workplace. Social events and parties are significantly predicated on the separation of males and females. Sexual segregation, which keeps family female members from contact with male strangers, follows from the extreme concern for female purity and family honour.

The effect of Islam also extends to every aspect of the lives of Saudi citizens, including food, behaviour, family life, sexuality, business and healthcare. Furthermore, Islam proffers beliefs about the maintenance of good health (El-Gilany and Al-Wehady, 2001). For instance, Islam decrees that people should exercise regularly, eat moderately, practice good personal hygiene and abstain from the use of alcohol and tobacco. However, the degree to which these Islamic guidelines are followed (e.g., smoking) can be effected by a range of other socio-cultural factors. For instance, increasing liberal notions have resulted in more young women taking up smoking in cafes and restaurants with their friends (El-Gilany and Al-Wehady, 2001; Rawas et al., 2012).

Religion seems to exert a powerful effect on people's health beliefs (McAuley et al., 2000). Religion is found to affect healthcare and medical decision-making, such as blood transfusion and organ donation (Rady and Verheijde, 2009; Alozaibi, 2011). Furthermore, in the health centres, Muslim women prefer to have same gender nurses and doctors in order to follow rules of modesty in regard to the opposite sex. Related to this, Muslim women cover their head and body in various Islamic coverings (*Al hijab*), according to the custom of their country of origin. To show respect, healthcare workers should ask a Muslim woman for permission to uncover parts of her body for injection, or for any other medical reason (Taheri, 2008).

The degree to which cultural and religious factors impact Saudi women's lifestyle-related health beliefs and behaviours is rarely addressed in literature. In the available literature, religion is sometimes reported as an obstacle to changing health behaviour when describing patients' beliefs in predetermined fate and fatalism (Grace et al., 2008; Shuval et al., 2008; Alozaibi, 2011). Other studies describe the positive role of religion in enhancing compliance, patients' empowerment and acceptance of illness

(Abdoli et al., 2008; Alozaibi, 2011). Muslims believe that God is the creator of the universe and all creatures. They believe that their bodies are gifts from God and that they should protect and care for them. Muslims show gratitude to God for their good health through worship and protecting themselves from harm (Rawas et al., 2012). For example, in a study describing Saudi women's knowledge and beliefs about illnesses, women reported causes of illness as being God, along with contact with an ill person, the weather and germs (Ide and Sanli, 1992). Religion is regarded as a significant factor in determining almost all facets of a Muslim person's life. Therefore, the perception of PA and health is also underpinned by religion and by culturally-mediated health beliefs (Pratt, 2010). There has been limited exploration of the role of religion in the level of PA undertaken by Muslims.

Most studies that have investigated the relationship between some aspects of religious belief and some indicators of health have found a positive correlation between religion and mental and physical health (Alozaibi, 2011; Koenig et al., 2012). Religious beliefs were also found to be useful in boosting social support, abstaining from self-harming behaviour (e.g., substance abuse and alcoholism) and enhancing patients' ability to cope with their illnesses (Alozaibi, 2011). About sixty studies have examined the role of religion in helping patients cope with a number of chronic diseases, such as CVD, diabetes, asthma, HIV/AIDS and kidney diseases. Subjects in these studies reported that religion provided them with meaning, a sense of relief and optimism when dealing with their illnesses. Thus, religion enables patients to cope with and accept their health conditions (Alozaibi, 2011; Koenig et al., 2012). Such perceptions were mainly popular in patients who considered themselves religious, women, elderly patients and patients from ethnic minorities (Alozaibi, 2011; Koenig et al., 2012).

The positive role of religion in health was elicited in a qualitative study that explored women's health needs. A study conducted six focus groups with 60 females 16-54 years old. The study did not report a fatalistic attitude towards health influenced by the subjects' religious beliefs. Rather, Islam was perceived as a bridge through which subjects gained psychological and physical comfort. Religion, according to the study subjects, facilitated health and treatment through three routes: (i) reading the Quran

and praying when distressed leads to psychological comfort; (ii) abiding by Islamic teachings preventing Muslims from engaging in harmful practices, such as drinking alcohol; and (iii) the Quran has healing abilities (some women talked about seeking religious healers to recite Quran scripts for them) (Winslow and Honein, 2007). There is also growing evidence of the role of religion in health and well-being. A review of 35 studies that invistgated the relationship between religious beliefs and health-related physiological processes reported that both Eastern religious and Judeo-Christian practices were correlated with reduced BP and improved immune function (Seeman et al., 2003). Religious beliefs were also correlated with better glycaemic control, lower rates of cancer, better cardiac health and outcomes lower cholesterol levels, improved BP, better health behaviour (How et al., 2011) and even lower rates of death (Koenig., 2012).

2.3.2. The role of social norms

Social norms are hypothesised to affect health-related attitudes, such as PA and diet, and are believed to be the most powerful forms of social control over human behaviour (Shuval et al., 2008; Draper et al., 2015).

Social norms and Arabic traditions in countries of the Middle East are derivatives of Islamic teachings. However, they are sometimes interchangeable and individuals find them hard to differentiate. Social norms might sometimes divert from what Islamic teachings instruct; however, they are sometimes more popular and practised in a community than the original Islamic teachings. Social norms might differ in nature and intensity of practice from one Muslim/Arabic country to the other depending on the country's cultural context (Dutta, 2008; Helman, 2014). Despite the modernisation of Saudi society and the cultural exchange with neighbouring non-Muslim countries, social norms and Arabic traditions are highly manifested and influential in individuals' everyday life. Most of the KSA social norms revolve around preserving modesty, in both the way people dress and interact with one another (Dutta, 2008; Helman, 2014). For instance, men wear the '*thobe'*, which is a white, full-length shirt-dress, together with a head cloth. Women, on the other hand, wear long black cloaks known as '*abaya'* that cover their normal clothes, along with a black headscarf (*shela*), in public, and some women prefer to wear black veils (*niqab*) to cover their faces

(Andersson and Togelius, 2010). In that regard, it has been argued that the traditional, long, comfortable and loose clothing worn by women in the KSA might prevent them from noticing gradual weight change over time (Al-Solaim and Loewenthal, 2011).

In this unique country, conservative interpretations of social norms can sometimes have a negative effect on the health and well-being of women (Al-Khateeb, 1998; Mobaraki and Soderfeldt, 2010). The country ranks 135th out of 146 countries on the Gender Inequality Index (Malik, 2013). The most severe violation of the fundamental rights of Saudi females is the system of male guardianship, which states that every adult woman must have a male guardian. All Saudi women are affected by this system, regardless of social or economic status. This institutionalised system of guardianship controls adult Saudi women´s daily life. Normally, it is a father, a husband or a son who fills the role of making critical judgements concerning a woman´s life. Women must ask for permission in matters such as work, education, travel, marriage or even to undergo invasive medical surgery (Mobaraki and Soderfeldt, 2010).

A systematic review highlights the many challenges faced by Saudi Arabian women and suggests that their limited roles and rights within Saudi society may have a negative effect on their general health (Mobaraki and Soderfeldt, 2010). The majority of Saudi women perceived their health to be worse than males and attributed this to their child-bearing, their domestic and caregiving roles, restrictions on their mobility, psychological stress regarding their responsibilities for children, and marital conflict (Alyaemni et al., 2013). Women's health in the KSA is only now emerging as a primary concern. The restriction of Saudi women from public PAs and the expectation to centre their roles at their homes makes their health needs distinct from those of men (Abahussain and El-Zubier, 2005). Women in the KSA have special health needs, including the prevention and management of obesity and T2D (Al-Sharafi and Gunaid, 2014; Jahan, 2016). Overall, lifestyle-related conditions among women in the KSA are influenced by social, cultural and religious factors; however, these factors are rarely addressed in the literature in relation to health (Khatib, 2004; Al-Hussein, 2008; Gosadi, 2016). A review by Mobaraki and Soderfeldt (2010) identified a number of significant examples of ways in which women's roles and rights in the KSA are likely to have negative impacts on their health. A woman in the KSA cannot be admitted to a

governmental hospital without her male guardian, nor can a Saudi woman sign a consent form for an invasive medical procedure. Furthermore, men in rural areas in the KSA do not allow a male gynaecologist or obstetrician to examine their wife or sister. Mobaraki and Soderfeldt (2010) identified that women in some regions in the KSA can be forced to marry at any age. As there is no minimum age for marriage, the high infant mortality rate in the KSA may, in part, be related to teenage pregnancies being more common. Additionally, there is no national screening for high risk pregnancies, breast or cervical cancer or inherited blood diseases (Mobaraki and Soderfeldt, 2010).

Acknowledging social norms, in the form of Islamic and/or old Arabic traditions, was perceived to be vital in the success of lifestyle intervention. Subjects in Grace et al.'s study (2008) found walking more acceptable than other PAs, because it preserved modesty. Another study that explored the attitude of Asian overweight women towards PA showed that walking slowly was an appealing form of workout compared to running or other vigorous activity. Subjects believed that it was not acceptable for women to walk fast in public (Khanam and Costarelli, 2008; Alozaibi, 2011). In a study by Shuval et al. (2008), subjects felt male were more active than female because of conservative social norms. Female participants could not exercise or power-walk outdoors without being accompanied by a male family member. Women were sometimes also subject to verbal abuse from the community when attempting to exercise outdoors. In such cases, women were inclined to power-walk next to western towns away from their Arab communities. According to a study conducted in the United Arab Emirates (UAE), cultural reasons were reported to be the third most limiting factor to PA (29%) after lack of time (30%) and coexisting diseases (32%). It was reported that the lack of culturally-sensitive health clubs that respect their Islamic religious beliefs was one of the culturally-related barriers to exercising. Also, subjects claimed that traditional clothes (Islamic dress for women) were inconvenient and hindered efficient outdoors exercising, particularly in hot climates (Alozaibi, 2011).

Despite the limited number of studies that have invistgated the effect of the socio-cultural context in the KSA, other studies conducted on participants of similar religious backgrounds confirmed the strong role social norms play in altering physical

interventions and behavioural change. One would assume that Muslims or Arabs living in Western or non-Muslim countries would have a less socially-imposed restriction to lifestyle interventions; however, data presented in this section suggest otherwise (Alozaibi, 2011; Ludwig et al., 2011). Most of the data available illustrated the effect of social norms on behavioural change of women with great focus on obstacles to PA with a broader focus that included other aspects of management as equally important. The literature identified portrayed negative effects of social norms. Thus, it would be interesting to see if social norms that enhance management and behavioural change exist and whether such norms can be utilised to help improve people's health behaviour.

There is also a distinct lack of education for women as to the value of sports and regular exercise to their health and well-being. This is a fundamental problem which is now being addressed. As the country becomes more westernised and seeks to be accepted internationally, the treatment of women has forced its way to the top of the agenda in terms of the challenges the country must overcome (Cordesman, 2009). The government has recently announced plans to introduce PA programmes for girls in public schools (Elwazer, 2013). However, it will take some time to work out how these new policies can be implemented nationwide, keeping within the boundaries of the culture and traditions of the Kingdom.

2.4. Factors influencing lifestyle intervention in KSA women

2.4.1. Factors influencing physical activity in Saudi women

2.4.1.1. Lack of knowledge

A review of previous studies showed that it remains unclear as to whether knowledge about the benefits of PA is a primary factor in sports participation. It is also uncertain whether increased levels of knowledge will contribute to an increase in sports participation (Chaubal, 2011).

Dishman et al. (1985) reviewed the known determinants of physical exercise and concluded that knowledge of, and beliefs in, the health benefits of PA may motivate initial involvement, but the feelings of enjoyment and well-being seemed to be

stronger motives for continued participation in health programmes. Additionally, no evidence supported the idea that increased knowledge about PA leads to enhanced sports participation. Also, Morrow et al. (2004) found that PA knowledge alone was not sufficient to elicit a behaviour change. However, it provided educators with an understanding of the public's PA knowledge that might be helpful in the development of health promotion and PA interventions. In an attempt to review and update the evidence relating to social, environmental and personal factors associated with exercise in adults, Trost et al. (2002) found that the barriers to PA emerged as a strong influence, whereas knowledge related to health and PA had a poor association with PA.

However, the results of Giardina et al.'s (2009) study showed that PA and education were significantly related. Within an undergraduate population, women who had completed their graduation had greater total activity time than those with just a high school education. A study about the knowledge and opinion of Saudi female school teachers on sports for children showed that the majority believed that PA for children was important and that girls should have PA classes at school. However, the findings indicate that the teachers' levels of knowledge regarding exercise recommendation for children were low (Al-Arfaj, 2013).

Another study conducted in the KSA about knowledge and practice of PA among male school students and their teachers revealed that the vast majority of students knew that PA was protective against diseases generally (93%) and was particularly helpful in the prevention of obesity (74%). Teachers had substantially better knowledge about the benefits of PA. Both teachers and students had poor knowledge about the role of PA in preventing high BP and diabetes (43% and 46.5% for teachers vs. 36.6% and 28.8% for students, respectively). The frequency and duration of the practice of effective PA were significantly better for students than their teachers (46% and 71% for students vs. 23% and 37% for teachers, respectively). Knowledge about and the age at which PA protects from obesity were the major determinants of the practice of PA among students. Youthfulness was statistically significantly correlated with the practice of PA. These results support the need for health promotion programmes that will increase the number of students actively engaging in PA. Such programmes should

include health education, increased supervised physical education and PA classes, competition and prizes, and active teachers' involvement (Taha, 2005).

2.4.1.2. Socio-cultural environment

The applications of health behaviour theories to physical exercises have identified the role of environmental effects, most often in terms of obstacles (Humpel et al., 2002; Gosadi, 2016). As already discussed, on account of socio-cultural restrictions, Muslim women are confronted with a number of constraints and impediments to their participation in sport. Muslim women face many more barriers to their participation in PA, as many people believe that sports are forbidden to them (Klein, 2007). Musaiger (2011b) argued that women have more responsibility than men for their families, so they keep themselves busy with housework and care of children. Several studies have been conducted focusing on different barriers to women's participation in sport. Tradition, lack of time, lack of knowledge, lack of facility, weather, long distance to activity areas, family problems and lack of a companion are indicated as the most significant recreational barriers in many studies (Amin, 2011; Al-Otaibi, 2013; Carroll, 2013; Awadalla, 2014; Jahan, 2016). In addition to the above, fear of assault, gender, the Government, education, transportation and high entrance fees are some of the other factors influencing participation of different groups of people in recreational activities (Carroll, 2013; Khalaf et al., 2013; Musaiger et al., 2013; El-Sobkey, 2014).

Unlike in Western culture, women in some Islamic countries face traditional obstacles that are rooted in these social restrictions and taboos that make it difficult for them to practise exercise outdoors and in sports clothing, as many families do not allow their girls to practise exercise outdoors for religious and safety reasons (Musaiger et al., 2013). Alozaibi (2011) indicates that some Emirati traditions constrained their PA. In some families, fathers or husbands disallowed their daughters or wives from running and power-walking in public places. Such activities were sometimes permitted when in groups or in the company of a male family member. Some participants reported that they willingly refused outdoor exercising to avoid scrutiny or disdainful comments by passers-by if they tried to walk briskly (Alozaibi, 2011). One health educator explained that women's avoidance of outdoor PA is due to fear of being

identified. Although walking outdoors in gardens and the seafront is not a dishonourable act, Emirates woman are very conservative and like to maintain their privacy. Moreover, some participants in the study mentioned that they cover their faces with a veil while exercising to avoid being identified by the public (Alozaibi, 2011). Others felt that such modest long clothes could be uncomfortable when exercising outdoors in hot climates. In their perception, exercise was a complex activity and clothes that hinder movement can add to its complexity and alter people's adherence to regular exercising (Alozaibi, 2011).

More recently, Samara et al. (2015) reported that the most important obstacle for Saudi women was the lack of designated areas available for PA, while they disagreed that family or the Islamic community were obstacles to PA. By the same token, AlQuaiz and Tayel (2009) indicated that the most common barrier to PA among Saudi adults was the lack of resources (80.5%), which was significantly higher among women than men and among the lower income versus the higher income group. This was in addition to the lack of public transport near facilities and the fear of assaults and being raped (Carroll, 2013; Awadalla, 2014).

Furthermore, available evidence has indicated that most of the women-only health clubs in the UAE are fenced buildings with security guards that do not allow men to access or use these facilities. However, some women are reluctant to join women-only health clubs because of the presence of security cameras, referred to as 'hidden cameras'. Women also feared mobile phone cameras that might be secretly used by other female members to take their pictures while exercising (Alozaibi, 2011). Some conservative women reported that they were mainly scared of having their pictures distributed to strangers or posted on the Internet. In their perception, such an act would jeopardise their reputation and dishonour their family names. Hence, some of the women-only health clubs have a bad reputation as a result of this rumour. Therefore, women decide to avoid them altogether (Alozaibi, 2011).

A number of studies have also reported that the urban planning of some cities does not encourage pedestrian activities and they have to rely mostly on cars and buses. However, physical features of the environment that have been associated with PA include access to locations and facilities where people can be active (such as parks,

arcade zones, walking/jogging trails, playgrounds, sports fields, schools and worship facilities) as well as better street lighting, having sidewalks available and using a mall for walking (Alozaibi, 2011; Carroll, 2013; Musaiger et al., 2013).

2.4.1.3. Socioeconomic and climatic conditions

As mentioned previously, the rapid economic growth in the KSA during the last few decades has brought significant prosperity and easier lifestyles for the Saudi population. Financial hardships are responsible for the low or non participation of women in sport. Indeed, in the majority of Muslim families, women discharge the household responsibilities and have nothing to do with earning a livelihood. The male has always been in the driving seat as regards to earning and controlling the family's financial affairs. On account of a lack of authority in the dispersal of the financial resources, the women cannot spend money on taking part in any sport. Being dependent on their husbands, it has always been difficult for women to have money to spend on recreational activities (Marwat et al., 2014). Economic status and family income level are also among the main determinants of participation in sport. Being among the most significant recreational constraints, level of income plays a more important role in the participation of people in recreational activities than educational level, race, age or gender (Marwat et al., 2014). Individuals having high-income level participate in natural sports more frequently than those in low-income level (Kara and Demirci, 2010).

In relation to the climate condition, the KSA consists mostly of desert, and the summers (April to October) are extremely hot and dry with temperatures exceeding 129F (54°C) (Owen, 2017). The extremely hot weather and dry climate in the KSA, coupled with the desertification and lack of forestation and vegetation, generally forces people to stay indoors, leading to decreased PA time and the encouragement of a sedentary lifestyle (Badran and Laher, 2011).

Amin et al. (2011) reported that the most frequently cited obstacles against leisure time exercise among their Saudi subjects were related to the weather and traditions (especially for women), unlike lack of time, as reported by most of the developed countries (Oliveira et al., 2011; Amin et al.,2012). The KSA is known for its hot and

harsh weather. Outdoor activity is only possible from afternoon to sunset and schools and universities remain closed for three months in summer. However, centrally air-conditioned facilities for indoor exercise and football stadiums are available in every major city (Oliveira et al., 2011).

2.4.1.4. Lack of time and motivation

Promoting PA and motivating people to exercise involves a multitude of complex variables, including social, personal, environmental, programmatic and related factors. It is critical to get people to individually adapt to behavioural change to facilitate a physically active lifestyle (Kauko, 2010).

According to Alozaibi (2011), some subjects interviewed in the study indicated that personal factors, including lack of motivation and social and family support, prevented them from frequently exercising. Some subjects lacked the motivation to join the gym or exercise on a regular basis. Family and social support were perceived as motivating factors that might enhance people's engagement in exercise. Other subjects lost the motivation and willpower to exercise due to long working hours and exhaustion, constant travelling, running family chores, childcare and other social and family responsibilities (Alozaibi, 2011). Available evidence investigating the guidelines that can help providers to ensure that their activities are more accessible and motivating to Muslim women concluded that establishing sensitive health clubs that respect cultural and religious concerns was one of the most important factors that could encourage women to participate in sports. These included:

• Making sure the changing rooms, showering and WC facilities are safe, private environments which cannot be overlooked.

• Allowing a wide range of clothing choices; for instance, when swimming, women may wish to wear more than is conventional.

• Putting up signs on doors when women's sessions are in practice.

• Turning off cameras when sessions take place.

• Ensuring that all staff on duty are female: women lifeguards, etc. (Women's Sport and Fitness Foundation, 2010).

Several previous studies indicated lack of time as the most important external barrier to PA (Al-Otaibi, 2013; Musaiger et al., 2013; Awadalla et al., 2014), whereas lack of energy was the most important internal barrier (Phillips et al., 2009; Al-Otaibi, 2013). Awadalla et al. (2014) also found that the top reported barrier to PA among inactive students in the KSA was time limitation (51.3%). It was found that lack of time due to a busy lesson schedule and lack of time due to responsibilities relative to family and social environment were the most commonly cited barriers among university students (Daskapan et al., 2006; Awadalla et al., 2014). For women, time constraints are considered a significant barrier to participation. It has been found that the majority (66%) of women experience time pressures and that these pressures are most acute among working women, and working mothers in particular (Women's Sport and Fitness Foundation, 2007).

In an attempt to overcome the cultural and environmental obstacles and motivate Saudi women to exercise, a more recent study revealed that the use of Instagram with a home exercise programme as a motivational modality could be attractive and effective to reinforce adherence and maintain appropriate PA levels. During the four weeks of intervention, women from the intervention group performed more than eight sessions (with 17% of adherence) compared to the control group, which performed two to three sessions only (with 4% of adherence) (Al-Eisa et al., 2016).

2.4.1.5. Family influences on sports participation

Muslim Arab women's status is linked primarily to their family roles as mothers, daughters, sisters, or wives. Men have responsibility for their families and have the power and authority to make decisions, while women have limited power and no entitlements (Crocco et al., 2009; Rawas et al., 2012).

In an exploratory study on sports and culture carried out in Iran, women perceived that culture-based constraints and traditions limited their freedom, including participating in sports activities. Women reported that they had to get permission from family members to participate in leisure activities and were not allowed to engage in gender-integrated activities (Arab-Moghaddam et al., 2007). Moreover, sports were purely perceived as leisure for males, and only watching TV, reading and

family gatherings were perceived as types of leisure for females (Arab-Moghaddam et al., 2007).

Another qualitative study among Turkish women also showed the importance of family and kinship relations, which play a particularly critical role when it comes to women's involvement in physical leisure activities. Turkish women reported being frequently confronted with negative attitudes by family and relatives towards their practising exercise (Koca et al., 2009; Musaiger, 2011b). The most commonly reported family-related constraint was the husband's jealousy (Koca et al., 2009). Other studies have also demonstrated the fact that parents have been shown to be instrumental in increasing levels of activity for their children, whether by parental encouragement or parental modelling (Canfield, 2012).

2.4.1.6. Screen time and sedentary lifestyle behaviour

Screen time is one of the factors influencing PA. The Australian government recommended "children and young people should not spend more than 2 hours a day using electronic media for entertainment (e.g. TV, Internet, computer games), particularly during daylight hours" (Diabetes Australia, 2016).

Several studies have indicated that there is a positive correlation between the amount of time spent watching TV and obesity rates among children and youth due to the decrease in time available for PA (Abuzaid, 2012). Three possible factors contributing to screen time's influence on overweight/obesity rates include: decreasing time available to engage in PA and, therefore, decreasing energy expenditure; increasing the intake of food while watching TV (primarily unhealthy food); and increasing exposure to advertisements about the purchasing and intake of such foods (Caroli et al., 2004; Abuzaid, 2012).

Higher levels of television watching were correlated with higher body weight status or skinfolds. In a study carried out by Alkahtani and Awad (2016), prospective analysis found an increased risk of obesity correlated with higher TV watching; this increased risk was independent of PA. These findings also provide some evidence in support of the 'displacement hypothesis', which holds that sedentary activities, such as TV watching, are substituted for more active pursuits. Because many adults have only a

few hours daily for discretionary activities (Robinson and Godbey, 2005; Meyer et al., 2008), watching TV during free time may displace exercise or physically-active leisure pursuits. An inverse correlation was observed between TV exposure and each type of PA (i.e. work, sport, leisure biking or leisure walking). If high exposure to TV encourages individuals to expend less energy in other aspects of their daily lives, then the chances of these people meeting the recommended guidelines for PA are decreased (Meyer et al., 2008). Moreover, previous literature has shown that TV may impact risk of chronic disease, independent of PA. "*The Health Professionals Follow-up* and *Nurses' Health"* studies have identified significant correlations between TV watching, obesity and biomarkers for CVD, such as HDL, LDL and leptin, as well as higher risk of obesity and developing T2D (Meyer et al., 2008).

2.4.2. Factors influencing diet control in Saudi women

2.4.2.1. Eating-centric social activities and traditional foods

Food plays an integral role in the lives of Arab families, particularly at ceremonial occasions (often religious) and in the observance of certain events like births and weddings, and even during funerals. Care and love are intertwined with food and its offering. Family get-togethers are planned around elaborate meals; discussion and conversations are only incidental (Obeidat, 2002).

Arabic population traditionally eat sitting cross-legged on the floor on carpets and cushions, especially for celebrations and feasts, or at a low table. Food is served on large plates and is usually eaten using the fingers of the right hand only, or with bread for dips or to mop up stews (Food and Drink in Saudi Arabia, 2016).

Arab customs centre on hospitality around food and socialising with family and friends (Obeidat, 2002). The arrival of a guest at one's home is an event that leads to a special meal in honour of the visitor. Traditional etiquette required that a camel, goat or sheep be sacrificially slaughtered, and this is still often done. However, chicken might be substituted and, in many urban households, meat dishes have replaced eating the whole animal. Major ritual occasions correlated with Islamic feasts, reunions of family and kin, weddings and other social events, still require the sacrificial slaughter of sheep or, less commonly, camels or goats. For these events, meat is boiled in huge

pots and part of the soup is passed among the guests, with the rest poured over large trays of rice, on top of which the cooked meat is placed (Culture of Saudi Arabia, 2015).

A qualitative study conducted in the UAE reported that social norms and cultural factors were influencing people's adherence to their recommended diet regimen. These were: (i) eating-centric social activities, (ii) sharing one plate of food and (iii) traditional foods and cuisines (Alozaibi, 2011). Most of the participants indicated eating-centric social activity to be one of the main factors that limited people's ability to adhere to their diet plan. Social gatherings and events where food is served in abundance are very popular activities in the region (Alozaibi, 2011). In the UAE, as in many countries in the Middle East, people have the habit of serving food during social gatherings of families and friends or at weddings and lunch invitations. During such gatherings, guests are served lots of food and a lavish choice of expensive delicacies in abundance. In the Arabic tradition, it is considered courteous for the guests to eat what they are served. To refuse such hospitality when offered can cause offence to the host, and this hinders adherence to healthy diet programmes (Alozaibi, 2011). Additionally, some Arab families still practise the tradition of eating foods such as rice by sharing one large plate. This eating custom has made portion size and plate size difficult for people to implement in their daily lives and is considered a barrier to diet control (Alozaibi, 2011). Al-Tawil et al. (2007) hypothesised that the cultural habit of eating from the same plate by family members might influence the quantity of food eaten, as it is neither measurable nor limited for each person. This might encourage some family members to eat more. They observed that the prevalence of overweight/obesity among those who shared a plate with family members was higher (78%) than those who had individual plates (69%), but the difference was not significant ($p=0.59$) (Al-Tawil et al., 2007; Musaiger, 2011b).

Traditional foods are also an important part of an individual's diet and a demonstration of their cultural uniqueness, but the evidence on traditional foods is insufficient and conflicting (Obeidat, 2002). Arab culture depends on socialising lunch and dinner invitations; big feasts are a way of showing hospitality and one's generosity, so people indulge when it comes to food, especially, and mainly, with carbohydrate-based meals, rather than vegetable-based meals (Alozaibi, 2011).

Indeed, rice is “one of the oldest food sources in the country and has played a major role in the cultural, social and economic aspects of the lives of the Saudi people” (Alhemoud, 2011, p. 93). Rice is consumed almost daily by Saudi people and is considered an affordable food item for almost all Saudi people, regardless of their socioeconomic status (Mohieldein et al., 2011). For instance, Kabsa, a traditional Saudi dish of rice and meat, is common and consumed by most people in the KSA (Midhet et al., 2010; Alhemoud, 2011; Bakhotmah, 2012) and contains large amounts of fat (Winter et al., 2011; Bakhotmah, 2012). Dates, also a traditional nutrient source that are consumed almost daily in the KSA, are considered rich in sugar and usually served with Arabic coffee (*Gahwa*) to guests as an act of generosity (Al-Rethaiaa et al., 2010; Winter et al., 2011).

According to Alozaibi (2011), traditional foods served at homes or during events, such as rice with meat drenched in fat, were a concern and believed to be damaging to people’s healthy diets. Subjects described traditional cuisines as unhealthy foods that were rich in carbs and saturated fatty acids content (Alozaibi, 2011). Conversely, it has been reported that, in the UAE, people living in isolated rural areas still maintain a Bedouin lifestyle and eat traditional foods and, consequently, have lower obesity rates than those in urbanised areas (AL-Nohair, 2014). Another study by Al-Mssallem (2014) revealed that traditional Saudi foods are a good source of healthy carbohydrates that are consumed in forms of whole grains, which are rich in fibre, some vitamins and minerals. Moreover, the glycaemic index and insulinaemic index value of some traditional Saudi foods are within low range, which suggests that these foods may have benefits on postprandial glycaemic and insulinaemic levels. These important features of traditional Saudi foods could provide substantial contribution to the improvement of Saudi diets in the management and prevention of diabetes (Al-Mssallem, 2014).

Furthermore, traditional foods are served more during Ramadan, which is the ninth month of the Islamic calendar (*hijri*), when Muslims abstain from food and drink from dawn until sunset. The common practice is to eat two meals, one before dawn and one after sunset, rather than the three meals normally consumed during other months (Hallak and Nomani, 1988). In general, food intake habits are changed dramatically, as

the consumption of meat and traditional sweets is increased. It is highly believed that these changes may negatively affect the health of Muslims during this month. The influence of Ramadan fasting on body weight and composition remains a controversial subject. Some research has demonstrated a reduction in body weight, while other studies showed a gain in body weight (Yucel et al., 2004; Syam et al., 2016). In the KSA, Al-Numair (2006) reported that there was a significant decrease ($p<0.05$) in the level of serum TAG, glucose and total protein, and, in contrast, there was a significant increase ($P<0.05$) in uric acid. There were no significant changes in the levels of TC and LDL-C. Another study explored the changes in body weight and blood lipids during Ramadan fasting in Syrian men on hypocaloric diets. By the end of Ramadan, it was found that body weight, blood TAGs and HDL-C had decreased significantly ($p<0.05$), while LDL-C had increased and TC had not changed compared to baseline values (Hallak et al., 1989; Musaiger et al., 2011a). A more recent study indicated that the influence of Ramadan fasting on decreased body weight and composition was temporary. By the 28th day of Ramadan, it was found that weight, BMI and body fat had decreased significantly; however, these measurements were regained four to five weeks after Ramadan (Syam et al., 2016).

2.4.2.2. Nutrition transitions/Change in food consumption

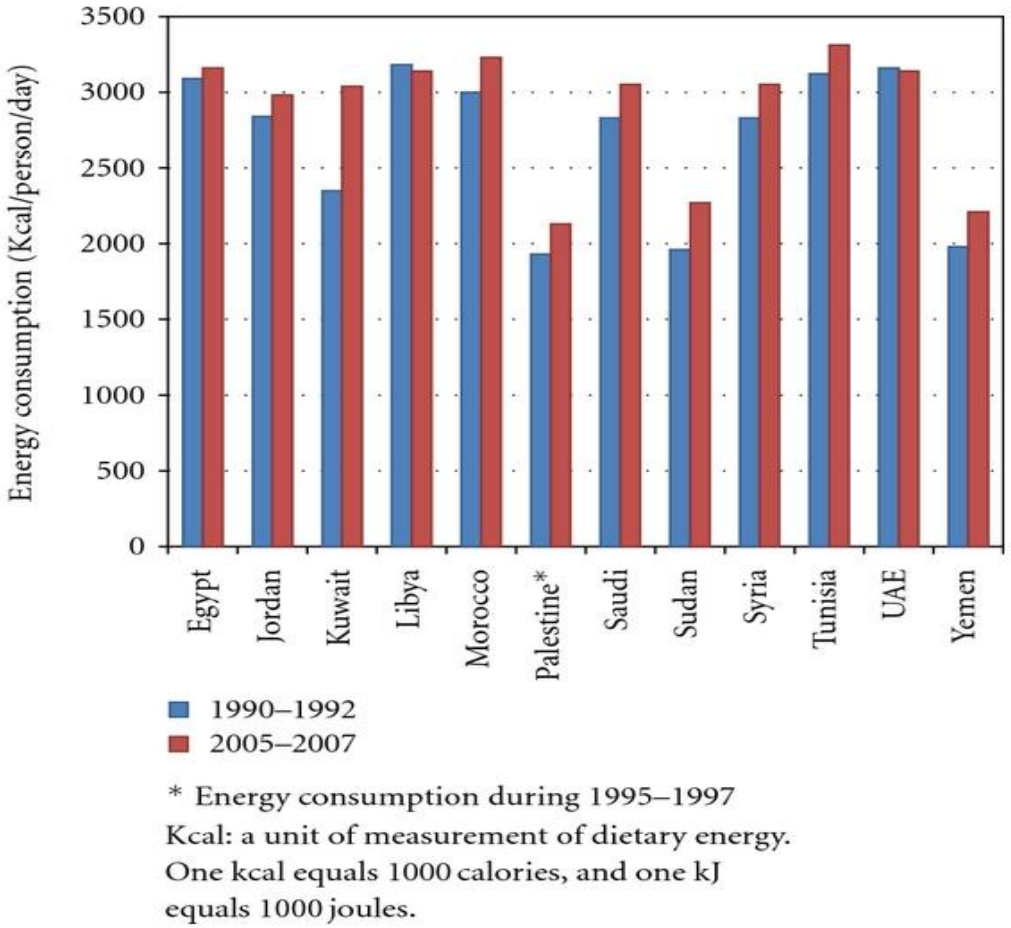
The KSA has experienced a rapid change in dietary patterns and lifestyle during the past four decades with the sharp increase in income as a result of the oil revenue (Musaiger, 2011a).

Meals were generally healthy in the past, but, due to westernisation, the nutrition of Saudis has shifted from a traditional diet, which consisted of dates, milk, vegetables and fruit, and whole-wheat bread and fish, to a more westernised diet, with a high energy and fat-rich food consumption, eating out and an increase in food portion sizes (Musaiger et al., 2011a). It is observable that, due to the westernisation of the Saudi Arabian diet, the increased consumption of high levels of free sugars and saturated fatty acids, cholesterol and sodium have become much more common in daily dietary habits (Al-Daghri et al., 2013). There was an increase in calorie supply during 1990-2007 in Arabic countries (see Figure 2.3) and a high percentage of these calories came from animal-derived foods (Musaiger, 2007).

According to Musaiger (2011a), the per capita availability of energy in most Eastern Mediterranean Region (EMR) countries increased by 716kcal during 1964-1999, and is projected to reach 880kcal by 2030. This makes the average daily per capita energy availability in excess of 3000kcal in most countries of the region. Cereal intake seems to have reached a ceiling, with a contribution to overall dietary energy supply of 35%-42%. The main cereals consumed are rice and wheat, and the rice consumed is polished and contains only 0.5% crude fibre. Wheat is mostly consumed as bread made from flour, with an extraction rate of 70%-75%. (Musaiger, 1998; Musaiger et al., 2011a). Sugar intake is rising from an already relatively very high level of 80-110g/head/day and contributes 10%-15% of daily energy supply. The same trend was seen for fats and oils, with consumption around 80g/head/day and contributing 30% of daily calorie supply. The intake of animal products is high compared to most developing countries (160-190g meat, 400-490g milk and 22-32 eggs/head/day) (Musaiger, 1998; Musaiger et al., 2011a; Carroll, 2013).

Other evidence has indicated that, in the past, the traditional diets in many Arab countries were characterised by high intakes of cereals (WHO, 2007; Poskitt, 2009). In the early 1960s, Middle Eastern citizens' total energy intakes were based on the energy derived from cereals (57%), vegetable oils (7%), meat and pulses (9%), fruit (6%), milk and dairy products (5%), and from added sugars and solid fats (14%) (Poskitt, 2009; Khalaf et al., 2013). In recent years, many EMR countries have adopted typical Western eating habits. The typical meals are often high in meat, fat and calories and low in fruit and vegetables. People have more access to fast food and ready meals than ever before, with outlets such as McDonalds and KFC spreading across the region (Nagata et al., 2011; Khalaf et al., 2013).

Figure 2.3: The dietary energy intake per person, in kcal per day, according to the Food and Agriculture Organization of the United Nations (Statistics Division 2010, Food Balance Sheets)



* Energy consumption during 1995–1997
Kcal: a unit of measurement of dietary energy. One kcal equals 1000 calories, and one kJ equals 1000 joules.

(Badran and Laher, 2011).

Adam et al. (2014) indicated that, in the last five decades, the overall supply of the different food groups in Saudi Arabia has changed dramatically. The per capita consumption of meat, eggs, animal fat, sugar and sweeteners, milk and offal has increased, while the consumption of fruit and vegetable has fluctuating trends. The contribution of fats showed an increased trend from just 15% in 1961/70 up to 1981/90 and stabilised at 25% up to the 2001/07 period, while the share of protein in the dietary supply remained stable from 1961/70 to 2001/07 (Adam et al., 2014). The supply of vegetables showed a sharp drop, from over 400g/capita/day in 1990, down

to less than 250g in 2000. Fruit supply was slightly better than vegetable during the same period (1990-2007). Meat supply increased from about 26g/capita/day in 1990 up to 139g/capita/day in 2007, an increase of 435%. However, the share of carbohydrates in the dietary supply decreased from 75% in 1961/70 to 64% in 2001/07 (Adam et al., 2014). Such 'a nutritional transition' has been claimed for the rising rates of obesity and other metabolic disorders which have been recently observed among the Saudi population (Al-Rethaiaa et al., 2010).

2.4.2.3. The globalisation of the food distribution system

It is widely accepted that globalisation is playing an important role in the development of dietary patterns linked with nutrition transition and the subsequent growth of diet-related chronic diseases in Arabic countries (Costa-Font et al., 2013). The development of these dietary behaviour has been influenced by changes in food demand and food supply. On the demand side, income growth, urbanisation and changes in employment are important. National income growth and urbanisation are correlated with increased intake of fats and sweets and a higher BMI (Hawkes, 2007). Costa-Font et al. (2013) has already argued that globalisation has helped promote obesity by speeding up the 'nutrition transition'.

Consequences of modernity on food practices among countries in transition were reported as follows: disintegration of meals, increased nibbling, eating at workplaces, less time allocated for home cooking and increased tendency towards convenience fast foods. Modernisation has also brought with it more industrialised energy-dense food products, meat-based products, more sugar and the availability of all foods during all seasons (Chamieh, 2013).

The ever-increasing influence of global food choices in recent years has led to many international restaurants and fast food franchises opening in the KSA. In 2011, there was a total of about 12,700 fast food outlets of all kinds in the KSA, with estimated sales of about $3.89 billion annually (Mousa, 2013). In most Saudi families, the frequency of eating food prepared outside the home is increasing (Musaiger, 2011a). Factors that have caused this shift are: the increased number of women who are involved in the workforce, which leads to decreased time available for preparing food

at home; and the limited number of places to spend leisure time for many families, especially in the Arabian Gulf states, due to the extreme climate and lack of indoor recreation centres, which has caused dining out at restaurants to become an ideal way to pass the time during weekends and holidays (Musaiger, 2011a). Findings by Al-Faris et al. (2015) provide evidence of the high prevalence of fast food consumption among Saudi females. Among the study participants, 95% consumed restaurants' fast food and 79% ate fast food at least once weekly. In the same study, international restaurants were preferred by participants to buy fast food compared with local restaurants (71% vs. 29%) (Al-Faris et al., 2015). Amin et al. (2008) revealed that, as eating outside the home increased in primary schoolchildren (6–11 years), the rate of obesity also increased. Among those who did not eat outside the home, 9% were obese and the rest were non-obese. The proportion of obesity increased to reach 53% among those who eat outside the home more than five times/week. The correlation between eating outside the home and obesity among these children was highly statistically significant ($p<0.001$) (Amin et al., 2008; Musaiger, 2011b).

Worldwide, the portion sizes of foods prepared outside the home have been increasing, both in pre packed, ready-to eat products and at restaurants. For instance, in 1916, a carbonated drink bottle was sold at 6-5 ounce (oz), while, in the 1950s, 10oz and 12oz bottles were available. Today, soft drinks intended for individual consumption are sold in 20oz or 32oz bottles. Fast food restaurants typically offer a range of portion sizes, from small through to super-sized items (Musaiger, 2011a). A recent study indicated a high degree of soft drinks consumption among Saudi university students: 47.8% of male students and female 43.5% students consumed soft drinks up to six times a week (Alkahtani and Awad, 2016). Moreover, the Global Energy Drinks Report (2012) revealed that the KSA was ranked among the top ten countries for the consumption of energy drinks (Epuru et al., 2015). Studies have shown alarmingly rising trends in the consumption of energy drinks among all age groups of Saudi population, including children and adolescents, with 54.60% of men and 26.15% of women habitual energy drink consumers (Alsunni and Badar, 2011).

Food advertising and promotion drive globalisation by increasing demand and speeding the flow of food products into the global marketplace. In turn, globalisation

has stimulated more advertising and promotion by bringing to the countries the advertising and marketing agencies with the most expertise in designing marketing campaigns (Mousa, 2013). Expenditure on food advertising is high and increasing in Arab countries; a significant proportion of this advertising is for energy-dense processed foods targeted at children and adults. The objective of this advertising is to encourage greater intake, and two major systematic reviews have concluded that advertising does affect food choices (Mousa, 2013).

Globalisation affects the nature of the food supply chain, thereby altering the quantity, type, cost and desirability of foods available for consumption. Industry data indicate that the KSA is the largest fast food market in the region. The acceleration of food intake change is driven by a fundamental change in the food marketing and distribution system (Musaiger, 2011b). Supermarkets are playing two roles in the nutrition transition: shifting demand for home-produced foods or foods purchased in open markets to increased dependence on store-bought foods supplied and expanding available choices of packaged and processed foods (Mousa, 2013). Foreign direct investment is also playing an important role in shaping the growing global market for processed foods, leading to their greater availability. It is also likely to stimulate sales by lowering prices, providing the means of growth for transnational supermarkets, and creating incentives for advertising and promotion (Mousa, 2013). Bagchi (2004) reported that, in the Arab countries, the very high consuption of energy-dense foods (fats, sugars and refined carbohydrates) and low fruit and vegetable intake, combined with a sedentary lifestyle with minimum PA, is correlated with the aggressive commercial marketing of fast foods.

The growing processing of foodstuffs has also had an impact on food intake habits. Advances in food processing and preservation in many countries in the region have led to the availability of a wide range of food products in the market. Vegetable oils, for instance, were not commonly used three decades ago in the EMR countries, but are now readily available in portable packaging and at a very low cost. Milk and dairy products are available in various packaging and reach rural and even more remote areas. However, the processing of foods has also had negative aspects on food

consumption patterns, through providing refined wheat flour, which contains less fibre, vitamins and minerals than whole wheat flour (Musaiger, 2011a; Mousa, 2013).

2.4.2.4. Snacking/Frequency of eating and breakfast skipping

Culturally, a snack is often defined as "food consumed between meals, i.e. breakfast, lunch and dinner" (Bin Zaal et al., 2009, p. 437). A Study conducted among young normal-weight male showed that certain types of foods, especially those perceived as unhealthy due to low nutritional quality (e.g. micronutrient poor; high in fat and/or added sugars; or low in fibre, such as cookies and potato chips), are also referred to as snacks. But confusion lies in the fact that micronutrient-dense, high-fibre foods, such as apples, are usually viewed in a more positive light and can also be eaten as snacks (McCrory and Campbell, 2011).

Well-controlled studies, conducted both within and outside of a laboratory, that account for implausible energy consumption reporting provide evidence to suggest that, regardless of snack macronutrient composition, consuming snacks can lead to overeating and, probably, weight gain. The primary reason is a lack of compensation in later energy intake; i.e. less is not consumed at other eating times, such as the next meal (McCrory and Campbell, 2011). Some studies have demonstrated that, as snacking increases, the total energy consumption increases. Snacks contribute to about 20%–75% of total energy consumption in Western countries such as the US and UK (Musaiger, 2011a). Forslund et al. (2005) showed that the obese group consumed snacks more frequently compared to the reference group ($p<0.001$) and females more frequently than males ($p<0.001$). Energy consumption increased with increasing snacking frequency, irrespective of PA. Statistically significant differences in trends were found for cookies/cakes, chocolate/candies and desserts for the relation between energy consumption and snacking frequency, whereas energy consumption increased more by snacking frequency in obese participants than in reference participants (Forslund et al., 2005). In the long run, unhealthy snacking will not only result in overweight or obesity, but also increase the intake of saturated fatty acids and sodium, which will lead to incidence of chronic diseases such as diabetes and CVD (Sachithananthan and Al Rashedi, 2014). Higher adherence to an "unhealthy snacking

pattern" was also independently associated with increased incidence of MS (Pimenta et al., 2016).

Available evidence has observed an inverse relationship between eating frequency, defined as the number of eating occasions per day, and the prevalence of excess adiposity and increasing risk factors for chronic disease, such as high blood cholesterol and poor glycaemic control (McCrory and Campbell, 2011). Based on controlled feeding studies, there might be a small benefit to appetite of eating six meals/day relative to eating three meals/day, and eating <3 meals/day might negatively affect appetite. However, it is premature to make specific recommendations on eating frequency due to several methodological weaknesses (McCrory and Campbell, 2011) and there is little evidence that a higher frequency of eating per se is a potential cause of obesity. WHO (2003b) revealed that there is insufficient evidence that increased eating frequency leads to increased or decreased obesity. A number of studies in the Middle Eastern countries showed a negative relationship between snacking and obesity. Undertaking a study in the UAE, Bin Zaal et al. (2009) showed that 60.5% of male adolescents (12–17 years) who always took snacks between breakfast and lunch were obese, compared to 39.5% of non-obese adolescents, but the difference was not statistically significant (p=0.149). However, the corresponding proportion amongst females was statistically significant (p<0.044) (68.2% and 31.8%, respectively). There was a significant association between the frequency of snacking between breakfast and lunch (P = 0.044) and obesity in girls but not in boys. Also, the obesity risk was higher in girls who always consumed midnight snacks (OR = 1.2; CI 0.6-2.2), but was not so in boys (OR =0.5; CI 0.2-1.0). (Bin Zaal et al., 2009. Another study showed that among snackers, obesity prevalence was 10.4%, 14.4% and 20.5%, respectively, in those consuming >15%, 15% to 20%, and <20% of their energy intake from snacks. Subjects were also classified according to the timing of consuming the most caloric snack of the day. The mean percentage of the total snack calories in the morning was 63.9%, and in the afternoon was 64.4%, whereas the highest caloric content was in the evening snack (69.3%) (Bo et al., 2014). Kelishadi et al. (2003) revealed that the mean frequency of consumption of rice, pasta, bread, fast food and fatty snack was significantly higher amongst obese than non-obese adolescents. However, the

consumption of vegetables and fruit was significantly higher in non-obese adolescents than obese.

Skipping breakfast or consumption of a poor nutritional value breakfast is common among both children and youth. A systematic review showed that people who consume breakfast meals regularly are less likely to be obese or to have diabetes than those who skip breakfast (Musaiger, 2007). In general, the percentage skipping breakfast was higher among women than men. Skipping breakfast by school children in some Arab countries was estimated to range from 28% to 70%, depending on sex, age and social class (Musaiger et al., 2011a). Studies in the relationship between breakfast intake and obesity in the KSA showed that 68.7% of Saudi females who skipped breakfast were obese and the rest (31.3%) were non-obese ($p<0.007$) (Monteiro et al., 2004; Musaiger, 2011a). Data from cross-sectional studies consistently show that skipping breakfast is correlated with excess body weight and markers of IR (McCrory and Campbell, 2011).

2.5. Conclusions

It is important to recognise that obesity and its metabolic consequences are global problems. While the increased incidence of obesity–related diseases such as CVD, diabetes and certain cancer were originally seen as 'Western' diseases often associated with North America and Europe, they now represent major health problems on every continent. Excessive energy consumption, coupled with reduced PA and sedentary life style are clearly the major reasons for the rise of such diseases. However, country-specific differences are seen in how and why these manifest themselves. This literature review has illuminated the complex processes of culture and its influence on health and health behaviour. Exploring underlying cultural influences is essential to understanding values, attitudes and barriers toward health behaviour and to effectively promoting PA. Environmental and behavioural factors, including obesity, physical inactivity and diet, are blamed for the global burden of CVD and T2D. In order to combat the growing epidemics of these diseases, a better understanding of the aetiology behind MS and interventions designed to ameliorate the early mechanism driving the comorbidities is needed.

2.6. Thesis objective

There are two major parts to the project: the first was to investigate the relationship between dietary intake and PA with BMI in Saudi women and to explore the barriers to a healthy lifestyle in Saudi women in two settings (KSA and UK). The findings informed the design of the second part. Study two was a pilot study that examined the impact of exercise training and/or diet in improving risk factors associated with MS. From the findings, it was anticipated that this new additional information would help the development of public health policy in KSA.

CHAPTER THREE

ASSOCIATION OF PHYSICAL ACTIVITY AND DIETARY BEHAVIOUR WITH BODY MASS INDEX AMONG SAUDI WOMEN LIVING IN SAUDI ARABIA AND THE UK (STUDY I)

3.1. Introduction

As discussed in Chapter One, Saudi Arabia has one of the highest rates of obesity in the world, particularly among women. Findings from national surveys conducted between 1996 and 2011 showed that, over a period of ten years, the prevalence of obesity in women increased from 23.6% to 44.0% (AlQuaiz et al., 2014). The consequences of obesity include an increased incidence of MS, T2D and hypertension and it is considered an independent risk factor for Coronary Artery disease (WHO, 2015c). Evidence indicates that the root cause of increasing obesity can be traced back to poor eating habits and a sedentary lifestyle (Ford et al., 2016).

The KSA has been undergoing rapid urbanisation and this has had a direct influence on the dietary habits and lifestyles of its people. The recent influence of Western lifestyle on Saudi culture is considered responsible for the increased consumption of high-fat and 'junk' foods (Winter et al., 2011; Alfawaz, 2012) and sugar-rich soft drinks are consumed widely (Midhet et al., 2010; Mohieldein et al., 2011). According to Musaiger (2011a), the per capita availability of energy in most EMR countries increased by 716 kcal from 1964-1999 and is projected to reach 880 kcal by 2030. This makes the average daily per capita energy availability in excess of 3000kcal in most countries in the region. During the period 1970-2005, a rise in the consumption of animal products and a reduction in the consumption of fruit, vegetables and complex carbohydrates has been documented. As a consequence, the consumption of fat, especially saturated fatty acids, and simple sugar has risen, while, at the same time, the consumption of dietary fibre has declined. As a result, the population is at increased risk of diet-related chronic diseases, particularly obesity, CVD, diabetes mellitus and cancer (Musaiger, 2011a). Statistics indicate that the populations in Arab countries, including the KSA, suffer from paradoxical nutritional problems: those associated with nutrient deficiencies, such as vitamin D and calcium deficiencies,

anaemia from iron deficiency and some individuals being underweight, and those associated with over-nutrition and changes in lifestyle, such as obesity, diabetes and hypertension (Musaiger et al., 2011a;b). This situation presents a great challenge for the Saudi Health Authority.

Changes in lifestyle and socioeconomic status in the region have also had a significant impact on PA. Saudi women have limited access to sport, while rapid economic growth has brought notable prosperity and an easier lifestyle in terms of transportation and access to cheap migrant labour, accompanied by new technologies that promote sedentary lifestyles (Al-Hazzaa, 2004b). In addition to these factors, multiple pregnancies are considered another important factor in the high rate of obesity in women in Arabic countries (Badran and Laher, 2011). Previous studies have shown that physical inactivity is extremely prevalent among both sexes and all age groups of the Saudi population (Al-Hazzaa, 2004b). There were, however, significantly more inactive females (98.1%) than males (93.9%) (Al-Nozha et al., 2007). The high prevalence of physical inactivity in Saudi society has emerged as a serious threat to public health (Al-Hazzaa, 2004a).

Unlike in Western culture, women in Islamic countries face traditional obstacles to exercising, particularly outdoors and in sports clothing; these difficulties are rooted in social restrictions and taboos as many families do not allow their girls to practise exercise outdoors for religious and safety reasons (Musaiger et al., 2013). It is reported that the lack of culturally-sensitive health clubs that respect Islamic religious beliefs is one of the culturally-related barriers to exercising (Alozaibi, 2011). AlQuaiz and Tayel (2009) indicate that the most common barrier to PA among Saudi adults is the lack of sports resources (80.5%). This is in addition to the lack of time, lack of public transport near facilities and the fear of assaults and being raped (Carroll, 2013; Awadalla et al., 2014). PA and dietary intakes of any population are influenced by multiple factors including income, prices, cultural traditions, individual preferences and beliefs, as well as social, geographical, environmental and economic factors (Adam et al., 2014). Environmental factors play a fundamental role in shaping human health and locational issues are of central importance to addressing health questions. As such, considerable evidence suggests changes in health–related behaviour occur when individuals

migrate to other countries. Adverse dietary outcomes, such as obesity and non-communicable diseases, resulting specifically from migration or mobility of population groups, have been reported by various authors (Kumar et al., 2006; Gilbert and Khokhar, 2008; Perez-Cueto et al., 2009). Franzen and Smith (2009) reported that environmental changes and increased levels of acculturation have a negative impact on the weight and health of adults after temporal migration by altering their eating and PA behaviours.

Perez-Cueto et al. (2009) reported that 85% of international students made dietary changes on their arrival in Belgium. Pan et al. (1999) suggested that even a short- term stay in a foreign country could result in a significant and often undesirable change in eating habits. The foreign students, however, tried to retain their traditional foods. Cost, availability and convenience were challenges and these made them adopt the eating habits and food choices of the host country (Soyer et al., 2008; Danquah et al., 2010). The main dietary trend after the migration was a fundamental increase in energy and fat consumption, a reduction in carbohydrates and a switch from whole grains and pulses to more refined sources of carbohydrates, resulting in a low intake of fibre. The data also indicated an increase in consumption of meat and dairy foods. Some groups also reduced their vegetable intake. The results suggest that these dietary changes may all have contributed to higher risk of obesity, T2D and CVD (Holmboe-Ottesen and Wandel, 2012).

In addition, environmental influences play an important role in promoting or inhibiting PA (Gosadi, 2016). Non-Western migrant populations living in Western countries are more likely to be physically inactive during leisure time than host populations. It is argued that this difference will disappear as they adapt to the culture of the host country (Hosper et al., 2007). It has been demonstrated that the attitudes of Muslim women and girls towards sport and fitness activities in the UK are heavily influenced by the way activities are delivered and whether due regard is given to cultural sensitivities (Women's Sport and Fitness Foundation, 2010). Young Muslim women in the UK appear to have very negative views regarding PE in schools. A study conducted with Muslim girls in the school environment demonstrated that the girls were put off participating in sporting activities to the point where some were skipping classes. This

was due to a requirement to shower communally and wear clothing which was considered as 'inappropriate' to the children's cultural traditions and beliefs (Women's Sport and Fitness Foundation, 2010). Carroll and Hollinshead (1993) found that, for the devout Muslims, there is a real feeling of guilt and shame at exposing their bodies and legs which had not been fully appreciated by the teachers.

Making individuals with obesity move and improving adherence to exercise is a critical challenge: hence the importance to better understand the psychological and cultural determinants of exercise behaviour. Investigating the main reasons for not engaging in PA reported by obese subjects and the possible solutions to increase motivation and adherence are good strategies to start physical exercise but do not guarantee maintenance (Grave et al., 2011). According to a review article by Schutzer and Graves (2004), overcoming the environmental obstacles and improving the participants' knowledge about PA do not necessarily translate into adhering to a long-term PA regimen. A more recent study confirmed that overcoming or removing common barriers to exercise and awareness of its health benefits do not necessarily lead to behaviour change of the participants (Withall et al., 2011). However, perceived feelings of enjoyment and satisfaction have appeared to better predict higher levels of adherence (Päivi et al., 2010).

Fundamentally, food intake and PA are two of the factors that are a part of an individual's own choice of behaviour and lifestyle (Zhang and Wang, 2004). Undoubtedly, the final decision to consume a particular food item or beverage, or whether to exercise or not, is an individual choice. However, exposure to a sedentary environments and access to a wide array of foods and technologies inevitably impacts on behaviour and can promote habitually unhealthy lifestyles (Swinburn et al., 2011). For example, studies have shown that exposure to a wide array of tastes and flavours can actually promote energy consumption (Epstein et al., 2009) and that this is accentuated by the widespread advertisements for energy dense foods, large portion sizes served in a variety of eateries and, most importantly, changes in food preparation practices at home (Zhang and Wang, 2004; Chamieh, 2013).

Numerous studies have confirmed that bringing about changes in people's patterns of PA and diet remains the central goal of all treatment programmes, due to the salutary

effects on health and longevity of moderate activity and a varied, balanced diet (Kaur, 2014). Thus, it is important to identify modifiable risk behaviours, including physical inactivity, prolonged sitting time and dietary intake, particularly those which may influence women and may impact on the likelihood of obesity and its complications. However, relatively little is known about the knowledge, attitudes and barriers that prohibit PA and influence the dietary habits of Saudi women. Additionally, to the best of our knowledge, there have been no previous studies in Saudi Arabia examining the changes in PA and dietary behaviour of Saudi women outside of their home country. Therefore, the purpose of this study was to examine the effect of PA and food intake on BMI of Saudi women living in the KSA and the UK.

3.2. Hypotheses

1. Adiposity (as determined by increased BMI) is directly associated with both increased energy intake and reduced PA in Saudi women.

2. Cultural and social norms barriers restrict the amount and type of PA undertaken by Saudi women.

3. Levels of PA and energy intake differ between Saudi women living in the KSA and the UK as migrant women adapt to the host environment.

3.3. Aim

To investigate the impact of PA and food intake on BMI among Saudi women living in Saudi Arabia (W-SA) and women living in the UK (W-UK).

3.4. Objectives

1. To determine the prevalence of physical inactivity among W-SA and W-UK aged between 18 and 54.

2. To investigate knowledge, attitudes and barriers relating to PA among W-SA and W-UK.

3. To measure usual intake of particular food groups (fruits, vegetables, grains and cereal products, dairy products, meats and alternatives, nuts and seeds, beverages, snacks/sweets and crackers, fast food) and assess dietary intake from a 24-hour recall

record, analysing carbohydrates, proteins, fats, selected vitamins and minerals, fibre and sugar intake in both groups.

4. To compare PA data and dietary intake between W-SA and W-UK.

5. To determine the correlation between BMI and dietary intake (energy and macronutrients) and levels of PA in W-SA and W-UK.

3.5. Methodology

This section sets out in detail the methodological procedures employed in this study and discusses the research strategy, providing details about the development and translation of the questionnaire. In addition, it describes the study population and methods of data collection, the piloting of the questionnaire and main study procedures.

3.5.1. Study design

The research design is intended to facilitate the responses to the research questions about the effect of diet and PA on body weight of Saudi women living in the KSA and the UK; assessing the participants' knowledge about the benefits of exercise, participation in PA, attitudes and barriers. It is an action plan that outlines a systematic approach to carrying out research. The design includes the selection of an appropriate study population, techniques for data collection, analysis and interpretation. The methodological design of this study was largely informed by the objectives and research questions but was also affected by the particular constraints of the research setting, time and resources available to conduct the research.

The participants were 258 healthy Saudi women aged 18-54 years, of which 206 were living in Saudi Arabia and 52 living in the UK. They were asked to fill in a questionnaire to assess the level of PA and collect data relating to their knowledge, attitudes and common barriers to PA. In addition, dietary intake was assessed using a 24-hour dietary recall record (Appendices 1 and 2). The study was carried out in Al-Ahsa Governorate, located in the Eastern province of Saudi Arabia, and in the Nottingham region of the UK between August and October 2013.

Study participants in both groups were recruited via distribution of electronic and hard

copies of the self-reporting questionnaire around the sampled regions using snowball sampling techniques. This was in addition to e-mail, SMS, WhatsApp messages and posters (Appendices 3 and 4). People interested in participating were asked to contact the researcher as there were no specific exclusion criteria for participation in the study. The W-UK group was also recruited by sending an electronic questionnaire to the Nottingham Saudi student club. Questionnaires from 31 respondents were excluded from the study due to missing data and/or dietary data not being available.

3.5.2. Ethical approval

Ethical approval for the study was obtained from the Medical School Research Committee of the University of Nottingham in June 2013 (Ethics Reference No: OVSB06062013 SBS Nutrition) (Appendix 5).

3.5.3. Study sample

The selection of the study participants is important when planning a survey. The success of population research in any country requires an understanding and appreciation of many local factors, such as population composition, access to individuals, legislation and sociocultural attitudes and beliefs (Aw et al., 2011). Unavailability in the public domain of sampling frames of the KSA population is a barrier in the selection of representative samples of the target population (Mytton et al., 2016).

In this study, and in both locations (the UK, KSA), snowball sampling techniques were considered the most appropriate research design. Snowball sampling, also known as chain sampling, chain-referral sampling or referral sampling, is a non-probability sampling technique, which allows researchers to identify and recruit key informants from an anonymous community (Etikan et al., 2016a). It is useful in situations where it is hard to reach respondents in the study population (Sadler et al., 2010).

In Saudi Arabia, there were no lists from which sampling frames could be drawn. Additionally, traditional customs and social norms restrict the freedom of women and prohibited spontaneous personal interviews for research (Andersson and Togelius, 2010). It is either difficult or impossible for a stranger to gain access to any household. All contact has to be made by an introduction from another person. Since Saudi society

is a patriarchal society, women have to get approval from their parents or "male guardian" before participating in the study. Consequently, random sampling in this country is not possible (Alwedinani, 2016; Mytton et al*.,* 2016).

For all these reasons, data in this study were collected through direct contact with participants, who were then asked to recruit others based on a snowball sampling method. This process continued until a target sample size was reached. Hard copies of the questionnaire in addition to the internet- and email-facilitated sampling methods were used, which have the benefit of recruiting participants from different geographical locations.

It is widely believed that caution should be shown in making inferences about the host population based on data collected from snowball samples. However, multiple entry points into the communities were used, choosing as wide a range of people as possible to provide further contacts to reduce selection bias inherent in this method (Bloch, 2007; Sulaiman-Hill et al., 2011).

To determine the sample size, RaoSoft (2004) an online sample size calculator was used to calculate the sample size required for this study. With an accepted margin of error of 10%, confidence level of 95%, and response distribution of 50%, the sample size required was 96. For the W-SA group, in order to overcome erroneous results and increase the reliability of the results and the conclusion, the target sample size has been increased to 206 women (with a margin error of 6.8%).

For the W-UK group, despite the attempt to obtain a larger sample by sending the questionnaire to the Nottingham Saudi student club, and contact through a large number of friends and colleagues, it did not prove possible to recruit more than 52 participants (with a margin error of 13.6%). This is likely to be because in a strange environment, friendship relations are limited and most of the Saudi women come to the UK just for studying. It was not possible to obtain any statistics about the total number of Saudi women had scholarships or who were visiting with their spouses in the region.

3.5.4. Measuring instruments

A self-reported method was considered the most appropriate tool for collecting data

in this study based on Saudi women situation. Participants completed a self-reporting questionnaire that contained anthropometric measurements and a PA questionnaire, in addition to a food intake diary.

3.5.4.1. Anthropometric measurements

Self-reported anthropometric data remains the most widely used measure to diagnose obesity in large-scale population research and surveys as it is quick, simple, inexpensive and non-intrusive (Bhurosy and Jeewon, 2013). However, self-administered height and weight may be influenced by response or recall bias; typically, body weight is under-reported, while height is often over-reported leading to under-reported BMI (Gorber et al., 2007; Bowring et al., 2012).

Some studies have determined a greater discrepancy in self-administered and measured height and weight amongst certain groups, including overweight/obese adults compared to healthy or underweight adults, females, dieters compared to non-dieters, and older individuals. Such systematic error might lead to lower prevalence estimates of overweight/obesity and systematic bias in studies investigating the relationship between obesity and health outcomes dependent on self-administered measurements (Gorber et al., 2007; Elgar and Stewart 2008; Bowring et al., 2012).

In Canada, a study compared self-administered and measured height and weight among adults. Self-administered height was found to be on average 0.88 cm greater than measured height, and self-administered weight was 2.33 kg lower than measured weight. Accordingly, BMI derived from self-administered height and weight was 1.16 less than BMI derived from measurements. In the same study, self-administered overweight was 31.9% compared with 33.7% measured overweight, and self-administered obesity was 15.3% compared with 22.9% measured obesity (Elgar and Stewart, 2008).

In contrast, Fonseca et al. (2010) found a high correlation between reported and recorded weight (0.84) and between reported and recorded height (0.96). Among girls, self-reported BMI and measurement based BMI were highly correlated, with reported BMI explaining approximately 79% (R = 0.785) of the variance in measured BMI, with a standard error of approximately 1.6 kg/m^2. Among boys, computed BMI

(from self-reported height and weight) explained 65% (R = 0.651) of the variance in measurement based BMI, with a standard error of 2.1 kg/m^2 (Fonseca et al., 2010).

Even though BMI has been used extensively in research and clinical practice, there are few studies testing its diagnostic accuracy (Romero-Corral et al., 2008). The available evidence indicates that there is not an overall, statistically significant difference between self-administered BMI and measured BMI, as captured in two nationally representative surveys. This finding remains when comparing the samples by ethnicity, gender, and socio-economic deprivation quintile (Kruse, 2014). Self-administered BMI seems to be a sufficiently valid measure, especially if it is treated in analyses as a dichotomous independent variable for the entire sample (i.e., overweight/obese or not). For instance, statistical tests to assess a correlation between BMI and a health behaviour could be undertaken with confidence in the validity of the BMI classification (Kruse, 2014).

Similarly, in another study, self-reported height and weight acquired from phone interviews were valid to estimate the overweight/obesity prevalence in the population. Self-administered data about weight and BMI (calculated from self-administered values) acquired by means of phone interviews demonstrated high validity and agreement in comparison to their respective measured values (CCC = 0.87 for BMI and CCC = 0.95 for weight). However, self-administered height was observed to be less reliable (CCC = 0.60 among female and CCC = 0.75 among male) compared to the measured height. There was a high level of agreement between self-administered and measured BMI (ICC = 0.81 and CCC = 0.87). BMI validity, computed from self-administered values and evaluated by means of high specificity (96%) and sensitivity (71%) of the diagnosis of obesity, showed that self-reported BMI is a reasonable instrument to diagnose obesity prevalence in target populations (Lucca et al., 2010).

In our study, self-reported weight and height were obtained from the questionnaire. Estimated weight and height were used to calculate the subjects' BMI using the formulae weight (kg)/height (m²), which was categorised according to the World Health Organisation (WHO) criteria into the following: underweight (BMI less than

18.5), healthy weight (BMI 18.5 – 24.9), overweight (BMI 25 – 29.9), obese (BMI 30 – 39.9) and morbidly obese (BMI 40 or more).

3.5.4.2. Physical activity questionnaire

Questionnaires, in general, are good for gathering data about abstract ideas or concepts that are otherwise difficult to quantify, such as knowledge, attitudes and beliefs (Artino et al. 2014). Self-reporting questionnaires are the most common tool for undertaking studies in PA. The questionnaire, according to Collis and Hussy (2009), is "a list of structured questions, chosen after considerable testing, with the purpose of eliciting reliable responses from a chosen sample to find out what a selected group of participants do, think or feel". The use of PA questionnaire is popular and allows the collection of a large volume of data in a short time from a sizeable population in a highly economical way. In addition, it is faster to conduct and more convenient for subjects than interviews, as well as allowing participants to answer questions freely without the potential of interviewer bias (Finger et al., 2015; Alahmad, 2016).

However, some studies found that self-reports had low to moderate validity as respondents are susceptible to lying or giving inaccurate information in questionnaire responses (Kohl et al., 2000). Previous results have shown that the correlations between self-administrated and direct measures of PA were generally low to moderate and ranged from -0.71 to 0.96. No clear pattern emerged for the mean differences between self-administered and direct measures of PA. Trends differed by measure of PA employed, the level of PA measured, and the gender of subjects. Assessment of the risk of bias indicated that 38% of the studies had lower quality scores (Prince et al., 2008).

Despite limitations, self-report tools still offer considerable potential for measuring general activity levels (Troiano et al., 2008; Alahmad, 2016). Well-structured questionnaires can collect useful information about frequency, intensity, duration, and type of PA (Alahmad, 2016). Also, there is some evidence from other studies that used objective approaches to measure PA level (e.g. accelerometer and pedometer) and confirmed that there were similarities with the findings of studies that used self-reporting (Troiano et al., 2008; Alahmad, 2016).

A systematic review evaluating the measurement properties of 10 self-report PA questionnaires completed within healthy adult populations demonstrated good/excellent test-retest reliability (intra-class coefficient (ICC) = 0.76, $p < 0.0001$; $r = 0.627–0.91$; $r = 0.618$, $p < 0.001$, respectively), while variable criterion validity ($r = 0.67$, $p < 0.0001$; $r = −0.02–0.43$; $r = 0.392$, $p < 0.01$, respectively). The single-item measure showed significant criterion validity against an accelerometer for moderate to vigorous PA ($k = 0.23$, 95% CI 0.05 to 0.41) and PA ≥ 10/min bouts 0.39 (95% CI 0.14 to 0.64) (Silsbury et al., 2015).

In this study, self-reporting was employed for reasons that include assessing a broad range of factors related to PA behaviours, knowledge, attitudes, barriers, motivations and preferences. It is considered an appropriate tool for Saudi society, specifically faciltiating the collection of data from Saudi women. This method also facilitates the responses to the research questions as Crawford (2010) reported that "the methodology that's used comes from the research question and applicability, not from the personal preferences for one design or another."

3.5.4.2.1. Questionnaire development

Systematic development of the questionnaire for data collection is important to reduce measurement errors in the questionnaire content, questionnaire design and format, and respondent. Well-crafted conceptualization of the content and transformation of the content into questions is important to minimize measurement error (Radhakrishna, 2007). Following appropriate and systematic procedures in questionnaire development, testing and evaluation are important steps to gain a valid and reliable questionnaire, thereby enhancing the quality of the research (Radhakrishna, 2007). Therefore, in the current study, specific steps for developing the questionnaire (Scheuren, 2004) were undertaken as shown in (Figure 3.1).

Figure 3.1: Flow diagram summarizing the stages required to carry out a survey

STAGE 1 Development and Validation of Questionnaire	STAGE 2 Piloting	STAGE 3 Finalizing Questionnaire Design	STAGE 4 Implementation Data Collection	STAGE 5 Data Coding and Analysis
1.1 Questionnaire literature and corresponding 1.2 Questionnaire construction and validation process 1.3 Compilation of pilot questionnaire 1.4 Final pilot questionnaire 1.5 Prepared questionnaire in Arabic and English language	2.1 Identify target population & devise sampling plan for pilot study 2.2 Recruit pilot participants 2.3 Readability and collect questionnaire data commitment 2.4 Analysis pilot data	3.1 Evaluate pilot result and identify any problems 3.2 Identified strengths and limitations of piloting 3.3 Discussion and revision questionnaire 3.4 Finalised questionnaire	4.1 Prepare the questionnaire & plan the schedule 4.2 Distribute questionnaire among women living in the KSA 4.3 Distribute questionnaire among women living in the UK	5.1 Data coding 5.2 Data entry 5.3 Data verification/ Checking error 5.4 Statistical analysis

The initial research instrument was developed based on the review of the literature and the elicitation study to produce a self-administered questionnaire that would be consistent with Saudi cultural norms, while addressing the research aims and objectives. It is important to revise previous work from others to avoid any redundant questions and to enable the comparison (Boynton and Greenhalgh, 2004).

Using previously validated and published questionnaires saves time and resources and enables the researcher to compare their results with those from other studies (Boynton and Greenhalgh, 2004). If there is no “off the peg” questionnaire available, researchers need to construct their own. Using one or more standard instruments alongside a bespoke questionnaire can save the need to develop and validate a long list of new items (Boynton and Greenhalgh, 2004).

According to Remenyi and Bannister (2013) if previously developed questionnaires are used, then the source of the questionnaires need to be stated. Where the questionnaire combines components of existing validated instruments with new questions or sections, a careful explanation and justification of its construction must be provided and in particular why overall validity is retained. These activities would then constitute the researcher's claim that the questionnaire was a validated measuring instrument (Remenyi and Bannister, 2013).

The survey questionnaire of this study was mostly a composite of other established and published PA questionnaire surveys which were modified and adapted to be culturally appropriate for Saudi society. Where possible, questionnaire items that had been standardised and validated were used or adapted for use in the present study.

The self-administrated questionnaire consisted of 37 questions relating to the knowledge, constraints and motivation that may influence women’s participation levels in PA and sport. The questionnaire was designed to collect information on frequency, duration and intensity of a variety of light, moderate and vigorous intensity PAs during a typical week. It consisted of six self-reporting sections made up of closed-ended and open-ended questions including: demographic data, personal exercise routines, health-related knowledge and attitudes, the common barriers to PA, motivation for exercising, PA programmes and services in the participants’ community.

Section 1 included questions relating to demographic data, i.e. age, height/weight, education level, marital status, number of children, employment status and income (five categories from less than £500 to £2500 or more/monthly, and its equivalent in Saudi Riyal).

Section 2 assessed participants' PA level. All the questions in this section were based on the Arab Teens Life Style (ATLS) research instrument which has been used in studies about PA in the KSA (Al-Hazzaa et al., 2011a,b) and in other Arab countries (Kilani et al., 2013; Musaiger et al., 2014) among adolescents and young adults. The original questionnaire was previously shown to have a high reliability (interclass correlation = 0.85; 95% CI: 0.70–0.93) and acceptable validity ($r = 0.30$; $p < 0.05$) against pedometer-assessed activity in a convenience sample of young males aged 15–25 years (Al-Hazzaa and Al-Ahmadi, 2003; Al-Hazzaa et al., 2011a). Items 8–17 comprise personal exercise habits questions and items 18–19 relate to sedentary activities. The PA portion of the questionnaire was designed to collect information on the frequency, duration and intensity of low, moderate and vigorous intensity physical exercise during a typical week. The PA measured in the survey included moderate-intensity activities (pace walking, brisk walking, household activities and recreational sports such as volleyball, badminton and table tennis) and vigorous-intensity activities (e.g. stair climbing, aerobic exercise, basketball and singles tennis) (Al-Hazzaa et al., 2011a, b). For sedentary behaviours, the questionnaire was adapted to assess typical time spent per day on sedentary activities, including TV viewing and using the computer or smart devices, whether at home or work. The total screen time was reported as hours per day spent on screen viewing (Al-Hazzaa et al., 2011a, b).

Section 3 assessed participants' knowledge and attitudes towards their health, weight and fitness status. The questions of this section were adapted from Roper (2002) and covered overall basic knowledge about the importance of exercise and attitudes towards it, knowledge of recommended levels of PA and attitudes towards using PA, either to prevent or treat chronic diseases. A 5-point Likert scale was used as an indicator of attitudes to PA (1 = strongly disagree and 5 = strongly agree).

Section 4 investigated the salient perceived barriers to PA. Participants rated statements concerning exercise beliefs, as well as potential barriers to exercise for

women, on a 5-point Likert scale representing the most severe barrier. Examples of the obstacles identified included lack of time, bad weather, traditions and beliefs.

Obstacles identified were adapted from Hakobyan (2008) study where barriers to addressing exercise with people were examined with some modification to fit the Saudi culture. The original questionnaire was shown to have reasonable measurement properties for monitoring population levels of PA (Spearman's Rho clustered around 0.8 indicating reliable responses between repeat administrations; criterion validity had a median Rho of 0.3 against the accelerometer for minutes of moderate, vigorous, walking and sedentary behaviours, which was comparable to most other self-administrated validation studies). Some extra barriers to PA were added to the list to be comprehensive for all PA barriers (e.g. lack of a partner, lack of a suitable facilities for sport, lack of transportation, bad weather, traditions and beliefs.

Section 5 assessed factors that would motivate participants to be more physically active. The questions were adapted from Roper (2002) and Hakobyan (2008) and addressed a number of themes, including preventing diseases, weight loss, improved physical appearance, reduced depression and reduced anxiety levels.

Section 6 investigated the PA programmes and services in the participants' community. The possibilities identified were adapted from Roper (2002) and included questions on the participants' intention to be physically active and the most common activities in which women want to participate (e.g. dancing, swimming and aerobics). One question about activities and community resources asked participants for suggestions; through an open-ended question, it asked them to identify what could be done in their community to make it easier for them to exercise more regularly.

The questionnaire was designed to ensure the questions did not deviate from the research objectives (Oppenheim, 2000). Questions were then defined from the required variables and modified to optimise the data collection process.

For structuring and validating the questionnaire, the following aspects were considered:

- Are questions associated with good reproducibility and reliability?
- Are answer choices mutually exclusive/biased/objective?
- Are the questions necessary to the objective?
- Are the questions too brief/vague/ precise?

Consideration was also given to the clarity of the questions including:

- Will the words be understood clearly with/without abbreviation?
- Is the question too demanding and is too much knowledge being assumed?

The face validity of the questions was considered by addressing the questions:

- Do the answers to the question provide the required data and how valid are they?
- Is the question accurate and can it stand alone?
- Is the question applicable to all respondents?

In terms of external validity, the important question is whether responses could be compared with other surveys or not. All of these considerations are important to make the questions as reliable as possible and produce meaningful and valid results.

In order to establish the content validity of the questionnaire, the first version of questionnaire was translated into Arabic and then arbitrated by three experts in sports nutrition. Feedback from experts was important to make sure the questions were well expressed, well balanced and contained the entire domain to be measured. Only a few questions were modified and one question was removed completely because experts considered that is was too general as shown in table 3.1. The feedback from experts was positive as they agreed that the questions covered all the objectives and would easily be understood. This was considered enough to demonstrate the content validity of the questions; accordingly gave the confidence to continue to pilot the questionnaire.

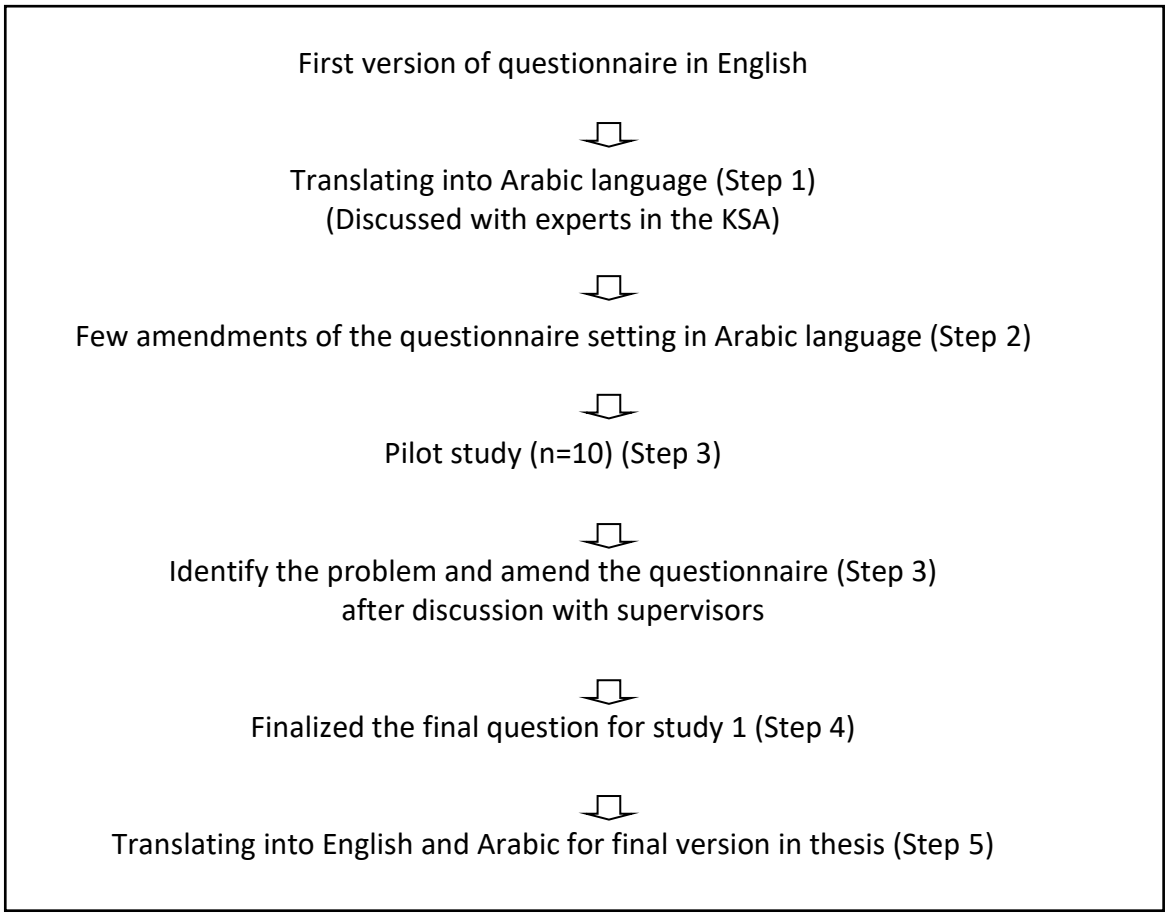
Table 3.1: Summary of prior pilot results

Question	Response
8. How many days per week do you regularly walk?	Amend question to include 'On average' and 'for more than 10 minutes' 8. On average how many days per week do you regularly walk for more than 10 minutes?
11. How many times per day do you use the stairs in work, home, or elsewhere? (One floor or stair count as 1 time)	Amend question to include 'On average' and 'more than 10 steps' 11. On average how many times per day do you use the stairs (more than 10 steps) in work, home, or elsewhere? (One floor or stair count as 1 time)
19. How long do you spend using a computer per day?	Amend question to include 'On average' and 'tablet or mobile-phone' 19. On average, how long do you spend using a computer, tablet or mobile-phone per day?
24. Circle the number that best corresponds to your attitude about exercise. (1= Lowest, 5= Highest)	Change the Likert scale from (1= Lowest, 5= Highest) to (1= strongly disagree, 5= strongly agree)
31. Circle the number that best corresponds to your Barriers or obstacles to exercise. (1= strongly disagree, 5= strongly agree	Add 'Lack of child care' to the other options
31. Circle the number that best corresponds to your Barriers or obstacles to exercise. (1= Lowest, 5= Highest)	Change the Likert scale from (1= Lowest, 5= Highest) to (1= strongly disagree, 5= strongly agree)
How would you rate your current knowledge of the benefits of physical activity and exercise for health?	Remove question

3.5.4.2.2. Pilot study

A pilot study is a fundamental part of the questionnaire design process. Piloting the questionnaire can increase the chances of the questionnaire's validity, reliability and feasibility (Aljammaz, 2016). It also provides an opportunity to ensure that it is readable for the target audience, and confirm the clarity of the questionnaire items, instructions and layout. Additionally, feedback can be obtained on the types of questions to use and their format, as well as on the appearance of the questionnaire and removal of any redundant questions. Piloting the questionnaire also identifies the amount of time required to complete the questionnaire (Cohen et al., 2013; Aljammaz, 2016). In the current study, the major purposes of piloting the questionnaire were to test the readability, understandability, and cultural relevance of the Arabic versions of the research instruments and to determine the feasibility of the study on a larger scale. The development of the questionnaire using a pilot process for this study was conducted according to the flow chart below (Figure 3.2).

Figure 3.2: The flow chart of piloting and finalizing the questionnaire



The pilot study was conducted with women from the community by face-to-face interviews to assess the comprehension, clarity, ambiguity, length, time and for potential difficulties completing either instrument as suggested by Krosnick and Presser (2010). Pre-testing the questions helped to determine whether the instrument was sufficiently generative and comprehensive in relation to the research questions of the study and to ensure data obtained could meet the study objectives.

The questionnaire was piloted with a convenience sampling of ten women aged between 20 and 50 years (who were not included in this study). The interviews lasted, on average, for 30 minutes and consisted of 37 semi-structured questions with follow up queries. Prompts and probes were used where necessary to encourage more detailed responses.

The answers to the questionnaire were then investigated manually, according to the evaluation list of piloting process, which was prepared to ensure the questions were all acceptable to women (Appendix 6). This was assessed by questions including: are there any questions that cannot be answered/answered easily, cannot be understood and need rewording/re-structuring, ambiguous which requires re-designing the layout and are there any missing questions that are worth adding. It was also important to recognize questions that took longer to answer and how long it took to complete the questionnaire (Brancato et al., 2006).

Feedback was obtained about the length of the instrument, the format of the scales, content validity, and question clarity. Piloting showed that the questionnaire was feasible for implementation because it was self-explanatory, the list of activities was comprehensive, and the time taken to complete the questionnaire was about 20 minutes. However, a few questions were modified in the questionnaire taking into consideration the participants' understanding as shown in table 3.2. The questionnaire was amended accordingly and translating into English and Arabic for final version was prepared.

Table 3.2: Summary of post pilot results

Question	Response
19. On average, how long do you spend using a computer, tablet or mobile-phone per day? At home At work (if applicable)	Amend question to include At work 'or university' (if applicable)
27. How often do you think a person needs to exercise to be healthy?	Amend question to include a person 'your age'
28. For how long daily, do you think a person should exercise?	Amend question to include a person 'your age'
34. What types of physical activity interest you?	Rephrasing the question to What types of physical activity classes or programmes do you want to participate in?

3.5.4.2.3. Translating the questionnaire

The questionnaire was adapted into Arabic the mother tongue in Saudi Arabia. The process of translating the content of the research instruments from English to Arabic took into consideration the impact of linguistic and cross-cultural influences, which may change the meaning and interpretation of words translated. Poorly translated words and phrases in the research measures may mean erroneous responses are given and consequently invalidate the data gathered (Sperber, 2004).

The translation of the different measures was a forward-backward, four-step process (Figure 3.3) which has been highlighted as a valid measure to ensure the linguistic and conceptual equivalence (WHO, 2009). The questionnaire was developed in English and then translated into Arabic language and culture in accordance with translation methodology by two different experts. The obtained Arabic form was translated into English by another expert using the back-translation method. The English forms and the forms obtained through the back-translation method were compared, and only minor changes were made to some phrases in the light of expert opinions (Table 3.3). Additionally, in the list of question 7 in the questionnaire, what is your monthly

household income? The income was translated from Pounds to its equivalent in Saudi Riyal.

The review of the back translations for the questionnaire showed that the items were accurate with no errors, ambiguities or inconsistencies, thus, the Arabic versions (forwarded translations) were of sufficient quality to be tested with potential study participants. Both English and Arabic final versions of the study instrument are presented in Appendices 7 and 8.

Figure 3.3: The questionnaire forward and back translation process

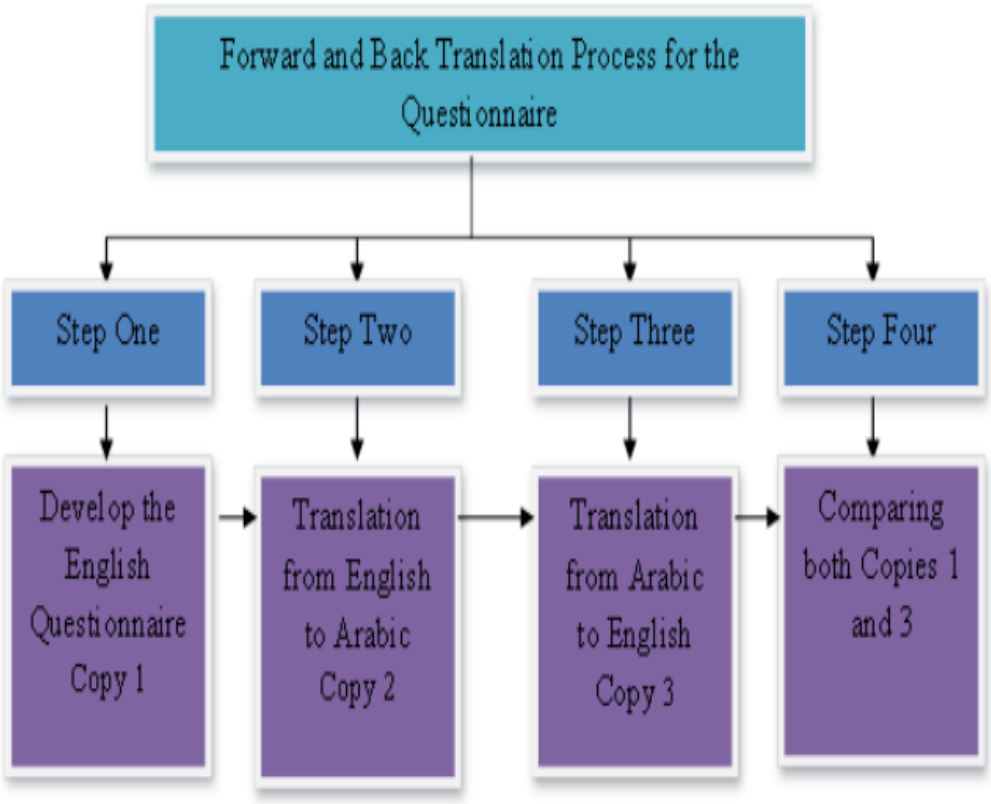


Table 3.3: Summary of the back translated changes

Question	Response
14. How many days per week do you regularly play vigorous sports (e.g. soccer, rugby, hockey, netball, basketball, handball, athletics, tennis squash, etc.)?	Change the word 'vigorous' to 'high intensity' 14. How many days per week do you regularly play high intensity sports (e.g. soccer, rugby, hockey, netball, basketball, handball, athletics, tennis squash, etc.)?
16. Do you have a domestic worker?	Change the phrase from 'a domestic worker' to 'a maid'
31. Circle the number that best corresponds to your Barriers or obstacles to exercise. (1= strongly disagree, 5= strongly agree) Time constraints	Change the phrase from 'Time constraints' to 'Lack of time'

3.5.4.3. Dietary intake diary

Self-reported dietary assessment methods remain the backbone of dietary assessment and monitoring. The single 24-hour recall method is an inexpensive instrument widely used in diet-human health studies (Davies and Deery, 2013) because it requires less time to attain accurate dietary information with less complex cognitive processes and a lower burden on the respondent (Castell et al., 2015). According to Jackson et al. (2008), this method is appropriate for measuring food intake in a large sample and group mean intakes of different diets. Self-reported 24-hour recall uses open-ended questions so that abundant information can be collected and analysed in various aspects. In addition, this method can be easily applied to diverse groups with a wide range of eating habits and could be used to estimate the average intake of a certain population (Shim et al., 2014). However, a recurrent issue in dietary self-reports is the extent to which participants under-report their energy intake. Bias and under-reporting of energy intake are a major concern in dietary surveys, particularly among obese subjects (Bogl et al., 2009). A study by Kye et al. (2014) revealed that the under-reporting of energy intake from 24-hour recalls in Korean adults accounted for 23% of

women and 14.4% of men and the under-reporting rate was higher in the age group 30–49 years for both genders. Although 24-hour recalls focus on a short period of intake (the preceding 24 hours), they still provide details about types of foods and amounts consumed (Dodd et al., 2006; Chamieh, 2013). Researchers have proven that a sufficiently large number of 24-hour recalls does provide a valid estimate of the mean energy and nutrient intake when applied to a group of 50 individuals and more (Kipnis et al., 2009; Chamieh, 2013).

In this study, since the PA questionnaire is relatively long, a single 24-hour recall method was used so as not to pose any further burden on the respondent in terms of time. Participants were asked to provide a detailed record of food intake (type, frequency and quantity) using self-reported, 24-hour dietary recall to capture daily dietary intake, including main meals, snacks and drinks consumed over the day. Intake was assessed assuming standard food portion sizes according to a 'food portion sizes booklet' (Crawley et al., 2002). The food diary data was analysed using the computerised nutritional analysis package Dietplan6 P3 (Windows and Mac Serial No: 6918). When an item of food or dish was not found in the database, a similar food item or dish in the database was entered. If no suitable food item or dish could be identified, information on the energy and nutritional content of that specific food or dish was manually entered into the database. As for Saudi traditional local dishes, the food composition data was complemented by another local study (Musaiger, 1993).

The daily food intake data was used to estimate total energy, total intake of a range of nutrients and the percentage of energy derived from fat, protein and carbohydrates. The main purpose of the nutritional analysis of Saudi women living in the KSA and Saudi women living in the UK was to observe and compare dietary intakes. In addition, the analysis allowed for comparison between the two groups with Dietary Reference Values (DRVs), Reference Nutrient Intake (RNI) and Estimated Average Requirements (EARs) for specified ages and gender for macronutrients (fats, carbohydrates and protein) as well as for micronutrients to find out if it is less or above the recommendations as it has a significant effect on health and weight gain. The percentage of dietary fat was estimated to be 35% of the daily energy requirement, 50% from carbohydrate and 15% from protein (British Nutrition Foundation, 2015).

The core nutrient categories for this study were:

- Energy (kcal) and energy-related nutrients: carbohydrate, fat and protein
- Selected vitamins including thiamine, B_{12}, vitamin B_9 (Folate), vitamin A, vitamin C, vitamin E and vitamin D
- Selected minerals including calcium, zinc, magnesium and iron
- Cholesterol
- Fibre

Foods were also categorized into groups: fruits, vegetables, grains and cereal products, dairy products, meats and alternatives, nuts and seeds, beverages, snacks/sweets and crackers, fast food to evaluate the overall quality of the diet.

3.5.4. Statistical analysis

Before making any statistical comparisons, Levene's test was used to investigate equality of variances. Descriptive statistics were used to analyse the data for the sections of the survey questionnaire containing closed-ended questions and discrete responses. Tables and graphs were used to show frequencies, mean and mode of the variables of interest. Results have been expressed as means and standard deviations or percentages. P-value ($p<0.05$) was used for level of significance. To compare data such as demographic information and some general data for categorical variables, Chi-square was used. T-tests were used to compare food intake between the two groups. ANOVA analysis was used to detect the association between food intake and PA and the prevalence of overweight/obesity individuals. For the combined group, a post-hoc (Tukey) analysis was used to identify which of the age groups differed significantly from each other. Multiple regression analyses were then conducted to assess the association between BMI and energy, carbohydrate, protein and fat intake. Statistical analysis was carried out using SPSS version 21.

3.6. Results

Data for 258 Saudi Arabian women, aged from 18 – 54, were collected, including those living in Saudi Arabia (n= 206) and those in the UK (n=52).

3.6.1. Socio-demographic characteristics

Participants' demographic characteristics appear in Table 3.4. The majority of W-SA and W-UK were in the 25-34 age range (44.8% and 46%, respectively). The majority of women in both samples were university graduates, with a significantly higher percentage of postgraduates in the UK group ($p<0.001$). More than half of W-SA and W-UK were married (60.2% and 53.8%, respectively) and had two to eight children, with no significant differences between them. Almost 47% of W-SA were employees, whereas the majority of W-UK were students (62%). Table shows that a monthly family income of £834-£1660 was the most common family income among W-SA (29.6%), while £1661-£2500 was the most common family income for W-UK (38.5%) and the difference between the two groups was significant ($p<0.001$).

3.6.2. Physical activity and sedentary behaviours

Table 3.5 shows the self-reported time spent in different intensities of PA. A large proportion of the survey sample did not participate in any type of moderate (68.9% and 69.2% for W-SA and W-UK, respectively) or vigorous-intensity sports (85.4% and 90.4% for W-SA and W-UK, respectively). Among those who exercised, 23.3% of W-SA and 25% of W-UK were doing moderate PA only one to two times a week and 9.7% of W-SA and 7.7% of W-UK were doing vigorous PA one to two times a week. It was noticeable that W-UK were significantly ($p<0.001$) more physically active than W-SA; almost 44% of W-SA did not walk regularly (for a minimum of 10 minutes per day) versus about 33% of W-UK, who were walking every day (on average for 24 minutes). In response to the question "How many times per day do you use the stairs?", most of the subjects reported using stairs one to two times (34.5% and 28.8% for W-SA and W-UK, respectively). These findings indicate that women's rate of participating in PA is commonly low, particularly in the W-SA group.

Table 3.6 presents the sedentary behaviour of participants. The survey found a high prevalence of sedentary lifestyles in both groups. About 40% of W-SA had a maid and

21.5% of them did not engage in household work, whereas 44% of W-UK did household work for one to two hours a week. In addition, the vast majority of the two groups spent long hours sitting watching TV. Almost 59% of W-SA and 50% of W-UK watched TV for two hours or more per day; the difference was not statistically significant (p=0.398). Additionally, a high proportion of women used the computer, either at home or work, with a significantly higher percentage of those in the W-UK group. About 70% of W-SA and 87% of W-UK used the computer for two hours or more per day at home (p=0.015) in addition to 61% of W-UK and 39.45% of W-SA who also used the computer at work or university (p=0.031).

3.6.3. Attitudes towards health, weight, fitness and physical activity

Approximately half of the survey population considered themselves to be of average health (55.3% and 59.6% for W-SA and W-UK, respectively) and of average fitness (51.5% and 42.3% for W-SA and W-UK, respectively). The majority of respondents classified themselves as of average weight (42.7% and 34.6% for W-SA and W-UK, respectively) or overweight (35.9% and 44.2% for W-SA and W-UK, respectively), which broadly corresponds to the BMI results.

With regard to women's attitudes towards their weight, about half of the subjects in each of the two samples reported that they would like to lose weight, but were not actively trying at the time of the survey, whereas the remainder indicated that they were content with their weight. Participants were asked to rate how they currently felt about exercising regularly, on a 5-point Likert scale, as an indicator of their attitudes to PA. Although the differences between groups were not statistically significant, the answers were very varied; some respondents considered exercise to be fun, exciting and attractive and some considered it stressful and boring, but the majority in both groups agreed that exercise is important (63.6% and 78.8% for W-SA and W-UK, respectively). Although approximately half the survey sample was aware that exercise is the best thing they can do for their health, the other half reported that exercise is important, but many other things are more important. More complete information on this question is presented in Tables 3.7 and 3.8.

Table 3.4: Socio-demographic characteristics of Saudi women living in SA and in the UK

	Women- SA Percent %	**Women – UK Percent %**
(years)		
16-24	23.6	24
25- 34	44.8	46
35-44	22.2	24
45-54	9.4	6
Educational level		
Intermediate school or less	12.1	5.8
Secondary school	31.1	21.2
Technical or college school	4.4	3.8
University graduate	47.6	36.5
Postgraduate studies	4.9	30.8
	P<0.001	
Marital status		
Married	60.2	53.8
Single	34	44.2
Widowed	0.5	1.9
Divorced	5.3	0
	P=0.146	
Number of children (Mean)	2 ± 2.3	1.5 ± 1.9
	P=0.858	
Employment status		
Not employed and not seeking work	24.8	15.4
Not employed but seeking work	9.2	3.8
Student	18.9	61.5
Employed	46.6	17.3
	P<0.001	
Monthly household income		
< £ 500	9.2	1.9
£ 501-£ 833	21.4	9.6
£ 834-£ 1660	29.6	11.5
£ 1661-£ 2500	14.6	38.5
£ 2500 or over	20.9	32.7
	P<0.001	

Data are presented as percentages

P-values were determined by chi-squared test

Table 3.5: Response to physical activity questions

	Women – SA Percent %	**Women – UK Percent %**
Regular walking for more than 10 minutes /week		
Never	43.7	23.1
1-2 days	34.5	11.5
3-4 days	10.7	17.3
5-6 days	3.9	15.4
Every day	6.8	33
	P<0.001	
The pace of walk		
Slow	12.6	15.4
Moderate	44.7	61.5
Fast	1	3.8
	P=0.004	
Duration of walking minutes/day (Mean)	15.8 ± 18.1	24.4 ± 22
	P<0.001	
Using the stairs (more than 10 steps)		
Never	17	17.3
1-2 times	34.5	28.8
3-5 times	26.2	21.2
5 times or more	20.4	32.7
	P=0.334	
Engagement in moderate intensity sports		
Never	68.9	69.2
1-2 days	23.3	25
3-4 days	4.9	3.8
5-6 days	0.5	1.9
Every day	1	0
	P=0.775	
Duration of moderate intensity sports minutes/day (Mean)	8.2 ± 16.6	11.4 ± 21.5
	P=0.274	
Engagement in high intensity sports		
Never	85.4	90.4
1-2 days	9.7	7.7
3-4 days	1	0
5-6 days	0	0
Every day	0.5	1.9
	P=0.451	
Duration of high intensity sports minutes/day (Mean)	2.7 ± 7.4	4.4 ± 7.2
	P=0.037	

Data are presented as percentages or mean values **±** standard deviation
P-values were determined by chi-squared test

Table 3.6: Lifestyle patterns and sedentary behaviour for women

	Women – SA Percent %	**Women – UK Percent %**
Having a maid		
Yes	39.8	11.5
No	57.3	88.5
	P<0.001	
Engagement in the household work hour/week		
Never	21.5	17.3
1-2 hour	27.3	44.2
3-4 hours	28.3	26.9
5-7 hours	12.2	5.8
More than 7	9.8	1.9
	P=0.049	
The number of hours daily spent watching TV and/or DVD/Video		
1/2 hour or less	21.4	36.5
1 hour	18.9	13.5
2 hours	23.8	23.1
3 hours	15.5	7.7
4 hours	12.1	9.6
5 hours or more	6.8	7.7
	P=0.398	
The number of hours spent using a computer, tablet or mobile phone		
At home		
1/2 hour or less	13.1	7.7
1 hour	16	5.8
2 hours	16	9.6
3 hour or less	16	19.2
4 hour	15	36.5
5 hours or more	23.3	21.2
	P=0.015	
At work or university		
1/2 hour or less	40.4	16.1
1 hour	19.2	22.6
2 hours	12.5	22.6
3 hour or less	11.5	19.4
4 hour	4.8	16.1
5 hours or more	10.6	3.2
	P=0.031	

Data are presented as percentages
P-values were determined by chi-squared test

Table 3.7: Health-related attitudinal response for participants

	Women – SA Percent %	Women – UK Percent %
In general, I regard myself as:		
Very healthy	4.9	0
Healthy	20.4	13.5
Of average health	55.3	59.6
Unhealthy	11.2	25
Very unhealthy	7.8	1.9
	P=0.038	
At the present time, I regard myself as:		
Very unfit	9.2	8.5
Unfit	15	34.6
Of average fitness	51.5	42.3
Fit	19.9	17.3
Very fit	4.4	0
	P=0.017	
At the present time, I regard myself as:		
Very underweight	1.5	0
Underweight	8.7	7.7
Of average weight	42.7	34.6
Overweight	35.9	44.2
Very overweight	11.2	13.5
	P=0.658	
The participant's attitude towards their weight		
I am content with my weight	30.6	28.8
I would like to gain weight, but am not actively trying at the moment	6.8	1.9
I am currently trying to gain weight	2.4	0
I would like to lose weight, but am not actively trying at the moment	45.1	48.1
I am actively trying to lose weight	15	21.2
	P=0.402	

Data are presented as percentages
P-values were determined by chi-squared test

Table 3.8: Attitudes to physical activity for women

	Women – SA Percent %	Women – UK Percent %	P-value
The best corresponds to participants' attitude about exercise			
Fun	37.9	42.3	0.967
Exciting	23.3	32.7	0.542
Important	63.6	78.8	0.315
Attractive	23.8	23.1	0.362
Stressful	33.5	44.2	0.751
Boring	20.9	23.1	0.383
Describe how important exercise is for personal health			
Exercise is not very important for my health	3.9	0	
Exercise is important for my health, but many other things are more important	43.2	44.2	
Exercise is the best thing I can do for my health	47.6	46.2	
Do not know/refused	5.3	9.6	
			0.352

Data are presented as percentages
P-values were determined by chi-squared test

3.6.4. Knowledge regarding physical activity

Table 3.9 presents the knowledge of diseases and how risk can be minimised by undertaking regular PA; a high proportion of women in both groups answered that PA is beneficial for preventing diseases. The most frequently cited diseases sequentially were obesity, CVD, diabetes, hypertension and stress, with no significant difference between the study groups. A significantly higher percentage of W-UK answered that PA is beneficial for reducing the risk of colon ($p=0.009$) and breast cancer ($p=0.010$). Some examples of diseases which are not thought to be associated with regular PA were also cited in the questionnaire, with some respondents suggesting that PA helps to prevent pneumonia, tuberculosis and HIV/AIDS, but the percentage was very low.

In terms of knowledge about the concept of 'enough' physical activity, about 39% of W-SA and 48% of W-UK reported the correct amount of PA for a healthy lifestyle (30 minutes a day), but only 14% of W-SA and 23% of W-UK believed that a person of their own age should take part in PA five times or more a week to be healthy (differences were not significant). This means that the majority of women were aware of the diseases that can be prevented by doing regular PA and the recommended duration of exercise, but lacked knowledge of the recommended number of times exercise is required to be good for health (five times per week).

3.6.5. Perceived barriers to exercise

Figure 3.4 displays the most common barriers to regular exercise. Over half (53%) of the W-SA group reported that lack of transportation is the main barrier to PA, followed by lack of time, lack of suitable facilities for sport, bad weather, lack of partner and lack of safe places. As for the W-UK group, lack of time was significantly the largest obstacle to exercise for over two-thirds (64%) of the respondents, followed by bad weather, lack of partner and lack of energy/tiredness. When investigating barriers to exercise, the chi-squares showed significant differences between groups on the lack of transportation barrier ($p<0.001$), lack of safe places ($p=0.002$), lack of suitable facilities ($p<0.001$) and lack of a partner ($p<0.001$).

3.6.6. Physical activity motivation

For many individuals, the primary perceived health benefit of exercise was 'controlling weight' (73.8% of W-SA and 82.7% of W-UK), while 80.1% of W-SA and 92.3% of W-UK

also stated 'looking good' as a major reason to exercise, followed by improving overall health and preventing diseases. The only significant difference between the two groups was that nearly 60% of W-UK indicated a desire to reduce stress compared to 49% of W-SA (p=0.016) (Figure 3.5).

3.6.7. Physical activity programmes and services in the community

Although most respondents were aware of the documented health benefits of regular exercise, almost half of the W-SA, and more than two-thirds of the W-UK, did not participate in any PA classes or programmes at the time of the survey (with a significant difference between the groups, P<0.001). It should be noted that 37% of W-SA reported that there were no PA classes in their community. The most commonly cited activity that women in both groups would like to do more of was walking, followed by dance and aerobics, with no significant differences between the groups (Figure 3.6). With respect to the desire to exercise, W-SA had a significantly greater intent to exercise than W-UK; about two-thirds (63%) of the W-SA reported that they wanted to exercise for about 30 minutes a day, most days of the week, whereas about two-thirds (62%) of the W-UK reported that they would not be able to exercise (p<0.001) (Table 3.10).

3.6.8. Body mass index (BMI) classification

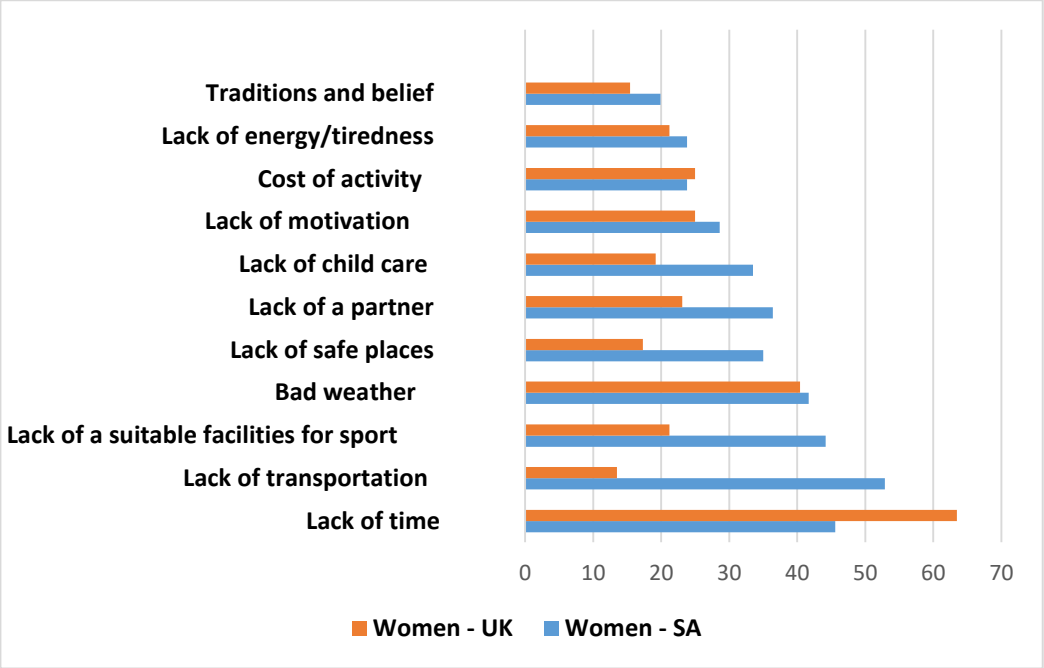
Findings reveal that both groups exhibited a high prevalence of participants being overweight (35% and 44% for W-SA and W-UK, respectively) and obese (22% and 14% for W-SA and W-UK, respectively), with a higher percentage of morbidly obese individuals in the W-SA group (3%). In contrast, 5% of W-SA and 2% of the W-UK group were underweight. It is noteworthy that the normal weight rate (35% and 40% for W-SA and W-UK, respectively) was significantly similar to the overweight rate, as shown in Figure 3.7.

Table 3.9: Response to health-related knowledge questions

	Women – SA Percent %	Women – UK Percent %	P-value
Diseases that can be prevented by doing regular physical activity			
Cardiovascular diseases	71.4	73.1	0.806
Hypertension	58.3	73.1	0.050
Diabetes	66.5	75	0.240
Obesity	88.3	94.2	0.216
Colon cancer	9.7	23.1	0.009
Breast cancer	11.2	25	0.010
Stress	45.1	50	0.530
Pneumonia	8.7	13.5	0.304
Tuberculosis	2.4	5.8	0.214
HIV/AIDS	2.9	7.7	0.111
Number of times a person needs to exercise to be healthy			
Not at all	1	0	
Less often than once a month	1.5	1.9	
Once or twice a month	5.3	0	
About once a week	27.2	17.3	
About three times a week	51	57.7	
Five or more times a week	14.1	23.1	
			0.191
How long daily a person should exercise			
10 minutes or less	14.1	9.6	
About 20 minutes	26.2	23.1	
About 30 minutes	38.8	48.1	
45 minutes or more	19.9	19.2	
			0.825

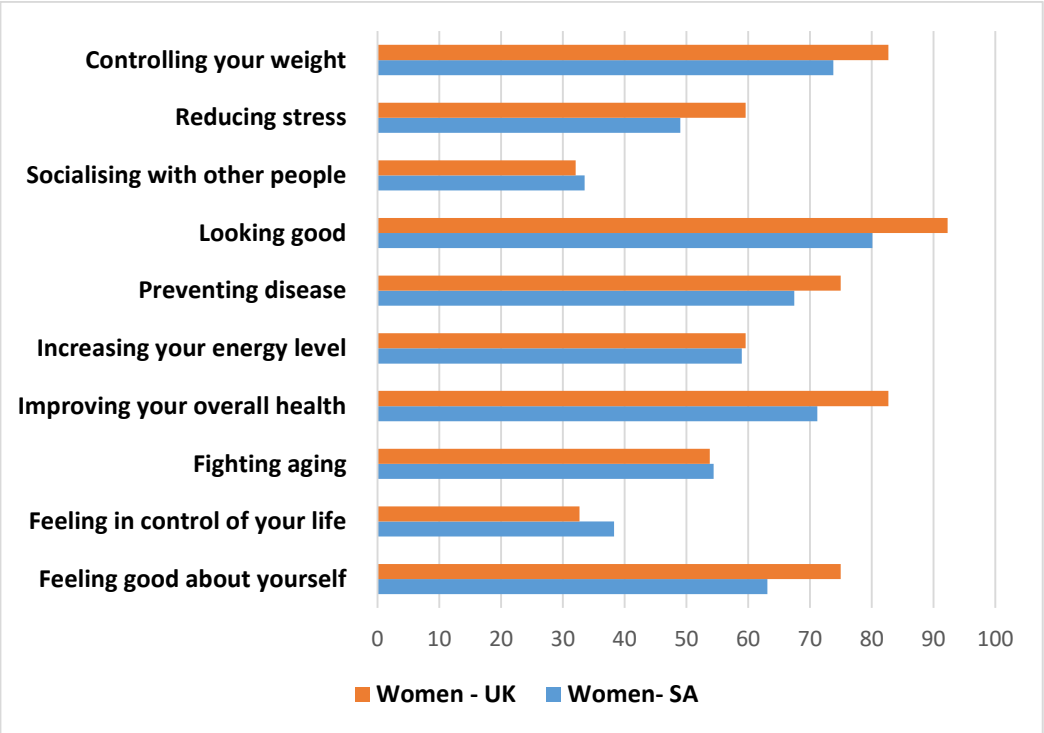
Data are presented as percentages
P-values were determined by chi-squared test

Figure 3.4: The top reported barriers to physical activity



Data are presented as percentages

Figure 3.5: Response to motivation for exercising questions



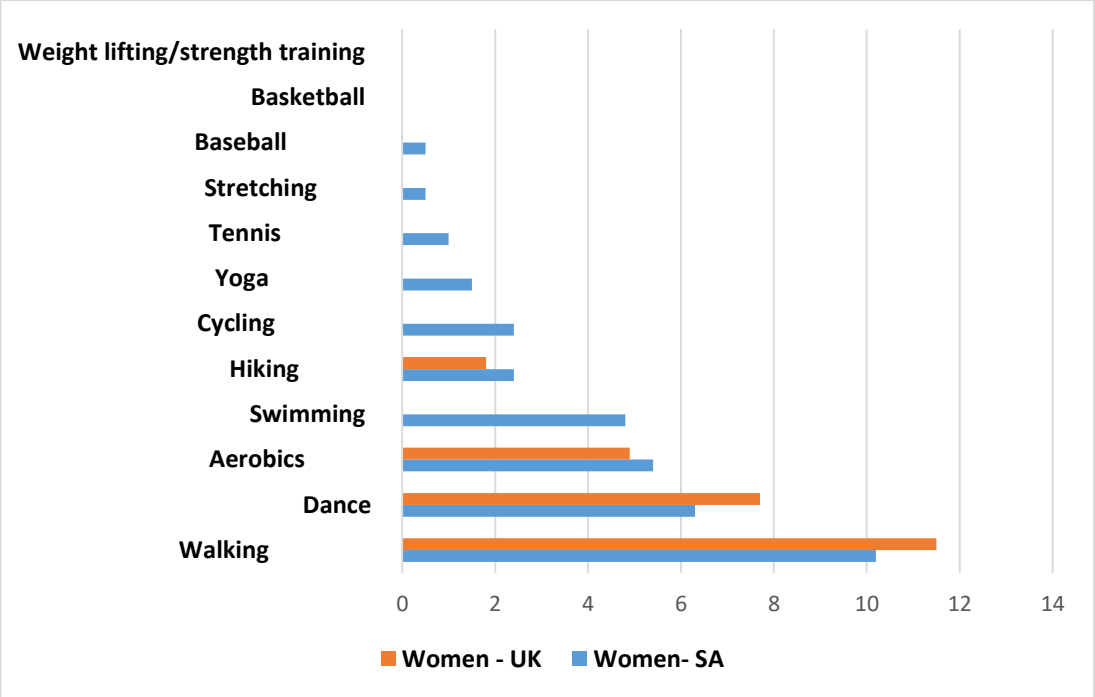
Data are presented as percentages

Table 3.10: Response to programmes and services in the community questions

	Women – SA Percent %	Women – UK Percent %
Current participation in physical activity classes or programmes that are offered in the community		
Yes	15.6	13.5
No	45.9	76.9
There are no physical activity classes in my community	37.1	9.6
	P<0.001	
When thinking about your community are there activities or community resources not currently available that you think would help make it easier for you to exercise?		
Yes	53.4	40.4
No	43.7	57.7
	P=0.193	
The ability to exercise about 30 minutes a day		
Yes	62.6	23.1
No	29.1	61.5
Already exercise 30 minutes or more per day	6.3	13.5
	P<0.001	

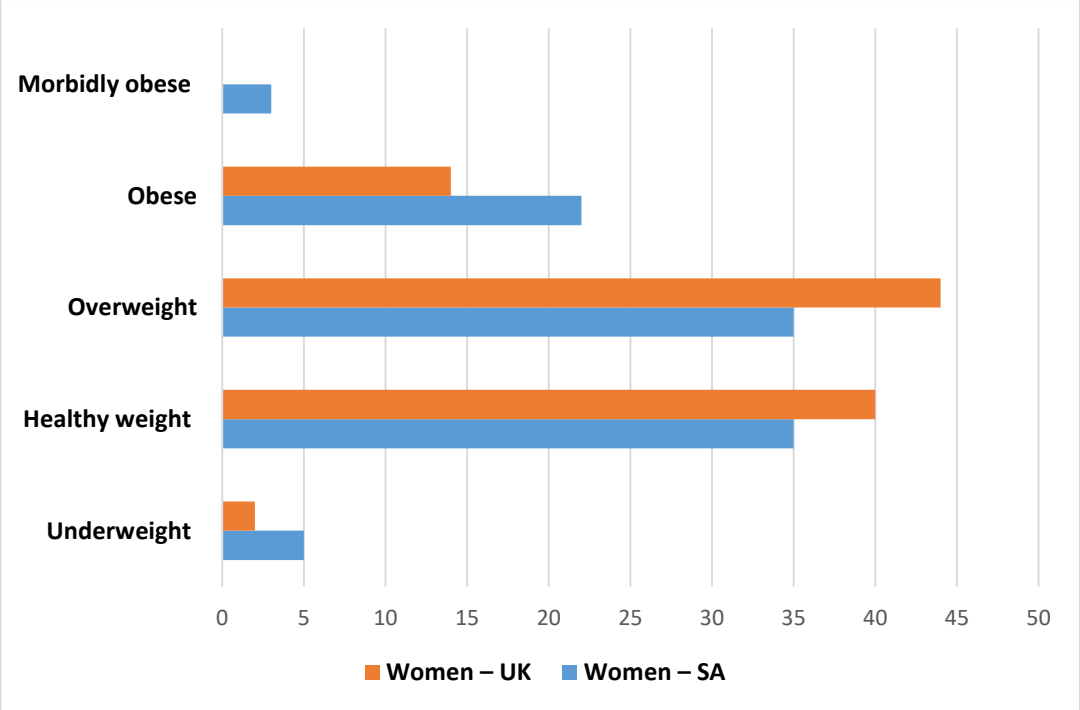
Data are presented as percentages
P-values were determined by chi-squared test

Figure 3.6: Types of physical activity women prefer



Data are presented as percentages
P-values were determined by chi-squared test

Figure 3.7: Body Mass Index classification



Data are presented as percentages
P-values were determined by chi-squared test

3.6.9. Nutritional intake for Saudi women and comparison with Dietary Reference Values (DRVs)

Nutritional intakes for the two groups of women were compared to the DRVs (excluding alcohol) as described by the UK panel on DRVs of the British Nutrition Foundation (2015). Data for the two groups have been expressed as a percentage of the appropriate DRVs. Energy intake was compared to the EARs and micronutrient intake to the RNI. In addition, energy percentages (E%) from protein, carbohydrate fat and fatty acids from total calories consumed were assessed and compared to the DRVs recommended. The reference values used for this aspect of the analysis are specifically quoted for women between 18 and 54 years of age; any subjects outside this range have been excluded.

The independent t-test showed no significant differences between both groups in terms of energy, macronutrient, sugar and fibre intake. It is clear from Table 3.11 that women in both groups apparently consumed considerably more energy than the EAR given in the UK reference standards. This was particularly evident in carbohydrate intake, which was substantially high in both groups. The carbohydrate E% was 54.6% in W-SA and 56.1% in W-UK, which is higher than the DRVs.

The same trend was found for sugar intake for which the mean daily intake of sugars (non-milk extrinsic sugars (NMES) was high according to the maximum recommended intake of 60g/day by the DRVs (Department of Health, 1996). The sugar E% was 11.1% in W-SA and 12% in W-UK, which is exceeded the DRV recommendation of 10%.

The mean daily intake of dietary fibre (non-starch polysaccharides) (NSP) was low, particularly in the W-UK group (14.6g for W-SA vs. 13.5g for W-UK). These values apparently fell short of the Dietary Recommended Values (average at least 18g/d).

The mean intake of protein in grammes exceeded the recommendations in both groups, but these findings were slightly lower than the DRV recommendation of the protein E% (13.1% in W-SA and 12.4% in W-UK). The mean total fat intake in grammes was also high in both groups but these findings were close to the DRV recommendation of the fat E% (35.7% in W-SA and 34.9% in W-UK).

Table 3.12 shows the types of fatty acid and cholesterol consumed during the study. Compared to W-UK, W-SA had significantly higher cholesterol intake (312.3g of W-SA vs. 241.9g of W-UK, p=0.034), which is higher than the recommendations from DRVs. There were no significant differences between groups in terms of monounsaturated, polyunsaturated, saturated and trans fatty acids consumed and the amounts of these fats consumed were close to the recommendations, except for the saturated fatty acid intake, which was higher than the DRV.

There were no significant differences between the two groups in terms of vitamin or mineral intake, except for vitamin B_{12} intake, which was significantly higher among W-SA. It is clear from Tables 3.13 and 3.14 that vitamin intake (for vitamins E, C, B_1, B_{12} and B_9) and mineral intake (for calcium and zinc) were higher than the RNI for both groups. By contrast, Vitamin A, Vitamin D and iron intakes were below the recommended amounts for both groups.

The results imply that, in general, subjects in both groups had adequate nutritional intake, except for vitamin A, D and iron, with excess intakes of energy, protein, carbohydrate and fats. There were no significant differences between the two groups in terms of energy and macro or micronutrient consumption, except for vitamin B_{12} and cholesterol.

The foods were also listed in groups to represent all major food groups consumed by the participants (Figure 3.8). On average, W-SA reported eating 2.1 servings/d of fruits and 2.6 servings/d of vegetables versus 2.0 servings/d of fruits and 2.5 servings/d of vegetables in W-UK. Cereals are an important staple in the diet of both groups particularly white rice and white bread; the participants reported eating cereals 9.8 servings/d in W-SA and 9.4 servings/d in W-UK. The mean intake of lean meats and alternatives was 2.7 servings/d in W-SA and 2.5 servings/d in W-UK and among the meat group, poultry was consumed more often than fish or red meat. Both groups consumed nearly 2 servings/d of dairy products. For beverage consumption, women in both groups consumed an average of 1can/d of carbonated drinks. There were no significant differences between both groups in any of the above food groups' intake. Intake of snacks was significantly higher in W-SA than W-UK (2.7 servings/d vs. 2.3 servings/d respectively, p=0.04). While the average fast food meals intake was

significantly higher in W-UK (twice /d) than W-SA (once/d) (p< 0.001). The common fast food choices in both groups include pizza followed by fried chicken and burgers and the significant difference between the groups was only in pizza (p< 0.001) and fish and chips (p< 0.001) (Figure 3.9). The most popular snacks among W-SA were dates followed by crisps and ice cream while among W-UK were crisps followed by chocolate and sweets. The significant difference between the groups was only in dates (p< 0.001) and ice cream (p< 0.001) (Figure 3.10).

Table 3.11: Daily intake of energy macronutrient, sugar and fibre among study participants

Nutrients	Women-SA	Women-UK	Reference value
Energy (kcal/d)	2609 ± 1186.9	2517.9 ± 1204.1	1940 kcal/d
Protein (g/d)	85.2 ± 45.9 (13.1%)	78.3 ± 39.8 (12.4%)	(15%)
Fat (g/d)	103.5 ± 57.9 (35.7%)	97.7 ± 53.4 (34.9%)	(35%)
CHO (g/d)	356.2 ± 169.6 (54.6%)	353.2 ± 185.2 (56.1%)	(50%)
Sugar (NMES) (g/d)	72.2 ± 74 (11.1%)	75.6 ± 70.7 (12%)	(10%)
Fibre (NSP) (g/d)	14.6 ± 10.1	13.5 ± 9.5	18 g/d

Data are presented as mean ± SD. Values in parentheses indicate % of total energy intake
P-values were determined by independent t-test

Table 3.12: Daily intake of fatty acids and cholesterol among study participants

Nutrients	Women-SA	Women-UK	Reference value
Saturated fatty acids (g/d)	36.6 ± 22 (12.6%)	34.9 ± 22.6 (12.5%)	(11%)
Monounsaturated fatty acids (g/d)	36.1 ± 21.1 (12.5%)	30.7 ± 17.7 (11%)	(13%)
Polyunsaturated fatty acids (g/d)	19.4 ± 14.2 (6.7%)	17.5 ± 11.7 (6.3%)	(6.5%)
Trans fatty acids (g/d)	2.6 ± 5.9 (0.9%)	2.4 ± 2.4 (0.9%)	(2%)
Cholesterol (mg/d)	312.3 ± 263.9	241.9 ± 195.1 ‡	245

Data are presented as mean ± SD. Values in parentheses indicate % of total energy intake
P-values were determined by independent t-test
‡ Significantly different from the other group

Table 3.13: Daily intake of selected vitamins among study participants

Nutrients	Women-SA	Women-UK	Reference value
Retinol (µg/d)	516.3 ± 106.9	457.5 ± 507.5	600
Vitamin D (µg/d)	2.3 ± 4.9	2 ± 3.8	10
Vitamin E (mg/d)	9.9 ± 7.9	10.2 ± 8.5	6
Thiamine (mg/d)	1.6 ± 1	1.5 ± 0.9	0.8
Vitamin B_{12} (µg/d)	5.1 ± 12.6	3 ± 2.2 ‡	1.5
Folate (µg/d)	233.7 ±185.8	217.7 ± 175.5	200
Vitamin C (mg/d)	86.5 ± 102.5	86.4 ± 140.5	40

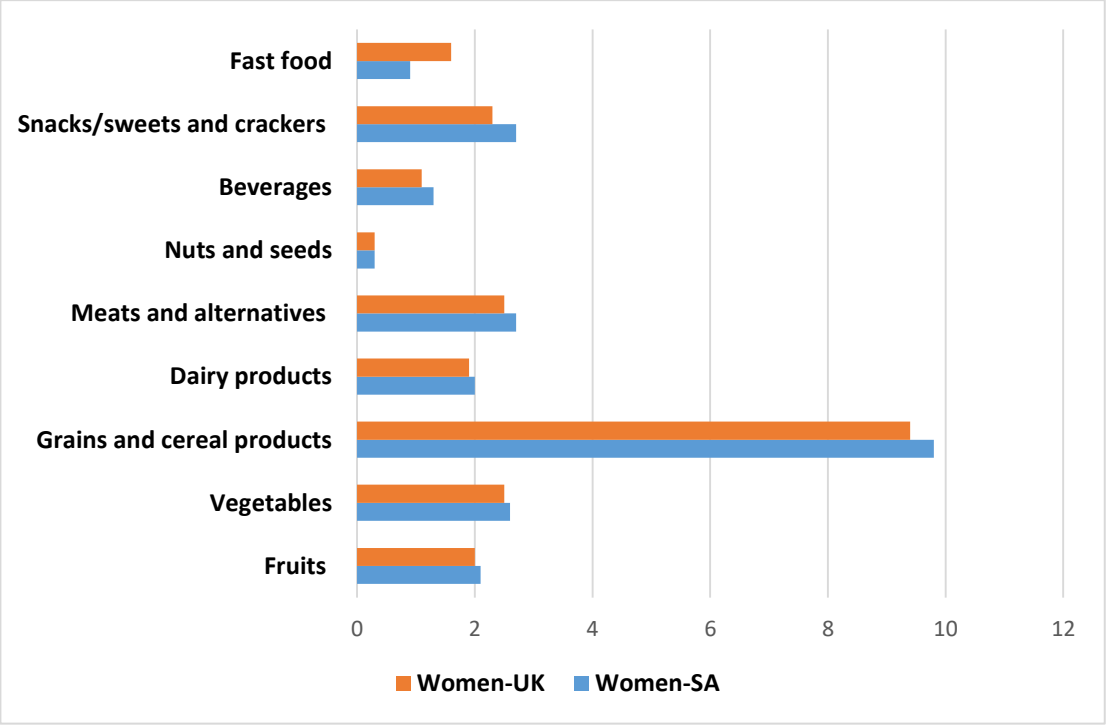
Data are presented as mean ± SD. P-values were determined by independent t-test
‡ Significantly different from the other group

Table 3.14: Daily intake of selected minerals among study participants

Nutrients	Women-SA	Women-UK	Reference value
Calcium (mg/d)	1100.7 ± 595.4	1023.8 ± 640.1	700
Magnesium (mg/d)	279.3 ± 172.1	260.1 ± 131.1	270
Iron (mg/d)	12.6 ± 6.6	13.8 ± 4.6	14.8
Zinc (mg/d)	10.1 ± 5.4	9.3 ± 4.8	7.0

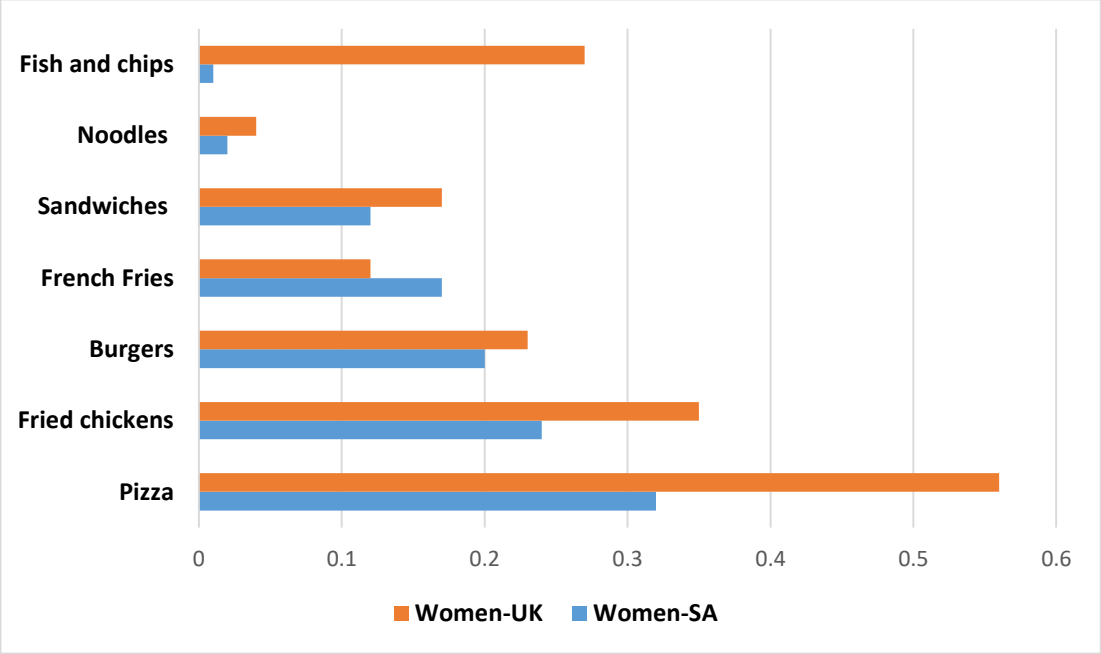
Data are presented as mean ± SD
P-values were determined by independent t-test

Figure 3.8: Average daily consumption of servings in each food group among study participants



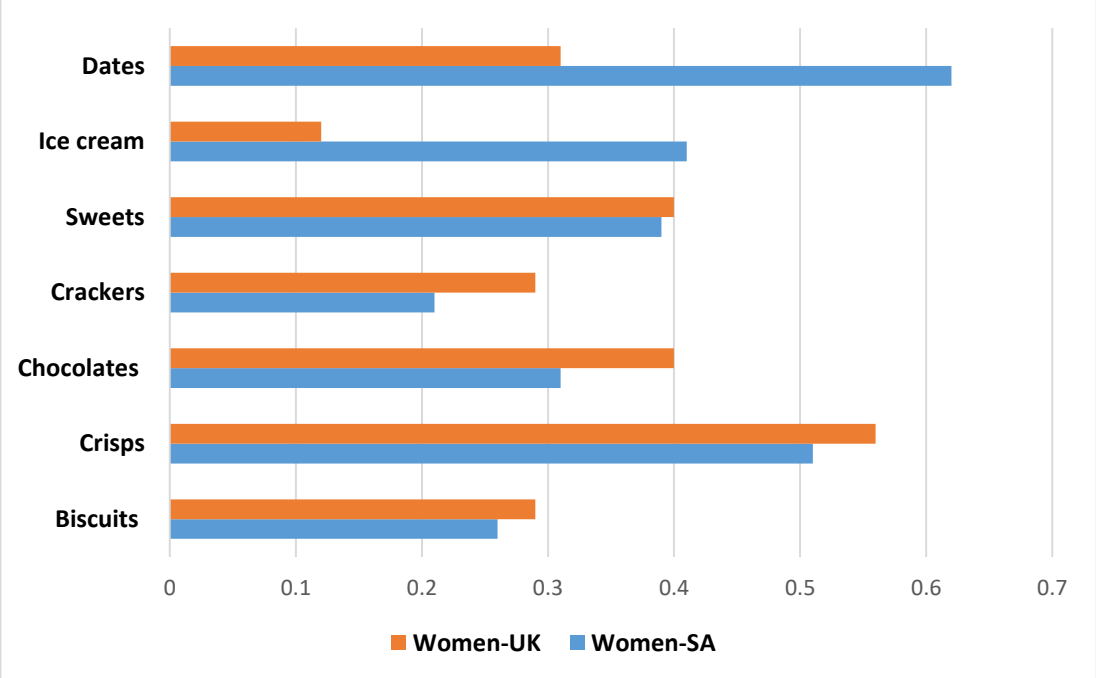
Data are presented as numbers
P-values were determined by independent t-test

Figure 3.9: The most popular fast food among study participants



Data are presented as numbers
P-values were determined by independent t-test

Figure 3.10: The most popular snacks among study participants



Data are presented as numbers
P-values were determined by independent t-test

3.6.10. Associations between obesity and age in women

Figure 3.11 shows data for BMI by age group in each country and indicates an increase in BMI with age. Three outliers (183,182 and 225) who had a BMI above 35 have been excluded from subsequent analysis. A two-way ANOVA was performed with age group and country as factors, which showed no significant differences between W-SA and W-UK ($p=0.989$) (Table 3.15).

Levene's test suggests that the data are not normally distributed and should probably be transformed. However, there is clearly no effect of country or an interaction between country and age. Therefore, the data were pooled and investigated for an effect of age alone by one-way ANOVA. After combining the groups from the two countries, the data were normally distributed and showed a significant effect of age ($p<0.001$) (Table 3.15). The post-hoc (Tukey) test showed that the youngest group (16-24) had a healthy BMI (approximately 22kg/m^2), which is significantly lower than all other age groups. It also shows that the 25-34 age group had a lower BMI than the 45-54 group. There is step-change in BMI between the 16-24 and the 25-34 groups. After that, BMI increases progressively up to the 45-54 group, which, with a mean BMI of 30.3kg/m^2, is classified as obese.

The subjects were further grouped according to age and BMI classification (Table 3.16). In general, it is noted that BMI showed a gradual increase with age. The number of subjects classified as normal or underweight was higher within younger age groups (57% and 16%, respectively, in the 16-24 age group) and declined in the oldest age group. In contrast, the overweight, obesity and morbid obesity rate was higher in older age groups. Being overweight was more common than obesity, rising from 25% in the 16-24 age group, to 65% in the 35-44 age group, before falling again to 55% for the 45-54 age group. The proportion of those who were obese increased from 2% of those aged between 16 and 24 to 15% of those aged between 45 and 54; this followed the same pattern for those who were morbidly obese.

Figure 3.11: BMI change by age groups and country

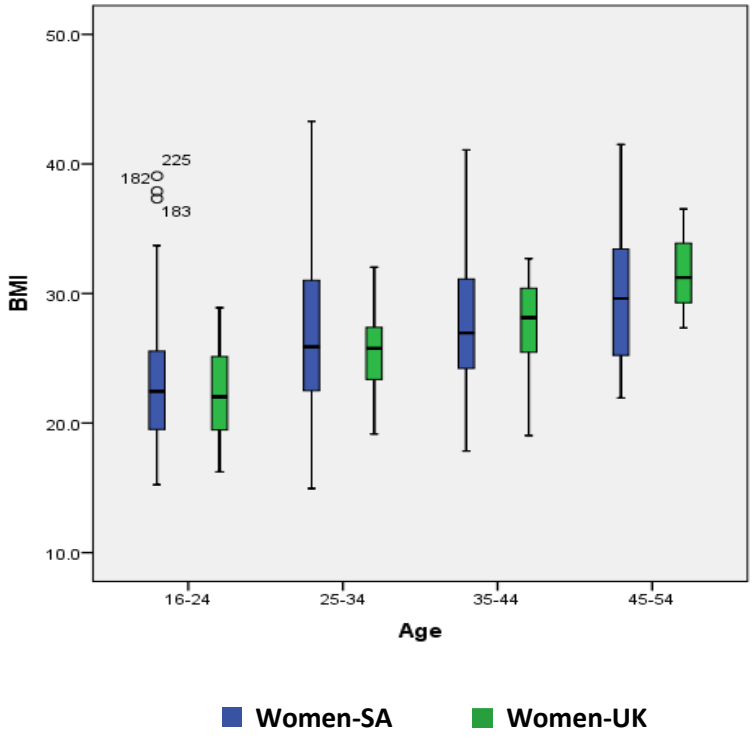


Table 3.15: Body Mass Index by age groups, country and combined

Classification (years)	**Women – SA**	**Women – UK**	**Combined**
16-24	22.6 ± 4.3	22.4± 3.6	22.6 ± 4.1 [a]
25-34	27.1 ± 6.0	25.4 ± 3.2	26.8 ± 5.5 [b, c]
35-44	27.5 ± 5.1	27.7 ± 3.8	27.6 ± 4.8 [c, d]
45-54	30.1 ± 6.0	31.7 ± 4.6	30.3 ± 5.8 [d]
Total	26.5 ± 5.8	25.6 ± 4.2	26.3 ± 5.6

Data are presented as mean ± SD
Values sharing common superscript are not significantly different (p<0.05)
P-values were determined by ANOVA

Table 3.16: BMI classification among different age categories of Saudi women

		16-24y	25-34y	35-44y	45-54y
Mean BMI (kg/ m²) mean± SEM		22.6±0.54 (n=57)	26.8±0.52 (n=114)	27.6±0.63 (n=57)	30.3±1.23 (n=22)
<0.18.5	**%Underweight**	16	2	2	0
18.5-24.9	**%Normal**	57	39	22	20
25.0-29.9	**%Overweight**	25	54	65	55
30.0-39.9	**%Obese**	2	3	11	15
40.0>	**%Morbidly obese**	0	2	0	10

Data are presented as percentages or mean values **±** standard error of mean
P-values were determined by ANOVA

3.6.11. Associations between obesity and energy and macronutrient intake in women

The box plot shows data for energy intake for each age group in each country, which suggests a trend towards increases with age (Figure 3.12). Outliers were removed and a 2-way ANOVA was performed.

Table 3.17 displays energy intake (kcal) by age group and country. A two-way ANOVA was performed using age group and country as the factors and, once again, it showed no effect of country or country*age interaction (p=0.874) therefore, a one-way ANOVA was performed. After combining the two countries into a group, the data were normally distributed and showed a significant effect of age (p<0.001). Post-hoc analysis showed that the youngest group (16-24 years) had the lowest energy intake and that this is close to the recommendations. It also showed that the 25-34 age group and the 35-44 age group had a lower energy intake than the 45-54 age group, which is higher than the recommendations.

Intake of carbohydrate, protein and fat all increase with age, but remain relatively constant when expressed as percentages of total energy intake (Table 3.18) and all were high compared to the DRVs for all age groups.

To identify whether the BMI is related to energy intake and energy from specific macronutrients (carbohydrate, protein and fat), regression analysis of BMI against energy, carbohydrate, protein and fat intake was carried out (see Figures 3.13, 3.14, 3.15 and 3.16).

Regression analysis showed that there is a strong relationship between energy intake and BMI ($p<0.001$). There is also a strong relationship between carbohydrate, protein and fat intake and BMI. However, none of these relates to BMI more strongly than total energy.

Figure 3.12: Energy intake change by age groups and country

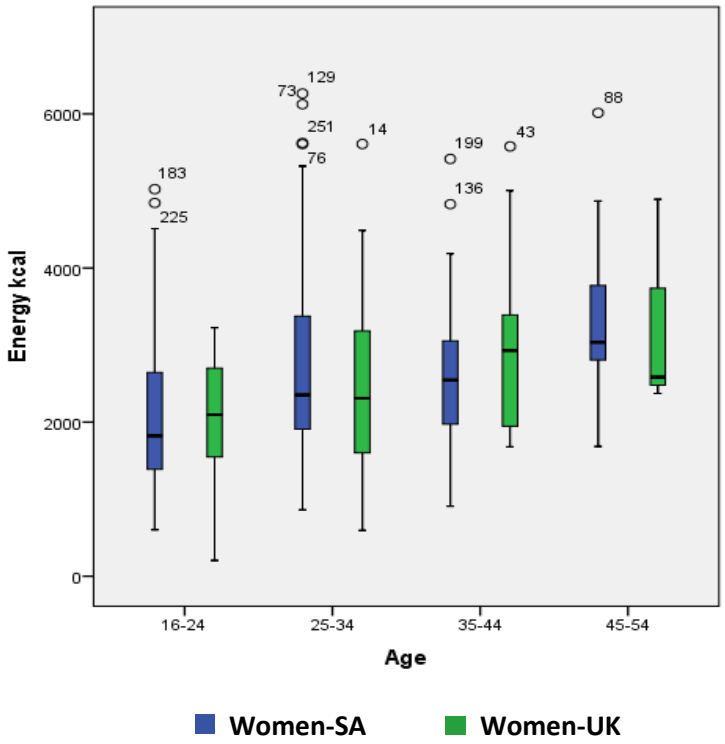


Table 3.17: Energy intake (kcal) by age groups and country

Classification (years)	**Women – SA**	**Women – UK**	**Combined**
16-24	2010.9 ± 1003.1	2042.0 ± 835.3	2017.3 ± 964 [a]
25-34	2571.3 ± 1081.5	2353.1 ± 1109.8	2527.3 ±1085.7 [b]
35-44	2513.4 ± 795.8	2773.6 ± 982.6	2566.4 ± 833.8 [b]
45-54	3227.5 ± 812.2	3282.7 ± 1396.8	3235.4 ± 869.6 [c]
Total	2486.5 ± 1029.7	2429.8 ± 1057.0	2475.2 ± 1033.2

Data are presented as mean ± SD
Values sharing common superscript are not significantly different ($p<0.05$)
P-values were determined by ANOVA

Table 3.18: Carbohydrate, protein and fat by age groups

Classification (years)		Carbohydrate	Protein	Fat
16-24	**g**	282.6 ± 143.7	64.6 ± 36.6	77.7 ± 45.7
	% of total energy	56	12.8	34.7
25-34	**g**	345.9 ±154.2	79.8 ± 41.7	101.1 ± 55.7
	% of total energy	54.7	12.6	36
35-44	**g**	351.5 ± 136.4	86.7 ± 33.3	99.9 ± 39.3
	% of total energy	54.8	13.5	35
45-54	**g**	427.6 ± 142.2	109.7 ± 37.6	132.7 ± 52.6
	% of total energy	52.9	13.6	36.9
Total	**g**	339.1 ± 151	80.3 ± 40	97.9 ± 51.6
	% of total energy	54.8	13	35.6

Data are presented as mean ± SD and % of total energy intake
P-values were determined by ANOVA

3.6.12. Associations between obesity and physical activity in women

The relationship between BMI and PA levels was explored by ANOVA analysis. To assess the level of PA, population was broken down in response to:

Q8 How many days a week do you walk more than 10 minutes?

Q12 How many days per week do you take part in moderate intensity sport?

Q14 How many days per week do you take part in high intensity sport?

This created four groups:

1) Answered 1 to Q8, Q12, Q14
2) Answered 2-3 to Q8, 1 to Q12,Q14
3) Answered 4-5 to Q8, 1 to Q12,Q14
4) Answered >1 to Q12 and/or Q14

Table 3.19 shows the results of the post-hoc analysis and suggests that the highest activity group had the lowest BMI, but that the relationship was relatively weak and was only significantly different from group 2.

Table 3.19: Mean body mass index (BMI) in different physical activity groups of women

Activity groups	Number of women	BMI
1	63	26.7 ± 5.6 [ab, c]
2	77	27.2 ± 5.3 [a]
3	40	26.6 ± 5.0 [a, c]
4	78	24.6 ± 5.3 [c]
Total	258	26.2 ± 5.4

Data are presented as mean ± SD
Values sharing common superscript are not significantly different ($p<0.05$)
P-values were determined by ANOVA

3.7. Discussion

The general demographic characteristics of the subjects (Table 3.4) showed that the majority of the study group living in Saudi Arabia (W-SA) and in the UK (W-UK) were in the 25-34 age range. Most of the sample was made up of university graduates, with a higher percentage of postgraduates in the UK group; the higher number of employees was in W-SA (as opposed to students in the UK group). More than half of the women were married. Demographic factors which cannot necessarily be changed can greatly influence the regularity of adult exercise (Lusmägi et al., 2016). Umstattd and Hallam (2007) found that being married, having a higher income and better education were all linked to being regularly active. A study by Murray and Ipsos (2006) also confirmed a positive and significant correlation between the socioeconomic status, education and social supports and participation rates in PA among Scottish women. In contrast, Hakobyan (2008) found no statistically significant associations between PA level and such socio-demographic indicators as age, education, gender, marital status and income level after stepwise logistic regression analysis. The only statistically significant association was found between PA level and occupational status.

According to the WHO, PA is defined as “any bodily movement produced by skeletal muscles that require energy expenditure” (WHO, 2014). This definition encompasses any daily life activity, from household, occupational and other daily tasks to sports and exercise, but physical inactivity is now a global health hazard and it is increased in both developed and developing countries.

This study endorses the idea that the prevalence of physical inactivity is relatively high, particularly within the W-SA group. The majority of individuals in the survey sample did not participate in any type of moderate or vigorous intensity sports. A considerable number of studies have been performed on members of the Saudi population and they show similar results. In a review, Al-Hazzaa (2010) reported that physical inactivity ranged from 43.3%-99.5% in the KSA. These levels are higher than those reported in American countries (33.2% of women vs. 29.9% of men age-adjusted) (American Heart Association, 2013). A recent survey conducted by the Ministry of Health in Saudi Arabia has revealed that physical inactivity is extremely prevalent among both genders and all age groups of the Saudi population, but significantly among females. About half of

the country's women do not perform any form of exercise and, of the rest, 29% perform light PA (Ministry of Health Saudi Arabia, 2014). Furthermore, data taken from the National Epidemiological Health Survey reported that both genders were inactive, citing that 98.1% of females and 93.9% of males fell into this 'inactive' group (AL Nozha et al., 2007). Our study also showed that, among those who exercised, most were doing moderate PA only one to two times a week and less than 10% were doing vigorous PA one to two times a week. These results are in agreement with data from the WHO report on the KSA in 2005 which shows overall low percentages of high (16%) and moderate (16%) PA and high percentages of low (68%) activity among men and women from 15–65 years of age. Based on our findings, it seems that W-UK were more physically active than W-SA. This is may be because most of the W-UK sample were PG students, so they might be going to university on foot, or there might be a link between higher levels of educational attainment and a generally active lifestyle, as indicated in other studies (Al-Nozha et al., 2007; Amin et al., 2011; Lusmägi et al., 2016).

In this research, a large number of women in both groups seemed unable to meet the national recommendations and, therefore, may not experience the benefits of PA. For example, the UK guidelines recommend that adults engage in 150 minutes of moderate intensity PA per week, and that bouts of activity should be at least 10 minutes in duration (Department of Health, 2011). Alternatively, adults can get comparable health benefits by engaging in 75 minutes of vigorous intensity PA per week. It has been proven that adults who engage in this amount of activity are likely to reduce their risk of diseases such as coronary heart disease, stroke and T2D, while maintaining a healthy weight and the ability to perform everyday tasks (WHO, 2010).

Sedentary behaviour has been defined in the academic literature as both low energy expenditure while sitting or in a reclined position, or as not meeting PA guidelines (Sedentary Behaviour Research Network, 2012). In the current study, questions on sedentary behaviours related to typical daily time spent on sedentary activities, including engagement in household work, time spent viewing TV, playing video games and computer and Internet use. Specific official guidelines for viewing TV or using a computer for the adult have not been established, but previous studies have recommended no more than one hour per day for computer use (Janssen et al., 2005)

and no more than two hours per day for viewing TV (Al-Hazzaa et al., 2011c). The results of this study indicate a high prevalence of sedentary behaviours in both groups. The vast majority of individuals spent long hours sitting watching TV or using the computer, either at home or work/university.

These results are in agreement with previous studies with regard to the high levels of sedentary behaviour. Data from a comparative study of 20 countries showed that the KSA was among the countries that reported the highest amounts of time spent sitting (Bauman et al., 2011). This was confirmed in a study by Al-Hazzaa et al. (2011c) which found that 84% of Saudi men and over 91% of women watched television and used the computer for more than two hours per day. That means only 16% of the men and less than 11% of women met the recommended screen time guidelines of two hours or less per day. There is some evidence that spending too much time sitting at work or at home increases the risk of becoming obese (Hu et al., 2003; Blanck et al., 2007) and may also increase the risk of chronic diseases and early death (Patel et al., 2010; Thorp et al., 2011). Other research findings have shown that TV viewing (sedentary activity) and PA appear to be separate entities and are independently associated with obesity and metabolic risk (Ekelund et al., 2006). For every two hours women spend watching TV each day, they have a 23% higher risk of becoming obese and a 14% higher risk of developing diabetes (Hu et al., 2003).

Referring to the household work, 40% of W-SA have maids and 21.5% of them did not engage in household work, whereas 44% of W-UK do household work, but only for one to two hours a week. This may be a factor which decreases women's chances of reaching the required amount of PA. Indeed, traditional/cultural restrictions in lifestyle choices available to women in Arabic countries are one influence on increased rates of sedentary behaviour and obesity. According to Badran and Laher (2011), women have limited access to exercise activities; this may be aggravated by the easy access to cheap migrant labour for domestic chores. Many families in the KSA and Kuwait commonly employ maids and chefs, adding to a sedentary lifestyle among indigenous women, and this agrees with our study (Badran and Laher, 2011).

As for knowledge of diseases for which regular PA can minimise the risk, a high percentage of women answered that PA can prevent diseases, the most frequently cited of these being obesity, CVD, diabetes, hypertension and stress. Additionally, a significant majority of women (39% of W-SA and 48% of W-UK, respectively) were aware of the recommended duration of exercise (30 minutes a day), but there was a lack of knowledge about the recommended number of times to exercise, which should be at least five times a week to be good for their health. However, the subjects who were knowledgeable about the benefits of exercise did not appear to be applying this knowledge to their day-to-day activities, as most of them were physically inactive, as mentioned previously. Similar to our results, Chaubal (2011) found that knowledge related to health and PA had a poor association with PA. Also, Morrow et al. (2004) concluded that PA knowledge alone was not sufficient to elicit PA behaviour. However, Dishman et al. (1985) reviewed the known determinants of PA and reported that knowledge of, and belief in, the health benefits of PA might motivate initial involvement, but the feelings of enjoyment and well-being seemed to be stronger motives for continued participation in health programmes. Additionally, Enjezab et al. (2012) reported that lack of knowledge was considered to be an effective barrier to the shortage of PAs. The results of Giardina et al.'s (2009) study showed that PA and education were significantly related. Within an undergraduate population, women who had completed their graduation had greater total activity time than those with some high school education. This is in contrast with our study, since, although most of this sample was made up of university graduates, with a higher percentage of postgraduates in the UK group, PA level in general was low.

The attitude, beliefs and the will to be involved might be the main contributing factors to encouraging people to engage in PA. Attitude is commonly defined as an individual's favourable or unfavourable evaluation of an object or target behaviour (Hagger and Chatzisarantis, 2008). The majority of participants in this study seem to hold favourable attitudes towards PA. Positive attitudes towards PA (in general) have been similarly reported by Chaubal (2011) and Mohammed (2016), even though a change in attitude is not always necessary to bring about a lifestyle change (Hitschfeld, 2011) and that motivation is also required (Enjezab et al., 2012). Doran's (2010) study

conducted on pregnant women reported that PA behaviour did not seem to match the positive attitudes towards moderate PA because their intentions did not match their behaviour.

In the present study, although approximately half the survey sample was aware that exercise was the best thing they could do for their health, the other half reported that "exercise is important, but many other things are more important." These results may be because over half the sample was married with children. Additionally, almost half of the W-SA were employees and over half of the W-UK were students. This indicates that many of the women had responsibilities and obligations towards family, job or study. In line with this, available evidence indicates that subjects believed that additional intentional efforts were necessary to increase their PA. It was often not prioritised as highly as family and work and the PA schedules were easy to break and change depending on other life events (Im et al., 2011). Additional research shows similar trends. Enjezab et al. (2012) reported that women's family responsibilities and their busy schedule at home are other effective factors in not having a healthy lifestyle. Even though, nowadays, women make up a big part of the workforce, this has not changed expectations of them. Women still have a major responsibility in caring for family, both children and other relatives. This large complex set of responsibilities leaves them with little time for self-care. As a result, and as confirmed by our study subjects, women feel a lack of time to be a major obstacle to exercise. Furthermore, almost half of the survey population considered themselves to be of average fitness. Indeed, those who were satisfied with their level of PA, were, in reality, the less active individuals. In general, the subjects correctly classified themselves as either average weight or overweight. This means that the majority of subjects were aware of their real weights, but about half of them reported that they were not actively trying to lose weight at the time of the study.

Regarding factors that can motivate people to exercise, generally, a high percentage of women had an understanding of PA as having specific benefits. These benefits were mainly associated with health and well-being. 'Controlling weight' was a major reason for exercise, while the majority also mentioned 'looking good' to be a major reason, followed by improving overall health and preventing diseases. The noticeable

difference between the two groups was that nearly 60% of W-UK pointed out that they wanted to reduce stress as opposed to 49% of W-SA. Similar trends were observed in a study conducted by Economic and Social Development (ECOS) (2011), which found that the most common reasons related to motivation for exercising were to stay in good health (78%) and to get fitter and/or lose weight (75%). In the same context, Murray and Ipsos (2006) concluded that, when subjects who exercised at least weekly were asked their main reasons for doing so, health reasons were the most common with 84% of subjects citing at least one of the following benefits: keeping fit, keeping in shape/toned, or losing weight. Mental health was also an important reason with almost half (45%) exercising to relieve stress or relax.

There is no doubt that multiple barriers play a substantial role in preventing people exercising and that these vary based on country, culture, religion, customs and traditions. The concept of perceived barriers has been defined as "a person's estimation of the level of challenge of social, personal, environmental, and economic obstacles to a specified behaviour or their desired goal status on that behaviour" (Glasgow, 2008). A review of 108 published studies addressing correlates of PA identified perceived barriers as the most consistent negative psychological correlate of PA (Bailey et al., 2005). The current study highlighted the most common barriers to regular exercise. Interestingly, the greatest barrier for W-SA was the lack of transportation. This is because women in SA are prohibited from driving, do not have access to public transportation and require a guardian for commuting. This, in addition to lack of time, lack of suitable facilities for sport, bad weather, lack of partner and lack of safe places, all impact on involvement in PA. In fact, most of these barriers are mainly linked to social norms, which are theoretically hypothesised to influence health-related attitudes, such as PA and diet, and are believed to be the most powerful forms of social control over human behaviour (Draper et al., 2015). Consistent with our study, Khan (2015) found that the opportunities to exercise in public are extremely limited for women living in many Middle Eastern countries due to socio- cultural norms, such as a limited number of women-only health clubs, lack of transportation, accepted dress codes and a lack of safe and easy-access places to partake in PA. Furthermore, bad weather, lack of time, lack of facilities and health programmes were

cited as some of the structural determinants to PA among middle-aged women (Chaubal, 2011; Amin et al., 2012; Awadalla et al., 2014; Samara et al., 2015; Al-Drees et al., 2016). Our findings also showed that the lack of suitable facilities is the second barrier to participation in sport in W-SA (44.2%). According to a study conducted in the KSA, the most frequently reported barrier to PA was a lack of resources (80.5%), which was most widely reported among females and low-income individuals (AlQuaiz, 2014). Also, Alozaibi (2011) reported that the lack of culturally-sensitive health clubs that respect Islamic religious beliefs was one of the culturally-related barriers to exercising. Available evidence investigating the guidelines that can help providers to ensure that their activities are more accessible and motivating to Muslim women concluded that establishing sensitive health clubs that respect cultural and religious concerns was one of the most important factors that could encourage women to participate in sports. These included:

• Making sure the changing rooms, showering and WC facilities are safe, private environments which cannot be overlooked.

• Allowing a wide range of clothing choices; for instance, when swimming, women may wish to wear more than is conventional.

• Putting up signs on doors when women's sessions are in practice.

• Turning off cameras when sessions take place.

• Ensuring that all staff on duty are female: women lifeguards, etc. (Women's Sport and Fitness Foundation, 2010).

As for the W-UK group, lack of time was cited as an important issue for over two-thirds of the W-UK group. This might be due to study commitments and responsibilities related to family and social environment, as most of these participants were students. By the same token, several previous studies indicated lack of time as the most important external barrier to PA (Daskapan et al., 2006; Al-Otaibi, 2013; Musaiger et al., 2013; Awadalla et al., 2014), whereas lack of energy was the most important internal barrier (Phillips et al., 2009; Al-Otaibi, 2013). Another study by Awadalla et al. (2014) found that the most significant reported barrier to PA among inactive students in SA was time limitation (51.3%). Furthermore, it was found that lack of time due to

a busy lesson schedule or to responsibilities relating to family and social environment were the most commonly cited barriers among university students (Daskapan et al., 2006; Awadalla et al., 2014). For women, time constraints are considered a significant obstacle to participation. It has been found that the majority (66%) of females experience time pressures and that these pressures are most acute among working females, and working mothers in particular (Women's Sport and Fitness Foundation, 2007). However, researchers have suggested that lack of time is an excuse rather than a barrier (Carron et al., 2003). The suggestion is that, if they were committed to undertaking PA, they would find time to do so. For example, university students have more flexible time to attend different social activities. They still considered that a social invitation during workout time was the biggest barrier to attending PA (Gyurcsik et al., 2006).

What is more, in this study, it is noticeable that bad weather has been cited as a common barrier by both groups. The extremely hot weather with temperatures exceeding 54°C (Owen, 2017) and dry climate in SA, coupled with the desertification and lack of forestation and vegetation generally forces people to stay indoors, leading to decreased PA time and a sedentary lifestyle (Badran and Laher, 2011). Amin et al. (2011) deduced that the most frequently cited obstacles to leisure time exercise among their Saudi subjects were related to traditions and weather (especially for women), unlike lack of time, as is reported in most developed countries (Oliveira et al., 2011; Amin et al.,2012). In the same context, weather was also repeatedly mentioned as impacting on people's PA in European countries (UK) (DuBois, 2010) where the W-UK group lived. Additionally, a few women mentioned extra barriers, the most notable of these being having menstrual periods or being pregnant. Some subjects reported that their mothers discouraged them from exercising because they worried about their reproductive organs being injured by strenuous PAs such as bike riding.

According to our results, the first type of PA that was preferred by the participants was walking, which is consistent with Al-Rafaee and Al-Hazza (2001) who found walking to be the exercise most practised by the active group (70%), and with AboZaid and Farahat (2010) who showed that walking was the activity most practised by physicians

(70%). The second favourite PA in our study was dance, followed by aerobics, which also agrees with other studies (Majeed, 2015; Samara et al., 2015). In contrast, some studies indicated that swimming, basketball and yoga were the most commonly cited activities that adults would like to do more of (AboZaid and Farahat, 2010; Iqbal and Kokash, 2011).

In the current study, almost half of the W-SA and more than two-thirds of the W-UK did not participate in any PA classes or programmes (Table 3.10). It should be noted that 37% of W-SA reported that there were no PA classes in their community. This also confirms that the lack of facilities is one of the major obstacles to sports participation. With respect to the desire to exercise, W-SA have a greater intent to exercise than W-UK; about two-thirds of W-SA reported that they wanted to exercise for about 30 minutes a day most days of the week, whereas a similar proportion of W-UK reported they would not be able to exercise.

Finally, when asked the open-ended question, "what could be done in your community to make it easier for you to exercise more regularly", only a low percentage of people answered. The most common responses were: sports activities programme, competitions for women, establishing Astro Turfs, footpaths with a playground for kids, sidewalks and safety planning, flexible working hours and availability of a gym at the workplace, and sports club/gym close to home, including children's healthcare. Interestingly, some subjects suggested using public schools as sports clubs after school hours (evenings). Indeed, creating an active environment is thought to directly facilitate people's PA levels by offering more opportunities and options in their daily routine. The mechanism of the influences of environmental factors on different types of PAs still requires a more comprehensive understanding (Trost et al., 2002). Obviously, safe and attractive scenery for outdoor activities and convenient and affordable facilities and programmes may all encourage people to adopt active lifestyles (Chen, 2008). Other studies have indicated that the physical features of the environment that have been correlated with PA in Arab countries include access to locations and facilities where people can be active (e.g. parks, arcade zones, walking/jogging trails, playgrounds, sports fields, schools and worship facilities), as well as better street lighting, having sidewalks available and using a mall for walking)

(Alozaibi, 2011; Carroll, 2013; Musaiger et al., 2013).

Based on BMI classification, this study revealed that both groups exhibited a high prevalence of overweight (BMI 25 – 29.9), with a higher percentage for W-UK (44%) than W-SA (35%). In contrast, the prevalence of obesity (BMI 30 – 39.9) was higher among W-SA (22%) than W-UK (14%). A small proportion (3%) of the W-SA group were classified as morbidly obese (BMI>40). Overall, approximately 60% of both groups were classified as either overweight or obese. These outcomes are consistent with the worldwide spread; 40% of the global population of women are overweight and 15% of women are obese (WHO, 2015b). Also, our results are in accordance with a previous study which found that 37.17% of Saudi women are of normal weight, 31.5% are overweight and 18.8% are obese, while 2.3% are morbidly obese (Al-Malki et al., 2003). A systematic review conducted in the Gulf Cooperation Council (GCC) region reported that the prevalence rates for overweight women ranged from 25%–35% and the prevalence rates for obesity ranged from 16%–49% (Alhyas et al., 2011). In contrast, based on a study conducted by DuBois (2010) on university students aged between 18 and 22 years, more than half of the students (54.7%) were of normal weight, which is a higher percentage than our results, while the prevalence of overweight individuals and obesity was 24.2% and 10%, respectively, which is lower than our findings. This could, potentially, be due to the age factor. Conversely, obesity levels in our study are lower than those reported by the Ministry of Health (2014) and those estimated in Badran and Laher (2011).

With respect to nutritional intake, 258 women in this study completed the 24-hour dietary recall, while 21 diaries were excluded, possibly reflecting the burdensome nature of completing a diary (Washburn and Montoye, 1986) especially if the questionnaire was long. It was not possible to compare any differences between those who completed the diary and those who chose not to complete it.

The independent t-test showed no significant differences between both groups in terms of energy, macronutrient, sugar and fibre intake. It is clear from Table 3.11 that women in both groups apparently consumed considerably more energy than the EAR from the UK reference standards. The mean calorie intake for W-SA and W-UK was 2609kcal/d and 2517kcal/d, respectively. These results are similar to data from Arab

countries which found that the average energy consumption, according to the Food and Agriculture Organization of the United Nations (Statistics Division), from 1990 to 2007, was 2780kcal/day (FAO, 2010). Another recent study showed that the dietary energy supply for Saudi adults was 3078kcal/capita/day (Adam et al., 2014), which is above the calorie intake reported in the present study. According to Musaiger (2011a), the per capita availability of energy in most EMR countries increased by 716kcal from 1964-1999, and is projected to reach 880kcal by 2030. This would make the average daily per capita energy availability in excess of 3000kcal in most countries of the region. This information coincides with a recent Saudi report which found that the average per capita calorie intake is 3176 per day, which is 14% higher than the world average (Saudi Arabia report, 2014). Indeed, high consumption of energy by the survey sample is a cause for serious concern. Could excessive calorie intake have contributed to the high prevalence of overweight/obese Saudi women in this study?

It must be stressed that the range of dietary intakes is considerable and that the mean intake values cover a whole range – both very low and very high intakes. This was particularly evident in the carbohydrate intakes, which were higher than the DRVs in both groups (54.6% in W-SA and 56.1% in W-UK). The mean total fat intake was also high in both groups, but close to the recommendations. Although the average protein consumption was well in excess of the recommendations in both groups, the proportion of energy derived was slightly lower than that recommended. Although there are methodological differences between the present study and other dietary studies, our outcomes are consistent with Al-Assaf and Al-Numair (2007) who suggested that overweight individuals and obesity among adult Saudis are due to a high consumption of macronutrients combined with inadequate consumption of some micronutrients. The mean consumption of fat, protein and carbohydrates was 84g, 99g and 334g, respectively. The intakes of macronutrients for all participants were within the Acceptable Macronutrient Distribution Range (AMDR) (Institute of Medicine, 2005), but they were considered high due to high calorie consumption (Al-Assaf and Al-Numair, 2007). However, the mean consumption of total fat in the present study was lower than earlier findings conducted in the KSA. Al-Nozha et al. (1996) reported that the mean consumption of total fat for both genders was 145g, which represented

42% of calorie consumption. This high consumption of fat raised the calorie consumption to 3082kcal, which is above the calorie consumption reported in the present study.

There were no significant differences between groups in terms of monounsaturated, polyunsaturated and trans fatty acids intake, which were consumed at close to recommended levels. However, saturated fatty acids intake was consumed at a higher level than DRVs. High intake of saturated fatty acids presented in our study (12.6 and 12.5% of total energy for W-SA and W-UK, respectively) is in agreement with a high intake of saturated fatty acids among healthy young Saudi men reported by Alissa et al. (2005) and among adult Saudis reported by Al-Assaf and Al-Numair (2007). In a similar vein, results from Alissa et al. (2005) concluded that dietary cholesterol and the percentage of energy derived from saturated fatty acids were both higher than the RNI for participants. This may relate to the availability and consumption of high levels of food products of animal origin.

In the present survey, higher mean total fat intake and increasing values of saturated fatty acids and cholesterol among women may be explained by their more frequent intake of fat rich foods, such as meats, eggs and whole milk and dairy products. Additionally, it has been observed from the food diaries that women have adopted a largely fast food style diet. It is remarkable that, due to the westernisation of the Saudi Arabian diet, the increased consumption of high levels of free sugars and saturated fatty acids, cholesterol and sodium have become much more common on a daily basis (Al-Daghri et al., 2013). There has been an increase in calorie supply in Arabic countries and a high percentage of these calories come from animal foods (Musaiger, 2007). Animal fat represents 40%–52% of total per capita fat consumption in the region (FAO, 2010; Musaiger, 2011).

Our study also showed that the mean daily intake of sugars (NMES) in both groups (over 70g/day) was high according to the maximum recommended intake of 60g/day suggested by the DRVs. It is also of note that there was large variation in intake between both groups.

In fact, the increase in carbohydrate and sugar consumption may be due to the increasing intake of starchy foods. The most frequently consumed foods, as observed in the food diaries, were grains and cereal products particularly white rice and Arabic bread with no significant differences between groups (Figure 3.8). Eating snacks was also a common habit among women and its daily consumption was significantly higher in W-SA than W-UK (2.7 servings/d vs. 2.3 servings/d respectively, p=0.03). W-SA mostly snack on dates followed by crisps and ice cream while W-UK mostly snack on crisps followed by chocolate and sweets. The majority of women were consuming fast foods; the common fast food choices include pizza, fried chicken and burgers. The average fast food meals intake was significantly higher in W-UK (twice /d) than W-SA (once/d) ($p< 0.001$).

These findings were in accordance with previous studies in KSA. Sabra et al. (2007) found that 64.2% of students university consumed fast foods 1-5 per weeks and one the fifth consumed fast food in a frequency of 6-10 times per week. The KSA ranked among the top ten countries for the consumption of soft drinks (Sheth, 2017). A recent study indicated a high degree of soft drinks consumption among Saudi university students: 47.8% of male students and 43.5% female students consumed soft drinks up to six times a week (Alkahtani and Awad, 2016). Eating snacks was a daily habit in about one third of Saudi students with the exception of dates which are taken at least three times weekly by 60.5% of students (Al-Rethaiaa et al., 2010). Similarly Sabra (2014) has shown that 35.7% of the university students take snacks as their main eating pattern 6 to 10 times/week; 82.7% of the students consume fast/junk food 1 to 6 times/week and 73.1% consume soft drinks more than 7 times/week.

The food choices and eating habits progressively, became more and more “Westernized”. Such “a nutritional transition” has been claimed for the rising rates of overweight/obesity among Saudi population (Al-Rethaiaa et al., 2010). Studies found strong correlations between increasing BMI and snacks consumption rate ($p=0.018$) (Al-Rethaiaa et al., 2010), fast food ($p<0.001$) and sugar soda ($p= 0.013$) (Li, 2013).
On the other hand, our findings show that the mean daily consumption of dietary fibre (NSP) was low, particularly in the W-UK group (14.6g for W-SA vs. 13.5g for W-UK). These values fell considerably short of the DRVs (average at least 18g/d). This is

apparently due to low intake of fresh fruit and vegetable (about 2 servings/d of fruits and 2.5 servings/d of vegetables in the both groups) and possibly due to insufficient quantities of other sources of fibre, such as whole grains, legumes and high fibre cereals. This is as reported by a study conducted on Saudi female students, which showed that 78% were not consuming fruit and vegetable on a daily basis (Al-Otaibi, 2013). Bano et al. (2014) also reported that many university students had poor nutritional habits. Consumption of fruit and vegetable (<5 servings/day) and mean consumption of fibre was found to be low (14.6g/y).

In this study, there were no significant differences between the two groups in terms of vitamin and mineral intake, except in the case of vitamin B_{12} intake, which was higher among W-SA. It is clear that vitamin intake (E, C, D, B_1, B_{12} and B_9) and mineral intake (calcium and zinc) were higher than the RNI for both groups. By contrast, vitamin A, D and iron intakes were below the recommended amounts for both groups. Consistent with our study, deficiency in some micronutrients among certain groups of the Saudi population was reported. Low intake of vitamins A, D and C, in addition to iron, was common among Saudi men and women (Alsufiani et al., 2015). Mirmiran et al. (2012) also found that, in Middle Eastern countries, the three commonest micronutrient deficiencies were in iron, iodine and vitamin A. However, Al-Saleh et al. (2007) reveal that there is a mild vitamin A deficiency among the Saudi population, according to WHO criteria.

Iron and vitamin D status have been studied widely in the KSA. The overall country-wide prevalence of anaemia caused by iron deficiency is 30%–56% (Verster and Jolieke, 1995). A more recent study among female university students showed that 64% of students were found to be anaemic (Al Hassan, 2015).

In the present study, the mean daily intake of vitamin D among women (2.3 for W-SA and 2 for W-UK) was lower than RNI standards of 10µg/d and RDA standards of 5µg/d. This is in line with previous findings which revealed that vitamin D deficiency is common in healthy Saudi adults. The prevalence of vitamin D deficiency was significantly greater in females at 34.8%, as compared to 13.4% within the male population (Alsuwadia et al., 2013). This is in accordance with Attar and Al-Ghamdi (2010) and Alissa et al. (2011) Osteoporosis and bone conditions are prevalent among

Saudi women who suffer from vitamin D deficiency and low calcium. Wearing of traditional clothes, deliberate avoidance of the sun and inadequate dietary consumption are likely to be the principal causes of low vitamin D levels. Anaemia was also a predictor for vitamin D deficiency or insufficiency (Alsuwadia et al., 2013).

3.7.1. Associations between obesity and age in women

To analyse the data, females in both groups were divided into four age groups: 16–24 years old, 25–34 years old, 35–44 years old and 45–54 years old. It should be noted that the age groups of current study started at 18 years, however, the age category 16-24 year was selected to be identical to the UK study (Moody, 2012) to allow comparison as shown in Figures 3.17 and 3.18. It is, therefore, recognised that caution should be taken when comparing data from the two studies in this youngest age group.

There was clearly no effect of country, or an interaction between country and age, in this analysis. Therefore, the data were pooled and investigated for an effect of age alone using a one-way ANOVA. This finding was in accordance with previous studies (Alhyas et al., 2011). The data showed no obvious trends or anomalies dependent on country, although the data from Oman (two studies, reporting combined overweight/obesity rates) suggest prevalence there might be relatively low.

After combining the data from the two countries it was clear that, with increasing age, weight and BMI increased. The youngest group (16-24 years of age) had a healthy BMI (approximately 22kg/m²), which was significantly lower than all the other age groups. It was particularly noticeable that there is a big jump in BMI between the 16-24 age group and the 25-34 age group. After this age group, BMI increases progressively up to the 45-54 age group, by which time the mean BMI (30.3kg/m²) is within the obese range. The possible explanation for the step-change in BMI between the 16-24 age group and the 25-34 age group is due to the fact that this age group is the age at which most women marry and become pregnant in the KSA; it is also the age at which women get a job and an increase in income, which could offer one reason for gaining weight. Consistent with our study, Al-Malki et al. (2003) reported that, when females are grouped into different age groups, an increase in BMI occurs, from 22.9kg/m² in the 16–20 age group to 30.9kg/m² in those 40–45 years old, and the correlation between age and BMI is statistically significant. Another study classified the BMI ranges by age

group and gender and concluded that 36% of participants were found to be overweight and 42.9% were obese. The youngest age group (20-29 years) had mostly normal BMI, but most of the older participants were either overweight or obese (p=0.011) (AL-Nohair, 2013). Also, a systematic review in the GCC region demonstrated a correlation between overweight individuals/obesity and age, and a significantly higher mean BMI in the 45–54 age group versus the 55–64 age group (Alhyas et al., 2011).

It is interesting to compare the results of this study with a study conducted in the UK by Moody (2012) which showed similar findings, with obesity strongly related to age. In general, in both countries, the chances of being overweight rose with age up to the age of 54. However, in all but the youngest group, the mean BMIs were higher among the Saudi population (Figure 3.13). Interestingly, when the women were further grouped according to age and BMI classification, by the age of 35 almost 80% of Saudi women were classified as overweight or obese, while the figure for UK women was closer to 50%. Thus, a comparison of the data suggest that young women in the two communities have similar incidences of overweight and obesity, the problem becomes more acute in Saudi women as they become older (Figure 3.14).

3.7.2. Associations between obesity and energy and macronutrient intake in women

As macronutrient intake differed little between countries, data were again combined and analysed for effects of age. In the whole group, the mean energy intake was approximately 2500kcal/d. Calorie consumption was shown to increase gradually with age, which was statistically significant. The youngest group (16-24) had a lower energy intake (2017kcal/d), which was significantly lower than all other age groups and close to the recommendations. This may be because younger women, particularly unmarried women, are more concerned about their body image and, hence, they are more aware of avoiding foods higher in energy, as indicated in other studies (Gharib and Rasheed, 2011; Khalaf et al., 2015).

Figure 3.13: Comparison the mean of BMI in Saudi Arabian and English Women

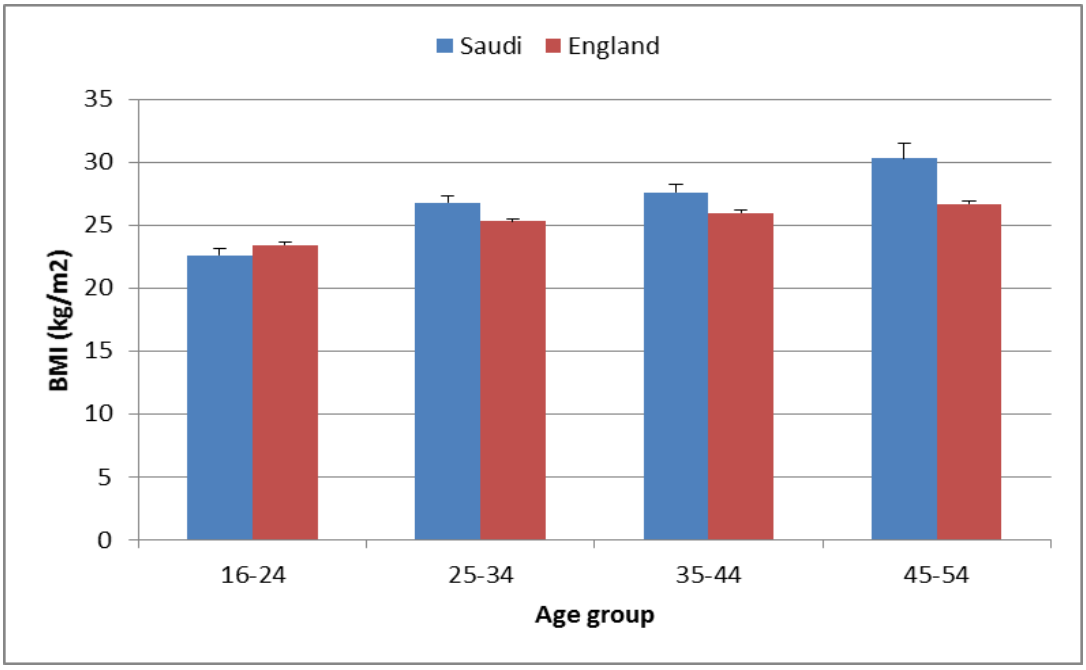
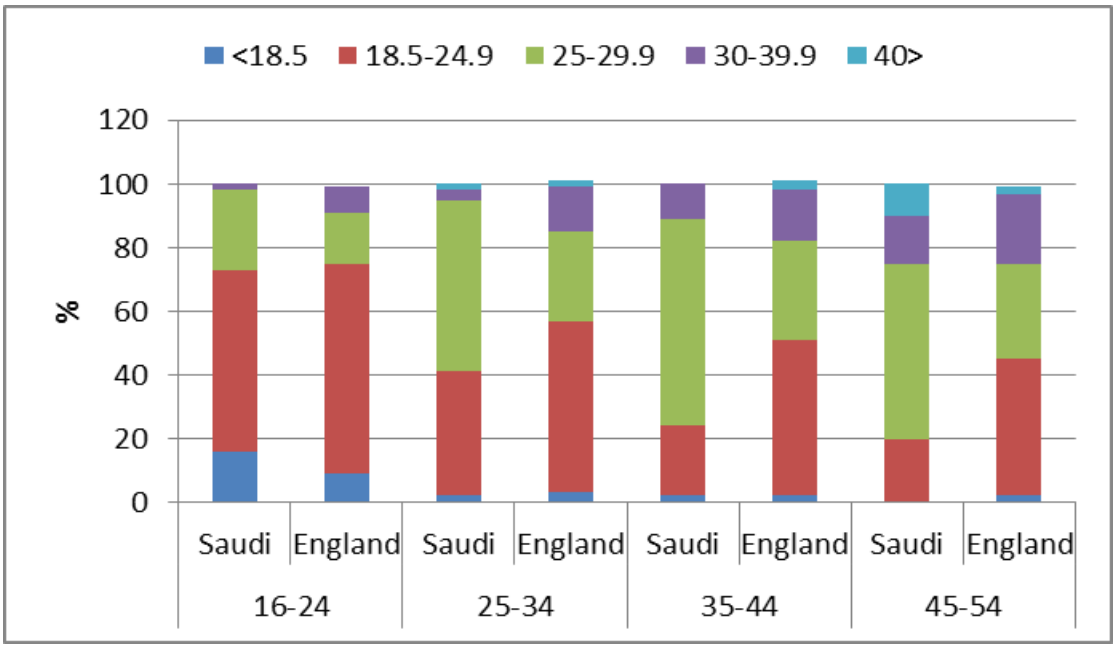


Figure 3.14: Comparison of BMI and age classification in Saudi Arabian and English Women



The data also showed that the 25-34 age group and the 35-44 age group had a lower energy intake than the 45-54 age group and this was higher than the recommendations. After these ages, energy intake increased progressively, with the oldest group consuming 3235kcal/day (more than 50% higher than the recommended amount). Similarly, individual macronutrient intake increased with age and, in general, was high compared to the DRVs for all age groups. The mean daily intake of carbohydrate, fat and protein increased progressively with age, but was almost similar for all groups when expressed as a percentage of energy intake.

The available information on differences in dietary consumption according to change among populations in the Middle East is relatively limited. However, our outcomes are fairly consistent with Gharib and Rasheed's study (2011). The mean intake of energy, macronutrients and sugar among Bahraini children and adolescents was high, as per DRV recommendations. Carbohydrate and sugar consumption significantly increased with age, while protein and fat intake remained consistent across all age groups. In contrast, Alissa et al. (2005) indicated that energy and carbohydrate intake fell with age among Saudi men. Total dietary carbohydrate and fat consumption were similar for all groups when expressed as a percentage of energy consumption, while the percentage of energy as protein increased with age.

In this study, to identify whether BMI is related to energy intake and energy from specific macronutrients, a regression analysis of BMI was carried out against energy, carbohydrate, protein and fat intake. Regression analysis showed that there is a strong relationship between energy intake and BMI ($p<0.001$). There is also a strong relationship between carbohydrate, protein and fat intake and BMI ($p<0.001$), but none of these are related to BMI more strongly than total energy. Overall, excess energy intake plays a major role in excessive weight gain. However, there is no evidence that this relationship is associated with excessive intake of one macronutrient and it is likely to be due to a combination of all of them.

Consistent with our study, findings by Al-Assaf and Al-Numair (2007) suggested that instances of being overweight and obesity among adult Saudis are due to high consumption of macronutrients combined with inadequate consumption of some micronutrients (vitamin D, calcium and folate), which are as a result of a non-balanced

diet and inappropriate consumption patterns. The study also suggests that there is a need to increase nutritional education and awareness among Saudi men. A recent study found that dietary intake of fat is positively correlated with BMI. The findings show that mean fat consumption increased with increasing BMI. Accordingly, a strong positive association was found between the BMI of the subjects and their respective average percentage of body fat as well as average visceral fat (Bano et al., 2014). It has been proven that nutritional imbalance due to high energy, fat and cholesterol intake is considered to be a risk factor for the occurrence of obesity and MS (Al-Daghri et al., 2013).

According to our results, women reported a trend towards higher intake of total energy, fat, saturated fatty acids, cholesterol and simple sugars, a pattern consistent with a Western diet, as reported previously. Indeed, the recent influence of a Western lifestyle on Saudi culture is considered responsible for the increased consumption of fat and fast food in the KSA (Winter et al., 2011; Alfawaz, 2012) and is associated with several metabolic abnormalities (Bullo et al., 2007).

In our study, it has also been observed from food diaries that women mostly snack on crisps, chocolates, crackers and sweets and consume high amounts of carbonated soft drinks. These factors may be responsible for high BMI within the sample groups. De Graaf (2006) reported that snack consumption may contribute to higher energy intake and increased body weight. Studies conducted on Saudi women also found a significant relationship between BMI and consumption of sugar, sweets (Majeed, 2015) and soft drinks (Al-Bannay, 2013). Conversely, Memish et al. (2014) claimed that diet indicators and PA were not significantly associated with obesity among women. In fact, traditional/cultural restrictions in lifestyle choices available to Saudi women, depression, sleep disorders, demographics and genetic factors, as well as multiple pregnancies, may be other important factors that contribute to the increased prevalence of obesity sweeping Arabic countries and which have not been investigated in the present study (Memish et al., 2014).

3.7.3. Associations between obesity and physical activity in women

To analyse the data, both countries were pooled and the population was divided into four groups in response to questions related to the frequency and intensity of exercise.

Not surprisingly, the analyses showed a significant effect for PA on BMI (p=0.014). This study shows that, as women become more physically active, the number of overweight women and the obesity rate drop. The relationship between PA and obesity has been extensively studied in adults. Recent findings from a Saudi study of female university students showed that PA had an inverse association with BMI (Majeed, 2015). Similarly**,** a cross-cultural explorative study carried out in the KSA and the UK reported that significant differences in percentages of people who were overweight/obese and PA levels were evident among the youth from both countries, with men being generally more physically active than women. In addition, there were significant correlations between BMI, PA and sedentary behaviours; the participants with higher BMI reported lower levels of PA and higher amounts of sedentary time (Al-Nakeeb et al., 2012). In another study into the changes in body mass over 10 years, Williamson et al. (1993) reported that inactive participants were three to four times more likely to gain weight than physically active participants. It has even been suggested that the association between PA and instances of being overweight/obesity may be bidirectional, i.e. that physical inactivity may lead to weight gain, and being overweight/obesity may lead to physical inactivity (Ekelund et al., 2008; Bauman et al., 2012). However, Canfield (2012) reported that BMI was not significantly associated with PA, but was significantly and positively related to sedentary behaviours.

3.8. Strengths and limitations

The present study has several notable strengths. To the best of our knowledge, this is the first study in Saudi Arabia examining PA and dietary behaviour of Saudi women living in the UK compared to those living in their home country.

In the KSA, most previous studies have focused on investigating nutritional status, prevalence of metabolic diseases, food habits, knowledge and PA generally, whether in small or large cohorts. This study is different as it assessed a broad range of factors related to PA behaviours, knowledge, attitudes, barriers, motivations and preferences. We included measures that captured duration, frequency and intensity of activities. PA measures included in other studies are usually brief, measuring only one or two components of PA (Cust et al., 2007; Gil and von Gruenigen, 2011).

The study collected data on PA and dietary intakes and demonstrates some important associations with weight and BMI which appear to be specific to the age group studied. It also collected data rating specific cultural/religious barriers that need to be overcome if the PA levels of Saudi women are to be increased. This is the first such study to holistically assess the impact of all of these factors on body weight in this population of women.

There are a number of methodological limitations associated with this study that needs to be taken into consideration. The first limitation of this research was the relatively small sample size particularly among W-UK also, the data was limited to women over the age of 18 and up to 54 living in Al-Ahsa province that requires caution in generalising the findings over the whole population. Replicating this study with larger sample groups and in other cities and regions of Saudi Arabia may shed light on further social and cultural contexts, an understanding of which could augment the PA levels. Also, replicating this study among Saudi men of all age groups would provide further information as to the relative importance of the gender specific cultural barriers identified.

Secondly, the study used a snowball sampling method for the reasons explained in the methodology and, whilst effort was made to make it representative, self-selective bias of individual participants inevitably impact on the generalisability of the study results. It is therefore recommended that future studies address this limitation by using a research design that incorporates randomised sampling.

In the current study, self-reported anthropometric data was considered the most appropriate tool to diagnose obesity which may, however, be influenced by response or recall bias. However, other workers have suggested that there is not an overall, statistically significant difference between self-administered BMI and measured BMI (Kruse, 2014) and the self-reported height and weight are valid to estimate the overweight/obesity prevalence in the population (Lucca et al., 2010). Also, the current study did not quantify PA using accelerometers or other such devices which can provide objective assessments of PA and offer more accuracy than self-reported data from questionnaires or activity diaries. However, there is some evidence from other studies that used objective approaches to measure PA level (e.g. accelerometer and

pedometer) and confirmed that there were similarities with the findings of studies that used self-reporting (Troiano et al., 2008; Alahmad, 2016). Therefore, future studies could address these limitations and utilise a mixed approach in data collection through both objective and self-report measures of PA.

Another limitation is that, while attempts were made to validate the reliability of the questions when developing the survey, this has not been tested statistically. As such, further research is needed to evaluate the PA questionnaire's reliability and validity to to ensure that the measurements obtained are representative and stable over time and suitable for use in large-scale population-based studies.

Moreover, the use of more than one 24-hour recall would be more useful to estimate usual intake. As explained, this was decided so as not to pose a burden on the respondent in terms of time but it is recognised that it may not be completely representative of habitual diet on an individual level. Furthermore, a recurrent issue in dietary self-reports is the extent to which participant's under-report their energy intake. Bias and under-reporting of energy intake are a major concern in dietary surveys, particularly among obese subjects (Bogl et al., 2009). However, researchers have proven that a sufficiently large number of 24-hour recalls does provide a valid estimate of the mean energy and nutrient intake when applied to a group of 50 individuals and more (Kipnis et al., 2009; Chamieh, 2013).

The computerised nutritional analysis package (Dietplan6 P3 Windows & Mac Serial No: 6918) used in this study is based on the UK composition of foods database. Using this programme for Saudi traditional foods (e.g. Margog, Kabsa, Mandi and Quzi) may have introduced error. Limitations were also found when coding different types of food; other options were chosen when the exact match was not available. Also, this method is not useful for analysing foods that do not have nutritional information that is easily accessible (e.g. foods that do not have a nutrient label or have not been previously analysed for nutrient content). However, if no suitable food item or dish could be identified, information on the energy and nutritional content of that specific food or dish was manually entered into the database. As for Saudi traditional local dishes, the food composition data was complemented by another local study (Musaiger, 1993). These problems highlight the need for a publicly available database

of food composition specific to the Middle East region.

Finally, in this research, theories for measuring attitudes toward PA have not been used. Theories and models have been proposed to link attitude and behaviour in research on PA. For instance, the theory of reasoned action (TRA) and the theory of planned behaviour (TPB) have been used particularly in the field of exercise psychology (Biddle et al., 2015). Future work could expand on our finding to include a more detailed consideration of attitudes and behaviour towards PA in this population.

3.9. Conclusion and recommendations

The findings of this study highlight an important public health problem affecting a high proportion of women in Saudi Arabia. Physical inactivity, sedentary lifestyles and poor eating patterns are extremely prevalent in Saudi women leading to a high prevalence of overweight and obesity. This study endorses that the prevalence of physical inactivity is relatively high, particularly in the W-SA group. A significant number of participants in the survey sample did not take part in any type of moderate or vigorous intensity sports. Almost 44% of W-SA did not walk regularly for a minimum of 10 minutes per day versus about 33% of W-UK, who walked every day, for an average of 24 minutes.

Furthermore, there is evidence of a high prevalence of sedentary behaviours within both groups. The vast majority of the two groups spent long hours sitting watching TV or using the computer, either at home or work and university. Despite having the knowledge and positive attitudes towards PA, it seems that Saudi culture, social norms and environmental barriers restrict the amount and type of PA undertaken by Saudi women. The most common barriers to regular exercise were lack of transportation, lack of time, lack of suitable facilities for sport and bad weather.

Nutritional intake showed no significant differences between the two groups in terms of energy and macro or micronutrients, except for vitamin B_{12} and cholesterol. The results imply that subjects in both groups had adequate nutrient intake, except for intake of vitamin A and iron, with excess intake of energy, protein, carbohydrate, fats and cholesterol. Excess energy intake plays a major role in excessive weight gain. However, there is no evidence that this relationship is associated with excessive intake

of one macronutrient and is likely to be a combination of all of them. There is a tendency among Saudi Arabian women to rapidly gain weight once over the age of 24, and this continues as they get older. The biggest change is the move from 18-24 to the 25-34 age group, suggesting that early intervention is required. This is associated with increased energy intake from all major macronutrients. In addition to this, there is some evidence to suggest a link between the highest activity group and the lowest BMI group, indicating that interventions in diet and PA could have a major impact. This study confirms that dietary energy intake is the major factor associated with control of body weight. However, it also suggests that low PA also makes a significant contribution.

The present study does not measure the impact of overweight and obesity on metabolic health. As discussed in chapter one, obesity, particularly when associated with increased visceral adipose tissue, is associated with MS which leads to increased risk of T2D and CVD. Our findings suggest that excess energy intake coupled with low PA may predispose the Saudi female population to these disease outcomes. The following chapter describes the occurrence of various components of the MS in a group of overweight Saudi women and the relative efficacy of short term intervention involving dietary advice (with or without increased PA) on weight loss and metabolic health.

It is recommended to develop interventions that provide social support for PA in community settings. These interventions would be designed to promote PA by helping people create, strengthen and maintain social networks that support their efforts to exercise more; examples would include exercise buddy programmes and the establishment of exercise contracts or walking groups. Also, establish some specialised foundations for sport and losing weight such as women's sports foundations, slimming world and weight watchers to support Saudi women.

Additionally, representatives of Saudi healthcare need to spread basic knowledge about nutrition through education and awareness campaigns, to encourage improvement in diet and greater levels of exercise. Another solution may be to tax fast food or to artificially increase the price of unhealthy foods. It is also recommended that the government establish a standard sports infrastructure exclusively for female

sports users, at least at each divisional headquarters. These facilities should ensure properly covered training circuits where women are out of sight of men, exercise laboratories, gymnasiums, running tracks, playing spaces and fitness rooms. Improvements should be also made in lighting and security in public exercise areas such as walking paths (sidewalks, trails) and bike paths and increase safety of the places.

CHAPTER FOUR

THE IMPACT OF EXERCISE AND DIETARY ADVICE ON METABOLIC HEALTH IN SAUDI ARABIAN WOMEN (STUDY II)

4.1. Introduction

The terms Metabolic Syndrome, Insulin Resistance Syndrome or Syndrome X have been used to define the clustering of factors that increase the risk of developing CVD and T2D (Sayon-Orea et al., 2014). The principal cause of MS is central obesity, being overweight with adipose tissue accumulation mainly around the waist. This results in the development of a range of risk factors for CVD/T2D including impaired fasting glucose, IR, elevated TAG level, high BP and decreased HDL cholesterol (IDF, 2006).

The prevalence of MS has dramatically increased over the last few decades and has become a worldwide pandemic. It is estimated that about 20%-25% of the world's adult population has MS (Stern et al., 2004). People with MS are three times as likely to have a heart attack or stroke, and twice as likely to die from this compared with people without the syndrome. Additionally, people with MS have a fivefold greater risk of developing T2D (Stern et al., 2004). The prediction that the incidence of diabetes will double by 2025 seems likely to parallel the rise in cardiovascular-related diseases and death (IDF, 2013b).

Saudi Arabia has experienced a marked increase in the prevalence of adult obesity over the last few decades, particularly in women. The consequences of obesity include an increased incidence of MS, CVD, T2D and other chronic diseases. MS is an important and increasingly common public health problem in the KSA. According to the national epidemiological health survey, the prevalence of MS among the Saudi population has been reported to be approximately 40%, with a higher prevalence in females compared to males (42% vs. 37.2%) (Al-Nozha et al., 2005). Studies predict a sharp increase in the prevalence rates of the syndrome among Saudi females during the next few years (Al-Qahtani et al., 2006). Obesity is the greatest, most easily observed and measurable risk factor for this syndrome. MS is found in about 5% of adults with normal body weight, 22% of those who are overweight and 60% of those who are obese. People who continue to gain five or more pounds annually increase their risk

of developing MS by up to 45% (Stöppler, 2016). BMI and weight gain remain strong significant predictors of the syndrome. A BMI of less than 25kg/m^2 is the goal for prevention and treatment of MS. A study by Nacata et al. (2009) demonstrated that moderate weight loss of 8%-13% of the initial body weight is associated with reduced risk of developing CVD and glucose intolerance.

However, as already indicated it is not only the amount of excess adipose tissue but also its distribution that may be important. Females have more body fat than males, but in contrast to the deleterious metabolic consequences of the central obesity typical of males, the pear-shaped body fat distribution of many females correlated with lower cardiometabolic risk (Karastergiou et al., 2012). Females, compared to males, have higher percent body fat and deposit it in a different pattern, with relatively more adipose tissue in the hips and thighs (Manolopoulos et al., 2010). Central obesity is a key feature of MS, reflecting the fact that the prevalence of the syndrome is driven by the strong relationship between WC and increased the adiposity (Després et al., 2008). Abdominal adiposity is associated with IR and creates an atherogenic inflammatory milieu. High levels of these biomarkers correlate with increased risk of T2D and CVD. A slight decline in body weight can significantly decrease abdominal adipose tissue, IR, LDL-C, TAG, BP and reduced overall cardiometabolic risk (Janet et al., 2006).

Weight reduction represents the major goal in preventing and treating MS. Interventions to modify dietary behaviour have been successful in both cases of people already diagnosed with metabolic disease, or in those at risk of developing such disease (Ammerman et al., 2002; Laws et al., 2004; Sinclair et al., 2008). Evidence from experimental epidemiological studies has confirmed a strong relationship between changes in dietary habits or nutrient intake and prevention of chronic diseases, including diabetes (JAMA and Archives Journals, 2009). Lifestyle interventions, including dietary changes, have been shown to reduce the incidence of diabetes by 58% compared to a control group of individuals at high risk (Kaur, 2014). It should be pointed out that no single diet is currently recommended for patients with MS. Therefore, it may be best for dietitians to focus on each patient's specific metabolic alterations when offering dietary advice. The evidence suggests that more specific

dietary advice to modify intake of fat sources, particularly dietary saturated fatty acids, and to increase the consumption of fruit and vegetables, is probably necessary for combating CVD risk (Ammerman et al., 2002; Spyreli, 2015). Babio et al. (2014) found that patients with MS who were advised to undertake the DASH diet were able to raise their non-HDL cholesterol and experienced a significant reduction in BP, lowered their blood sugar and TAG levels and even lost weight after six weeks. It has also been proved that participants who followed the Mediterranean diet pattern showed a reduction in blood sugar levels and abdominal obesity, in addition to 28.2% of participants with MS on the diet who no longer met the criteria at the end of the study.

While the benefits of reducing energy intake are widely accepted, the impact of increased physical activity on the features of MS remains more controversial. As body weight represents a balance between energy intake and expenditure, it might be expected that a combination of dietary restriction and increased PA would be of greater benefit than diet alone. Indeed, it has recently been suggested that approximately 60 minutes of moderate intensity endurance exercise on most days of the week can produce significant improvement in cardiometabolic risk factors, including a 30% reduction in intra-abdominal fat, 30-85% improvement in insulin sensitivity, 5% increase in HDL cholesterol, 15% decrease in TAG levels, a shift in the density distribution of LDL and a 4mmHg reduction in both systolic and diastolic BP (International Chair on Cardiometabolic Risk, 2014). For these reasons, the WHO (2013) included both reduced energy intake and increased energy expenditure in its *Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020*.

However, not all studies report that exercise plus diet are more successful in the treatment of MS than diet alone. In 2005 Kukkonen-Harjula et al reported that adding physical exercise to dietary counselling did not significantly alleviate MS more than diet alone. Casazza et al. (2009), showed that energy intake was more closely related to MS components than physical exercise. Carbohydrate consumption was adversely related to WC, TAG and glucose levels. Similarly, Jacobs (2009) reported in a group of Norwegian men, that diet pattern, as opposed to physical activity, was the most important factor in change towards a more favourable body size and metabolic profile.

Another study found that the insulin sensitivity index improved in 70% of individuals in the diet group and in 86% of those in the diet plus exercise group, but improvements were not seen in the exercise only or control groups (Nancy, 2012). There is also evidence to suggest that some people frequently increase their food consumption after exercise either because they thought they utilized a significant amount of energy or because they were hungrier (Church et al., 2009; Belluz and Zarracina, 2017). Another review of studies found that individuals generally overestimated how much energy exercise burned and ate more when they worked out (Thomas et al., 2012; Belluz and Zarracina, 2017). Thus, it can be seen that, while there is a generally held perception that the combination of dietary restriction and increased PA is more beneficial in treating or preventing MS than diet alone, the existing evidence is far from conclusive.

Physical exercise also varies in terms of its intensity, duration and this may influence its overall impact on MS. Chen et al. (2013) investigated the different PA subtypes (brisk walking, swimming, climbing mountains or stairs, tai chi and dancing) and the risk of MS in China and found that only tai chi, jogging and dancing had a significant association with a reduced probability of MS. Moreover, Kauko (2010) found that greater amounts of high-intensity exercise per week resulted in larger and more widespread effects than lesser amounts of moderate-intensity exercise. A study conducted in Saudi Arabia found that vigorous PA had a strong positive correlation with HDL-C and a negative correlation with BMI (Al-Ajlan and Mehdi, 2005).

Physical inactivity has previously been reported as extremely prevalent across all sex and age groups within the Saudi population (Al-Hazzaa, 2004b), with there being significantly more less active females (98.1%) than males (93.9%) (Al-Nozha et al., 2007). Data presented in Chapter three of this thesis supports these findings in the adult female Saudi population and highlights the significant barriers such individuals face in increasing PA. While no metabolic data was collected, this high prevalence of physical inactivity in Saudi females represents a serious threat to public health, as evidenced by the high risk of metabolic disease in the Saudi population compared with the populations of the UK and US (Al-Hazzaa, 2004a). Furthermore, the dietary data presented in Chapter three supports the previously described trends in dietary intake

with an increased consumption of energy and fat -dense foods and a decreased intake of fruit, vegetables and wholegrain (Midhet et al., 2010). The relative impact of excess energy intake and decreased PA on metabolic risk in this population remains to be fully established. This is important as it might be anticipated that, in Saudi women, who face significant barriers to increasing PA, specific focus on dietary intervention may be more acceptable than increasing energy expenditure. It is possible that, too much focus on the latter may actually discourage this population from participating in healthy lifestyle changes. To the best of our knowledge, in Saudi Arabia there have been no previous intervention studies specifically examining the association between PA, diet and MS in females. Therefore, the purpose of this pilot study is to examine the effect of an intensive dietary programme, including individual nutrition counselling, with or without increased PA, on MS-associated risk factors among Saudi women.

4.2. Hypotheses

1. Lifestyle modification (aerobic exercise and/or dietary advice with individual nutrition counselling) will significantly reduce early markers of MS and decrease body fat in Saudi women.

2. The combination of diet and exercise would result in greater changes in anthropometric measurement and metabolic risk factors than diet alone.

4.3. Aim

To measure the impact of exercise training and/or diet in improving risk factors associated with MS in Saudi women (a pilot study).

4.4. Objectives

1. To determine the metabolic status (including BMI, WC, BP, fasting plasma glucose, insulin level, IR, TAG, TC, LDL and HDL) for two groups of overweight, adult, Saudi females, a diet-only group (D) and a diet plus exercise group (D+E).

2. To improve MS–associated risk factors by modifying dietary habits and energy intake through provision of dietary advice, including follow-up (individualised nutritional counselling) using WhatsApp messages, focusing on dietary goals for reducing energy intake and adopting a 'healthy diet' involving lifestyle modifications and weight loss.

3. To increase the PA of the diet plus exercise group through access to a fitness centre with a qualified fitness instructor, one hour six times a week.

4. To measure usual intake of particular food groups (fruits, vegetables, grains and cereal products, dairy products, meats and alternatives, nuts and seeds, beverages, snacks/sweets and crackers, fast food) and assess dietary intake (analysing carbohydrates, proteins, fats, selected vitamins and minerals, fibre and sugar intake) and assess level of PA pre- and post-intervention using a seven-day food/exercise diary.

4.5. Methodology

This section discusses the research methodology adopted for this project. The research design, sampling method, measuring instruments, data collection and data analysis employed in this research are included.

4.5.1. Study design

The study was carried out in Al-Ahsa Governorate, located in the Eastern province of Saudi Arabia, from September 2013 to June 2014. The study recruited 40 apparently healthy women, aged 18-54, who were at risk of developing MS (BMI over 27) to participate in the study; 20 subjects for the diet only group and 20 subjects for the diet plus exercise group. Details of recruitment of subjects are included in Section 2 below.

Baseline activity levels, water consumption and dietary intake were assessed using a seven-day diet and exercise diary for both groups. At the end of the 30-day period, the dietary intake and activity levels of participants were reassessed after receiving the information needed to alter their diet and lifestyle habits.

All subjects in both groups were provided with dietary advice, including follow-up using WhatsApp messages, for a period of 30 days, focusing on goals for managing MS

and weight loss involving lifestyle modifications, including changes in diet and exercise habits. For group D+E, daily one-hour exercise sessions in the gym with a qualified fitness instructor were provided for six days a week for 30 days. Factors associated with MS were measured before and after 30 days of intervention, including anthropometric indices (BMI, WC), BP and fasting blood samples (plasma glucose, insulin level, IR, TAGs, TC, HDL and LDL).

Dietary advice was provided, on an individual basis, by mobile phone using the WhatsApp programme. This was used in preference to providing printed material, which, in a previous study, this researcher found to be of limited value due to limited engagement by the subjects. WhatsApp provides a convenient alternative to meeting with each participant face-to-face. Further details of the type of, and rationale for, the advice provided via WhatsApp are detailed in Section 8 below.

Permission and a letter of agreement were obtained from the researcher's official sponsor (King Faisal University) and approval from the clinic's owners; in addition, written informed consent was obtained from all subjects. Exclusion criteria included participation in exercise programmes in the previous 12 months, smoking, chronic diseases, pregnancy, bariatric surgeries and any medications contraindicated for study participation. Two participants from group D and one from group D+E withdrew at the baseline intervention and there were no reasons for withdrawal. It was not possible to compare any differences between those who withdrew because the data was not available. MS was defined based on the International Diabetes Federation's (IDF) new criteria with ethnic-specific values (Table 4.1-4.2).

Table 4.1: The new International Diabetes Federation definition

Table 1: The new International Diabetes Federation (IDF) definition

According to the new IDF definition, for a person to be defined as having the metabolic syndrome they must have:

Central obesity (defined as waist circumference* with ethnicity specific values)

plus any two of the following four factors:

Raised triglycerides	≥ 150 mg/dL (1.7 mmol/L) **or specific treatment for this lipid abnormality**
Reduced HDL cholesterol	< 40 mg/dL (1.03 mmol/L) in males < 50 mg/dL (1.29 mmol/L) in females **or specific treatment for this lipid abnormality**
Raised blood pressure	systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg **or treatment of previously diagnosed hypertension**
Raised fasting plasma glucose	(FPG) ≥ 100 mg/dL (5.6 mmol/L), **or previously diagnosed type 2 diabetes** If above 5.6 mmol/L or 100 mg/dL, OGTT is strongly recommended but is not necessary to define presence of the syndrome.

** If BMI is >30kg/m², central obesity can be assumed and waist circumference does not need to be measured.*

(IDF, 2006)

Table 4.2: Ethnic-specific values for waist circumference

Table 2: Ethnic specific values for waist circumference

Country/Ethnic group		Waist circumference
Europids* In the USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes	Male	≥ 94 cm
	Female	≥ 80 cm
South Asians Based on a Chinese, Malay and Asian-Indian population	Male	≥ 90 cm
	Female	≥ 80 cm
Chinese	Male	≥ 90 cm
	Female	≥ 80 cm
Japanese**	Male	≥ 90 cm
	Female	≥ 80 cm
Ethnic South and Central Americans	Use South Asian recommendations until more specific data are available	
Sub-Saharan Africans	Use European data until more specific data are available	
Eastern Mediterranean and Middle East (Arab) populations	Use European data until more specific data are available	

** In future epidemiological studies of populations of Europid origin, prevalence should be given using both European and North American cut-points to allow better comparisons.*

*** Originally different values were proposed for Japanese people but new data support the use of the values shown above.*

(IDF, 2006)

4.5.2. Study sample

It is recognised that the ideal design for such an intervention study would be the selection of a representative sample of the target population and subsequent randomization to different treatment groups. Such groups could include a control (no intervention), diet only, exercise only and diet + exercise. The size of these groups would be decided on the basis of power analysis relating to the key outcome measures of the study. Data would be analysed on an 'intention to treat' basis to ensure that differences in dropout rate did not adversely impact on the outcome of the study. However, due to time constraints and the difficulty in recruiting Saudi females for such a study (as explained in Chapter three) a number of significant compromises had to be made in the study design. The possible impact of these compromises on the outcome of the study is addressed below and further in the discussion of the results.

Convenience sampling was considered the most appropriate research design in terms of obtaining satisfactory responses. Convenience sampling is a specific type of non-probability sampling method that relies on data collection from population members who are conveniently available to participate in study (Etikan et al., 2016b). Because very little preparation is needed to effectively use convenience sampling for data collection, it is useful in time-sensitive research (Farrokhi and Mahmoudi-Hamidabad, 2012). Convenience sampling technique may prove to be effective during exploration stage of the research area, and when conducting pilot data collection in order to identify and address the feasibility of the study (Etikan et al., 2016b).

Although the sample may not be sufficiently representative of the entire population, and it might be biased by volunteers, it is usually used when do not have access to the population (Sousa et al, 2004). In this study, an attempt was made to increase the validity of samples by using selection criteria which ensured the groups studied were matched in terms of age and BMI. However, the model of having two distinct population groups means that not all bias could be eliminated.

The sample size was primarily limited by the availability of subjects within the timeframe available (particularly those prepared to join the diet + exercise group). This meant that it was not feasible to include an exercise only group. As described

above it would be good practice to undertake a power analysis to investigate the magnitude of statistically significant effects which might be expected to be seen. However, this does depend on the availability of data on the variance of the parameters to be measured within the population studied. Such data was not available, though it is recognised that data from other populations could have been used to estimate this. In the absence of such a power analysis, retrospective consideration of the baseline data is included in the discussion which could potentially help in a future follow-up study. However, according to Connelly (2008), extant literature suggests that a pilot study sample should be 10% of the sample projected for the larger parent study. In the medical field, Julious (2005) reiterated that "a minimum of 12 subjects per group be considered for pilot studies" whereas, some other literature suggest 10-50 sample per group (Hertzog, 2008).

4.5.3. Study length

For this pilot study, an intensive, four-week exercise and/or dietary intervention was selected. The study time frame was short but considered long enough to show changes in body weight and MS parameters as proven in previous studies (Clark and Burden, 2005; Johnson et al., 2009; Kauko, 2010).

4.5.4. Participants

For the diet only group, 20 subjects were selected after sending out e-mails, SMS, WhatsApp messages and posters. Thereafter, one group was created in the WhatsApp programme to include all participants so that the researcher could send nutritional advice to all of them simultaneously. This helped the subjects to exchange experiences, compete with and encourage each other, which could have an impact on reducing the participants' weights and adherence to diet (Foster-Schubert et al., 2012). This was in addition to the individual dietary counselling for all participants.

For the diet plus exercise group and as mentioned previously cultural barriers, strict families and lack of public transportation restrict access to PA classes for many Saudi women. It was, therefore, necessary to select women on the basis of intention to participate in such classes, where these barriers had already been overcome. There is widespread belief that the best sample is a random sample, but this is rarely possible

or desirable for sports research (Armour and MacDonald, 2012). For example, sports clubs are different in terms of sports facilities, costs, types of exercise and duration of the sessions provided, therefore, random sampling is unlikely to be achievable. Also, it is not very often that a researcher has access to or the freedom to manipulate all of the subjects in a population. Thus, researchers draw up specific delimitations for subjects and include any volunteer subject who meets that description (Berg, 2008). In many studies of PA, random sampling procedure is not possible; what is really needed is a sample that is "good enough for the study's purpose." This concept is extremely important for research in PA (Thomas et al., 2015).

A sample of 20 participants was selected from two clinics. The two clinics both had the same owner, the same system and same rules, and both had gyms with qualified expert fitness instructors, who designed the exercise sessions. Participants were required to perform an exercise session, six times per week, during which they undertook approximately 20 minutes' vigorous and 40 minutes' moderate exercise. Subjects were identified by the clinic medical directors and fitness instructors as potential participants. It was agreed with the clinics to display posters (see Appendices 9 and 10) and to ask women, who come to register in the gym for the first time, to participate in the experiment. It has been recruit women who met the inclusion criteria and were eligible to participate in the project according to the pre-exercise screening questionnaire, which was adapted from the Active8 questionnaire (2009) (see Appendix 11), and to give them the researcher's phone number to make contact, in order to determine suitable and serious subjects for the project.

The nutritional advice was sent to participants separately (not as a group) because of the differences in the dates of joining the gyms. The exercise programme was a combination of different types of PA, including aerobics, stretching and dance (Zumba) with warming up and cooling down. The researcher selected gyms which included the types of exercise that the women in study one reported that they preferred. In addition, based on the finding in study one that the major barrier to regular exercise was lack of transportation, the researcher asked the dispensary's director to provide some minibus drivers' phone numbers (a common private transportation in the region and more commonly used by women than taxis) to facilitate the participants'

attendance at the gym when needed.

After the initial selection, the researcher contacted the women in both groups by Tango (a free calling programme) in order to collect data on socio-demographic characteristics (age, marital status, number of children, educational level and occupational status) and the health status of the participants in order to determine if they were suitable to join in the project or not. Once the final selection was verified, the researcher spoke to the subjects to thoroughly explain the research and they were told they could terminate the intervention at any time if they so desired. After the explanation was completed, the subjects were given the opportunity to ask questions. The researcher remained in communication with them after their involvement in order to perform a follow-up nutritional analysis.

4.5.5. Anthropometric data and biochemical measurements

Anthropometric measurements, including height, weight, WC and BP, were taken based on standardised techniques. To ensure the reliability, all the anthropometric measurements both at baseline and at follow-up for both groups were taken by the same two nurses who have an extensive experience in the use of anthropometry.

As emphasised in current guidelines, BMI determination remains the most reliable measure for the assessment of obesity, and should thus remain the cornerstone of anthropometric measurements in primary care (National Institute for Health and Clinical Excellence, 2006). A study by Sebo et al. (2008) found that the inter-observer reliability for height, weight and derived BMI were excellent ($R > 0.99$). Another study also has indicated that BMI tends to perform even better than more sophisticated measures like adipose tissue-free mass or fat-free mass estimated by dual-energy X-ray absorptiometry (Heymsfield et al., 2007). However, BMI does not directly measure fat, so it is not the most reliable or valid way of determining body fat levels or fat distribution. Athletic people whose BMI falls into the higher side of normal or lower end of overweight may actually have a healthy amount of body fat, but an abundance of muscle that causes them to weigh more (Cespedes, 2017).

WC has been proposed as reliable measure of abdominal adiposity and as a better predictor of metabolic risk factors (Chen et al., 2001). This measure, together with the

assessment of BMI, has the potential to help physicians in their assessment of their patients' obesity-related cardiovascular risk and are also believed to be easy to perform (Chen et al., 2001; Sebo et al., 2008). Anthropometric studies have shown that, with appropriate training, the intra-observer reproducibility (reproducibility of the measurement by the same observer) and the inter-observer reproducibility (reproducibility of the measurement by two or more observers) for these measurements can be excellent (Sebo et al., 2008). Another study also found that WC is a better predictor of cardiovascular risk factors and has acceptable intra- and inter-observer reliability. The intra-observer ICC was 0.987 (95% confidence interval [CI]: 0.983 to 0.990) and inter-observer ICC was 0.988 (95% CI: 0.982 to 0.993) (Chen et al., 2001).

4.5.5.1. Height

Height was measured using a stadiometer mounted on a wall with a fixed headpiece to measure the length from the floor, with the subject standing erect without shoes, arms to the sides, legs straight, shoulders relaxed and head in the Frankfort plane achieved when the orbital (lower edge of the eye socket) is in the same horizontal plane as the tragion (the notch superior to the tragus of the ear). Measurements were recorded to the nearest 0.5cm (International Standards for Anthropometric Assessment, 2001).

4.5.5.2. Weight

Participants were weighed to the nearest 0.1kg using a calibrated balance (Seca model 11770 Germany) in light indoor clothing and with bare feet or stockings.

4.5.5.3. Body Mass Index (BMI)

BMI was calculated using the formula Weight (kg)/Height (m^2) and classified according to WHO criteria into the following: underweight (BMI less than 18.5), healthy weight (BMI 18.5 – 24.9), overweight (BMI 25 – 29.9), obese (BMI 30 – 39.9), morbidly obese (BMI 40 or more).

4.5.5.4. Waist circumference

The WC as indicator of abdominal obesity was measured using a plastic measuring

tape to the nearest 0.5cm. The WC was measured over light clothing, so that the tape measure could be held as closely against the body as possible. It was measured as the point midway between the lower limit of the rib cage and the iliac crest (see Appendix 12).

4.5.5.5. Blood pressure

Seated systolic/diastolic BP was measured using a clinically-validated BP monitor (Omron HEM-907 model, Kyoto, Japan) on the left arm after at least five minutes of rest.

4.5.5.6. Blood analyses

Venous blood samples (two 20ml) were drawn from the participants' antecubital vein by two experienced nurses after a 12-hour fast and were then analysed in the clinics' laboratories by a laboratory technician. Blood serum was used to assay all the analyses. Fasting Blood Glucose (FBG, mmol/l), high-density lipoprotein cholesterol (HDL-C, mmol/l), low-density lipoprotein cholesterol (LDL-C, mmol/l), total cholesterol (TC, mmol/l) and triacylglycerol (TAG, mmol/l) were analysed using a Konelab 20 XTi Thermo Fisher Scientific (Vantaa, Finland) Analyser. Insulin (uU/ml) was analysed using an Immulite 1000 Siemens Medical Solution Diagnostic (LA, USA) Analyser.

IR was computed from the Homeostasis Model Assessment-Insulin Resistance model (HOMA-IR) using the following formula: fasting insulin (µU/ml) × fasting glucose (mmol/l)/22.5 (Matthews et al., 1985). The concentration of non-HDL-C was calculated using a simple equation: non-HDL-C (mmol/l) = total cholesterol – HDL-C (The International Atherosclerosis Society [IAS], 2013). A print-out of the blood results was sent to all participants; subjects with abnormal results (higher than optimal values shown in table 4.5) were urged to see the doctor to get further information.

4.5.6. Prevalence of metabolic syndrome

To examine the prevalence of the MS at the pre- and post-intervention assessments, the criteria of IDF (Table 4.1-4.2) were used. The data were read through and, if conditions for MS were satisfied (WC ≥80 cm and ≥2 of the other criteria) at the pre- or post-intervention assessments, participants were marked with number 1 and, if the

conditions were not satisfied, participants were marked with number 0.

4.5.7. Dietary and physical activity measurements (seven-day diet and exercise diary)

Baseline and post-intervention activity levels, water consumption and dietary intake were assessed using a seven-day diet and exercise diary for both groups (see Appendices 13 and 14).

4.5.7.1. Dietary intake assessment

A 'Handy guide' for estimation of portion size was used to help the subjects estimate portion size for food consumed by comparison to a household element. For example, four stacked dice, or a deck of cards, or a light bulb to refer to 1.5oz. of cheese, 3oz. beef steak, or a half cup of cooked vegetables, respectively (see Appendix 15). The food diary data were analysed using the computerised nutritional analysis package (Dietplan6 P3 Windows & Mac Serial No: 6918) and analysis was completed following the same protocol explained in Chapter Three.

The selected nutrients for this study included:

- Energy (kcal), and energy-related nutrients: carbohydrate, fat and protein
- Selected vitamins including thiamine, B_{12}, vitamin B_9 (Folate), vitamin A, vitamin C, vitamin E and vitamin D
- Selected minerals including calcium, zinc, magnesium and iron
- Cholesterol
- Fibre

The main purpose of the nutritional analysis of D and D+E was to observe and compare dietary intakes. In addition, the analysis allowed for comparison between the two groups with DRVs, RNI and EARs for specified ages and gender for macronutrients as well as for micronutrients to find out if it is less or above the recommendations as it has a significant effect on health and weight gain. Foods were also categorized into groups: fruits, vegetables, grains and cereal products, dairy products, meats and alternatives, nuts and seeds, beverages, snacks/sweets and crackers, fast food to

evaluate the overall quality of the diet.

Food and exercise diaries were given to the clinics' directors who, in turn, distributed them to the subjects in both groups when they came to the clinics to give blood samples and were returned in the same way. At the end of the 30-day period, the dietary intake and activity levels of participants were reassessed after receiving the information needed to alter their diet and lifestyle habits.

4.5.7.2. Physical activity assessment

The exercise diary was designed to collect information on frequency, duration and intensity of a variety of light, moderate and vigorous intensity PAs during a typical week. Moderate intensity PA included activities such as normal-paced walking, brisk walking, recreational swimming, dancing, household activities, use of sports equipment and recreational sports such as volleyball, badminton and table tennis; vigorous-intensity PA and sports included such activities as stair climbing, aerobic exercise, jogging, running, cycling, self-defence, weight training and vigorous sports, such as soccer, basketball, handball and singles tennis (Al-Hazzaa et al., 2011c).

The participants' PA intensity was categorised into three groups: (1) low, defined as subjects who reported not participating regularly in programmed recreation, sport or heavy physical labour; (2) moderate, defined as subjects who reported participating regularly in moderate PA for a minimum of 150 minutes or in vigorous PA for a minimum of 60 minutes per week; and (3) high, defined as subjects who reported participating regularly in vigorous PA for ≥60 minutes or in moderate PA for ≥150 minutes per week. This latter score was defined according to the public health recommendation of the American College of Sports Medicine and the American Heart Association (Haskell et al., 2007; Yoo, 2011).

4.5.8. Dietary and exercise advice provided

At the start of dietary intervention, the researcher asked detailed questions about the subjects' previous diet, exercise habits, general health and lifestyle. These questions allowed the researcher to assess food preferences and tailor individual eating plans to their needs. Therefore, the researcher not only gave general advice to the subjects, but also individual counselling depending on their weight and condition in order to

modify their eating habits and dispel some common dietary myths in the community. All subjects in both groups were provided with dietary advice, including follow-up using WhatsApp messages for a period of 30 days, focusing on goals for managing MS and weight loss involving lifestyle modifications, including changes in dietary habits and exercise training.

Most of the nutritional information about how to choose healthy food was based on the DASH and Mediterranean diets (Nordmann et al., 2011; American Heart Association, 2014), with some instructions based on using the DASH and Mediterranean diet pyramids (Appendices 16 and 17). Women were counselled and assisted to select foods from the two diets that would fit in with their personal likes and lifestyles, because this is the most important process in finding a diet the person can adopt for the long term in combination with regular exercise (Zivkovic et al., 2007). In that regard, dietary advice was to eat moderate protein (lean meats, poultry without skin, fish rich in Omega-3, processed soy products, nuts, seeds, beans and peas) and free or low fat dairy products. A healthy diet also includes moderate heart-healthy fats, including healthier mono- and polyunsaturated fatty acids (olive and rapeseed oil, peanut butter), while limiting the amount of solid fat (saturated and trans fatty acids-rich). It also involves eating low carbohydrate food (which is actually low only in empty-calorie 'junk' carbs and rich in nutrient-dense, high fibre carbs) and emphasises vegetables and fruit, while cutting back on refined, processed and fast foods. Also, foods and drinks high in added sugars (sweets, sugary drinks, soft drinks, etc.) should be avoided and foods should be chosen and prepared using less sodium (salt).

The researcher also provided the women with information about how to prepare and cook healthy, well-balanced meals at home and gave them some healthy recipes, including some traditional Saudi cuisine that can be cooked with healthy low calorie, low fat choices. Additionally, topical issues related to diet were recommended, such as information on eating out, healthy snacking, increasing water intake and good nutritional choices on special occasions. Information was also given on reading nutrition fact labels and eating food that can stimulate the metabolism and strengthen the immune system, such as those rich in antioxidants and volatile substances, as well

as the health consequences of obesity and related diseases. Both groups were provided with the same nutritional information mentioned in Appendix 18.

Subjects were not instructed to count calories but requested to reduce their calorie intake gradually. Calorie restriction and counting calories accurately may not be effective for subjects in this study as they vary in terms of their BMI status (overweight, obese, morbidly obese), food preferences, life conditions, work and physical exertion.

Although consuming more calories than expended is part of the initial problem of obesity, some studies that concentrated on counting calorie intake to reduce body weight suggested that this is not the best approach (Benton and Young, 2017). Rather than simply counting calories, understanding the influence of the food consumed on satiety, satiation, and energy compensation may be advantageous (Benton and Young, 2017). Moreover, it has been claimed that "portion size is a modifiable determinant of energy intake that should be addressed in connection with the prevention and treatment of obesity" (Rolls et al., 2002). Studies proved that not all calories are the same; for example, the calories in processed sugar are digested and absorbed quickly. Snacks, sweets and soft drinks can all cause a surge in blood glucose levels, which then fall soon after eating, making individuals tired and hungry again (Cleave, 2013; DeFigio, 2013). In contrast, calories from complex carbs that contain high levels of dietary starch and are also rich in fibre are digested slowly by the body, realising energy over a long period of time which can lead to enhanced feelings of satiety (Paddon-Jones et al., 2008; Chambers et al., 2015). It is possible to lose more weight on the same calorie deficit by avoiding certain foods or macronutrients. Thus, focus should be on types of food, portion size and cooking methods more than calories (Duyff, 2012).

The participants in the exercise plus diet group were given extra general advice on how to be less sedentary. It is also noteworthy that the WhatsApp follow-up messages allowed the researcher to keep track of participants' progress, fine-tune their eating plans and educate them on how to eat in a way that kept them healthy, so that they could choose the best food themselves. Information was not only sent to participants in the form of texts, but also as images and videos to maintain interest.

4.5.9. Statistical analyses

Before making any statistical comparisons, Levene's test was used to investigate equality of variances. All data was found to be normally distributed, therefore no further transformations were required. Comparisons between the two groups for the anthropometric and parameters related to MS at the baseline were performed with an independent t-test. Associations between risk variables related to MS (biological and anthropometric measurements) at the baseline were determined by using Pearson correlation analysis in the whole sample. To test the hypotheses stated, significant changes in MS biomarkers before and after the intervention, and differences between intervention groups were tested using repeated measures ANOVA. Tukey's HSD post hoc comparison test was used to locate significant differences.

To compare the prevalence of MS at the pre- and post-intervention assessments (means and chi-squared test), the criteria of IDF (Table 4.1-4.2) was used. Independent t-tests were used to compare food intake between the two groups while differences within the groups were tested with the paired t-test. Data are presented as means ± standard deviation. For the participants in the project, a p-value of less than 0.05 was regarded as statistically significant. A p-value between 0.05 and 0.1 suggested a trend. Statistical analysis was carried out using SPSS version 21.

4.6. Results

A total of 40 subjects aged 18-54 completed the study (n = 20 in each group – D and DE) and provided pre- and post-intervention for blood samples and body composition measurements. The women also completed a medical history questionnaire, diet and exercise diary.

4.6.1. Baseline physical characteristics of participants

The baseline physical characteristics of women showed that there were no significant differences between groups in age, height, weight and BMI (Table 4.3).

4.6.2. Socio-demographic characteristics

The demographic characteristics are presented in Table 4.4. No significant difference

in age was seen between the participants in D and DE, 32.9± 6.8 and 35.1± 6.5 years old, respectively. The educational level for D was higher than DE; 65% of D subjects were university graduates versus 40% of W-SA. Similarly, the majority of participants in D were working (60%), whereas the women in the D+E group included 40% working and 55% non-working women/housewives. In relation to marital status, most of the sample was married, with a higher percentage in the D+E group, and a greater number of children as well.

4.6.3. The anthropometric and clinical characteristics of metabolic syndrome among study participants pre- and post-intervention

Table 4.5 presents the parameters related to MS and cardiovascular risk among study participants before the intervention. The independent t-test showed no significant differences at baseline between both groups for any of the MS parameters. It is noticeable that both groups of women at baseline displayed WC levels that would place them at risk of developing MS. However, all mean measures of metabolic health were within the normal range; only HDL-C was close to the range specified in the IDF criteria (mean 1.30 compared to cut-off of 1.29mmol/l).

Following the intervention (Table 4.6), women in both groups lost weight, but those in D lost significantly more (mean 5.6%) compared to those in D+E (mean 3.7%, p=0.016 for an interaction between group and time). WC also significantly reduced after the programme in both groups, but with no significant difference between the groups (D: 6.4%; DE: 4.7%, p=0.235). Similarly, both D and D+E showed similar significant decreases in SBP (5.0 and 5.4mmHg, respectively, p=0.008) and DBP (4.4 and 3.7mmHg, respectively, p=0.012).

Moreover, significant changes flowing intervention were found both D and D+E groups in TAG (0.2 and 0.1mmol/l, respectively, p=0.006); plasma insulin (2.9 and 2.1µU/ml, respectively, p=0.015); TC (0.2 and 0.2mmol/l, respectively, p=0.002); and LDL (0.1 and 0.3mmol/l, respectively, p=0.023), whereas plasma glucose and HDL remained statistically unaltered. Furthermore, non-HDL cholesterol was significantly decreased in both groups (p=0.007), while the ratio between non-HDL and HDL cholesterol did not significantly change in either group. IR significantly improved in both groups, as

indicated by HOMA analysis, which decreased by 0.7 and 0.6 in D and DE, respectively (p=0.008).

Table 4.7 presents the correlation matrix between the baseline parameters related to MS and cardiovascular risk. The analysis shows that WC and BMI were strongly associated with most of the MS and cardiovascular risk factors, mainly with TAG, glucose, insulin and HOMA-IR. Similar trends have been observed in most of the variables, e.g. there is a strong relationship between, weight, Insulin and HOMA-IR and also between DBP and plasma TC, etc. Analysis of Co-Variance (ANCOVA) was performed with BMI as a covariate but this did not have a significant impact on parameters (data not shown).

4.6.4. Physical activity level of the study participants

The prevalence of the various levels of PA among the study population is presented in Table 4.8. At baseline, the majority of females in both groups reported performing light PAs (D: 85% and DE: 75%). In total, 25% of D+E subjects reported performing moderate PA compared to the 10% of the D subjects and only 5% of the D subjects reported performing vigorous PA. However, at endpoint, the mean PA for both groups had increased in all the PA categories. The light PA percentage in D women decreased by 55%, whereas the moderate and vigorous PA percentages increased by 30% and 25%, respectively. As for the D+E women, PA level increased approximately twofold at endpoint. Regarding the intensity of PA, the intensity was low in both groups at baseline, but increased following the intervention from low to moderate in D and from low to vigorous in D+E (data not shown).

Table 4.3: Pre-intervention physical characteristics of participants

Variables	Diet	Diet+ Exercise	p-values*
Age (y)	32.9 ± 6.8	35.1 ± 6.5	0.292
Height (cm)	158.8 ± 5.4	157.8 ± 6.6	0.612
Weight (kg)	94.2 ± 16.2	89.4± 17.1	0.370
BMI (kg/m²)	37.2 ± 5.2	35.7 ± 5.1	0.365

Data are presented as mean ± SD
*t-test

Table 4.4: Socio-demographic characteristics of participants

Variables	Diet only group (%)	Diet plus exercise (%)
Educational level		
Intermediate school	15	20
Secondary school	20	30
Technical of college (diploma)	0	10
University graduate	65	40
Employment		
Unemployed or house wife	25	55
Student	15	5
Employed	60	40
Marital status		
Married	65	75
Single	35	25
Number of children (mean ± SD)	2 ± 2.1	2.4 ± 2.4

Data are presented as percentages or mean values **±** standard deviation

Table 4.5: Pre-intervention parameters related to metabolic syndrome and cardiovascular risk

Parameter	Diet	Diet + Exercise	p-values*	Optimal Values
WC (cm)	98.9 ± 11.9	99.9 ± 12.7	0.973	<80[1]
Systolic BP (mmHg)	116.5 ± 13.2	119 ± 10.2	0.499	<130[1]
Diastolic BP (mmHg)	79.4 ± 10.9	81.5 ± 8.8	0.506	<85[1]
TAG (mmol/l)	0.9 ± 0.3	0.7± 0.2	0.213	< 1.7[1]
Tot Chol (mmol/l)	3.4 ± 0.8	3.2 ± 0.6	0.395	<5.2[2]
LDL-C (mmol/l)	1.8 ± 0.8	1.6 ±0.7	0.640	<2.6[2]
HDL-C (mmol/l)	1.3 ± 0.3	1.3 ± 0.3	0.691	>1.29[1]
nonHDL chol (mmol/l)	2.2 ± 0.9	1.9 ±0.7	0.379	<3.4[2]
nonHDL/HDL (mmol/l)	1.8± 1.0	1.6 ± 0.8	0.424	-
Glucose (mmol/l)	4.9 ± 0.7	4.9 ± 0.6	0.787	<5.6[1]
Insulin (µU/ml)	11.4 ± 6.6	10.4 ± 4.9	0.644	-
HOMA-IR (Glucose (mmol/l)×Insulin (µU/ml))/22.5	2.5 ± 1.6	2.3 ± 1.1	0.692	<2.60[3]

Data are presented as mean ± SD *t-test, [1]based on IDF cut-off point for diagnosing MS,[2]based on International Atherosclerosis Society guidelines for primary prevention of cardiovascular disease (J Clinical Lipidology,2013, 7,561-564(, [3]based on findings of Qu et al. (2011) PLoS ONE 6(6): e21041. doi:10.1371/journal. pone.0021041

Table 4.6: Post-intervention parameters (and percent changes from baseline) related to metabolic syndrome and cardiovascular risk

Parameter	Diet		Diet + Exercise		Combined		p-values*	
	Mean ± SD	change (%)	Mean ± SD	change (%)	Mean ± SD	change (%)	Change within groups	Change between groups
Weight (kg)	88.9 ± 17.1	-5.6 ± 2.6	86.1 ± 17.3	-3.7 ± 2.3	87.5 ± 17.0	-4.7 ± 2.6	**<0.001**	**0.016**
BMI (kg/ m²)	35.1 ± 5.4	-2.1 ± 1.0	34.4 ± 5.3	-1.3 ± 0.9	34.7 ± 5.3	-1.7 ± 1.1	**<0.001**	**0.024**
WC (cm)	92.6 ± 11.9	-6.4 ± 4.9	95.2 ± 12.0	-4.7 ± 3.0	93.9 ± 11.9	-5.5 ± 4.2	**<0.001**	0.235
Systolic BP (mmHg)	111.5 13.1	-5.0 ± 9.5	113.6 ± 9.8	-5.4 ± 3.2	112.5 ± 11.4	-5.2 ± 11.5	**0.008**	0.894
Diastolic BP (mmHg)	75.0 ± 10.1	-4.4 ± 9.9	77.8 ± 8.7	-3.7 ± 9.1	76.4 ± 9.4	-4.1 ± 9.5	**0.012**	0.834
TAG (mmol/l)	0.7 ± 0.3	-0.2 ± 0.2	0.6 ± 0.3	-0.1 ± 0.3	0.7 ± 0.3	-0.1 ± 0.2	**0.006**	0.413
Tot Chol (mmol/l)	3.2 ± 0.8	-0.2 ± 0.4	3.0 ± 0.5	-0.2 ± 0.3	3.1± 0.7	-0.2 ± 0.4	**0.002**	0.770
LDL-C (mmol/l)	1.7 ± 0.6	-0.1 ± 0.6	1.3 ± 0.6	-0.3 ± 0.4	1.5 ± 0.7	-0.2 ± 0.5	**0.023**	0.092
HDL-C (mmol/l)	1.2 ± 0.3	-0.1 ± 0.4	1.4 ± 0.4	+0.1 ± 0.2	1.3 ± 0.3	0.0 ± 0.4	0.507	0.288
nonHDL chol (mmol/l)	2.0 ± 0.7	-0.2 ± 0.6	1.6 ± 0.7	-0.4 ± 0.5	1.8 ± 0.7	-0.2 ± 0.5	**0.007**	0.323
nonHDL/HDL (mmol/l)	1.7 ± 0.7	-0.1 ± 1.0	1.3 ± 0.7	-0.3 ± 0.6	1.5 ± 0.7	-0.2 ± 0.9	0.130	0.581
Glucose (mmol/l)	4.6 ± 0.7	-0.3 ± 0.9	4.7 ± 0.4	-0.2 ± 0.5	4.6 ± 0.6	-0.3 ± 0.8	0.096	0.643
Insulin (µU/ml)	8.5 ± 4.5	-2.9 ± 5.4	8.3 ± 4.8	-2.1 ± 3.2	8.4 ± 4.5	-2.6 ± 5.4	**0.015**	0.696
HOMA-IR (mmol/l×µU/ml)	1.8 ± 1.1	-0.7 ± 1.5	1.7 ± 1.0	-0.6 ± 0.8	1.8 ± 1.0	-0.7 ± 1.3	**0.008**	0.739

Data are presented as mean ± SD *repeated measures analysis of variance Values in bold are significant

Table 4.7: Correlation matrix* of baseline parameters related to metabolic syndrome and cardiovascular risk

	BMI	WC	Weight	SBP	DBP	Gluc	Chol	TAG	HDL	nHDL	nHDL_HDL	LDL	Ins	HOMA
BMI		**0.741** **<0.001**	**0.913** **<0.001**	0.122 0.453	0.042 0.797	**0.382** **0.024**	0.257 0.142	**0.465** **0.006**	-0.180 0.309	0299 0.086	0.310 0.075	0.308 0.076	**0.366** **0.033**	**0.432** **0.011**
WC			**0.753** **<0.001**	0.294 0.066	0.055 0.738	**0.420** **0.012**	0.203 0.250	**0.411** **0.016**	-0.296 0.089	0.295 0.090	0.326 0.060	0.313 0.071	0.219 0.213	0.290 0.096
Weight				0.180 0.267	-0.031 0.851	0.302 0.078	0.157 0.376	0.329 0.058	-0.262 0.089	0.237 0.178	0.280 0.108	0.258 0.141	**0.289** **0.023**	**0.437** **0.010**
SBP					**0.360** **0.022**	-0.091 0.605	0.126 0.479	0.015 0.933	-0.282 0.106	0.220 0.212	0.212 0.230	0.265 0.131	0.060 0.738	0.008 0.965
DBP						0034 0.845	**0.387** **0.024**	0.229 0.192	-0.275 0.116	**0.458** **0.006**	**0.486** **0.004**	**0.498** **0.003**	0.210 0.234	0.175 0.322
Gluc							0.124 0.484	**0.378** **0.027**	-0.031 0.457	0.132 0.457	0.157 0.376	0.086 0.627	0.238 0.175	0.422 0.013
Chol								**0.622** **<0.001**	-0.16 0.930	**0.936** **<0.001**	**0.712** **<0.001**	**0.879** **<0.001**	-0.035 0.843	-0.011 0.953
TAG									-0.100 0.575	**0.608** **<0.001**	**0.538** **<0.001**	**0.521** **0.002**	0.206 0.243	0.267 0.158
HDL										**-0.364** **0.034**	**-0.647** **<0.001**	**-0.411** **0.016**	-0.255 0.146	-0.247 0.158
nHDL											**0.893** **<0.001**	**0.981** **<0.001**	0.040 0.822	0.064 0.721
nHDL_HDL												**0.889** **<0.001**	0.091 0.609	0.117 0.509
LDL													0.005 0.980	0.021 0.905
Ins														**0.977** **<0.001**
HOMA														

*Pearson Correlation and p-value Values in bold are significant

Table 4.8: Physical activity level of the study participants pre- and post-intervention

Physical activity levels	Diet only group			Diet plus exercise group		
	Baseline %	After %	Changes %	Baseline %	After %	Changes %
Low	85	30	55	75	0	75
Moderate	10	40	30	25	0	25
High	5	30	25	0	100	100

Data are presented as percentages

4.6.5. Nutritional intake for Saudi women pre- and post-intervention and comparison with Dietary Reference Values (DRVs)

Nutritional intake for the two groups of women was compared to the DRVs (excluding alcohol) as described by the UK panel on DRVs of the British Nutrition Foundation (2015). Energy consumption was compared to the EARs and micronutrient intake to the RNI. Additionally, energy percentage (E%) from carbohydrate, protein, fat and fatty acids from total calories consumed was assessed and compared to the DRVs recommended. The reference values used for this aspect of the analysis are specifically quoted for women between the ages of 18 and 54 years of age.

The independent t-test showed no significant differences at baseline between both groups for any of the dietary intake variables, except for vitamin E, monounsaturated and polyunsaturated fatty acids, which were higher in D. It is clear from Table 4.9 that women in both groups at baseline consumed considerably more energy than the EAR given in the UK reference standards. Mean intakes of carbohydrate, protein, fat, sugar, fatty acids and cholesterol at baseline all exceeded the DRV and RNI recommendations in both groups.

Paired t-test showed significant differences within each group from before to after for intake of the majority of nutrients. Women in both groups had significant reductions in total energy consumption (D: -41.1% and DE: -35%), and that from protein (D: -

23.7% and DE: -22.4%), fat (D: -53.6% and DE: -45.4%) and carbohydrate (D: -35.8% and DE: -31.3%), which were close to the recommendations. Although the reductions in total caloric intake and macronutrients were greater in D subjects, there were no significant differences between both groups following the intervention. The mean daily intake of sugar (NMES) at baseline was high (D: 82.6g/d and DE: 91.2g/d) according to the maximum recommended intake of 60g/day (11%) by the DRVs. Following the intervention, the amounts of sugar consumed decreased significantly in both groups (D: 35.8g/d and DE: 38.5g/d), which met the recommendations (Table 4.10). The same trend was found for all fatty acids and cholesterol (Table 4.11).

On the other hand, the baseline dietary fibre (NSP) and water intakes were less than the recommended limit (Table 4.10) and these increased significantly after the intervention. Mean intake of fibre (NSP) was 14.3 g/day for D and 12.1 g/day for DE, below the DRV set for adults of at least 18g per day, and this increased significantly close to the recommendations after the intervention (D: 17.8g/day and DE: 16.9g/day).

Mean consumption of water in each of the two groups was below the European Food Safety Authority (EFSA) (2010) recommendation (2.0 litres of water for women per day) and that also significantly increased following the trial (D: 53.3% and DE: 32.7%). As for vitamin and mineral intake, there were no significant differences between the two groups following the trial, except for folate, which was lower in DE. Additionally, there were no differences within each group regarding vitamin and mineral consumption, which were within the normal range except for Vitamin D which was below the recommended amounts for both groups (Tables 4.12 and 4.13).

The foods were also listed in groups to represent all major food groups consumed by the participants (Table 4.14). The independent t-test showed no significant differences between the two groups for any of the food groups both at baseline and at follow-up. However, paired t-test showed significant differences within each group from before to after for intake of the majority of food groups.

After the intervention, women in both groups had significant reductions in grains and cereals consumption (D: -32.5%, $p<0.001$ and DE: -18.6%, $p<0.001$), beverages (D: -

42.9%, p=0.021 and DE: -50%, p<0.001), snacks/sweets (D: -32%, p=0.002 and DE: -41.7%, p<0.001) and fast food (D: -68.4%, p<0.001 and DE: -75%, p<0.001). On the other hand, the baseline vegetables consumption increased significantly after the intervention in both groups (D: 69.6%, p<0.001 and DE: 77.3%, p<0.001).

4.6.6. The prevalence of metabolic syndrome among the participants

Based on IDF criteria (Table 4.1-4.2), the overall baseline prevalence of the MS was 20% for D and 21% for D+E (Table 4.15) and there was no significance in the prevalence between the groups as tested by chi-squared test. Among the five MS components, abdominal obesity (WC) was the commonest abnormality among both groups (100% and 95% for D and DE, respectively) followed by low HDL-cholesterol (60% and 57% for D and DE, respectively) and high BP (30% in both groups).

At endpoint, the overall prevalence of the MS declined substantially to 5% for D and 7% for DE, but this change just failed to reach significance for the combined groups (p=0.074) and no significant difference was seen in prevalence of MS, or any of the components, when the distribution was compared between D and D+E post-intervention. Abdominal obesity (as measured by WC) decreased in both groups (80% and 85% for D and DE, respectively, p=0.024 for combined groups) and high BP decreased to 10% in D+E and 5% in D (p=0.016 for combined groups). The prevalence of low HDL-cholesterol appeared to drop more for the D+E group (28%) than the D group (55%), but this difference between groups was not significant (p=0.127).

Table 4.9: Daily intake of energy and macronutrients among study participants

Nutrients	Diet only group			Diet plus exercise group			Reference value
	Baseline	After	% change	Baseline	After	% change	
Energy (kcal/d)	3436 ± 739	2023 ± 822	-41.1 *	3173 ± 829	2060 ± 736	-35 *	1940 kcal/d
Protein (g/d)	108.9 ± 25.2 (12.7%)	83.1 ± 25.9 (16.4%)	-23.7 *	112.1 ± 30.4 (14.1%)	87 ± 23.5 (16.9%)	-22.4 *	(15%)
Fat (g/d)	145.9 ± 38.1 (38.2%)	67.7 ± 28.6 (30.1%)	-53.6 *	125.3 ± 36.6 (35.5%)	68 .4 ± 28.5 (29.9%)	-45.4 *	(35%)
CHO (g/d)	449.4 ± 99.2 (52.3%)	288.7 ± 130.5 (57.1%)	-35.8 *	424.8 ± 117 (53.6%)	291.7 ± 114.3 (56.6%)	-31.3 *	(50%)

Data are presented as mean ± SD Values in parentheses indicate % of total energy intake
P-values were determined by independent and paired t-test
*Significantly different within each group from before to after

Table 4.10: Daily intake of sugar, fibre and water among study participants

Nutrients	Diet only group			Diet plus exercise group			Reference value
	Baseline	After	% change	Baseline	After	% change	
Sugar (NMES) (g/d)	82.6 ± 35.2 (9.6%)	35.8± 25.3 (7.1%)	-56.7 *	91.2 ± 43.1 (11.5%)	38.5± 31.5 (7.5%)	-57.8 *	(10%)
Fibre (NSP) (g/d)	14.3 ± 4.1	17.8 ± 6.9	+24.5 *	12.1 ± 6.1	16.9 ± 10.6	+39.7 *	18 g/d
Water (ml/d)	1269.6 ± 353.4	1946.4 ± 254.6	+53.3 *	1360.8 ± 358.7	1805.4 ± 256.9	+32.7 *	2000 ml/d

Data are presented as mean ± SD Values in parentheses indicate % of total energy intake
P-values were determined by independent and paired t-test
*Significantly different within each group from before to after

Table 4.11: Daily intake of fatty acids and cholesterol among study participants

Nutrients	Diet only group			Diet plus exercise group			Reference value
	Baseline	After	% change	Baseline	After	% change	
Saturated fatty acids (g/d)	46.4 ± 10.5 (12.2%)	21.8 ± 9.5 (9.7%)	-53 *	43.1 ± 13.4 (12.2%)	23.4 ± 9.5 (10.2%)	-45.7 *	(11%)
Monounsaturated fatty acids (g/d)	49.6 ± 13.9 (13%) ‡	24.4 ± 11.5 (10.9%)	-50.8 *	40.9 ± 11.7 (11.6%)	22 ± 7.5 (9.6%)	-46.2 *	(13%)
Polyunsaturated fatty acids (g/d)	28.8 ± 9.5 (7.5%) ‡	12.4 ± 6.4 (5.5%)	-56.9 *	22 ± 8 (6.2%)	10.5 ± 5 (4.6%)	-52.3 *	(6.5%)
Trans fatty acids (g/d)	3.1 ± 0.9 (0.8%)	1.3 ± 0.6 (0.6%)	-58.1 *	2.9 ± 1.3 (0.8%)	1.6 ± 0.7 (0.7%)	-44.8 *	(2%)
Cholesterol (mg/d)	341 ± 116.4	273.4 ± 103	-19.8 *	349.1 ± 117.8	281.3 ± 84.2	- 19.4 *	245

Data are presented as mean ± SD Values in parentheses indicate % of total energy intake
P-values were determined by independent and paired t-test
*Significantly different within each group from before to after
‡Significantly different from the other group

Table 4.12: Daily intake of selected vitamins among study participants

Nutrients	Diet only group			Diet plus exercise group			Reference value
	Baseline	After	% Change	Baseline	After	% Change	
Retinol (µg/d)	736.1 ± 910.5	622.3 ± 1322.8	-15.5	1255.1 ± 1516	920.5 ± 1305.7	-26.7	600
Vitamin D (µg/d)	2.1 ± 0.7	1.4 ± 0.6	-33.3 *	1.9 ± 1	1.6 ± 0.8	-15.8	10
Vitamin E (mg/d)	15.3 ± 6.7 ‡	6.5 ± 3.2	-57.5 *	10.6 ± 5	6.3 ± 2.3	-40.6 *	6
Thiamine (mg/d)	2.1 ± 0.6	2 ± 0.7	-4.8	1.8 ± 0.5	1.9 ± 0.6	+5.6	0.8
Vitamin B_{12} (µg/d)	5.8 ± 4.5	5.3 ± 6	-8.6	8.6 ± 6.8	6.7 ± 4.7	-22.1	1.5
Folate (µg/d)	280.3 ± 113.2	350.4 ± 131.8	+25	235.7 ± 79	271.3 ± 99.4 ‡	+15.1	200
Vitamin C (mg/d)	134.2 ± 167.8	144.7 ± 87.5	+7.8	88.2 ± 50.4	127.8 ± 64	+44.9 *	40

Data are presented as mean ± SD P-values were determined by independent and paired t-test
*Significantly different within each group from before to after
‡Significantly different from the other group

Table 4.13: Daily intake of selected minerals among study participants

Nutrients	Diet only group			Diet plus exercise group			Reference value
	Baseline	After	% Change	Baseline	After	% Change	
Calcium (mg/d)	1329.5 ± 285.5	997.1 ± 300.3	-25 *	1231.6 ± 412.4	948.1 ± 348.9	-23 *	700
Magnesium (mg/d)	415.1 ± 133.9	333.2 ± 125.6	-19.7	366.2 ± 120.1	281.7 ± 91.6	-23.1 *	270
Iron (mg/d)	17.3 ± 5.1	16.7 ± 4.5	-3.5	18.3 ± 7.4	15.6 ± 8.5	-14.8 *	14.8
Zinc (mg/d)	14.2 ± 4.6	10.8 ± 3.8	-23.9 *	14.6 ± 4.5	11.1 ± 3.2	-24 *	7.0

Data are presented as mean ± SD P-values were determined by independent and paired t-test
*Significantly different within each group from before to after

Table 4.14: Average daily consumption of servings in each food group among study participants

Food groups	Diet only group			Diet plus exercise group		
	Baseline	After	% change	Baseline	After	% change
Fruits	2.1± 1.0	2.0± 0.7	- 4.8	2.2± 0.9	2.1±0.6	-4.5
Vegetables	2.3±0.8	3.9±1.2	+69.6 *	2.2±1.0	3.9±1.2	+77.3 *
Grains and cereal products	12.6±1.9	8.5±2.7	-32.5 *	11.8±2.3	9.6±3.0	-18.6 *
Dairy products	2.1±0.9	1.7±0.4	-19.0	2.3±0.7	1.8±0.6	-21.7
Meats and alternatives	3.0±1.2	2.4±0.8	-20	3.2±1.2	2.7±1.1	-15.6
Nuts and seeds	0.4±0.4	0.3±0.4	-25	0.4±0.4	0.3±0.4	-25
Beverages	1.4±0.7	0.8±0.8	-42.9 *	1.6±0.5	0.8±0.6	-50 *
Snacks/ sweets	2.5±0.8	1.7±0.7	-32 *	2.4±1.0	1.4±0.6	-41.7 *
Fast food	1.9±1.1	0.6±0.8	-68.4 *	2.0±1.1	0.5±0.7	-75 *

Data are presented as mean ± SD

P-values were determined by independent and paired t-test

*Significantly different within each group from before to after

Table 4.15: Prevalence of individual risk factors for metabolic syndrome pre- and post-intervention

Variables	Diet only group		Diet plus exercise group		Combined groups		p-values* for combined groups pre vs after
	Baseline %	**After** %	**Baseline** %	**After** %	**Baseline** %	**After** %	
Age (year)	32.9± 6.8		35.1± 6.5				
Abdominal obesity	100	80	95	85	98	83	0.024
High fasting blood glucose	5	5	7	0	6	3	0.555
High blood pressure	30	10	30	5	30	8	**0.016**
High triglycerides	0	0	0	0	0	0	-
Low HDL-cholesterol	60	55	57	28	59	42	0.225
Metabolic syndrome	20	5	21	7	21	6	0.074

The diagnosis of metabolic syndrome is made if subjects have central obesity plus any two or more other indicators are present
*chi-squared test Values in bold are significant

4.7. Discussion

The baseline physical characteristics of women showed that there were no significant differences between groups in age, height, weight and BMI (Table 4.3). Similarly, the independent t-test showed no significant differences at baseline between both groups for any of the parameters related to MS and cardiovascular risk (Table 4.5). This means that, in terms of metabolic health, the study is not affected by the non-random sampling. It is noticeable that both groups of women at baseline displayed WC levels that would place them at risk of developing MS. However, the mean values for each of the individual components of MS were all outside the ranges used to diagnose MS according to IDF criteria. Using the criteria of central obesity plus two other risk factors, approximately 20% of each group could be diagnosed as suffering from MS at baseline.

The demographic information showed that educational level and percentage of employees were higher in D, while the percentage of married couples and number of children were higher in DE. It is possible that this influenced why the participants in D reduced their body weight and BMI more than D+E participants. In relation to the results, several past studies have demonstrated that low educational attainment is directly associated with incidence of MS (Go et al., 2014; MacPherson et al., 2016). A recent study, conducted in Saudi Arabia, also found a significant association between marital status and a higher prevalence of MS in males. In the same study, and based on occupation, non-employed subjects presented a lower prevalence of MS than those in professional classes. For women, those with no professional activities were more susceptible to develop MS, while those with a higher level of education appeared to have a protection against the syndrome (Al-Daghri et al., 2014).

Associations between risk variables related to MS (biological and anthropometric measurements) at the baseline were determined by using Pearson correlation analysis in the whole sample. The analysis shows that BMI and WC were strongly associated with most of the MS and cardiovascular risk

factors, mainly with TAG, glucose, insulin and HOMA-IR. Our findings support and extend those of Akl et al. (2016), which showed a strong MS association with BMI>25kg/m². A study conducted in the UAE strongly indicated that problems with being overweight and obesity are associated with metabolic health conditions. Pearson correlations showed that, in men, BMI was significantly and positively correlated with WC, LDL-C and BP, whereas, in women, all parameters of MS were positively correlated with BMI, except for HDL-C, which was negatively correlated (P<0.01) (Al-Sarraj et al., 2010).

Although BMI serves as a useful marker for obesity, MS and related IR, stronger correlations are observed between abdominal obesity, visceral adipose tissue and metabolic risk factors (Park et al., 2003; Rodea-Montero et al., 2014; De Lucia Rolfe et al., 2015). Evidence indicated that WC is a strong predictor of cardiometabolic health among young adults; among lipid profile, TAG showed the closest correlation with WC (r=0.308, p<0.001), which is almost similar to our findings (Chehrei et al., 2007; Brenner et al., 2010; Aristizabal et al., 2016).

Another striking finding from this study was the strong relationship between weight, insulin, and HOMA-IR in addition to the strong correlation between DBP and plasma TC. Such results were similar to those observed in other studies (FAO 1994; Akl et al., 2016; Aristizabal et al., 2016). Consistent with our findings, evidence indicates that chronic elevation of plasma cholesterol is associated with higher DBP, probably as a result of atherosclerotic vascular changes (FAO, 1994). Similar analyses were found in a study by Pincherle and Robinson (1974); a significant relationship was found between serum cholesterol and both systolic and diastolic blood pressure at all ages under 65. On the contrary, two Swedish studies (Hjermann, 1978; Wilhelmsen et al., 1973) have reported a weak blood pressure/cholesterol correlation.

This study compared two four-week lifestyle change programmes, incorporating either separate dietary modification or combined with regular vigorous aerobic exercise intervention. Both interventions produced significant and clinically relevant reductions in body composition and improvements in MS abnormalities, which is in agreement with Hypothesis 1. Anthropometric

outcome measures showed significant changes in body weight and BMI. Participants in the D+E group lost an average 3.7% of their starting weight, whereas those in the D group had a more marked decrease in body weight with an average weight loss of 5.6%. Studies have demonstrated comparable degrees of weight reduction to those we found with our intervention, though research varies widely with respect to the type of PA, diet restriction, duration, size and measurement of MS (Roberts et al., 2002; American Diabetes Association, 2008; Kaur, 2014). Our findings for weight loss are similar to those published by McTigue et al. 2003, which found that counselling on diet or physical exercise and behavioural interventions resulted in a weight loss of 3-5 kg over three months.

As already discussed, the impact of increased PA on MS is unclear. However, it is generally accepted that long-term PA of sufficient intensity, duration and frequency has a favourable influence on weight reduction and body fat distribution. Evidence supports the hypothesis that the effectiveness of PA to induce weight loss is directly related to the initial degree of obesity and the total amount of energy expenditure (Pitsavos et al., 2006). However, a previous study showed that short-term (four weeks) aerobic exercise decreased circulating free fatty acids without weight loss in previously sedentary obese men and premenopausal women. In that study, a significant decrease in hepatic and visceral lipids was also observed, indicating that short-term aerobic exercise can mitigate cardiovascular risk and this is not contingent upon weight loss (Johnson et al., 2009). In a similar vein, recent results showed that, despite the absence of weight loss, aerobic training induced beneficial effects on functional, anthropometric and biochemical parameters in women with MS (Farinha et al., 2015). Moreover, Dunn (2009) studied the effects of exercise and dietary intervention on MS markers in inactive premenopausal women and it was found that, despite reductions in insulin, inflammation, WC, respiratory exchange ratio during exercise, BP and an increase in aerobic power, women gained body mass and fat mass following the intervention (Dunn, 2009). However, reductions (23%-44%) in all-cause mortality with increases in fitness,

regardless of weight loss, have been shown (Gaesser, 1999).

Our study produced two unexpected results. Firstly, despite exhibiting BMI and waist circumferences which would have predicted increased risk of MS, the prevalences of MS in the D and D+E groups at baseline were only 20% and 21% respectively. This suggests that despite the accumulation of adipose tissue (apparently within the visceral area as predicted by WC) many of these women were maintaining a level of insulin sensitivity which prevents the metabolic complications. This may be because of their relatively young age (32.9± 6.8 and 35.1± 6.5y in D and D+E groups respectively). In a future study it would be interesting to look at an older cohort with diagnosed MS. However, intervention at this early stage could still be vitally important to prevent future complications of obesity. There is also a lack of data specifically identifying the genetic susceptibility of the Eastern Mediterranean, female, population to MS.

The second unexpected result was that our findings show that diet alone apparently had a greater influence on women's body weight and BMI than did diet with exercise. Thus, these results do not support Hypothesis 2. The explanation for this finding is unclear, but may specifically relate to differences between the cohorts that have not adequately been identified. As discussed, by necessity, the design of the study was not randomized. Due to the cultural barriers, not all females would be prepared to undertake the exercise intervention and we were reliant on comparing a diet -only intervention with diet intervention in a group who had specifically identified their willingness to undergo exercise. This may have introduced factors which differed between the groups which have not been identified. Furthermore, while we attempted to use similar methods to identify dietary intakes between the groups it is possible that systematic differences in reporting intake were present. Another possibility, is that the reduction in the total caloric intake and macronutrients was greater in D subjects, although there were no significant differences between the groups following the intervention, or that the women in D were practising home-based exercise. A further potential contributing factor may be differences in changes in body composition. It might be anticipated that the

exercise group may actually increase muscle mass (and hence lean body mass) while losing fat mass. This would have the effect of reducing the total weight loss as muscle is heavier than adipose tissue. In a future study, this problem could be addressed by including measurement of body composition.

In any case, our outcomes are consistent with Melville's study (2012) in which it was reported that a diet intervention alone provided greater improvement in BMI than the combination of diet and exercise for obese adults with an average BMI of 37. They found that for the diet only group, body weight was decreased by about 10% and, in the diet plus exercise group, body weight loss was 9%, but there was no decrease in body weight in the exercise or control groups (Melville, 2012). In a similar vein, a systematic review found that the diet only group showed a greater BMI reduction than the diet plus resistance training group (pooled difference, −0.40; 95% CI, −0.71 to −0.08; I 2 = 0%) over 4 months (Ho et al., 2013). Bertz et al. (2012) reported that the dietary behaviour modification treatment was sufficient to provide significant and clinically meaningful weight loss in lactating women. The combined treatment (D+E) did not yield further significant weight or body composition changes beyond those of dietary treatment alone. Weight changes after the intervention and one year follow-up were −8.3 and −10.2 kg, respectively, in the D group; −6.9 and −7.3 kg, respectively, in the D+E group. The main effects of D treatment, but not of exercise treatment, on body weight were significant at both times ($p < 0.001$). Meta-analyses suggest that the observed increase in BMI in D+E compared to D may be due to gain in lean body mass, which is beneficial for long-term weight loss. (Ho et al., 2013).

In this study, a significant reduction in abdominal obesity was observed after the programme in both groups by means of WC (D: 6.4%; DE: 4.7%). Visceral body fat, as measured by WC, is used in conjunction with BMI to assess the risk of T2D and CVD (American Diabetes Association, 2008). In fact, the reduction in abdominal fat may be the main determinant for insulin sensitivity improvement (Hamman et al., 2006; Rana et al., 2007). This corresponds with the findings in our intervention that insulin sensitivity was significantly

improved in both groups, as indicated by HOMA analysis. Similar findings were found also in Schenk et al. (2009). Their study showed that weight loss was an important contributor to the improvement of insulin sensitivity, regardless of whether weight reduction occurred via dietary restriction alone or dietary restriction combined with physical training. A systematic review confirmed that lifestyle modification intervention was effective in resolving MS and reducing the values for its components, including WC, SBP and DBP, FBG and TAG (Yamaoka and Tango, 2012). Changing dietary and exercise habits may lead to a healthier WC and BMI measurements, improved values for HDL and lower blood glucose and BP (Alshehri, 2010).

Regarding BP, both diet modification and moderate aerobic exercise training have an effect on reducing BP. Our results showed significantly reduced mean values for SBP (4.3% in D and 4.5% in DE) and DBP (5.5% in D and 4.5% in DE). This almost agrees with studies which found that a short-term (under three weeks) strict diet and PA intervention reduced both SBP and DBP by 10% in participants and enhanced the metabolic profile (Roberts et al., 2002; Luo et al., 2013). Another study by Sharman et al. (2008) demonstrated that an intense 10 minutes of moderate aerobic exercise decreased DBP and SBP in healthy adults.

Based on our findings, plasma insulin decreased significantly following the intervention in both groups (25.4% and 20.2% for D and DE, respectively), which was similar to the reduction (25%) demonstrated by Dunn (2009) with a 12-week intervention using the same sprint protocol. A recent study reported that insulin sensitivity is considered to be a main pathophysiological indicator responsible for several clinical complications of MS (Gobato et al., 2014). Therefore, in this study, HOMA-IR was used to measure the changes in the sample as a surrogate risk factor. The HOMA-IR decreased substantially in both groups (D: 28%; DE: 26.8%). The current study showed no apparent additional improvement in HOMA-IR in the D+E group compared to D alone. This is in contrast to a study by Nelson et al. (2013) who found that moderate to vigorous daily activity during one year was effective in reducing IR and, thus, improved

metabolic profile. Sixty minutes of daily exercise improved IR by 25%. Another study by Misra et al. (2008) showed parallel results, but with combined diet and exercise over a period of three months. One important factor might be the length of intervention which was associated with the differences in the outcomes of metabolic health.

It is noteworthy that of the cardiometabolic risk factors associated with MS at the baseline, only HDL-C was close to the range specified in the IDF criteria (mean 1.30 compared to cut-off of 1.29mmol/l). Our results agree with those published by Al Qahtani et al. (2015) who found that low HDL-C level was the most common lipid disorder among Saudis, with 82.9%. Among the lipid disorders, only low levels of HDL-C contributed to significant mortality risk (p-value < 0.01) (Al Qahtani et al., 2015). Al-Daghri et al. (2010) also found that low HDL-C was the most prevalent of all MS risk factors, affecting 88.6% of Saudi adults. High prevalence of low HDL-C has also been documented among Saudi females (36.0%) with strong tendencies for higher BMI (Al-Qahtani et al., 2006). However, in this study, a slight (0.1mmol/l), but not significant, increase in HDL was only observed among the D+E group after four weeks of the intervention; this percentage may increase over a longer training period. Our finding is in agreement with previous studies which found that moderate exercise in Saudi young men having low levels of HDL-C resulted in significant effect on their TAGs levels, but no considerable change in their HDL-C levels (Al-Hazzaa et al., 1994; Al-Ajlan and Mehdi, 2005). Some of the studies have shown significant changes in HDL-C levels over time and only after certain miles ran per week (Al-Ajlan and Mehdi, 2005) or after increasing the maximum heart rate (HRmax) (Argani et al.,2014; Mann et al., 2014).

The combination of a diet programme involving low-calorie, unrefined and high fibre carbohydrates and intense moderate PA showed an improvement in TAG (Luo et al., 2013; Sonestedt et al., 2016). The reduction in insulin also played a role in decreasing TAG levels. A three-month study using a low carbohydrate diet also found a 20%–25% decrease in TAG in obese individuals (Foster et al., 2003). Similarly, in our four-week study, TAG decreased significantly in D and

D+E (22.1% and 14.3%, respectively). The improvement in TAG experienced by both groups could be due to adherence to the programme. Additionally, our data indicate a significant improvement in TC and LDL in both groups. This finding accords with a study which reported a 0.6–0.8 mmol/l reduction in TC in overweight women following 12 weeks of low-calorie intake and physical training (Nieman et al., 2002; Luo et al., 2013).

Regarding the practice of exercise, the baseline and post-intervention activity levels were assessed using a seven-day exercise diary. The different PA levels were then categorised into light, moderate and vigorous PA depending on the frequency, intensity of exercise and duration, taking into account the exercise sessions for DE. The prevalence of the various levels of PA among the study population is presented in Table 4.8. At baseline, the majority of females in both groups practised low to no PA at all (D: 85% and DE: 75%). In total, 25% of D+E subjects reported performing moderate PA compared to the D subjects (10%) and only 5% of the D subjects reported performing vigorous PA. Our finding is in line with that of Al-Hazzaa (2004b) who reported that, across all segments of the Saudi population, physical inactivity ranged from 43.3%-99.5% depending on age, gender, location and target population. Our data are also in accordance with a study conducted on Saudi college students which showed that 64.3% of female students had a light PA level, 35% had a moderate PA and only 0.7% had a heavy PA (Majeed, 2015). Additional research in the KSA shows similar prevalence rates. In a study assessing the PA pattern, Bano et al. (2014) revealed that a very small proportion (2%) was involved in Health Enhancing Physical Activity (HEPA). In all, 41% of the participants reported doing moderate PA and a high percentage (57%) was found to be inactive. These results are also in agreement with data from the WHO report on the KSA in 2005 which showed overall low percentages of high (16%) and moderate (16%) PA and high percentages of low (68%) activity among men and women from 15–65 years of age.

However, one of the most striking findings of our study was that, at post-intervention, the mean PA for both groups had increased in all the PA

categories. The light PA percentage in D women decreased by 55%, whereas the moderate and vigorous PA percentages increased by 30% and 25%, respectively. As for the D+E women, PA level increased approximately twofold. Such results were similar to those observed in other studies (Jassas, 2012; Al-Eisa et al., 2016).

Regarding the intensity of PA, in the present study, the intensity was low in both groups at baseline, but increased following the intervention from low to moderate in D and from low to vigorous in D+E (data not shown). The effects of exercise on metabolism are highly influenced by the intensity and duration of the exercise, but the level of PA needed for a beneficial impact on coronary risk remains controversial. Kauko (2010) found that a greater amount of high-intensity exercise per week results in more significant and widespread effects than moderate amounts of moderate-intensity exercise. A study conducted in Saudi Arabia found that heavy PA had a strong positive correlation with HDL-C and a negative correlation with BMI (Al-Ajlan and Mehdi, 2005). Another study indicated that two of the main pathophysiological aspects of MS, accumulation of the visceral adipose tissue and IR, as well as activity of the sympathetic nervous system, can be affected by intensive exercise (Kauko, 2010). Conversely, Gutin et al. (2002) reported no clear effect of the intensity of physical training on the reduction of visceral and total body adiposity. In the current study, despite the significantly higher level of intensive exercise in the D+E group, no additional metabolic benefits were seen over the D group. As already suggested, possible reasons for this might be the relatively short intervention period and/or the greater weight loss in the D- group.

Studies have shown that dietary advice plays an important role in modifying dietary behaviour and individuals' health. Meta analyses have shown that randomised controlled trials comparing weight loss programmes based on dietary counselling with usual care interventions produced a mean net weight loss of approximately 5kg after one year, of which about half was maintained after three years (Dansinger et al., 2007; Franz et al., 2007). It has been reported that participants receiving advice from dietitians experienced a

greater reduction in blood cholesterol than those receiving advice only from doctors (-0.25mmol/L [95% CI, -0.37, -0.12mmol/L]) (Thompson et al., 2003). The evidence suggests that more specific dietary advice to modify intake of fat sources, particularly dietary saturated fatty acids, and increase the consumption of fruit and vegetables, is probably necessary for combating chronic disease risk (Ammerman et al., 2002).

Furthermore, study has proven that patients with MS who were advised to undertake the DASH diet were able to raise their good cholesterol and experienced a significant reduction in BP, lowered their blood sugar and TAG levels and even lost weight after six weeks (Azadbakht et al., 2005). It has also been proved that participants who followed the Mediterranean diet pattern showed a reduction in blood sugar levels and abdominal obesity, in addition to 28.2% of participants with MS on the diet who no longer met the criteria at the end of the study (Babio et al., 2014; Salas-Salvado et al., 2016). The applicability of these results depends substantially on the availability of intensive counselling and adherence to these interventions. In that regard, adherence remains an issue of concern when treatment involves diet and/or PA. However, greater adherence is associated with greater improvement in the MS components (Fappa et al., 2008). Also, it has been shown that level of adherence to nutritional advice, rather than type of diet, was the main determinant of greater weight loss and CVD risk factor reduction (Desroches et al., 2013).

In terms of using new technology, such as the Internet, in delivering nutritional advice, a systematic review aimed to compare the impacts of interventions for enhancing adherence to dietary advice for the prevention of chronic diseases in adults (Desroches et al., 2013). Some interventions, such as telephone follow-up, video, contracts, feedback and nutritional tools, demonstrated a mixed effect on diet adherence, as it found some diet adherence outcomes favoured the intervention group compared to the control group (Desroches et al., 2013). By the same token, another study investigated the effect of advice from an intensive online dietitian, combined with a community intervention, in

promoting weight loss and optimising healthy behaviours and found an increase in weight loss among obese people from a baseline of 7.0kg after a mean maintenance period of 20 months (Brandt et al., 2011). Each of these two studies supports our research in terms of the success of using the WhatsApp programme for dietary counselling.

With regard to dietary nutrient intake status, in this study, subjects in both groups at baseline reported a trend towards high consumption of total energy intake, total fat, total protein, saturated fatty acids, cholesterol and sugar, a pattern consistent with a Western diet, as reported by Alissa et al. (2005). A Western diet is high in saturated fatty acids and simple sugars and is associated with several metabolic abnormalities including IR and inflammation, the initiating factors in the development of MS (Bullo et al., 2007). It is clear from Table 4.9 that women in both groups at baseline consumed considerably more energy than the EAR given in the UK reference standards. Mean intakes of carbohydrate, protein, fat, sugar, fatty acids and cholesterol at baseline exceeded the DRV recommendations in both groups. The high intake of carbohydrate and sugar was specifically associated with consumption of starchy foods and sugary drinks. The most frequently consumed foods, as observed in the food diaries, were grains and cereal products. Eating snacks and fast foods were also a common habit among women. The independent t-test showed no significant differences at baseline between both groups for any of the dietary intake variables, except for vitamin E, monounsaturated and polyunsaturated fatty acids, which were higher in D. The high intake of calories in this study explains the prevalence of overweight and obesity among participants, as illustrated by BMI. One study demonstrated that higher intakes of energy (>7500kj per day) showed a significant increasing trend in obesity in females aged 40-64 (Chamieh, 2013).

Despite the lack of studies showing calorie consumption rates among Saudis, particularly obese women, our results are similar to some recent national studies. Our data revealed that the mean daily intake of energy at baseline (3436 kcal/day and 3172.6 kcal/day for D and DE, respectively) coincides with a

recent Saudi report which found that the average per capita calorie intake is 3176 per day, which is 14% higher than the world average (Saudi Arabia report, 2014). Another recent study showed that the dietary energy supply for Saudi adults was 3078kcal/capita/day (Adam et al., 2014). According to the Food and Agriculture Organization (FAO) statistics (2010), energy consumption in Saudi Arabia for 2005-2007 was 3120kcal/person/day. This information is also confirmed by Musaiger (2011a). The per capita availability of energy in most EMR countries increased by 716kcal from 1964-1999, and is projected to reach 880kcal by 2030. This makes the average daily per capita energy availability in excess of 3000kcal in most countries in the region.

Furthermore, total fat intake per capita per day among the Saudi population was 145g, containing 72% animal fat and contributing 42% to the total energy intake (Madani, 1996). This percentage of fat is similar to our results (145.9g and 125.3g for D and DE, respectively). Indeed, the nutritional imbalance due to high energy, fat, high sugar intake and high energy % of saturated fatty acids and dietary cholesterol among a substantial proportion of Saudi women in this study is likely to increase their risk of MS and CVD in later life. However, our findings revealed that participants in both treatment groups decreased their total caloric intake and macronutrients significantly following the four-week intervention. Women in both groups showed significant reductions in their proportion of calorie intake (D: 41.1% and DE: 35%), protein (D: 23.7% and DE: 22.4%), fat (D: 53.6% and DE: 45.4%) and carbohydrate (D: 35.8% and DE: 31.3%), which were close to the recommendations. Although the reduction in total caloric intake and macronutrients were greater in D subjects, there were no significant differences between the groups following the intervention. This is perhaps one of the reasons that led to a decrease in the weight of D subjects more than D+E subjects. In fact, the decrease in the consumption of energy and macronutrients post-intervention is consistent with the decrease in the consumption of food groups. Women in both groups had significant reductions in grains and cereals consumption, beverages, snacks/sweets and fast food whereas they had a significant increase in the vegetable consumption. Cooking

methods have been also changed from frying and cooking food in a large amount of fat to boiling, stewing, steaming, grilling and roasting.

Numerous studies have confirmed that dietary modification is considered the cornerstone of the management of MS and T2D. Consistent with our study, Aldesi (2014) found that a 500kcal deficit/day, in the absence of exercise, during a three-month dietary intervention among adult Saudi females, resulted in improved anthropometric, glucose levels and lipid profile in both the overweight and T2D groups. Available evidence has also shown that calorie restriction, i.e., a low-calorie diet intervention, has a considerable impact on improving metabolic risk factors, even if the duration is only 7-10 days (Matsuo et al., 2015). A dietary interventional study in Saudi subjects with metabolic disease concluded that a three-month weight loss was secondary to the significant decrease in carbohydrates, fats and total caloric intake, which translated into better cardiometabolic health in the overweight and T2D group, noted clearly through lipid profile changes (Aldesi, 2014).

While most would agree that modifying diet and lifestyle is necessary for the prevention of MS, T2D and CVD, especially for individuals consuming a diet high in fat or high in processed foods, there is disagreement as to what macronutrient composition would provide the greatest benefit. A study reported a 0.6–0.8mmol/L decrease in TC in overweight women following 12 weeks of energy restriction and exercise training (Nieman et al., 2002; Luo et al., 2013), while a three-month study utilising a low-carbohydrate diet found a 20%–25% decrease in TAG levels in obese adults (Foster et al., 2003). Another study reported that the most satiating of all the macronutrients is protein and, when preloads of protein are ingested, both appetite and successive energy intake are equally reduced (Lejeune et al., 2005; Bowen et al., 2006). However, cohort studies showed no significant associations between protein intake and subsequent weight change in adults (Branca et al., 2007). Also, there are no available data on the relative impact of consuming protein from either animals or vegetable origin on body weight (Branca et al., 2007). Results from several studies also indicate that low fat diets were more effective for weight loss than

either low protein or low carbohydrate diets (Skidmore, 2007). On the other hand, some cohort studies have shown inconsistent results regarding the association of fat intake with excess weight gain or obesity (Summerbell et al., 2009; Chamieh, 2013). Furthermore, Shai et al. (2008) showed that weight loss was sustained for two years in three dietary regimens: 3kg with a low fat diet, 4kg with a Mediterranean diet and 5kg with a low carbohydrate diet. It may be easier for some subjects to reduce carbohydrate than fat, therefore, perhaps better individualised tailoring of different diets based on preferences and experiences in the nutrition counselling could increase compliance with dietary interventions.

Based on our findings, the mean daily intake of sugar (NMES) at baseline was high (D: 82.6g/d and DE: 91.2g/d) according to the maximum recommended intake of 60g/day (11%) based on the DRVs. In this regard, nutritional advice during this intervention focused on dietary habits to promote health and well-being rather than recommending what to eat or completely avoid. Subjects were requested to reduce intake of sugar and food containing added sugar. Following the intervention, the amounts of sugar consumed decreased significantly in both groups (D: 35.8g/d and DE: 38.5g/d), meeting the recommendations (Table 4.10). These results support previous findings showing that consumption of sugar and sugar products was as high as 67% among Saudi female students, which explains the significant relationship between BMI and consumption of sweets in their sample (Majeed, 2015). Previous evidence showed controversial links between added sugar intake, diet quality and increasing the prevalence of MS components (Van Horn et al., 2010). Evidence from cross-sectional studies in intervention trials with adults suggests that higher levels of added sugar consumption, primarily in the form of a liquid source, such as sugar–sweetened beverages, is linked to impaired glucose homeostasis and IR (Wang et al., 2014; Wang, 2014).

Our data revealed that the baseline dietary intake of saturated, unsaturated fatty acids and cholesterol exceeded the recommended limit, as shown in Table 4.11. In fact, obesity and saturated fatty acids-rich-diets have long been

associated with markedly increased IR and inflammation; both of which give rise to metabolic diseases, including T2D (Mathers et al., 2005; Al-Attas et al., 2014; Aldesi, 2014). In dietary treatment for MS, it is recommended that individuals decrease their intake of saturated fatty acids to less than 7% of total energy (Grundy et al., 2005). In this study, the intake of saturated and trans fatty acids decreased significantly following the intervention to meet the recommendation of DRVs, with no significant differences between the groups, which shows the women's response to the dietary tips given to them.

It is noteworthy that the dietary advice that was given to women in this study limited the intake of saturated fatty acids (found in animal fats and tropical oils) and trans fat (hydrogenated or hardened) along with vegetable fat found in margarine and many types of cookies, crackers and other snack foods. Both those types of fat have been shown to raise LDL-C and TAG. On the other hand, liquid or soft polyunsaturated fatty acids (vegetable oil, soft margarine), monounsaturated fatty acids and Omega-3 fatty acids are associated with lower LDL-C, TAG and increased HDL-C levels (Bednarzyk, 2009). The most common sources of monounsaturated fatty acids in the Mediterranean diet are olive oil, canola oil and nuts, while Omega-3 fatty acids are mainly found in higher-fat, cold-water fish, such as salmon, mackerel and herring, nuts, soy oil and seeds (Alsufiani et al., 2015). Previous studies have demonstrated that the diet for the treatment of MS and improvements in insulin sensitivity should be limited to the intake of saturated fatty acids, while moderate amounts of monounsaturated and polyunsaturated fatty acids could be permitted as they do not induce detrimental metabolic effects (Riccardi et al., 2004).

With regard to fibre, trends in the dietary pattern for the Saudi population illustrate a decreased intake of fruit, vegetables and wholegrain (Midhet et al., 2010). Indeed, the main cereals consumed in Arab countries are rice and wheat and the rice consumed is polished and contains only 0.5% crude fibre. Wheat is mostly consumed as Arabic bread made from flour with an extraction rate of 70%-75% (Musaiger, 1998). A study showed that 78% of Saudi female students were not consuming fruit and vegetables on a daily basis (Al-Otaibi, 2013) and

the mean intake of fibre was found to be low (14.6g/d) (Bano et al., 2014). These findings are in agreement with our study; the baseline mean intakes of dietary fibre (NSP) were 14.3g/day for D and 12.1g/day for DE, below the DRV set for adults of at least 18g per day. However, at endpoint, the amount of fibre consumed had increased significantly close to the recommendations (D: 17.8g/day and DE: 16.9g/day) (Table 4.10). Results from different cross-sectional studies have demonstrated that the increased fibre consumption was inversely associated with BMI and percentage body fat (Bano et al., 2014). Fibre intake was found to be positively associated with HDL-C among Saudi women, which appeared to be an important dietary component associated with metabolic health improvements (Aldesi, 2014). Available evidence also demonstrated that a high-fibre diet led to improvements in BP, dietary quality and IR, all of which are integral in the prevention of diabetes and CVD and the management of MS (Ma et al., 2015).

According to our results, there were no significant differences between the two groups in terms of vitamin and mineral intake following the trial, except for folate, which was lower in DE. Additionally, there were no differences within each group regarding vitamin and mineral consumption, which are close to or above the recommendations (Tables 4.12 and 4.13).

With respect to vitamin D intake, the new guidelines on vitamin D recommended by the Scientific Advisory Committee on Nutrition (SACN) that adults and children over the age of four years should increase the RNI for vitamin D to 10 µg, particularly during autumn and winter (British Nutrition Foundation, 2017). The mean daily intake of vitamin D for our sample was similar pre- and post-intervention and was lower than RNI standards of 10µg/d and RDA standards of 5µg/d. This is in line with previous findings which revealed that vitamin D deficiency is common in healthy Saudi females (34.8%) (Alsuwadia et al., 2013). Accumulating research suggests that circulating concentrations of vitamin D might be inversely related to the prevalence of diabetes, to the concentration of glucose and to IR. Additionally, vitamin D deficiency might be a risk factor for MS (Ford et al., 2005). Additional recent

research shows similar trends; compared to vitamin D deficient individuals, subjects with sufficient vitamin D status had a 34% reduced prevalence of elevated WC, 33% reduced prevalence of elevated TAG, 31% reduced prevalence of low HDL-C, and 20% reduced prevalence of lower FBG. It has been proven that every 10nmol/l increase in vitamin D levels is significantly associated with a 10% lower prevalence of MS (Vitezova et al., 2015).

4.8. Strengths and limitations

To the best of our knowledge, this is the first intervention in the KSA to examine the association between PA, diet and MS. Also, this is the first study in general using the WhatsApp programme for dietary counselling which was a culturally appropriate method for Saudi society. Along with careful monitoring of the diet, the programme provided all subjects with dietary advice, including follow-up (individualised nutritional counselling) using WhatsApp messages for 30 days. This enabled the researcher to maintain constant communication with the sample, a daily monitoring of the diet and to send nutritional information in interesting forms, such as images and videos. Moreover, its chief strength lies in the rigorously supervised exercise sessions at the gym for all D+E subjects, which reduced problems with adherence and helped ensure a standardised programme for all participants. In addition, the design of the exercise programme focused on moderate to vigorous exercise training, because this is what is recommended in most public health guidelines for adults. Also, it used a seven-day food diary, which is the most accurate and valid method for assessing diet. It is noteworthy that we experienced excellent adherence to the intervention and low drop-out rates.

In describing the design of the study a number of factors were highlighted that could potentially impact on the outcome. One of the biggest concerns was the necessity to use a non- randomized sampling to allocate subjects to each of the treatment groups. Essentially this meant that the D+E group had self –selected to undergo an exercise programme and, as such may exhibit important physiological, socio-economic or motivational differences to the D-group. Indeed, while the two groups were well-matched for age, BMI and WC, there

were some significant socio-economic differences between the groups. While there is little indication that this had any effect on baseline metabolic health, its impact on the differences in weight loss cannot be ruled out.

To our knowledge, this is one of the first studies to compare the impact of diet and exercise, on the components of MS in a group of overweight Saudi women. In the absence of measures of variance in these parameters in this population, a power analysis was not performed and the number of subjects was largely governed by the researcher's ability to identify a cohort of women prepared to undertake the exercise regime. The intensive nature of the dietary intervention, and limitations in resources available, inevitably meant that the study was also relatively short in duration. However, previous studies that investigated the effect of diet and exercise on markers of cardiovascular health and MS had shown in a group of a sample size ranges from 8-21 individuals significant reductions in body weight, visceral fat, insulin levels, plasma total and LDL cholesterol and triacylglycerol were seen after a similar intervention period (Clark and Burden, 2005; Johnson et al., 2009; Kauko, 2010).

Using the baseline data collected it is of interest to estimate the likely size of effect that would be required to be statistically significant using retrospective power analysis based on the variance of the baseline data obtained from the subjects in the study. Table 4.16 shows the mean and variance of some of the key features of MS in the 40 participants at baseline. Based on this data the minimum size of effect that was likely to be significant and the number of individuals that would be required to detect a 10% reduction in each variable are listed. The data predicts that with n=20 per group it is likely that a 10% change in SBP and plasma fasting glucose would be detected. It also suggests that an 11.5% decrease in body weight may be detected but, in the short period of the study, it is perhaps unrealistic to believe that this was achievable. The size of change in the other variables ranged from 17-24%. Analysis of the actual data suggests that this power analysis is rather conservative as significantly smaller changes in weight, blood pressure and total TAG were all detected. However, such data is useful in designing any future trial and suggests that a

great number of subjects may be required to see significant changes in some of these variables.

Table 4.16: Retrospective power analysis for key variables associated with metabolic syndrome

Variables	Mean	Variance	Predicted significant change detected with n=20 (% of mean)	n for detecting a 10% reduction from mean	Actual change
Weight	91.8	275	11.5	30	-4.7***
SBP	117.7	137.6	8.1	10	-4.4**
Glucose	4.8	0.5	10.2	21	-6.1
Total TAG	0.9	0.1	24.4	108	-12.5**
HDL chol	1.3	0.1	16.9	53	0

Based on a significance level (alpha) =5% and probability of detection (power) = 90%
Performed use sample size test facility within GenStat 17th Edition
Significant change from baseline, **p<0.01, ***p<0.001

While the study was clearly long enough to detect a significant weight loss in both groups it is possible that its short duration contributed to a lack of further effect of exercise on metabolic health. It could be argued that in a longer study, continued adherence to the exercise regime may have had positive effects on metabolic health through improvement in 'fitness' of the participants and perhaps changes in body composition. Exercise may also have helped subjects to maintain weight loss for a more extended period (Cook, 2009; Hall and Kahan, 2018). Additionally, the researcher not only gave general advice to the subjects but also individual counselling depending on their weight and condition in order to modify their eating habits which could potentially have an impact on equality of information given. To reduce this limitation in the future study, knowledge could be assessed to provide evidence of equivalence.

The current study did not quantify PA using accelerometers or other such

devices which can provide objective assessments of PA and offer more accuracy than self-reported data from questionnaires or activity diaries. This was due to the unavailability of these devices in Saudi Arabia at the time of the research application. For any future using such devices would be desirable.

Moreover, due to the unavailability of the devices in Saudi Arabia at the time of the research application the body composition was not measured in the current study and changes in lean body mass in the exercise group may have offset some changes in fat mass. Therefore, future studies should address these limitations by using method for estimating body composition, and in particular body fat such as Bod pod, Dual energy and Bio-electrical impedance.

PA and eating habits are not the only factors responsible for MS risk factors, but there are also other factors that were not included in our study due to the constraints in the pilot study, such as stress, age, ethnicity, family history and genetics which can be considered as useful context information in future studies.

Besides all the above limitations, the most challenges in this study were related to time constraints. A long time has been spent in analysing 818 of the food diaries for both study one and two in which a great effort has been made. Other challenges were overcoming obstacles due to bureaucracy and the tedious procedure which relates, as is often the case, to many collaboration and work with the appropriate authority during the study (i.e. Official Sponsor, medical clinics and gyms).

4.9. Conclusion and recommendations

Results of this pilot study support the feasibility of implementing an intensive dietary intervention which has favourable effects in altering MS risk factors in obese Saudi women. However, combining this with a rigorous exercise regimen did not produce any further improvement. At baseline, both groups of women displayed excessive intakes of dietary energy and low PA, which were associated with high BMI and WC levels that would place them at risk of developing MS. However, of the cardiometabolic risk factors associated with

MS, only HDL-C was close to the range specified in the IDF criteria (mean 1.30 compared to cut-off of 1.29mmol/l) in the group as a whole and only about 20% of the study groups fulfilled the criteria to be diagnosed with MS. Following the intervention, reduced energy intake and weight reduction considerably improved their metabolic profiles independently of whether this was accompanied by increased exercise. It has been found that WC, BP, TC, insulin, IR and plasma TAG were all significantly reduced independently of PA inclusion. The study suggests that, during short-term intervention, dietary energy restriction should be the primary goal in improving cardiometabolic health.

The results of this study demonstrated the positive impact of some of the lifestyle interventions in improving the MS biomarkers among Saudi women. Tests of efficacy and effectiveness over time are needed to determine the utility of this intervention as a programme to promote diet and PA among women and support long-term health outcomes. Based on this preliminary data, future studies could be designed to enhance power and generalizability. If the obstacles identified in providing Saudi females with access to increased PA could be overcome, then a study in which a more representative cohort of the population could be randomized to the treatment groups would overcome concerns around the introduction of bias. Increasing the length of the study may identify benefits of increased PA that were not seen in the present study. While such changes might be expected to lead to greater drop-out rates this could be addressed by adopting 'intention to treat' statistical analysis.

In the modem society, Internet-using habits are prevalent, especially for Saudi women. The Internet may become a powerful and effective mediator for educating and reminding women to proceed to an active lifestyle. By providing nutritional advice using new technology (WhatsApp), dietitians will be able to prescribe PA and diets and obtain insight into participants' performance in detail, which could contribute to the treatment of obesity and its complications. If the study is successful, it will make it easier to implement the programme nationwide for the benefit of many overweight or obese people, particularly women.

It is recommended that future research focus on how professionals could motivate middle-aged, overweight/obese women to exercise. The use of different motivational factors, for instance, pedometers, wrist computers and heartbeat monitors, can motivate some individuals to exercise. It is evident, however, that, with structured exercise programmes, the exercise is regimented and can be difficult to conduct for many. Less regimented exercise, for instance, with pedometer-monitored walking, may lead to better compliance and results. This allows people to fit exercise into their daily lives in longer (>30 minutes /session) or shorter (10 minutes /session) bouts (Albright and Thompson, 2006). The guidelines should address the prevention and control of the main dietary and PA problems and their related diseases in the KSA. They should be based on affordable and available foods that are commonly consumed by the public, including traditional foods, considering local dietary habits and food intake patterns in addition to the provision of adequate information on the calorie content of main foods.

The nature of this project was labour intensive for the principal investigator and hence would be difficult to maintain in a larger cohort over a greater length of time. In addition to increasing the size of the research team a model of reduced personal contact, e.g. 2-3 times a week, could be explored in a follow-up study or the use of digital health apps could also considered to reduce need for one to one contact via WhatsApp. Also, studies to examine the outcomes of PAs or sports equipment at home should be conducted as an alternative to the gym or outdoor PAs if a suitable environment is not available.

Overall, the present study indicates that in the short-term, dietary intervention leading to significant changes in energy and macronutrient intakes, can lead to significant improvements in the metabolic health of adult, overweight Saudi females. While we have failed to demonstrate that the inclusion of increased PA has a further positive impact on health over this period, it remains to be established whether any such additional benefits would be seen over a more prolonged period.

CHAPTER FIVE

GENERAL DISCUSSION

In order to combat the growing epidemics of CVD and T2D, a better understanding of the aetiology behind MS and interventions designed to ameliorate the early mechanism driving the comorbidities is needed. Environmental and behavioural factors, including obesity, physical inactivity and diet, are blamed for this global burden. The overall objective of this thesis was to examine the metabolic and environmental determinants of obesity in Saudi women, with particular reference to lifestyle behaviours such as PA and dietary intake. Identifying these determinants, in combination with previous research, was used to develop a novel intervention for the management and treatment of MS in a sample of overweight/obese women.

Before the discovery of oil, Saudi Arabia was a poor country and people were dependent on eating locally-sourced and generally unprocessed foods. Oil was first discovered in 1938, which led to the rapid socioeconomic development of the country (National Geographic Society, 2016) with improvements in health education and the environment and an increase in urban migration (El-Sobkey, 2014). This rapid urbanisation has had a direct influence on people's dietary habits and lifestyles (Musaiger and Zagzoog, 2013). Over the last 30 years, the country has been flooded with Western traditions and culture, particularly when it comes to food. The Middle East, as a whole, is home to more fast food chains and restaurants than anywhere else on the globe. The Saudi diet was drastically changed in a very short period of time, wherein foods rich in sugar and fats became the norm (Musaiger, 2011a).

Moreover, the nature of occupation has also changed throughout the last century, shifting away from heavy manual work, like fishing and pearl diving, farming, animal husbandry, ploughing, planting and harvesting, to more high technology work and service sector jobs which require less energy expenditure (Musaiger and Zagzoog, 2013). As a consequence, the health of the nation has suffered significantly, particularly among women. Obesity has become

prevalent in society, with the country now only behind the UK, the US and Australia in terms of highest rates internationally (Carroll, 2013). Diabetes, CVD and MS are also chronic problems. While the problems of obesity and associated metabolic disease are being seen in both genders, the situation in women appears most severe. With women having little or no access to sports or PAs, this lack of regular exercise, along with a poor diet, is having a major impact on the health of women across the nation, as well as creating a massive financial burden on state resources (Carroll, 2013). Recognition of this major public health problem is what will really drive the government to change its policies.

Numerous studies have strongly indicated that the main focus for the treatment of obesity and its complications is the management of risk factors which are within control, such as imbalanced diet and sedentary lifestyle. Chapter One describes the scale of the obesity problem, the prevalence of MS and burden of related diseases in the KSA. The review describes the pathogenesis of MS and the ways in which insulin affects metabolism and, specifically, how insulin dysregulation could contribute to the development of MS.

Although the literature review has demonstrated that the complexities of metabolic function are immense, changing lifestyle behaviours can alter the course of the metabolic disease. The chapter illustrates the effects of the lifestyle modification programmes involving exercise and healthy eating on altering the clinical markers of MS and decreasing obesity. Evidence indicates that approximately 60 minutes of moderate intensity endurance exercise on most days of the week can produce significant improvement in cardiometabolic risk factors, including a 30% reduction in intra-abdominal fat, 30%-85% improvement in insulin sensitivity, 5% increase in HDL cholesterol and 15% decrease in TAG levels, a shift in the distribution of LDL and a 4mmHg reduction in both systolic and diastolic BP (International Chair on Cardiometabolic Risk, 2014). Findings from a large population-based cohort of males and females, free of CVD, showed that a diet consistent with recommended dietary

guidelines and enhanced PA was associated with lower volumes of subcutaneous and VAT in both sexes (Molenaar et al., 2009; Golbidi and Laher, 2014).

Chapter Two sets out to provide the platform for the research through examining critically the published literature on the topic of PA levels and sedentary behaviours in the KSA population, focusing specifically on the actual situation as regards female participation in sport. The chapter examines the available literature looking at sports performance of Muslim women in the arena and the different constraints preventing them from involvement in sport. Particular attention was given to the environmental effects and a number of socio-cultural constraints preventing the presence of women in sports arenas at the national and international competition level.

"*Socio-cultural constraints provided an umbrella under which, other constraints are experienced*" (Marwat et al., 2014). Religious and socio-cultural restrictions, mixed gender sport, playing dress code, general trend of the masses towards female sport and limited resources are some of the basic constraints to women's participation in sport (Alozaibi, 2011; Marwat et al., 2014). The chapter also highlights the complex relationship between culture and health and the actors influencing diet control in Saudi woman. For example, the challenges the women face in managing traditional etiquette. Eating-centric social activity and Arab customs are the main factors limiting people's ability to adhere to their diet plan (Alozaibi, 2011).

In an attempt to overcome the cultural and environmental obstacles and motivate Saudi women to exercise, Chapter Three of this thesis presents study one, which investigated in detail knowledge, attitudes and barriers relating to PA and the influence of PA level and food intake on BMI among women living in the KSA and the UK. The study aimed to lay the foundations for ongoing research into the challenges facing women's sports development in the KSA. This study can become a starting point for future state, school and club policies for women's sports. It can help the government to draw up and implement a dynamic strategy to overcome the obstacles to women's sports participation in

the Kingdom. The study can shed light on and add substance to the many reasons that people may see as barriers by actually basing them on facts. The barriers to participation will be of high interest to Saudi women and will give them food for thought as to their own personal situation in relation to sports.

The findings of the study reveal that the sedentary lifestyle of many Saudi Arabian women is a multi-faceted issue. Women's rate of participation in PA is commonly low, particularly in the W-SA group. A significant number of the survey sample did not participate in any type of moderate (approximately 70%) or vigorous-intensity sports (85%-90%). Another aim was to compare levels of PA in Saudi females living in SA and the UK. It was noticeable that W-UK were significantly ($p<0.001$) more physically active than W-SA.

Recent evidence indicates that the very low PA, consistent with a sedentary lifestyle, may account for the increased risk of mortality, with higher BMI (Nelson et al., 2016). Turi et al. (2016) found that lower involvement in PA in different domains increases the prevalence of risk factors for MS. Participants with lower levels of PA in leisure time had higher chances of occurrence of hypercholesterolaemia, diabetes and MS. The occurrence of arterial hypertension was associated with lower levels of sports activities.

Furthermore, in this study, the vast majority of females in the two groups spent long hours sitting watching TV or using the computer, either at home or work. There is some evidence that spending too much time sitting at work or at home increases the risk of becoming obese (Hu et al., 2003; Blanck et al., 2007) and may also increase the risk of chronic diseases and early death (Patel et al., 2010; Thorp et al., 2011). For every two hours women spend watching TV each day, they have a 23% higher risk of becoming obese and a 14% higher risk of developing diabetes (Hu et al., 2003).

Regarding factors that can motivate people to exercise, generally, a high percentage of women had an understanding of PA as having particular benefits, especially the recommended duration of PA (30 minutes a day), but there was a lack of knowledge about the recommended number of times to exercise,

which should be at least five times a week to be good for health. However, the subjects who were knowledgeable about the benefits of exercise did not appear to be applying this knowledge to their day-to-day activities, as most of them were physically inactive, as mentioned previously.

The current study also highlighted the most common barriers to regular exercise. Interestingly, the greatest barrier for W-SA was the lack of transportation (53%). This, in addition to lack of time, lack of suitable facilities for sport, bad weather, lack of partner and lack of safe places, all impact on involvement in PA. In fact, most of these barriers are mainly linked to social norms, which are hypothesised to influence health-related attitudes such as PA and diet, and are believed to be the most powerful forms of social control over human behaviour (Draper et al., 2015), as discussed in detail in Chapter Two. Research reported that women's family responsibilities and their busy schedule at home are other effective factors in not having a healthy lifestyle. Even though, nowadays, women make up a big part of the workforce, this has not changed expectations of them. Women still have a major responsibility in caring for family, both children and other relatives. This large complex set of responsibilities leaves them with little time for self-care (Enjezab et al., 2012).

Based on our findings, the majority of participants in this study seemed to hold favourable attitudes towards PA, as both groups believed that exercise is important. Another study, conducted on pregnant women, appears to confirm that PA behaviour does not seem to match the positive attitudes towards moderate PA, because their intentions did not match their behaviour (Doran, 2010).

As for the desire to exercise, W-SA had a significant greater intent to exercise than W-UK; over half of the W-SA reported that they wanted to exercise for about 30 minutes a day, most days of the week, whereas about two-thirds of the W-UK reported that they would not be able to exercise. This might be because the majority of the W-UK sample were PG students and had study commitments, along with their responsibilities related to family and social environment. Moreover, the most commonly cited activity that women in both

groups would have liked to do more of was walking, followed by dance and aerobics, with no significant differences between groups.

With respect to nutritional intake, women in both groups apparently consumed considerably more energy and macronutrients than recommended. Various studies have reported that diets high in calories and/or low PA contribute to rapid weight gain, obesity and IGF-I levels, which are the highest risk factor for developing T2D (Pan et al., 2006; Boden et al., 2015; Nelson et al., 2016). These findings support our results; excessive calorie consumption by the survey sample with physical inactivity both contributed to the high prevalence of overweight/obesity in Saudi women. Based on BMI classification, findings from this study reveal that both groups exhibited a high prevalence of being overweight (BMI 25 – 29.9) with a higher percentage for W-UK (44%) than W-SA (35%). In contrast, the prevalence of obesity (BMI 30 – 39.9) was higher among W-SA (22%) than W-UK (14%). Statistical analysis in the present study found a significant increase in the prevalence of both overweight and obesity occurred with age. Additionally, there was a strong relationship between PA, energy intake, macronutrients and BMI.

In light of these findings, exploring these obstacles from the perspective of women living in the KSA and the UK, it gives a comprehensive insight into challenges being faced in the country. The study found that, while the government has the biggest role to play in overcoming the obstacles that exist, it is a combination of culture, education, personal, family and Islamic interpretation which are the biggest obstacles to participation. However, our findings provided a solid basis for study two; the information obtained has been used to design a culturally-sensitive intervention that could enhance adherence to PA and healthy diet to prevent obesity and MS risk factors.

A solution to manage obesity and MS is not difficult to achieve: eat less, exercise more. These solutions must become part of everyday life and be woven into our social life to be effective (Pitsavos et al., 2006). Chapter Four of this thesis represents study two, a pilot study, which aimed to examine the

impact of exercise training and/or diet in improving risk factors associated with MS in Saudi women.

All subjects in both groups were provided with dietary advice, including follow-up (individualised nutritional counselling) using WhatsApp messages for 30 days, focusing on goals for managing MS and weight loss involving lifestyle modifications, including changes in diet and exercise habits. For the D+E group, daily one-hour exercise sessions in the gym with a qualified fitness instructor were provided six days a week for 30 days.

On the basis of study one's findings and literature review, it was difficult for the researcher to communicate with women due to the Saudi culture, social norms, customs and traditions. Women are prohibited from driving and there is a lack of public transportation and they require a guardian for commuting. Therefore, the researcher chose to use a form of technology (WhatsApp programme) which is free, appealing and common in Saudi society to solve this problem. This enabled the researcher to maintain constant communication with the sample, daily monitoring of the diet and to send nutritional information in interesting forms, such as images and videos.

Furthermore, the exercise programme for the D+E group was a combination of different types of PA, including aerobics, stretching and dance (Zumba) with warming up and cooling down. The researcher selected gyms which included the types of exercise that the women in study one reported that they preferred. In addition, based on the finding in study one that the major barrier to regular exercise was lack of transportation, the researcher asked the dispensary's director to provide some minibus drivers' phone numbers (a common private transportation in the region and more commonly used by women than taxis) to facilitate the participants' attendance at the gym when needed.

This trial showed that a four-week lifestyle change programme, incorporating either separate dietary modification or combined with regular moderate aerobic exercise intervention, produced clinically important and significant reduction in body composition and improvements in MS abnormalities among

overweight and obese Saudi women. Women in both groups lost weight, but those in D lost significantly more (mean 5%) compared to those in D+E (mean 3%. WC also significantly reduced after the programme in both groups, but with no significant difference between the groups. Similarly, both D and D+E showed significant decreases in SBP and DBP. Furthermore, significant improvements were found in both D and D+E groups in TAG, plasma, insulin, total cholesterol and LDL. Of the risk factors studied, only plasma, glucose and HDL remained statistically unaltered. IR significantly improved in both groups, as indicated by HOMA analysis, which decreased by 28% and 26% in D and DE, respectively.

Regarding the nutritional intake, women in both groups at baseline consumed considerably more energy, carbohydrate, protein, fat, sugar, fatty acids and cholesterol than recommended. Post-intervention, women in both groups had significant reductions in the proportion of calorie intake, (protein, fat and carbohydrate), which were reduced to close to recommendations. Although the reductions in total caloric intake and macronutrients were greater in D subjects, there were no significant differences between the two groups following the intervention. The mean daily intake of sugar (NMES) at baseline was high (80-90g/d) according to the maximum recommended intake of 60g/day (11%) by the DRVs. Following the intervention, the amount of sugar consumed decreased significantly in both groups (<40g/day in both), which met recommendations. The same trend was found for all fatty acids and cholesterol. On the other hand, the baseline dietary fibre (NSP) intake was less than the recommended intake and increased significantly after the intervention.

In the present study, the prevalence of the various levels of PA among the study population at baseline was low. The majority of females (>75%) in both groups reported performing light PAs. However, only 25% of D+E subjects reported performing moderate PAs compared to 10% of D and only 5% of the D subjects reported performing vigorous PA. However, at the endpoint, the mean PA for both groups had increased in all the PA categories. The light PA percentage in D women decreased by 55%, whereas the moderate and vigorous PA percentages increased by 30% and 25%, respectively. As for the D+E women,

PA level increased roughly more than twofold. The reduction in energy and macronutrients with the increase in the PA level led to a reduction in metabolic syndrome-associated risk factors. Remarkably, the overall prevalence of MS declined from 20% to 5% for D and from 21% to 7% for D+E Based on IDF criteria.

In light of these findings, designing a lifestyle modification programme (exercise and healthy eating) which respects religion and social norms and overcomes the environmental and cultural barriers faced by women in sports participation has the potential to alter the early markers of MS and help decrease obesity.

5.1. Overall Conclusions

The data presented in this thesis confirm an alarming level of over-weight and obesity in SA, which is generally worse in women than men. It identifies a reasonable level of awareness of the health problems associated with obesity and the need to reduce energy intake and increase PA, but confirms the cultural and life-style barriers Saudi women face in achieving the necessary changes. A pilot scale intervention clearly demonstrates that a reduction in energy intake can lead to weight reduction and ameliorate many of the risk factors associated with MS. It also shows that, with appropriate support, Saudi women can increase PA levels. However, over the relatively modest time span the intervention took place, it failed to show any additional benefits of increased PA over and above dietary restriction. It appears probable that longer term intervention would be required to confirm whether such additional benefits would be seen. Overall, Saudi Arabia is facing a major crisis in the metabolic health of its citizens and the government needs to embark on a major public health campaign to mitigate against this. The studies reported here suggest that, if cultural barriers can be overcome, interventions can be designed to significantly improve the health of Saudi women and, indeed, the population as a whole.

5.2. Implications for future public health policy in KSA

A significant advantage of the work presented in this thesis is the contemporary nature of the findings about lifestyle issues. There is a rapid change in the culture and social life of Saudi Arabia, especially for women. Saudi Arabia is taking steps to give women more freedom as it seeks to overhaul its economy. The kingdom's women can now drive, join the military, visit sports arenas and cinemas with other changes planned (Chulov, 2018). Saudi women no longer need guardians' consent to receive services, "unless there is a legal basis for this request in accordance with the provisions of the Islamic Sharia" (Arab News, 2018). The increased visibility of and greater public roles for women as individuals will likely lead to further normalisation in society. This transformation will help women realise their individuality and prompt additional changes to their situation (Alhussein, 2014).

Furthermore, it is observable that, due to the westernisation of the Saudi Arabian diet, the increased consumption of high levels of free sugars and saturated fatty acids, cholesterol and sodium, eating out and an increase in food portion sizes have become much more common in daily dietary habits (Al-Daghri et al., 2013). It is therefore important to repeat this kind of work as the culture continues to change, to make sure the conditions are favourable for wider impact.

But taking the current results as an indicator of the facilitators and barriers we can see the potential to inform the development of future policies for the improvement of women's health and well-being. The results of this study demonstrated that women face significant structural barriers which, as individuals, they are unable to overcome. Currently, there is no governmental strategy to overcome the obstacles to women's sports participation in the Kingdom but this study clearly underpins the need for coordinated and dynamic policies for women's activities and sports. Furthermore, as noted in Chapter Two, the Kingdom is a specific setting, requiring a unique Nutritional Needs Assessment approach. For such policies to be effective, tradition and culture need to be clearly separated from Islamic teachings. These changes will be slow

to take place, and it may take a generation or longer for a real change of attitudes in families to come about. This also has implications when considering the effectiveness of any community interventions – recruitment and retention might be challenging, while effect sizes may be small. Furthermore, changes to lifestyle may only achieve by significant and long-term investment, thereby challenging the cost-effectiveness.

Intensive interventions, with the associated financial and infrastructure constraints, such as described here might, therefore, be most appropriate for those who have been identified to be at the greatest risk of metabolic disease. Based upon learnings from the current study, such an intervention might consider feasible with some changes. In addition to increasing the size of the research team a model of reduced personal contact, e.g. 2-3 times a week, could be explored in a follow-up study or the use of digital health apps (e.g. Diet assistant- weight loss and Weight Watchers) could also be considered to reduce need for one to one contact via WhatsApp. Another suggestion to improve the feasibility of the study is to reduce the intensity of the exercise sessions from 6 to 3 times/week. Also, studies to examine the outcomes of home-based exercise or sports equipment, digital apps (e.g. Steps counter and Work out trainer) or providing DVDs for specific types of exercise (to ensure standardised PA for the all population) could be conducted as an alternative to the gym or outdoor PAs if a suitable environment is not available. While at present cultural factors and lack of infrastructure restrict the opportunities for Saudi women to meet recommended PA goals, society is changing and might open up possibilities for improved transferability in the near future. With the increasing liberalization of Saudi society more achievable physical activities may become more culturally acceptable.

The burden of obesity and chronic diseases is rapidly increasing worldwide. Whether in a community setting or more targeted interventions for those at most risk, dietitians play a key role in the prevention and management of obesity and nutrition-related disease. For example, studies have demonstrated that registered dietitians' education and counselling on diet-related patient

outcomes were more effective than general education provided by the cardiac rehabilitation staff (Holmes et al., 2005; Agostini et al., 2016). The results showed significant improvements in the dietitian-led, compared with the general education groups, in achieving goals related to key MS risk factors: BMI, WC, LDL, TAG and TC (Holmes et al., 2005; Agostini et al., 2016). However, the mode of communication needs to be reconsidered.

Seeking dietary support and advice from dietitians most commonly involves a series of one-to-one sessions between the client and the dietitian (Nutritionist Resource, 2018). But cost challenges and difficulties in communicating with women due to the Saudi culture, social norms, customs and traditions, which prevent women from driving, lack of public transportation and the system of male guardianship are considered obstacles to the success of nutritional intervention by a dietitian. There are however emerging alternative and convenient means of conducting these sessions, including conducting them via the telephone and online. It is, therefore, a particularly interesting finding of the current study that, at least in the short term, it is feasible to use an intensive intervention with cheap technologies such as WhatsApp. WhatsApp provides a convenient alternative to meeting with each participant face-to-face and enabled the researcher to maintain constant communication with the sample, a daily monitoring of the diet and to send nutritional information in interesting forms, such as images and videos. The WhatsApp follow-up messages allowed the researcher to keep track of participants' progress, fine-tune their eating plans and educate them on how to eat in a way that kept them healthy so that they could choose the best food themselves. A study by Brandt et al. (2011) investigated the effect of advice from an intensive online dietitian, combined with a community intervention, in promoting weight loss and optimising healthy behaviours and found a reduction in the mean weight loss among obese people from a baseline of 7.0kg after a mean maintenance period of 20 months. More recently, Jacobs et al. (2016) found that use of a Smartphone app, 'Noom' (a Smartphone-based behavioural weight loss programme), was linked to significant short-term weight loss and improved adherence to the

dietary regime. An average 1.92 BMI points were lost after three months of using Noom and, for every 10% increase in adherence, there was a decrease of 2.59 BMI points. Sherrington et al. (2016) suggest that personalised feedback may be an important behaviour change technique to incorporate within Internet-delivered weight loss interventions. Participants who received personalised feedback via Internet-delivered interventions had 2.13kg mean difference greater weight loss in comparison with control groups providing no personalised feedback. However, the social networks have some negative aspects of with regard to uses cases, data protection, security and the concerns of women about exposure due to the taking of photos (Reed, 2018).

The role of the dietitian as a researcher in this study had an additional powerful yet relatively hidden impact. Dietitians work from a whole-diet approach, translate scientific information about nutrition into practical advice to help people make health-conscious decisions about their food intake. They assess, diagnose and treat diet-related problems and raise awareness of the link between food and health (Brug, 2008). Therefore, the researcher not only helped participants to lose weight but also avoided many of the negative 'dieting' style behaviours. Calorie restriction and counting accurate calories often may not be effective in losing weight due to the differences in the BMI status, food preferences, life conditions, work and physical exertion. Evidence shows that a healthy diet to a sustainable dietary pattern can help people to lose weight gradually and steadily (about 1 to 2 pounds per week) which are more successful at keeping weight off. Healthy weight loss is not just about a "diet" or "programme", it is about an ongoing lifestyle that includes long-term changes in daily eating and exercise habits (Centres for Disease Control and Prevention, 2018). Therefore, understanding the influence of the food consumed on satiety, satiation, and energy compensation may be advantageous (Benton and Young, 2017). Thus, the focus should be on types of food, portion size and cooking methods more than calories (Duyff, 2012). This has important implication for future work in this area. While primary outcomes will be focused on key MS risk factors, secondary and process outcomes should

be included to ensure that weight loss is achieved in healthy and sustainable manners.

Overall, the studies described in this thesis have confirmed the major public health crisis associated with overweight and obesity amongst women in Saudi Arabia. It has identified specific dietary and PA behaviours that are contributing to these problems and many of the barriers that such women face in adopting a healthier lifestyle. The intervention trial demonstrated that, despite being overweight, there does appear to be a window of opportunity in young/middle-aged women who have yet to develop many of the adverse metabolic symptoms associated with the condition. With intensive intervention, these women were able to achieve meaning weight loss. The future challenge remains to translate these finding into culturally appropriate, and affordable, strategies to intervene on a population-wide basis.

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APPENDIX 1: 24-HOUR DIETARY RECALL IN ENGLISH

Daily Food Diary



Name_____

Email_____

Daily Food Diary

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

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

Example Day

Daily Food Diary

Date (day/month/year) *1/6/13* ***Day of week*** ***Monday***

Food	Cooking method	Portion	Time
Breakfast			
Corn Flakes with semi-skimmed milk	Non-Cooked	Medium	9:00
Orange Juice		1 glass	
Toast with Orange Marmalade	Toasted	3 thick slices	
Coffee with Milk, One Sugar		small cup	
Mid-morning			10:00
Tea with Milk, One Sugar		1 cup	
Digestive Biscuits	Not Cooked	2 Biscuits	
Lunch			
White Rice or kabsa	Boiled	3 cup	12:30
Fish	Rosted	3 Egg-Sized	
Salad	Not Cooked	1 Bowl	
Kit Kat		1 bar (2fingers)	
Green Apple		1	
Cappuccino, 2 Sugars		1	
Mid-afternoon			
Tea with milk, One sugar	N/A	1 cup	2:00
Chocolate		50 g bar	3:00
Banana		1	4:00
Evening Meal			
Chicken with Gravy	Roasted	Large	7:00
Potatoes	Roasted	3 Egg-sized	
Carrots	Steamed	Potatoes	
Broccoli	Steamed	Medium	
Apple Pie	Baked	1 slice	

APPENDIX 2: 24-HOUR DIETARY RECALL IN ARABIC

سجل الغذاء اليومي



الأسم _____

الايميل _____

اذكري الأطعمة التي تناولتيها خلال الـ 24 ساعة الماضية في الجدول التالي :

اليوم: **التاريخ: / / 1434هـ**

الوجبة	المادة الغذائية	طريقة الطبخ	كمية الغذاء	وقت تناول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
قبل النوم				

(مثال) استمارة تقييم الغذاء

اذكري الأطعمة التي تناولتيها خلال الـ 24 ساعة الماضية في الجدول التالي :

اليوم: الأثنين **التاريخ:1 /1434/10هـ**

الوجبة	المادة الغذائية	طريقة الطبخ	كمية الغذاء	وقت تناول الطعام
الفطور	رقائق الذرة (كورن فليكس) مع حليب قليل الدسم عصير البرتقال بريد مع مربى البرتقال القهوة مع الحليب ، سكر	غير مطبوخ محمص	1 كاس متوسط 3 شرائح سميكة كاس صغير ملعقة صغيره واحده	الساعة 9
ما بين الفطور والغداء	شاي مع حليب، سكر ملعقة صغيره واحد بسكويت دايجستيف	غير مطبوخ	كاس صغير 3 قطع	الساعة 10
الغداء	أرز أبيض أو كبسة سمك سلطة كيت كات تفاح أخضر كابتشينو، سكر 2 ملعقة صغيره	سلق / تشويح مشوي غير مطبوخ	3 كاس حجم 3 بيضات طبق صغير إصبعين واحده كأس	الساعة 12:30
ما بين الغداء والعشاء	شاي مع حليب، سكر ملعقة صغيره واحد شوكولا موز	غير مطبوخ	كاس لوح / 50 جرام واحده	الساعة 2 الساعة 3 الساعة 4
العشاء	الدجاج مع المرق البطاطا جزر بروكلي فطيرة التفاح	مشوي مشوي على البخار على البخار مخبوز	حجم 3 بيضات 1 حبة متوسطة 1 حبة صغيرة طبق متوسط شريحة واحده	الساعة 7
قبل النوم	زبادي كامل الدسم خبز بر تمر	غير مطبوخ	علبه نصف رغيف 7 حبات	الساعة 12:5

APPENDIX 3: PHYSICAL ACTIVITY LEVEL POSTER IN ENGLISH



APPENDIX 4: PHYSICAL ACTIVITY LEVEL POSTER IN ARABIC



APPENDIX 5: STUDY ONE ETHICAL APPROVAL LETTER

Direct line/e-mail

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14th June 2013

Ahlam Alhajri c/o Dr Fiona McCullough

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Dear Ahlam and Dr McCullough

Ethics Reference No: OVSB06062013 SBS Nutrition

Study Title: Knowledge and Attitudes towards Physical Activity and Dietary Intake of Saudi Women Living in Saudi Arabia and the UK.

Chief Investigators/Supervisors: Professor Andrew Salter and Dr Fiona

McCullough, Division of Nutritional Sciences, School of Biosciences

Lead Investigators/Student: Ahlam Alhajri, PhD Student, Division of Nutritional Sciences.

Duration of Study: Jun2013-Jun 2014 1 year No of Subjects: 400

Thank you for your recent application to conduct a PhD project overseas and in the UK which was considered by the Committee and the following documents were received:

1. **Saudi women activity project: Application form, version 1.0, 17.05.2013**
2. **Saudi women activity project: Experimental Protocol, version 1.0, 17.05.2013**
3. **Saudi women activity project: Information Sheet for Normal Healthy Volunteers, version 1.0, 17.05.2013**

4. **Saudi women activity project: Consent form, version 1.0, 17.05.2013**

5. **Saudi women activity project: Questionnaire, version 1.0, 17.05.2013**

6. **Saudi women activity project: Food Record, version 1.0, 17.05.2013**

7. **Saudi women activity project: Recruitment Poster, version 1.0, 17.05.2013**

These have been reviewed and are satisfactory and the study is approved.

Approval is given on the understanding that the Conditions of Approval set out below are followed.

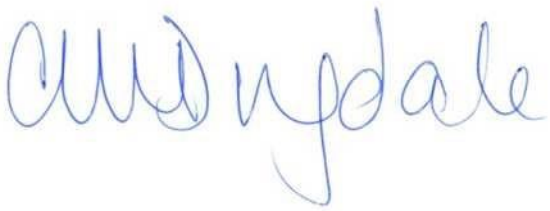
1. **A Favourable opinion is given on the understanding that all appropriate ethical and regulatory permissions are sought for each overseas project in accordance with all local laws, and that the host organisation involved also gives their permission where applicable.**

2. **You must follow the protocol agreed and inform the Committee of any changes using the attached notification of amendment form.**

3. **This study is approved for the period of active recruitment requested. The Committee also provides a further 5 year approval for any necessary work to be performed on the study which may arise in the process of publication and peer review.**

4. **An End of Project Progress Report is completed and returned when the study has finished.**

Yours sincerely



Dr Clodagh Dugdale

Chair, Nottingham University Medical School Research Ethics Committee

Medical School Research Ethics Committee Membership 2012/2013

Chair	**Dr Clodagh Dugdale, Lecturer in Sports and Exercise Medicine, Division of Orthopaedic and Accident Surgery, School of Clinical Sciences.**
School	**Representative**
Biomedical Sciences	**Dr Vince Wilson, Reader and Basic Scientist. Dr Liz Simpson, Chief Experimental Officer.**
	Dr David Turner, Clinical Associate Professor in Microbiology.
Molecular Medical Sciences	
Community Health Sciences	**Dr Isabella Robbins, Research Fellow, Research fellow: NIHR Medical Crises in Older People Programme** **Dr Rachel Murray, Lecturer, Public Health Medicine & Epidemiology Dr Gillian Doody, Clinical Associate Professor & Reader in General Adult Psychiatry, Division of Psychiatry.**
Clinical Sciences – Non Clinical	**Dr Philip Clark, Laboratory Manager, Pre-Clinical Cancer Studies. Dr Charlotte Billington, Research Fellow, Therapeutics & MM.**
Graduate Entry Medicine, Derby	**Dr Caroline Chapman, Associate Professor, Breast Surgery.***
Clinical Sciences - Clinical	**Dr Paul Maddison, Consultant Neurologist/Honorary Clinical Associate Professor, Queen's Medical Centre, NUH** **Dr Daren Forward, Consultant Orthopaedic Trauma Surgeon, Honorary Consultant Lecturer**
Primary Care	**Dr Richard Knox, General Practitioner/ Part-time Lecturer** **Dr Edward Tyrrell, General Practitioner/Part-time Lecturer** **Division of Primary Care, QMC Campus**
School of Nursing, Midwifery and Physiotherapy	**Dr Stephen Timmons, Associate Professor/Senior Lecturer, School of Nursing Midwifery and Physiotherapy.**
Lay (Out of Faculty)	
	Professor Nigel White, Professor of Public International Law, School of Law, University of Nottingham. **Lydia Davies-Bright, PhD Student, School of Law.** **Dr Emma Hall, Research Fellow, SPMMRC, School of Physics and Astronomy.** **Mary Beirne, Retired Mental Health Nurse, Birmingham and Solihull Mental Health Foundation Trust.** **To be appointed, 3rd Year Medical Student**
Medical Students nominated by ISC	
Postgraduate Student Member	**Prema Nirgude, PhD Student, IWHO, Division of Psychiatry Helen Smith, PhD Student, Division of Psychiatry.**
Administrator	**Mrs Louise Sabir, Division of Therapeutics & MM, School of Clinical Sciences**

APPENDIX 6: PILOTING QUESTIONNAIRE EVALUATION FORM STUDY 1: KNOWLEDGE AND ATTITUDES TOWARDS PHYSICAL ACTIVITY QUESTIONNAIRE

	GUIDELINE / CHECKLIST	**Note**
1	Are there any questions that cannot be answered easily (Note the questions, most often asked by participants)	
2	Are there any questions that cannot be understood and need rewording and re-structuring (identified by no answers from them)	
3	Are there any questions that are ambiguous and need re-designing the layout of questions?	
4	Are there any questions that are very easy to answer and endorsed by 99-100% participants?	
5	Are there any questions that take long time to answer?	
6	Are there any missing questions that worth to add?	
7	How long did it take to complete all the questions?	

APPENDIX 7: KNOWLEDGE AND ATTITUDES TOWARDS PHYSICAL ACTIVITY QUESTIONNAIRE IN ENGLISH



Knowledge and Attitudes towards Physical Activity of Saudi Women

Dear participant,
The purpose of this questionnaire is to study Knowledge and attitudes towards physical activity of Saudi women. Therefore, we would like you to answer the following questions as accurately as possible by ticking the box that represents your choice. What we are asking for is your activity in a typical (usual) week. All information provided will be treated with strict confidentiality and used only for research purposes.

Name……

Email……

(Estimate) Weight (kg)…… Height (cm)……

Part 1: Demographics Questions

1. Age (years)
a. 16-24 ☐ b. 25-34☐
c. 35-44☐ d. 45-54☐

2. What is the highest grade of school you completed?
Intermediate school or less ☐
Secondary school ☐
Technical or college school ☐
University graduate (4 years) ☐
Post-graduate studies ☐

3. What is your marital status?
Married ☐ Single, never married ☐
Widowed ☐ Divorced ☐

4. How many children do you have? (If applicable)
..... Child

5. Employment – at the present time you are
Not employed and not seeking work (e.g. housewife, caring for children) ☐
Not employed but seeking work ☐
Student ☐
Employed ☐

6. Please describe your job (e.g. teacher, doctor, shop-worker etc.)
…….

7. What is your monthly household income?
(Please leave blank if you do not wish to answer this question)
< £ 500 ☐ £ 501-£ 833 ☐
£ 834-£ 1660 ☐ £ 1661-£ 2500 ☐
£ 2500 or over ☐

Part 2: Physical Activity questions (practice)

8. On average how many days per week do you regularly walk for more than 10 minutes?
Never☐
1-2 days☐ 3-4 days☐
5-6 days☐ Everyday ☐

9. If you regularly walk, what is the pace of your walk?
Slow ☐ Moderate ☐ Fast ☐

10. If you regularly walk, on average, how many minutes do you walk each day?
Number of minutes: ……

11. On average how many times per <u>day</u> do you use the stairs (more than 10 steps) in work, home, or elsewhere? (One floor or stair count as 1 time)
Never ☐ 1-2 times ☐
3-5 times ☐ 5 times or more ☐

12. On average, how many days per <u>week</u> do you regularly engage in moderate intensity sports (e.g. volleyball, table tennis, bowling, badminton, aerobic dance or other similar activities)?
Never ☐
1-2 ☐ 3-4 ☐
5-6 ☐ Every day ☐

13. If you regularly play moderate intensity sports how many minutes do you play each time?
Number of minutes: ……..…

14. How many days per <u>week</u> do you regularly play high intensity sports (e.g. soccer, rugby, hockey, netball, basketball, handball, athletics, tennis squash, etc.)?
Never ☐
1-2 ☐ 3-4 ☐
5-6 ☐ Every day ☐

15. If you regularly play high intensity sports how many minutes do you play each time?
Number of minutes: ……

16. Do you have a maid?
Yes ☐ No ☐

17. If you do your own household work how many hours per <u>week</u> do you engage in these activities (e.g. gardening, vacuuming, washing, and cleaning)?
Never ☐
1-2 ☐ 3-4 ☐
5-7 ☐ More than 7 ☐

18. On average, how long do you watch TV and/or DVD/Video per <u>day</u>?
1/2 hour or less☐ 1 hour☐ 2 hours☐
3 hours☐ 4 hours☐ 5 hours or more ☐

19. On average, how long do you spend using a computer, tablet or mobile-phone per <u>day</u>?

At home
1/2 hour or less ☐ 1 hour ☐ 2 hours ☐
3 hours ☐ 4 hours ☐ 5 hours or more ☐

At work or university (if applicable)
1/2 hour or less ☐ 1 hour ☐ 2 hours ☐
3 hours ☐ 4 hours ☐ 5 hours or more ☐

Part 3: Health Related Knowledge and Attitudes

20. In general I regard myself as:
Very Healthy ☐
Healthy ☐
Of average Health ☐
Unhealthy ☐
Very Unhealthy ☐

21. At the present time I regard myself as:
Very unfit ☐
Unfit ☐
Of average fitness ☐
Fit ☐
Very Fit ☐

22. At the present time I regard myself as:
Very underweight ☐
Underweight ☐
Of average weight ☐
Overweight ☐
Very Overweight ☐

23. Which statement best describes your attitude to your weight?
I am content with my weight ☐
I would like to gain weight but am not actively trying at the moment ☐
I am currently trying to gain weight ☐
I would like to lose weight but am not actively trying at the moment ☐
I am actively trying to lose weight ☐

24. Circle the number that best corresponds to your attitude about exercise. (1= strongly disagree, 5= strongly agree)

a. Fun 1 2 3 4 5

b. Exciting 1 2 3 4 5

c. Important 1 2 3 4 5

d. Attractive 1 2 3 4 5

e. Stressful 1 2 3 4 5

f. Boring 1 2 3 4 5

25. Which ONE of the following statements describes how important you think exercise is BEST for your personal health? (Please only tick one)
Exercise is not very important for my health ☐
Exercise is important for my health, but many other things are more important ☐
Exercise is the best thing I can do for my health ☐
Don't know ☐

26. In your opinion, which of the following diseases can be prevented by doing regular physical activity? (Circle all that apply)

Cardiovascular diseases ☐

Hypertension (high blood pressure) ☐

Diabetes ☐

Obesity ☐

Colon cancer ☐

Breast cancer ☐

Stress ☐

Pneumonia ☐

Tuberculosis ☐

HIV/AIDS ☐

Other (mention) ……..

27. How often do you think a person your age needs to exercise to be healthy?

Not at all ☐
Less often than once a month ☐
Once or twice a month ☐
About once a week ☐
About three times a week ☐
Five or more times a week ☐

28. For how long daily, do you think a person your age should exercise?
10 minutes or less ☐ About 20 minutes ☐
About 30 minutes ☐ 45 minutes or more ☐

Part 4: Physical Activity Barriers

29. Have you ever started an exercise program but then found yourself unable to stick with it?
YES ☐ NO ☐

30. If yes how many times?
Once ☐ Twice ☐
3 times ☐ 4 times ☐ 5 times or more ☐

31. Circle the number that best corresponds to your barriers or obstacles to exercise. (1= strongly disagree, 5= strongly agree)

Lack of time 1 2 3 4 5

Cost of activity 1 2 3 4 5

Lack of energy/tiredness 1 2 3 4 5

Lack of information 1 2 3 4 5

Lack of motivation 1 2 3 4 5

Lack of skills 1 2 3 4 5

Fear of injury (or re-injury) 1 2 3 4 5

Lack of safe places 1 2 3 4 5

Lack of child care 1 2 3 4 5

Lack of a partner 1 2 3 4 5

Lack of suitable facilities for sport 1 2 3 4 5

Lack of support from others 1 2 3 4 5

Lack of transportation 1 2 3 4 5

Pain when I exercise 1 2 3 4 5

Bad weather 1 2 3 4 5

Traditions and beliefs 1 2 3 4 5

Other (mention)……
……

Part 5: Motivation for Exercising:

32. This is a list of benefits people say they get from exercise. For each one, please tell me how important this is to you to increase your exercise? (1- not important, 5- extremely important)

Feeling good about yourself 1 2 3 4 5

Feeling in control of your life 1 2 3 4 5

Fighting aging 1 2 3 4 5

Improving your overall health 1 2 3 4 5

Increasing your energy level 1 2 3 4 5

Preventing diseases 1 2 3 4 5

Looking good 1 2 3 4 5

Socializing with other people 1 2 3 4 5

Reducing stress 1 2 3 4 5

Controlling my weight 1 2 3 4 5

Part 6: Programmes and Services in Your Community

33. Do you currently participate in physical activity classes or Programmes that are offered in your community?

Yes ☐ No ☐

There are no physical activity classes in my community ☐

34. What types of physical activity classes or programmes do you want to participate in? (Circle all that apply)

Aerobics ☐ Baseball ☐ Basketball ☐

Tennis ☐ Cycling ☐ Dance ☐

Yoga ☐ Walking ☐ Hiking ☐

Stretching☐ Swimming ☐

Weight lifting/strength training ☐

Other ……...

35. When thinking about your community are there activities or community resources not currently available that you think would help make it easier for you to exercise?
Yes ☐ No ☐

36. IF "YES" what could be done in your community to make it easier for you to exercise more regularly?
……
……
……

37. If you wanted to, would you be able to exercise about 30 minutes a day, most days of the week?
Yes ☐ No ☐
Already exercise 30 minutes or more per day ☐

Thank you for participating in this study.

For further details, and/or to participate, please contact
Ahlam Alhajri at sbxaasa@nottingham.ac.uk

APPENDIX 8: KNOWLEDGE AND ATTITUDES TOWARDS PHYSICAL ACTIVITY QUESTIONNAIRE IN ARABIC

المعرفة و المواقف اتجاه النشاط البدني لدى السيدات السعوديات

عزيزتي المشتركه:
ان الغرض من هذا الاستبيان هو قياس معرفتك و موقفك اتجاه النشاط البدني , لذا نرجو منك التكرم بالإجابة على الاسئلة بكل دقة بالإشارة على المربع الذي يمثل افضل اجابة لك. سؤالنا هو عن نشاطك البدني المعتاد خلال ايام الأسبوع علما بان المعلومات التي ستدلين بها ستظل سرية وستستخدم لأغراض البحث العلمي فقط , وشكرا لك مقدما.

الاسم(اختياري) :.....

البريد الالكتروني:.....@.....

الطول:..... **سم** **الوزن:**..... **كجم**

الجزء الأول: المعلومات الديموغرافية

1-العمر

□ 24-16 □ 34-25

□ 44-35 □ 54-45

2- ماهو المستوى التعليمي الذي تم الحصول عليه؟

الشهادة المتوسطة او اقل □

الشهادة الثانوية □

دبلوم او معهد تقني □

الشهادة الجامعيه □

دراسات عليا (ماجستير او دكتوراه) □

3- الحالة الاجتماعية

متزوجة □ غير متزوجة □ ارمله □ مطلقه □

4- اذا كنت متزوجة كم عدد الأطفال لديك؟

عدد الأطفال ..... طفل

5- الحالة الوظيفية (حاليًا)

ربة منزل □

غير موظفة وابحث عن عمل □

طالبه □

موظفة □

6- إذا كنت موظفه ما هي وظيفتك؟ (مثلا معلمة , دكتورة , موظفة مبيعات ...الخ)

الوظيفة.....

7- ما هو دخل الأسرة الشهري تقريبا ؟

3000 ريال او اقل □ 3001 - 5000 ريال □

5001-10000 ريال □ 10001- 15000 ريال □

اكثر من 15000 ريال □

الجزء الثاني : أسئلة النشاط البدني

8- في المتوسط , كم يوما في الأسبوع تمارسين بانتظام رياضة المشي لأكثر من 10 دقائق؟

لا شيء □
مره - مرتين □ 3 – 4 مرات □
5-6 مرات □ كل يوم □

9- في حالة ممارستك للمشي بانتظام , ما هو وتيرة السير الخاص بك؟

مشي بطيء □ مشي معتدل السرعة □ مشي سريع □

10- في حالة ممارستك للمشي بانتظام, كم تستغرقين من الوقت تقريبا في كل مره؟

في كل مره أمشي لمدة ..... دقيقة

11- في المتوسط , كم مرة في اليوم تقومين بصعود الدرج (لأكثر من 10 درجات) سواء في العمل , المنزل , الجامعه أو في مكان آخر (صعود دور واحد يساوي مرة واحدة اما الدورين فيساوي مرتين وهكذا) ؟

لاشيء □ مرة – مرتين □
3-5 مرات □ 5 مرات أو أكثر □

12- في المتوسط ، كم مرة في الأسبوع تمارسين بانتظام انشطة رياضية معتدلة الشدة (غير مجهده) (مثل كرة الطائرة , تنس الطاولة , البولينج , الريشة ، الرقص وما شابه ذلك) ؟

لاشيء □
1-2 في الاسبوع □ 3-4 في الاسبوع □
5- 6 في الاسبوع □ 7 ايام في الاسبوع □

13- في حالة ممارستك تلك الرياضات المعتدلة الشدة بانتظام كم تستغرقين من الوقت فعليا في كل مرة ؟

في كل مرة أستغرق ..... دقيقة

14- في المتوسط ، كم مرة في الأسبوع تمارسين بانتظام انشطة رياضية مرتفعة الشدة (مجهدة بدنيا) (مثل كرة القدم، كرة السلة ، كرة اليد، ألعاب القوى، الاسكواش ، الخ)؟

لاشيء □
1-2 في الاسبوع □ 3-4 في الاسبوع □
5- 6 في الاسبوع □ 7 ايام في الاسبوع □

15- في حالة ممارستك تلك الرياضات مرتفعة الشدة بانتظام كم تستغرقين من الوقت فعليًا في كل مرة ؟

في كل مرة أستغرق ..... دقيقة

16- هل لديك خادمة في المنزل؟

نعم □ لا□

17- اذا كنت تؤدين الأعمال المنزلية بنفسك كم ساعة في الأسبوع تستغرقين لأدائها (مثل العناية بالحديقة ، كنس المنزل ، الغسيل ، التنظيف)؟

لاشيء □

1-2 ساعة □ 3-4 ساعات □

5- 6 ساعات □ 7 ساعات او اكثر □

18- في المتوسط ، كم ساعة تقضينها يوميا في مشاهدة التلفزيون / DVD/ فيديو؟

نصف ساعة او اقل □ 1 ساعة □ 2 ساعة □

3 ساعات □ 4 ساعات□ 5 ساعات او اكثر □

19- في المتوسط ، كم ساعة تقضينها يوميا في استخدام جهاز الكمبيوتر- النت ، الهاتف - الجوال , او الاجهزة الالكترونية؟

اذا كان في المنزل:

نصف ساعة او اقل □ 1 ساعة □ 2 ساعة □

3 ساعات □ 4 ساعات□ 5 ساعات او اكثر □

اذا كان في العمل او الجامعه : (إن وجد)

نصف ساعة او اقل □ 1 ساعة □ 2 ساعة □

3 ساعات □ 4 ساعات□ 5 ساعات او اكثر □

الجزء الثالث: المعرفة والمواقف المتعلقة بالصحة

20- بشكل عام أنا أعتبر نفسي على النحو التالي:

صحي جدا □

صحي □

متوسط الصحة □

غير صحي □

غير صحي جدا □

21- في الوقت الحاضر أنا أصنف نفسي من ناحية اللياقة البدنية على النحو التالي:

غير لائق بشكل كبير □

غير لائق □

متوسط اللياقة البدنية □

لائق □

لائق جدا □

22- في الوقت الحاضر أنا أصنف وزني على النحو التالي:

ناقص عن الوزن الطبيعي بكثير □

ناقص عن الوزن الطبيعي □

وزن طبيعي □

زايد عن الوزن الطبيعي □

زايد عن الوزن الطبيعي بكثير□

23- ما هي انسب عبارة لوصف موقفك اتجاه وزنك؟

أنا راضية عن وزني □

اريد أن اكتسب وزن ولكن لا أسعى بجد في هذه اللحظة □

أسعى حاليًا لزيادة وزني □

اريد أن اخفض وزني ولكن لا أسعى بجد في هذه اللحظة □

أنا أسعى بجد محاولة انقاص وزني □

24- ضعي دائرة حول الرقم الذي يتوافق مع موقفك اتجاه ممارسة الرياضة (1 = لا أوافق بشدة و 5 = أوافق بشدة)

الرياضة ممتعة	1	2	3	4	5
الرياضة مثيرة	1	2	3	4	5
الرياضة مهمة	1	2	3	4	5
الرياضة جذابة	1	2	3	4	5
الرياضة مجهدة	1	2	3	4	5
الرياضة مملة	1	2	3	4	5

25- اختاري العبارة التي تصف مدى أهمية الرياضة لصحتك الشخصية ؟ (الرجاء اختيار إجابة واحدة فقط)؟

ممارسة الرياضة ليست مهمة جدا لصحتي □

التمارين الرياضية مهمة لصحتي ، ولكن هناك أشياء أخرى أكثر أهمية □

التمرين هو أفضل شيء يمكنني القيام به لصحتي □

لا أعرف □

26- من وجهة نظرك ، أي من الأمراض التالية يمكن الوقاية منها عن طريق ممارسة النشاط البدني بانتظام (ضعي اشارة على كل الامراض التي ينطبق عليها ذلك)؟

أمراض القلب والأوعية الدموية □

ارتفاع ضغط الدم □

مرض السكري □

السمنة □

سرطان القولون □

سرطان الثدي □

الإجهاد (القلق) □

الالتهاب الرئوي □

السل □

فيروس نقص المناعة البشرية / الإيدز □

أخرى (اذكريها).....

27- باعتقادك كم مره يحتاج الشخص في مثل عمرك لممارسة الرياضة ليكون صحي؟

لا يحتاج نهائيا □

أقل من مرة في الشهر □

مرة واحدة أو مرتين في الشهر □

مرة واحدة في الأسبوع □

حوالي ثلاث مرات في الأسبوع □

خمس مرات أو أكثر في الأسبوع □

28- باعتقادك كم المدة الزمنية التي يجب ان يقضيها شخص في مثل عمرك في ممارسة الرياضة يوميا؟

10 دقائق أو أقل □ حوالي 20 دقيقة □

حوالي 30 دقيقة □ 45 دقيقة أو أكثر □

الجزء الرابع: معوقات النشاط البدني

29- هل التحقت فيما مضى في برنامج او نادي رياضي ولكن بعد ذلك وجدت نفسك غير قادرة على الاستمرار فيه ؟

نعم □ لا□

30- إذا كانت الإجابة بنعم, كم مرة وجدت نفسك غير قادرة على الاستمرار في هذا البرنامج ؟

مرة واحدة □ مرتين □

3 مرات □ 4مرات □ 5 مرات أو أكثر □

31- ضعي دائرة حول الرقم الذي يتناسب مع درجة المعوقات التي تمنعك من ممارسة الرياضة (1 = لا أوافق بشدة و 5 = أوافق بشدة)

ضيق الوقت 1 2 3 4 5

سعر الأندية الرياضة 1 2 3 4 5

نقص الطاقة / التعب 1 2 3 4 5

عدم توفر معلومات عن الرياضة 1 2 3 4 5

عدم وجود الدوافع 1 2 3 4 5

عدم توفر المهارات 1 2 3 4 5

الخوف من الإصابة إثناء الرياضة 1 2 3 4 5

عدم توفر أماكن آمنة 1 2 3 4 5

عدم وجود شخص يرعى الأطفال اثناء ممارسة الرياضة 1 2 3 4 5

عدم وجود شخص يرافقني اثناء الرياضة 1 2 3 4 5

عدم توفر مرافق او نوادي مناسبة للرياضة 1 2 3 4 5

عدم وجود دعم او تشجيع من الآخرين 1 2 3 4 5

عدم توفر وسائل المواصلات 1 2 3 4 5

الألم عند ممارسة الرياضة 1 2 3 4 5

سوء الاحوال الجوية 1 2 3 4 5

العادات والتقاليد والمعتقدات 1 2 3 4 5

أسباب أخرى (اذكريها).....

.....

الجزء الخامس: الدافع لممارسة الرياضة:

32 - هذه هي قائمة بالفوائد التي اشار الناس بأنهم حصلوا عليها من ممارسة الرياضة ، ما مدى أهمية هذا الأمربالنسبة لك من أجل زيادة ممارسة الرياضة؟ (1 - ليس مهما ، 5 - هام للغاية)

الشعور بالرضا عن النفس 1 2 3 4 5

الشعور بالقدرة على السيطرة على حياتك 1 2 3 4 5

لمحاربة الشيخوخة 1 2 3 4 5

تحسين الصحة العامة 1 2 3 4 5

زيادة مستوى الطاقة 1 2 3 4 5

الوقاية من الامراض 1 2 3 4 5

تحسين المظهر 1 2 3 4 5

تحسين العلاقات الاجتماعية مع الآخرين 1 2 3 4 5

الحد من الإجهاد والقلق 1 2 3 4 5

السيطرة على الوزن 1 2 3 4 5

الجزء السادس : البرامج والخدمات في مجتمعك

33- هل تشاركين حاليا في صفوف النشاط البدني أو البرامج التي يتم تقديمها في مجتمعك؟

نعم □ لا□ لا توجد انشطة بدنية في مجتمعي □

34- ما هي أنواع الانشطة البدنية أو البرامج التي ترغبين المشاركة فيها؟ (ضعي اشارة على كل الانشطة البدنية المرغوبة)

الرياضة السويدية □	البيسبول □	كرة السلة □
التنس □	ركوب الدراجات □	الرقص □
اليوغا □	المشي □	المشي لمسافات طويلة □
التمدد □	السباحة □	رفع الأثقال / تدريب القوة

أخرى (اذكريها) .....

35- عند التفكير في مجتمعك هل هناك أنشطة أو موارد غير متوفرة حاليا في مجتمعك والتي تعتقدين أنها قد تساعد في تسهيل ممارسة الرياضة بالنسبة لك؟

نعم ☐ لا ☐

36- اذا كانت الاجابة بنعم ما الذي يمكن توفيره في مجتمعك لجعل ممارسة الرياضة بانتظام أسهل بالنسبة لك؟

.....

.....

.....

.....

37- هل انت قادرة على المشاركة معنا في برنامج رياضي لمدة حوالي 30 دقيقة في اليوم معظم أيام الأسبوع؟

نعم ☐ لا ☐

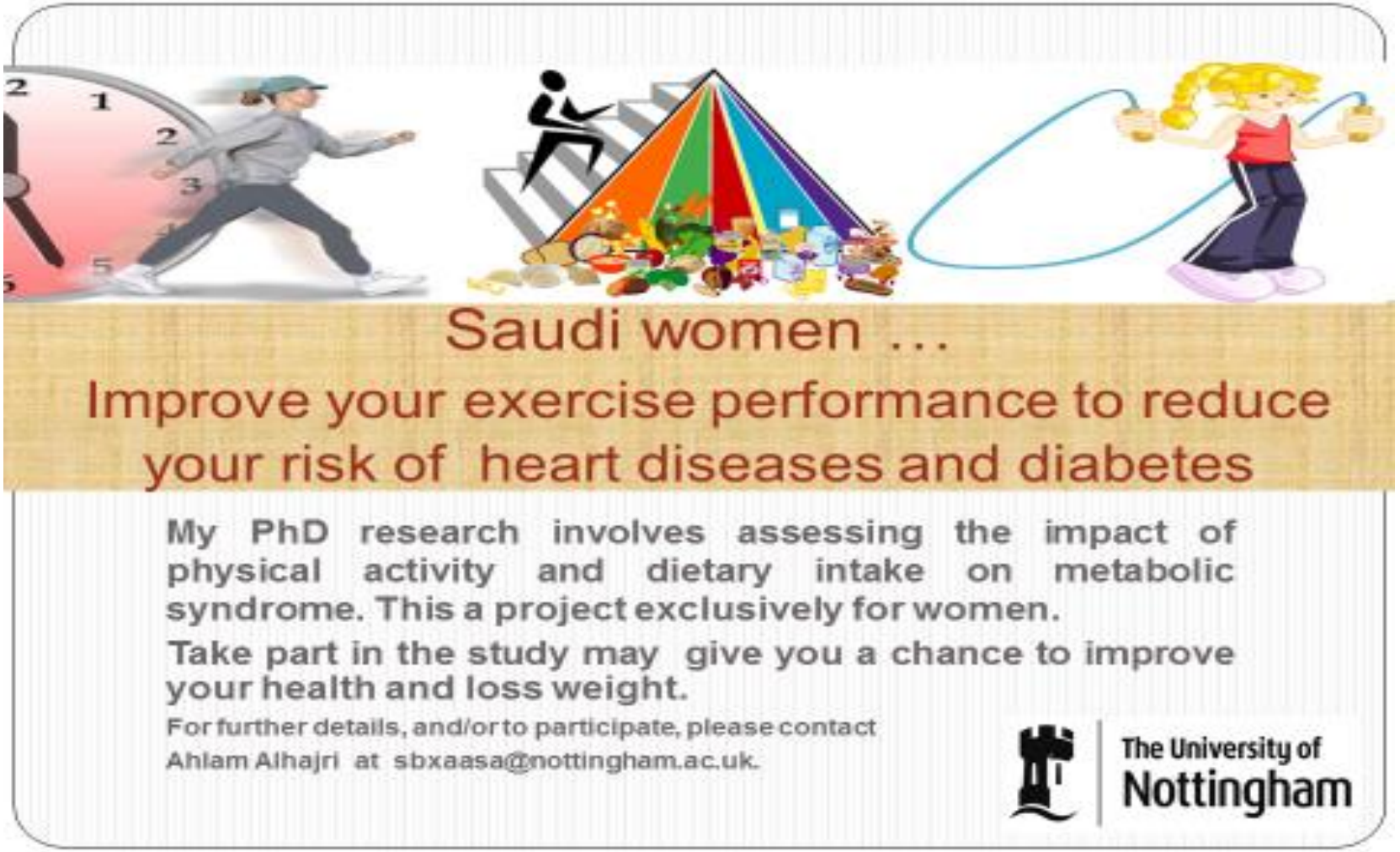
انا بالفعل امارس الرياضة لمدة 30 دقيقة أو أكثر في اليوم الواحد ☐

شكرا لك على حسن تجاوبك.

لمزيد من التفاصيل / أو للمشاركة في البرنامج يرجى التواصل على الإيميل التالي:

أحلام الهاجري sbxaasa@nottingham.ac.uk

APPENDIX 9: DIETARY AND EXERCISE INTERVENTION POSTER IN ENGLIS



APPENDIX 10: DIETARY AND EXERCISE INTERVENTION POSTER IN ARABIC



APPENDIX 11: PRE EXERCISE SCREENING QUESTIONNAIRE

Pre Exercise Screening

Name: ……Age: ..... DOB: ...../...../.....

Address: ……..…….……

Phone Home: ……Mobile: …… Email: ……..…

Emergency Contact Person: …….. Phone: ……

1/ Do you have, or have you had:

- ❑ heart disease (please specify):
- ❑ High blood pressure
- ❑ High cholesterol
- ❑ Diabetes
- ❑ Lung disorder (eg. asthma, emphysema)
- ❑ Other cardiac problem (incl. pacemaker):
  ……
- ❑ No/ or none of the above.

2/ Have you ever been told you are <u>at risk</u> of:

- ❑ Heart disease
- ❑ High blood pressure
- ❑ High Cholesterol
- ❑ Diabetes
- ❑ Stroke
- ❑ No/ or none of the above.

3/ Have you ever been told that you have heart problems, eg:

- ❑ Heart murmur
- ❑ Valve defect
- ❑ Racing heart
- ❑ Irregular beats
- ❑ Angina
- ❑ Other:
  ……
  ……
- ❑ No/ or none of the above.

4/ Do you have, or have you experienced:

- ❑ epilepsy ❑fainting ❑ seizures
- ❑ dizzy spells ❑ convulsions
- ❑ No/ or none of the above.

5/ Do you experience sudden shortness of breathe?

- ❑ Yes ❑No

6/ Have you ever had pain or pressure, either at rest or during exercise:

- ❑ in the middle of, or on the left side of, the chest,
- ❑ In the neck region,
- ❑ At the left shoulder or down the left arm.
- ❑ No/ or none of the above.

7/ Do you take any medications for (please name):

- ❑ Heart disease
- ❑ Diabetes
- ❑ Cholesterol
- ❑ Blood pressure
- ❑ Asthma, breathing problems
- ❑ No/ or none of the above.

8/ Are you aged over 60 years of age:

❑ Yes ❑ No

9/Are you pregnant or are you actively trying?

❑ Yes ❑ No

10/ Do you have any joint or muscular problems that may affect your ability to train:

❑ Yes ❑ No

If yes, please explain:

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

11/ Do you have any other conditions or injuries that may affect your ability to train:

❑ Yes ❑ No

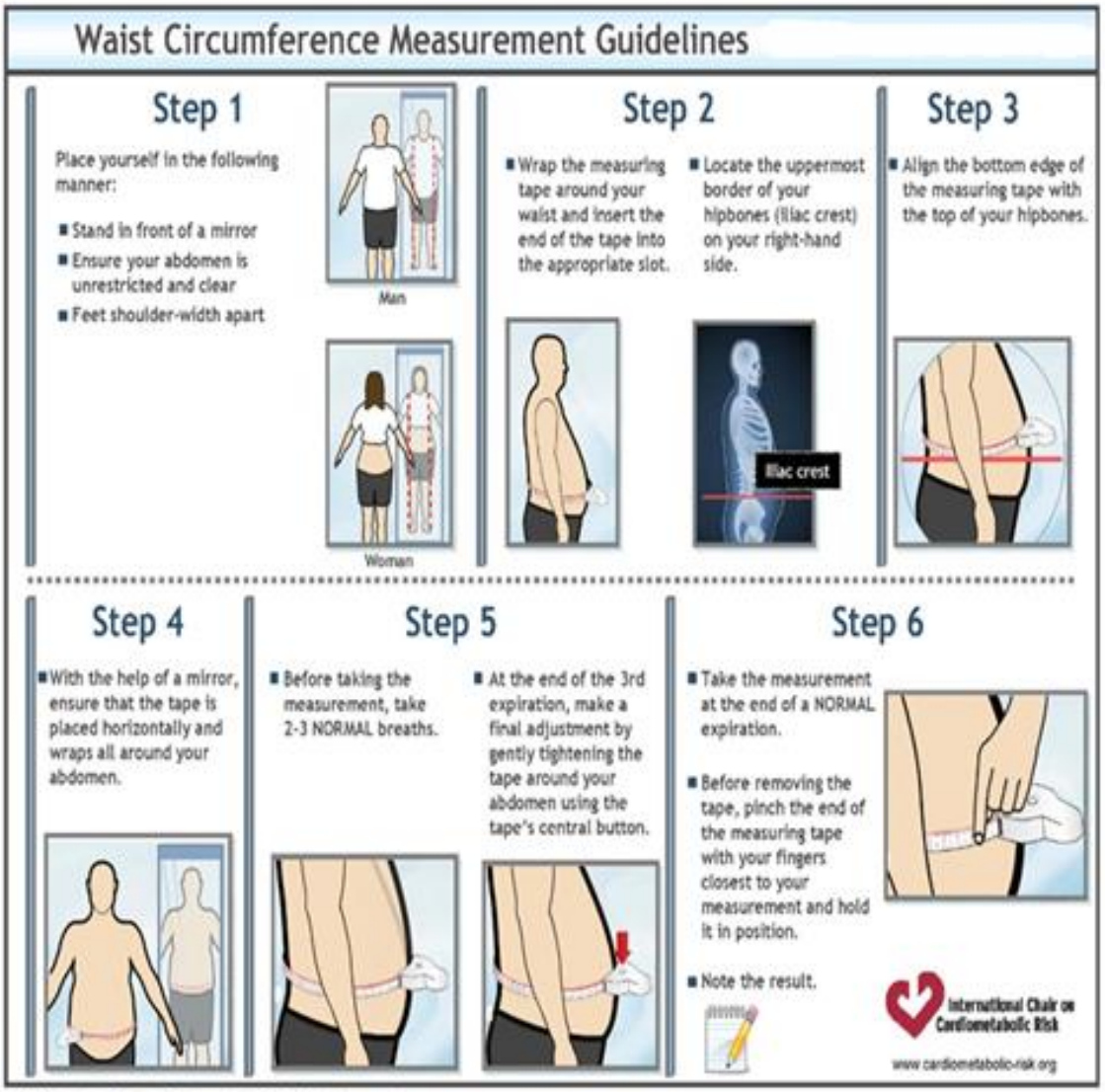
If yes, please explain:

……..……..……
……..……..……..
……..……

- ❑ **Client is: aged 18-60 and has <u>no</u> risk factors >>> cleared for moderate exercise prescription**
- ❑ **Client responded to one or more of Cardio-Respiratory risks >>> refer to Doctor for clearance**

Active8 Fitness Health Leisure (2009)

APPENDIX 12: WAIST CIRCUMFERENCE MEASUREMENT GUIDELINES



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APPENDIX 13: FOOD AND EXERCISE DIARY IN ENGLISH

Daily Food & Exercise Diary







Name_____

Email_____

Daily Food &Exercise Diary

First day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Daily Food &Exercise Diary

Second day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Daily Food &Exercise Diary

Third day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Daily Food &Exercise Diary

Fourth day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Daily Food &Exercise Diary

Fifth day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Daily Food &Exercise Diary

Sixth day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Daily Food &Exercise Diary

Seventh day

Date (day/month/year) __/___/___ ***Day of week (eg. Monday)***

Food	**Cooking method**	**Portion**	**Time**
Breakfast			
Mid-morning			
Lunch			
Mid-afternoon			
Evening Meal			
Any other snacks			
Cups of water			

Exercise	
Duration	

Example Day

Daily Food & Exercise Diary

First day

Date (day/month/year) *1/2/14* ***Day of week Monday***

Food	**Cooking method**	**Portion**	**Time**
Breakfast Corn Flakes with semi-skimmed milk Orange Juice Toast with Orange Marmalade Coffee with Milk, One Sugar	 Non-Cooked Toasted	 Medium 1 glass 3 thick slices small cup	9:00
Mid-morning Tea with Milk, One Sugar Digestive Biscuits	 Not Cooked	 1 cup 2 Biscuits	10:00
Lunch White Rice or kabsa Fish Salad Green Apple Cappuccino, 2 Sugars	 Boiled Roasted Not Cooked	 3 cup 3 Egg-Sized 1 Bowl 1 1	12:30
Mid-afternoon Tea with milk, One sugar Chocolate Banana	N/A	1 cup 50 g bar 1	2:15 3:00 4:00
Evening Meal Chicken with Gravy Potatoes Carrots Broccoli	 Roasted Roasted Steamed Steamed	 Large 3 Egg-sized Potatoes Medium	7:00
Cups of water	8 cups		

Exercise	Walking, Strength, Zumba
Duration	30 minutes

APPENDIX 14: FOOD AND EXERCISE DIARY IN ARABIC

السجل اليومي للغذاء والرياضة







الاسم:.....

البريدالإلكتروني:.....@.....

السجل اليومي للغذاء والرياضة

اليوم الأول

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

السجل اليومي للغذاء والرياضة

اليوم الثاني

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

السجل اليومي للغذاء والرياضة

اليوم الثالث

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

السجل اليومي للغذاء والرياضة

اليوم الرابع

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

السجل اليومي للغذاء والرياضة

اليوم الخامس

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

السجل اليومي للغذاء والرياضة

اليوم السادس

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

السجل اليومي للغذاء والرياضة

اليوم السابع

اليوم: **التاريخ:**

الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطور				
ما بين الفطور والغداء				
الغداء				
ما بين الغداء والعشاء				
العشاء				
عدد اكواب الماء				

الرياضة	
الفترة	

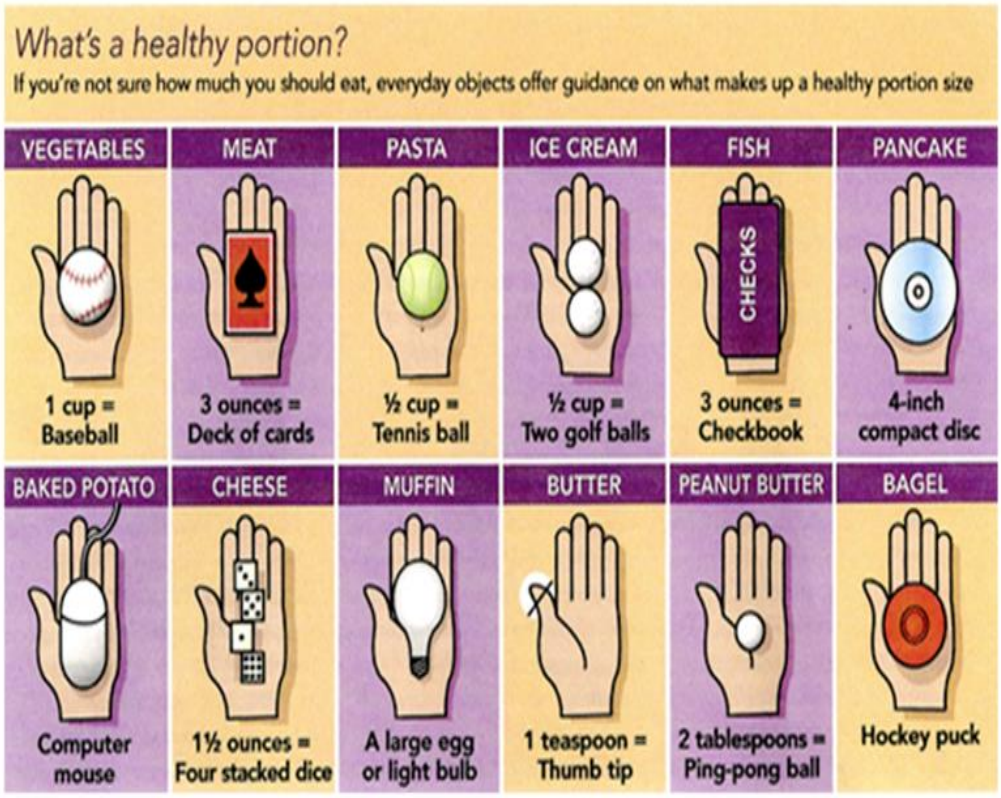
اليوم الأول

اليوم:الأثنين **التاريخ:1 /1435/3هـ**

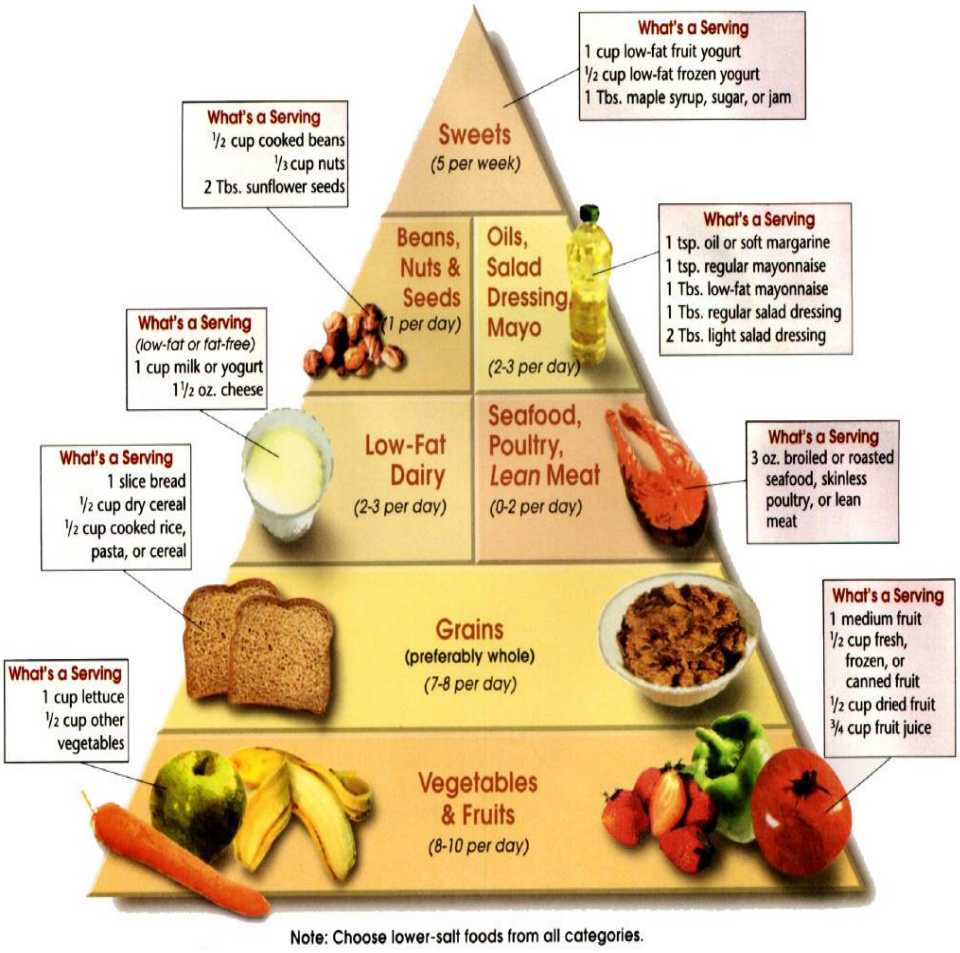
الوجـــــــبة	المـادة الغذائـية	طريقة الطبخ	كميـة الغـذاء	وقت تنـــــاول الطعام
الفطـــــور	رقائق الذرة (كورن فليكس) مع حليب قليل الدسم برتقاله القهوة مع الحليب ، سكر ملعقة صغيره واحد	غير مطبوخ واحده	1 كاس متوسط كاس صغير	الساعة 9
ما بين الفطور والغداء	شاي مع حليب، سكر ملعقة صغيره واحد بسكويت دايجستيف	غير مطبوخ	كاس صغير حبه واحده	الساعة 10
الغداء	أرز أبيض أو كبسة سمك سلطة التفاح الأخضر	سلق /تشويح مشوي غير مطبوخ	2كاس حجم 3 بيضات طبق صغير واحده	الساعة 12:30
ما بين الغداء والعشاء	شاي مع حليب، سكر ملعقة صغيره واحد شوكولا سوداء موز	غير مطبوخ	كاس لوح / 30 جرام واحده	الساعة 2:15 الساعة 3 الساعة 4
العشاء	الدجاج مع المرق البطاطا جزر بروكلي خبز بر	مشوي مشوي على البخار على البخار مخبوز	3 بيضات 1 حبة متوسطة 1 حبة صغيرة طبق متوسط شريحة واحده	الساعة 7
قبل النوم	زبادي قليل الدسم	غير مطبوخ	علبه	الساعة 10:30
عدد اكواب الماء	8 اكواب كبيره (2 ليتر)			

نوع الرياضة	المشي- ايروبيك-الرقص
الفترة	30 دقيقه

APPENDIX 15: HANDY GUIDE TO ESTIMATE PORTION SIZE

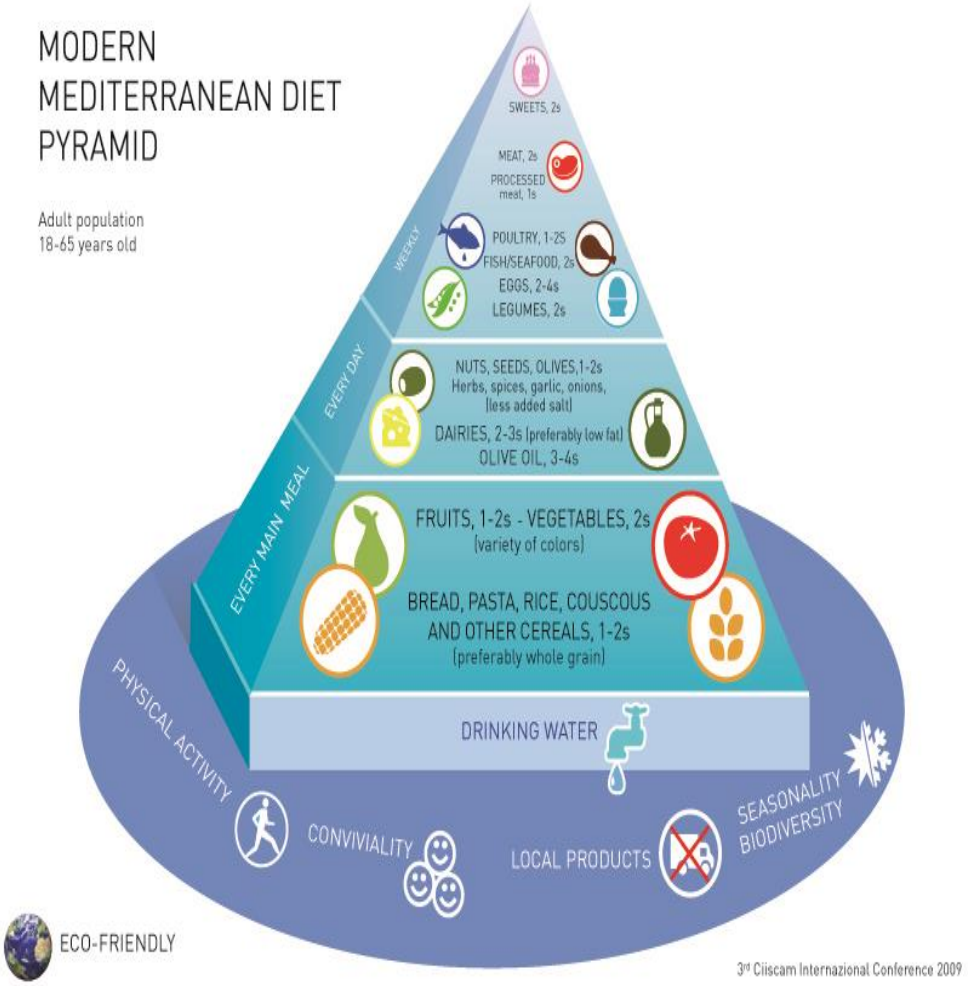


APPENDIX 16: THE DASH DIET PYRAMID



Note: Choose lower-salt foods from all categories.

APPENDIX 17: THE MEDITERRANEAN DIET PYRAMID



APPENDIX 18: THE NUTRITIONAL INFORMATION LIST

- Increasing water intake and its benefits
- DASH diet
- Mediterranean diet
- Portion sizes for each food group
- Fruit with nutritional analysis table
- Vegetables with nutritional analysis table
- Grains and fibre with nutritional analysis table
- Milk and its products with nutritional analysis table
- Meat and alternatives with nutritional analysis table
- Pulses with nutritional analysis table
- Nuts and seeds with nutritional analysis table
- Fats and types of oils and sauces with nutritional analysis table
- Cook healthy, well-balanced meals at home and gave them some healthy recipes, including some traditional Saudi cuisine that can be cooked with healthy low calorie, low fat choices.
- Eating out and fast food
- Healthy snacking versus crisps, chocolates and sweets
- Soft drinks, energy drinks and sugary drinks versus fresh fruit juice
- Sugar, honey and artificial sweeteners
- Reading nutrition fact labels
- Eating food that can stimulate the metabolism
- Eating food that can strengthen the immune system, such as those rich in antioxidants and volatile substances
- The health consequences of obesity and related diseases
- Sport
- Low glycaemic index food and complex carbs
- Slimming drugs
- Recommendations for breakfast(e.g. cereal, barley, out and beans)
- Start with soup and salad with some recipes
- The power of positive thinking and its effects on weight loss
- General advice (e.g. eat slowly and chewing food for a long time , use small plate and spoon, avoid late night snacks, don't need to starve yourself to lose weight, walk five minutes for at least every two hours etc.)