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The Association between Physical Activity, Dietary Behavior and Body Mass Index among Saudi Women Living in KSA and UK

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Abstract: This study investigates the association between Physical Activity (PA) and dietary intake with Body Mass Index (BMI) among Saudi women living in Saudi Arabia and women living in the UK. A survey of a snowball sample was used to recruit 258 female and explored factors influencing PA and food intake and their effects on BMI in women living in KSA and UK. Participants completed a self-reporting questionnaire relating to knowledge, attitudes, barriers, and levels of PA, sedentary activity and eating habits. Several results were concluded, most importantly: 1) Excessive energy intake, physical inactivity, and sedentary lifestyle were all prevalent in Saudi women, resulting in 80%، over the age of 35 years being overweight or obese. 2) 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. 3) Findings were generally similar between women living in Saudi Arabia and the UK. 4) This study confirms that excessive dietary intake and physical inactivity both contribute to overweight and obesity in Saudi Arabian women.

Keywords: Physical Activity, Dietary Behavior, Body Mass Index, KSA, UK.

العلاقة بين النشاط البدني والسلوك الغذائي ومؤشر كتلة الجسم بين النساء السعوديات اللواتي يعشن في المملكة العربية السعودية والمملكة المتحدة

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الملخص: تبحث هذه الدراسة العلاقة بين النشاط البدني والمدخول الغذائي مع مؤشر كتلة الجسم بين النساء السعوديات اللواتي يعِشن في المملكة العربية السعودية والنساء اللواتي يعشن في المملكة المتحدة. شملت الدراسة 258 امرأة واستكشفت العوامل المؤثرة في النشاط البدني وتناول الطعام وتأثيراتها على مؤشر كتلة الجسم لدى النساء اللواتي يعشن في المملكة العربية السعودية والمملكة المتحدة. أكمل المشاركون استبيانًا يتعلق بالمعرفة ومستويات النشاط البدني والنشاط المستقر وعادات الأكل. وقد أظهرت الدراسة عدداً من النتائج كان أهمها: 1) أن الإفراط في تناول الغذاء، وقلة النشاط البدني وأنماط الحياة المستقرة كانت كلها سائدة بين النساء السعوديات، مما أدى إلى انتشار السمنة بين 80% من النساء اللواتي أعمارهن فوق 35 سنة. 2) كما أظهرت الدراسة ارتباط مؤشر كتلة الجسم بكل من الاستهلاك الغذائي والنشاط

البدني، على الرغم من أن العلاقة مع مؤشر كتلة الجسم كانت أقوى. 3) وتبين ان العوائق الأكثر شيوعًا أمام ممارسة التمارين الرياضية تتمثل في استخدام وسائل النقل وضيق الوقت. كما كانت النتائج متشابهة بشكل عام بين النساء اللاتي يعشن في المملكة العربية السعودية والمملكة المتحدة. 4) وفي الختام تؤكد هذه الدراسة أن الإفراط في تناول الغذاء وعدم النشاط البدني يسهمان في زيادة الوزن والبدانة لدى النساء السعوديات.

الكلمات المفتاحية: النشاط البدني، السلوك الغذائي، مؤشر كتلة الجسم، المملكة العربية السعودية، المملكة المتحدة.

Introduction

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% [1]. 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 [2]. Evidence indicates that the root cause of increasing obesity can be traced back to poor eating habits and a sedentary lifestyle [3].

The KSA has been undergoing rapid urbanization 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 [4] as well as Sugar-rich soft drinks (Midhet et al., 2010; Mohieldein et al., 2011). According to Musaiger [5], 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. Consequently, the consumption of fat, especially saturated fatty acids, and simple sugar has risen, while, at the same time, the consumption of dietary fiber has declined. As a result, the population is at increased risk of diet-related chronic diseases, particularly obesity, CVD, diabetes mellitus and cancer [5]. 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, anemia from iron deficiency and some individuals being underweight, and those associated with over-nutrition and changes in lifestyle, such as obesity, diabetes and hypertension [5]. This situation presents a great challenge for the Saudi Health Authority.

Fundamentally, food intake and PA are two of the factors that are a part of an individual's own choice of behavior and lifestyle [6]. 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 environment and access to a wide array of foods and technologies inevitably impacts on behavior and can promote habitually

unhealthy lifestyles [7]. For example, studies have shown that exposure to a wide array of tastes and flavors can actually promote energy consumption [8] 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 [6, 3].

Numerous studies have confirmed that bringing about changes in people's patterns of PA and diet remains the central goal of all treatment programs, 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 behaviors, including physical inactivity, prolonged sitting time and dietary intake, particularly those may influence women and may influence 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 behavior 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.

Research Objectives

The major objective of the current study 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). Along with the main objective, the research is aiming to achieve the following:

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, analyzing carbohydrates, proteins, fats, selected vitamins and minerals, fiber 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.

Research Problem

Making individuals with obesity move and improving adherence to exercise is a critical challenge: hence, the importance to better understands the psychological and cultural determinants of exercise behavior. 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 [10]. According to a review article by Schutzer and Graves [11], overcoming the environmental obstacles and improving the participants' knowledge about PA does 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 behavior change of the participants [12]. However, perceived feelings of enjoyment and satisfaction have appeared to better predict higher levels of adherence [13].

In light of the abovementioned, the research problem could be summarized in the following question:

What is the association between physical activity, dietary behavior and body mass index among Saudi women living in KSA and UK?

Literature Review

Physical Activity within Saudi Context

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 labor, accompanied by new technologies that promote sedentary lifestyles [14]. In addition to these factors, multiple pregnancies are considered another important factor in the high rate of obesity in women in Arabic countries [15]. Previous studies have shown that physical inactivity is extremely prevalent among both sexes and all age groups of the Saudi population [14]. There were, however, significantly more inactive females (98.1%) than males (93.9%). The high prevalence of physical inactivity in Saudi society has emerged as a serious threat to public health [14].

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 practice exercise outdoors for religious and safety reasons [16]. 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. AlQuaiz and Tayel [17] 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. 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. Environmental factors play a fundamental role in shaping human health and locational issues are of central importance in addressing health questions. As such, considerable evidence suggests changes in health-related behavior 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 [18]. 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 behaviors.

Physical Activity within International Context

Perez-Cueto et al. [18] reported that 85% of international students made dietary changes on their arrival in Belgium. Pan et al. [19] 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. 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 fiber. The data also indicated an increase in the 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 a higher risk of obesity, T2D and CVD [20].

In addition, environmental influences play an important role in promoting or inhibiting PA [21]. 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. 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 [22]. 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 [23] 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.

Reasoning of Research from the Literature

Making individuals with obesity move and improving adherence to exercise is a critical challenge: hence, the importance to better understands the psychological and cultural determinants of exercise behavior.

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. According to a review article by Schutzer and Graves [11], overcoming the environmental obstacles and improving the participants' knowledge about PA does 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 behavior change of the participants. However, perceived feelings of enjoyment and satisfaction have appeared to better predict higher levels of adherence [13].

Method and Procedures

Research Design and Sample

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. 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 to recruit the study sample. This was in addition to e-mail, SMS, WhatsApp messages and posters. 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.

Research Method and Procedure

The researcher developed and distributed a self-reported questionnaire relating to knowledge, attitudes, barriers, and levels of PA, sedentary activity and eating habits.

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 (m^2), which was categorized according to the World Health Organization (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).

The questionnaire included the following sections:

- **Section (1):** included questions relating to demographic data, i.e. age, height/weight, education level, marital status, number of children, employment status and income.
- **Section (2):** assessed participants' PA and sedentary behaviors.
- **Section (3):** assessed participants' knowledge and attitudes towards their health, weight and fitness status.
- **Section (4):** investigated the salient perceived barriers to PA.
- **Section (5):** assessed factors that would motivate participants to be more physically active.
- **Section (6):** investigated the PA programmes and services in the participants' community.

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).

Socio-demographic characteristics

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

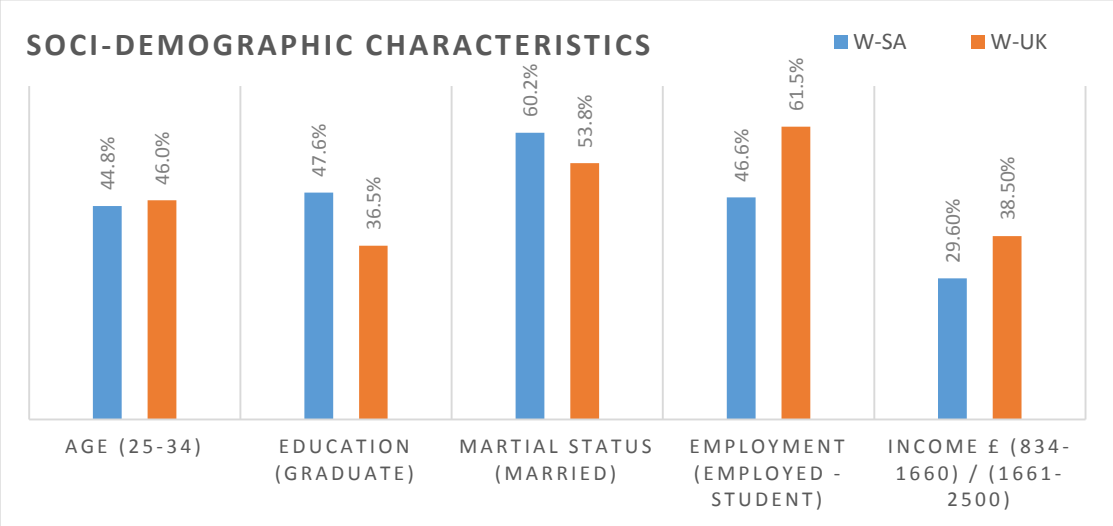

Figure (1) Soci-demographic characteristics

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%). The 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 ($p<0.001$).

Physical activity and sedentary behaviors

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.

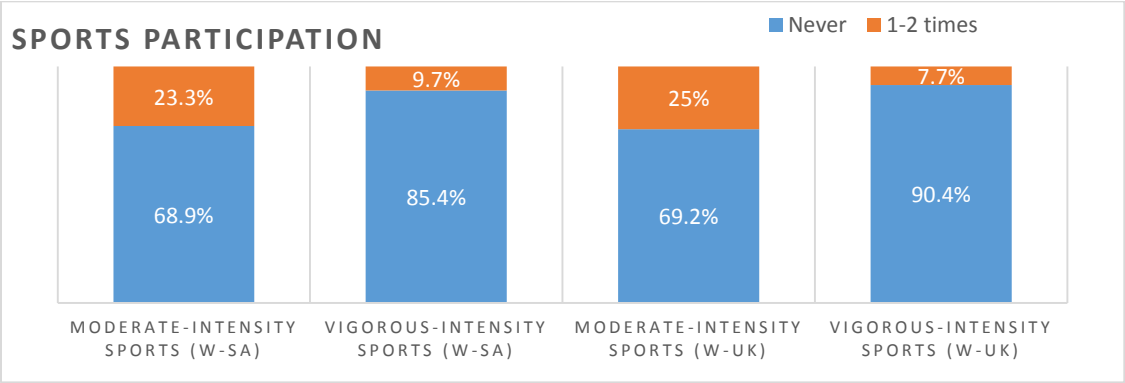

Figure (1) Sports Participation

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, high proportions 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).

Table (1) Lifestyle patterns and sedentary behavior

	WOMEN-SA	WOMEN-UK
HAVING A MAID	39.8% (yes)	11.5% (yes)
HOUSEHOLD WORK HOUR/WEEK	27.3% (1-2 hours) 28.3% (3-4 hours)	44.2% (1-2 hours) 26.9% (3-4 hours)
WATCHING TV	59% (2 hours or more)	50% (2 hours or more)
USING A COMPUTER (HOME)	70% (2 hours or more)	87% (2 hours or more)
USING A COMPUTER (WORK)	40% (2 hours or more)	61% (2 hours or more)

Knowledge and attitudes of participants towards their health, weight and fitness status

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.

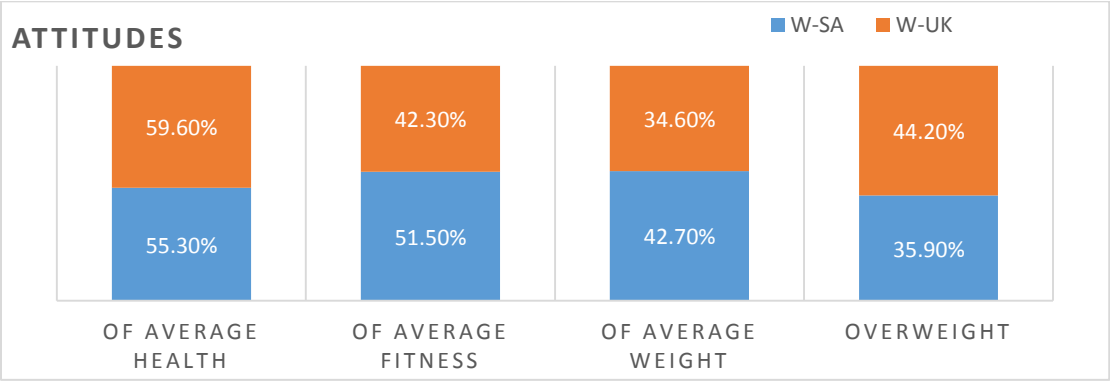

Figure (3) Attitudes towards health, weight, fitness and physical activity

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.

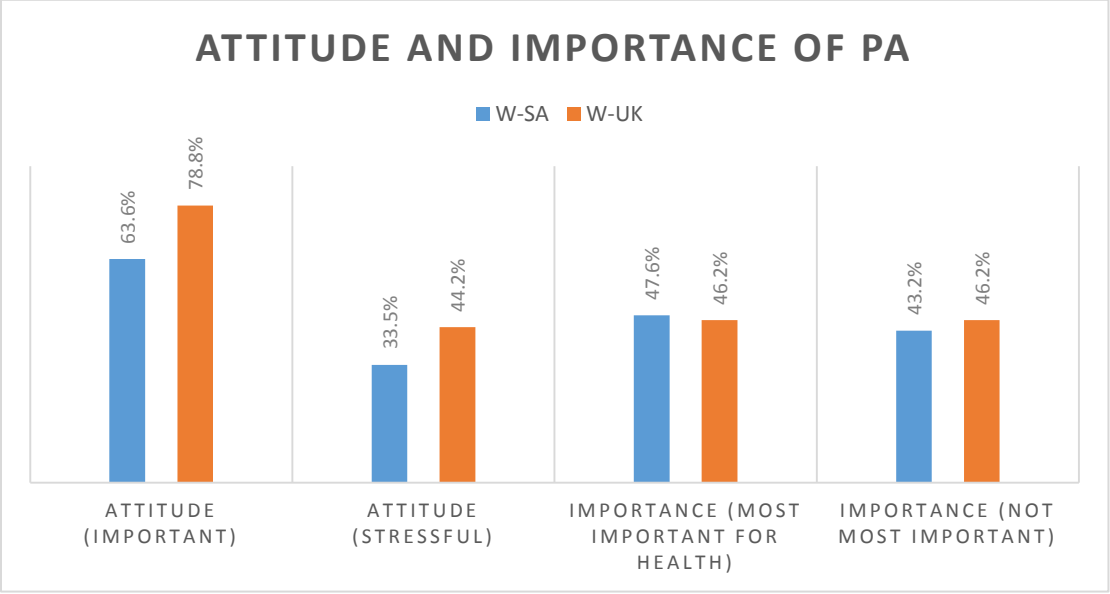

Figure (4) knowledge towards health, weight, fitness and physical activity

Knowledge regarding physical activity

The knowledge of diseases and how risk can be minimized 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.

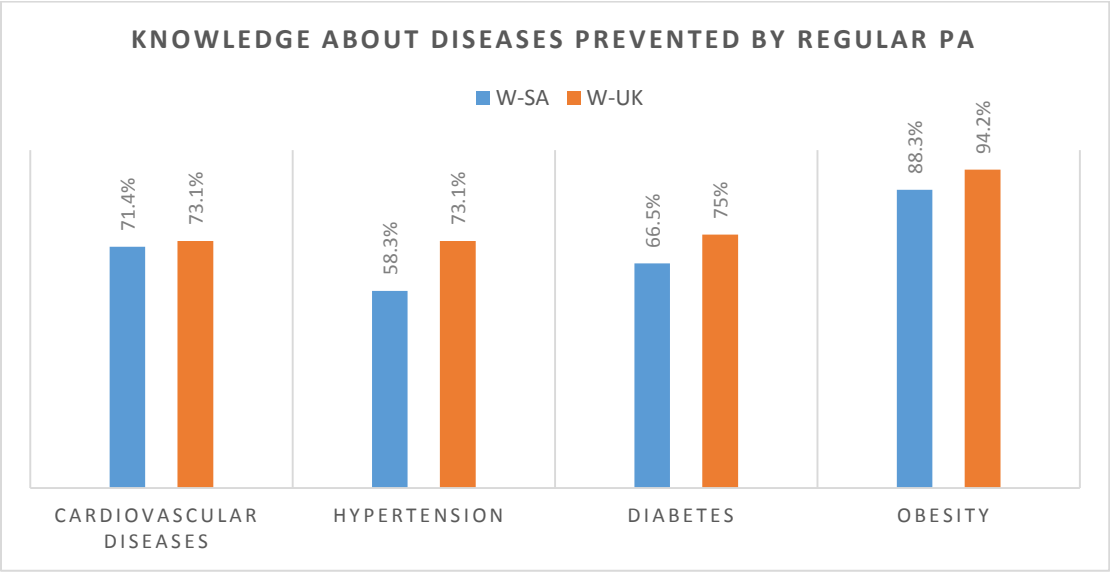

Figure (5) Knowledge regarding diseases prevented by regular physical activity

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).

Table (2) Amount of exercise

	WOMEN-SA	WOMEN-UK
AMOUNT OF EXERCISE PER DAY	38.8% (About 30 minutes)	48.1% (About 30 minutes)

	WOMEN-SA	WOMEN-UK
NUMBER OF TIMES PER WEEK	51% (3 times) 14.1% (5 or more)	57.7% (3 times) 23.1% (5 or more)

Perceived barriers to physical activity

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 ($p<0.001$).

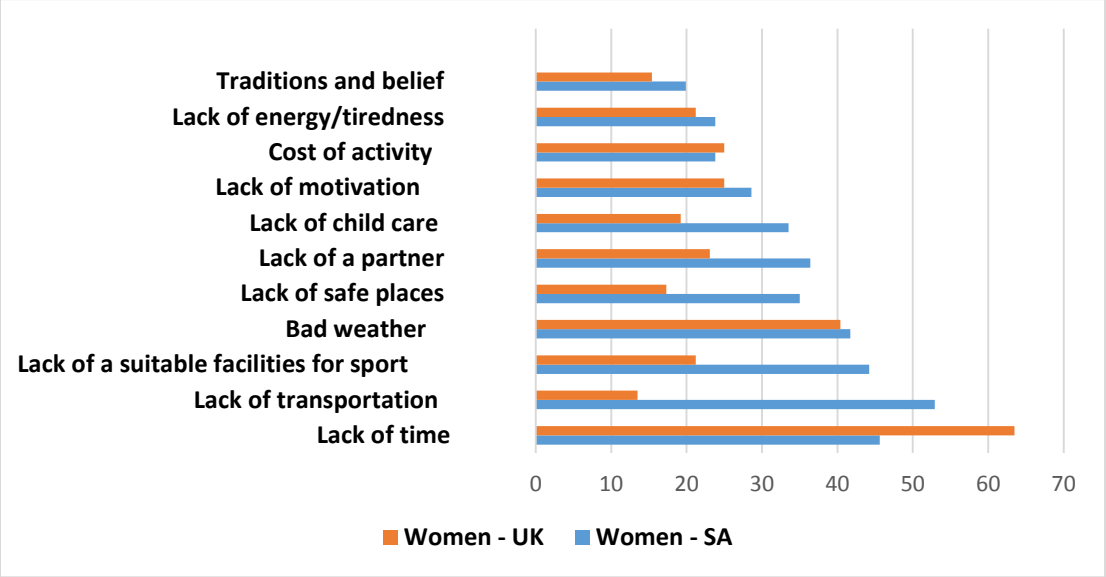

Figure (6) Perceived barriers to physical activity

Factors motivating physical activity of participants

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 ($p=0.016$).

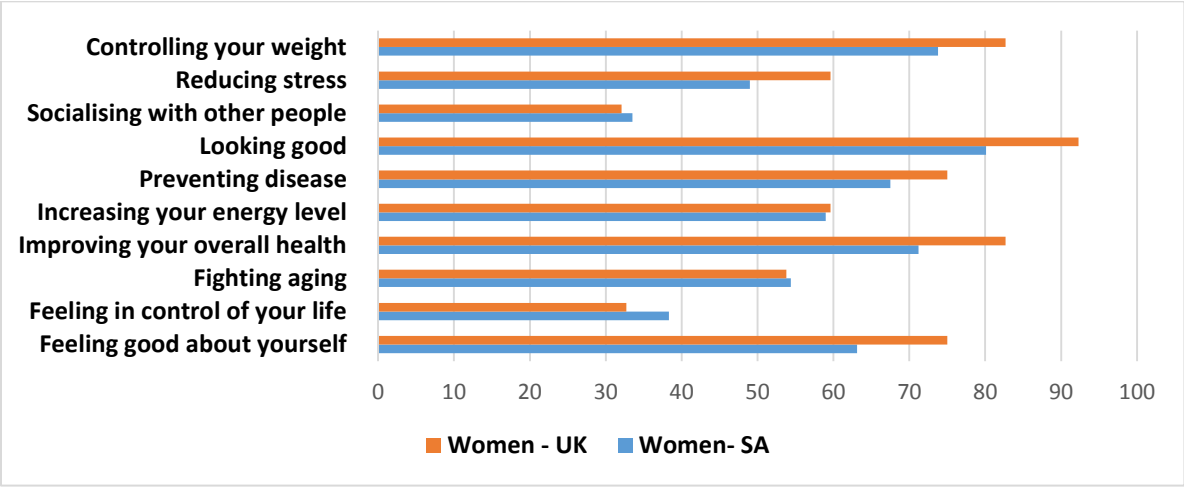

Figure (7) Factors motivating physical activity of participants

Physical activity programmes and services in the participants' 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. 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).

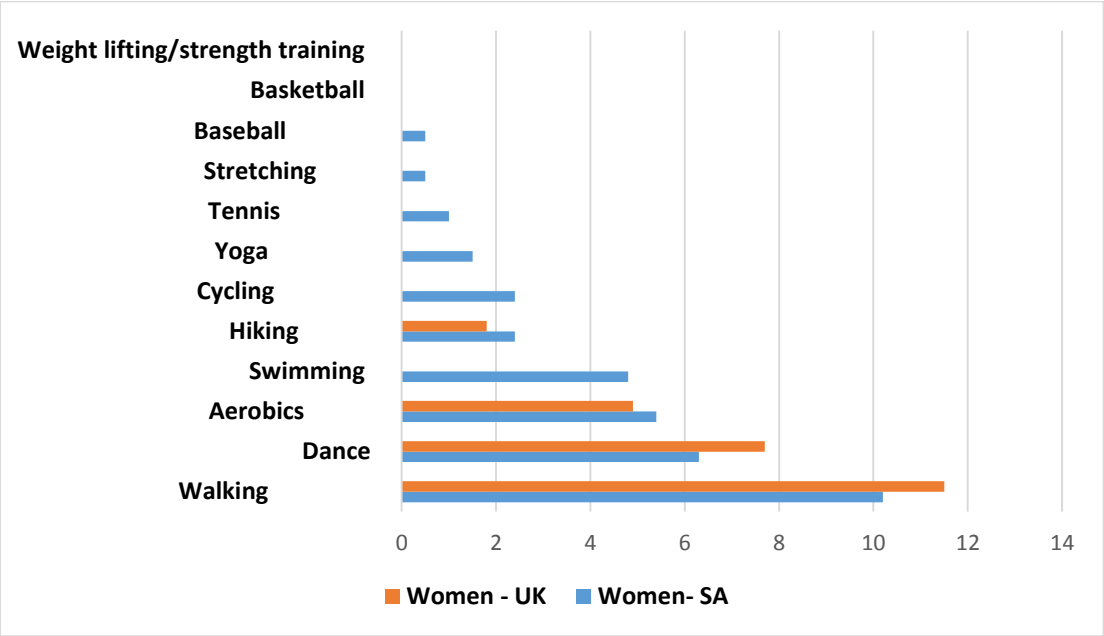

Figure (8) Types of physical activity women prefer

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.

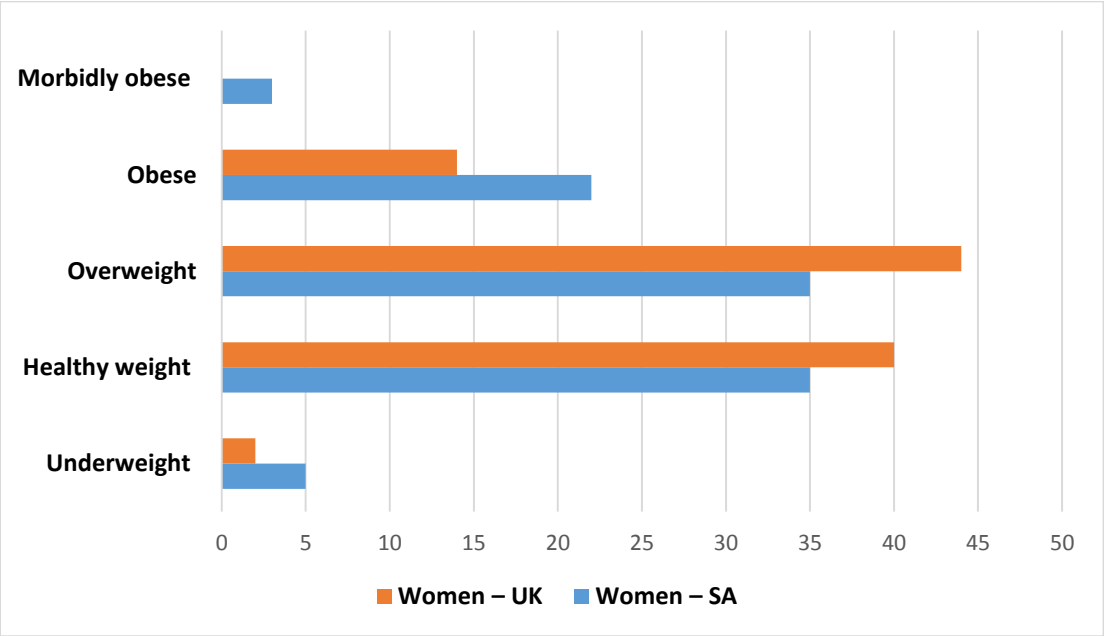

Figure (9) Body Mass Index classification

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 [25]. 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 fiber intake. It is clear from that woman 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 fiber (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 grams 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 grams 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) 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

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.

Table (4) 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%)

Nutrients	Women-SA	Women-UK	Reference value
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

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 that vitamin intake (for vitamins E, C, B_1, B_{12}, and B_9) and mineral intake (for calcium and zinc) was higher than the RNI for both groups. By contrast, Vitamin A, Vitamin D and iron intakes were below the recommended amounts for both groups.

Table (5) 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

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

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. 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 ($p< 0.001$). 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 (10) Average daily consumption of servings in each food group among study participants

Associations between obesity and age in women

The 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 the age group and the country as factors, which showed no significant differences between W-SA and W-UK ($p=0.989$).

Levene's test suggests that the data are not normally distributed and should probably be transformed. However, there is clearly no effect of a country or an interaction between country and age. Therefore, the data were pooled and investigated for the 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 ($p<0.001$). 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 groups 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 groups, 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. 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 were 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.

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. Outliers were removed and a 2-way ANOVA was performed.

A two-way ANOVA was performed using age group and the country as the factors and, once again, it showed no effect of the 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.

The computerized 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. Margot, Kabsa, Mandi and Quiz) 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. 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 [31].

Intake of carbohydrate, protein and fat all increase with age, but remain relatively constant when expressed as percentages of total energy intake 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.

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.

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, the 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

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.

Discussion

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 behaviors 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 an 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 specialized 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 the safety of the places.

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 of 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 [25]. 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" [26]. The increased visibility of and greater public roles for

women as individuals will likely lead to further normalization in society. This transformation will help women realize their individuality and prompt additional changes to their situation [27].

Furthermore, it is observable that, due to the westernization 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 [28]. It is therefore important to repeat this kind of work as the culture continues to change, to make sure the conditions are favorable 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 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 addressed. 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.

Conclusions

This study assessed a broad range of factors related to PA behaviors, knowledge, attitudes, barriers, motivations and preferences. Measures that capture the duration, frequency and intensity of activities were included. The study collected data on PA and dietary intakes and demonstrated 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.

Various methodological limitations were considered within this research. First, the relatively small sample size particularly among W-UK and the limitation of the study's sample to women over the age of 18 and up to 54 living in Al-Ahsa province requires caution in generalizing the findings over the whole population. Secondly, the study used a snowball sampling and, whilst effort was made to make it representative, the self-selective bias of individual participants inevitably impacts the generalisability of the study results.

In the current study, self-reported anthropometric data was considered the most appropriate tool to diagnose obesity which may 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 [29] and the self-reported height and weight are valid to estimate the overweight/obesity prevalence in the population.

Moreover, the use of more than one 24-hour recall would be more useful to estimate usual intake. Bias and under-reporting of energy intake are a major concern in dietary surveys, particularly among obese subjects. 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 [9].

Recommendations

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.

It is recommended that future studies use a randomized sampling research design instead of snowball sampling in order to achieve more generalizable results.

Future studies could utilize a mixed approach in data collection through both objective and self-report measures of PA.

The reliability of the questions has not been tested statistically. As such, further research is needed to evaluate the PA questionnaire's reliability and validity to ensure that the measurements obtained are representative and stable over time and suitable for use in large-scale population-based studies.

Limitations regarding computerized nutritional analysis highlight the need within future work 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 behavior in research on PA. For instance, the theory of reasoned action (TRA) and the theory of planned behavior (TPB) have been used particularly in the field of exercise psychology [32].future work could expand on our finding using theories for measuring attitudes toward PA to include a more detailed consideration of attitudes and behavior towards PA in this population.

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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