

University of Bahrain

College of Science

Department of Biology



Evaluation of Metabolic Derangement Among Bahrainis in Relation to Body Mass Index

**A Thesis Submitted in Partial Fulfillment of the Requirements for the
Master Degree in Nutrition and Dietetics**

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Defense Committee's Approval

University of Bahrain
Deanship of Graduate Studies
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عمادة الدراسات العليا والبحث العلمي

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The Discussion Committee met on 14-Feb-22 In MS Teams. Upon discussing the student whose details are stated above in public, the discussion committee recommends the following:

The student is awarded a grade A in the thesis subject.

- ☐ Without making any changes to the thesis.
- ☒ After making the modifications attached with this decision.

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Abstract

Objective: The main objective of the study was to evaluate metabolic derangements among Bahraini adults in relation to body mass index (BMI).

Methods: A cross sectional design was used on a convenient sample of Bahraini patients in the age group of 20-65 attending King Hamad University Hospital (KHUH) outpatient clinics of neurology, dermatology and respiratory between August 2021 and September 2021. Participant's data was checked using the electronic KHUH patients record and further verified through a phone call. Furthermore, Patients who met the inclusion criteria and consented to the research were approached on their scheduled appointment day and anthropometric, blood pressure measurements along with blood investigations were obtained. Then data were analyzed and interpreted using a statistical significance of less than 0.05. A total of 194 participants were investigated upon completion of data collection from the electronic records, phone interview and procedures carried out during the appointments. According to the findings, the prevalence of obesity among the participants was 39.2% with age and marital status being the only two variables having statistical significance with BMI ($P < 0.001$). On the other hand, statistical significance with BMI was achieved with all the metabolic variables, with the strongest association being between obesity and low-density lipoprotein (LDL-C). It was demonstrated that among obese individuals the percentage of hypertension was 28.9% ($P=0.002$), pre-diabetes was 36% ($P < 0.001$), abnormal total cholesterol was 47.4% ($P=0.006$), abnormal triglycerides (TG) was 25% ($P=0.002$), abnormal LDL-C 100% and abnormal high density lipoprotein (HDL-C) was 31.6% ($P=0.009$).

Conclusion: The findings of this study revealed that obese individuals demonstrated higher incidence of metabolic abnormalities than their under/normal weight counterparts. This demonstrates that BMI has a significant negative impact on metabolic parameters that increases as BMI rises and worsens over time.

Dedication

I dedicate my work to my supportive family and friends. Although finishing this thesis has been a rollercoaster, my family were like a backbone supporting me and encouraging me throughout the process. I'd like to thank my loving parents, Mohammed Alnashaba and Entesar Mirza whose belief in me inspired me to keep pushing forwards and pouring my energy to help others with my work. My husband, Bashar Alnashaba who always has been by my side through my ups and downs, I wouldn't have achieved anything without him as he compromised a lot of his time and energy to push me to persist and achieve. My sisters, Malak and Jenan Alnashaba whose love for me pushed them to volunteered to review my work with the little experience they have in my field, encouraging me to persevere while taking a break to prevent burnout.

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List of Abbreviations

ADA: American Diabetes Association

BMI: Body Mass Index

CHD: Congestive Heart Disease

CRP: C-Reactive Protein

CVD: Cardiovascular Diseases

ESR: Erythrocyte Sedimentation Rate

FPG: Fasting Plasma Glucose

HDL-C: High Density Lipoprotein Cholesterol

HOMA-IR: Homeostasis Model Assessment Index for Insulin Resistance

IFP: Impaired Fasting Glucose

KHUH: King Hamad University Hospital

LDL-C: Low Density Lipoprotein Cholesterol

MI: Myocardial Infarction

NCDs: Non-Communicable Disease

NOW: Normal Weight Obese

OWO: Overweight Obese

SSF: subscapular skinfold

TG: triglyceride

TSF: triceps skinfold

VLDL: Very Low Density Lipoprotein

WC: Weight Circumference

WHO: World Health Organization

Chapter One: Introduction to the Study

1.1 Introduction

1.2 Research Problem

1.3 Research Questions

1.4 Research Objectives

1.5 Research Significance

1.6 The Study's Setting

1.7 Research Terminology

Introduction to the Study

1.1 Introduction

According to the most recent statistics from the World Health Organization (WHO) in 2017, the global obesity has nearly tripled since 1975 (WHO, 2021). Obesity is a disorder that results from genetic and environmental interplay, and the metabolic consequences of this disorder varies widely among individuals. Over the past few decades urbanization, dramatic lifestyle, nutritional, socioeconomic and demographic changes have led to the development of the double burden phenomenon in many developed and developing countries including Bahrain. The double burden phenomenon refers to the ongoing problem of undernutrition with a surge in over nutrition which poses a great peril on the individuals health and the country's economy status because of the link between this problem and the development of non-communicable diseases (NCDs). In reference to the WHO, the undernourished population has decreased, while the over nourished population has increased (Misra et al., 2008).

Nowadays, it is difficult to discuss matters related to body shape, weight, and health status without referring to the body mass index (BMI). BMI is an international, standard metric measure, adopted by the WHO, that is used in clinical practice, studies, for setting public health policies and establishing disease related guidelines. Moreover, BMI defines adults' characteristics of the anthropometric measures height and weight and helps to classify individuals into a set of BMI categories that gives an indication on the level of body fatness and health.

The WHO stated that a high BMI is a key risk factor for NCD like cardiovascular disease (CVD), diabetes, musculoskeletal problems, and

some malignancies (WHO, 2021). Moreover, it is a major risk factor for the development of hypertension and dyslipidemia. That being said, high BMI is a modifiable risk factor that can be targeted by prevention strategies to lessen its impact on health and economy.

On the other hand, there is a subpopulation of people with obesity that have a normal metabolic profile, in spite of the level of body adiposity (Brochu et al., 2001). On the contrary, Meigs et al (2006) have reported individuals having normal BMI but exhibited metabolic derangements that are typical of obesity, these are called metabolically obese normal weight individuals. Consequently, in order to understand the size of the problem, and whether prevention plans should be developed and implemented to target BMI, the relationship between individuals with metabolic abnormalities and their BMI needs to be looked into in order to investigate whether a statistically significant relationship exists between the number of individuals with a particular metabolic derangement and high BMI.

1.2 The Research Problem

Contrary to the past where communicable diseases were common, NCD rates are steadily increasing locally and globally. This shift came as a consequence of many complex interconnected factors which includes genetic, environmental and psychosocial factors. The effect of excessive body fatness in the development of NCDs has been well established (Wildman et al., 2010, Chandra et al., 2014). Data from life insurance companies have shown that weight that is calibrated for height was considered as an independent indicator for life expectancy since the beginning of the twentieth century (Nuttall et al., 2015). More

importantly, many studies have established a link between obesity measured by high BMI and metabolic derangements which includes elevated blood pressure, and increased levels of both plasma glucose and plasma lipids, which eventually leads to the development of hypertension, type 2 diabetes mellitus, hypercholesteremia and cardiovascular disease (CVD) (Dua et al., 2014, Lazar et al., 2005). Nevertheless, this relationship is very complex and affected by many factors such as body fat distribution, genetics, hormones, and physical activity.

1.3 The Research Questions

Upon reviewing the literature, the following important questions arose:

- Is there a relationship between high BMI and metabolic derangement?
- Can BMI be used as an indicator for the risk of development of diabetes, hypertension, and dyslipidemia?
- Is targeting BMI by primary prevention programs a cost-effective strategy?
- Can individuals with high BMI have a metabolically normal profile?
- Can individuals with normal BMI have a metabolically abnormal profile?

1.4 The Research Objectives

The study was conducted/ undertaken to fulfil the following objectives:

- To measure the anthropometric parameters of the participants.
- To determine the metabolic derangements of the participants.
- To categorize participants according to their BMI.
- To assess the relationship between high BMI and various metabolic abnormalities.
- To evaluate the benefit of targeting BMI as a primary prevention strategy for high blood sugar, abnormal lipid profile and elevated blood pressure.

1.5 Research Significance

Research studies showed that overweight and obesity numbers are dramatically increasing. In 2016, 39% of adults over the age of eighteen were overweight, while 13% were obese (WHO, 2021). Due to this rise, many studies evaluated the effect of obesity on health, and this study showed a relationship between obesity and NCDs. Many of these studies depended on BMI as a credible measure to assess the participants weight and relate it to their metabolic profiles. On the other hand, it is wellknown that BMI is not a reliable indicator of body fat, moreover, a study by Brochu (2001) have found a subset of individuals with high BMI and normal metabolic profile (Brochu et al., 2001). Therefore, assessing whether BMI significantly impacts the metabolic profile of the selected population, will aid in planning prevention strategies that is both health and cost effective in preventing derangement in the metabolic profile and its consequences.

1.6 Study's Setting

The study will be conducted using participants attending King Hamad University Hospital (KHUH) in Muharraq, Bahrain in the outpatient clinics of neurology, dermatology and respiratory, by retrieving data from participants' medical records and by measuring their weight and height to calculate their BMI in the clinic. The results were analyzed to fulfil the objectives of this research.

1.7 Research Terminology

According to WHO:

- BMI: is a simple weight-for-height index that is often used to identify persons as overweight or obese. It is calculated by multiplying a person's weight in kilograms divided by the square of height in meters (kg/m^2).
- Overweight: $\text{BMI} \geq 25$ in adults.
- Obesity: $\text{BMI} \geq 30$ in adults.

Chapter Two: Theoretical Framework and Literature

Theoretical Framework and Literature

The first study was by Wildman (2010) handling the CVD risk of abdominal obesity versus metabolic abnormalities, the population of this study was extracted from three large studies, the Framingham Offspring Study (FOS), the Atherosclerosis Risk in Communities Study (ARIC) and the Cardiovascular Health Study (CHS), which used three constrained public databases. The FOS study started in 1917, enrolled 5124 women and men, aged between 5-70 years who were family members of subjects in the Framingham Heart Study. The ARIC (1987-1989), enrolled 15,732 women and men between the age of 45-64 years. Conducting a study with data pooled from three large studies, that included different participants from different populations strengthens the representation and the generalization of the current study results to the general population. Moreover, having data extracted from databases avoids the tendency of recall bias that can appear from interviewing the participants and saves time. (Wildman et al., 2010)

Extracting data from the three databases resulted in enrolment of 26,744 subjects. The exclusion criteria included baseline age less than 45 years (n= 1079), lack of age data (n= 1198), subjects in the underweight category ($BMI < 18.5 \text{ kg/m}^2$), lack of data on waist circumference (WC) (n= 85), medical history of stroke, peripheral vascular disease and CVD in all three studies and heart failure for FOS and CHS, at the baseline of the study for CHS and

ARIC and the baseline of the original study or at any time starting from the initial to the fourth visit for the FOS study (n= 3158); lack of data on stage four obesity (n= 273), and if fasting hours were less than 8 hours before attending the study visit (n= 490), ending with 20298 subjects included in the analysis of this study (Wildman et al., 2010).

In regard to data collection, blood pressure measurement was carried out in the sitting position after a period of rest with the average of two measurements taken. BMI was calculated by measuring the weight in kilograms and the height in meters then dividing the weight by the height in squared meters. BMI was categorized into three categories: normal ($\text{BMI} < 25 \text{ kg/m}^2$), overweight ($\text{BMI} 25\text{-}29.9 \text{ kg/m}^2$) and obese ($\text{BMI} \geq 30 \text{ kg/m}^2$). In all three studies, WC was measured in standing position at the level of the umbilicus. Therefore, the cutoff point for abdominal obesity was $> 88 \text{ cm}$ for women and $> 102 \text{ cm}$ for men. Smoking and alcohol consumption were evaluated using a questionnaire across all three studies. Across all studies, blood samples were collected after ≥ 8 hours of fasting. Blood collection included plasma glucose, triglyceride, high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein (VLDL), were all analyzed. The participants were followed up for an average of 8.3 years, which is a reasonable period of time to monitor for complications and disease development, during which there was 1766 CVD incidents, of these events 648 were due to stroke and 1118 were due to (CHD). Moreover, obese individuals were mostly African American women, aged between 45-64 years, low educational

level, without current or past history of smoking, nondrinkers or used to drink in the past and diabetics or with metabolic syndrome. Unlike participants without diabetes or metabolic syndrome, those with diabetes or metabolic syndrome were mostly African American older obese men, with low educational level, with serious cardiovascular risk factors, without past or current history of smoking and nondrinkers or used to drink in the past. Also, the study found that there was no significant association between obesity and the increase in the risk of CVD events in subjects with normal metabolic profile, metabolic syndrome or diabetes. On the other hand, there was an association between abdominal obesity and the risk of CVD events among individuals with one to two metabolic elements. Nevertheless, having one to two metabolic elements, metabolic syndrome or diabetes increased the risk of cardiovascular events among obese and non-obese individuals (Wildman et al., 2010).

The second study was a cross-sectional study by Suastika (2011), looking at the prevalence of obesity, metabolic syndrome and impaired fasting glycemia (IFG) in seven rural areas of Bali, Indonesia. Sampling from a wide geographical area resulted in inclusion of participants with different demographical characteristics, which strengthens the credibility of generalizing the results to the general population. The study enrolled 1840 individuals through random sampling and stratified sampling for larger villages. Data included age, BMI, WC, blood pressure, lipid profile and blood sugar level. Blood samples were obtained after at least ten hours of fasting. To classify obesity researchers

followed the WHO 2000 criteria for the Asia Pacific population. For diagnosing diabetes and IFG the American diabetes Association (ADA) 2009 recommendations were implemented, which is diagnosing IFG if plasma glucose level ≥ 100 and < 126 *mg/dl* and diagnosing diabetes if fasting plasma glucose (FPG) ≥ 126 *mg/dl*. For diagnosis of metabolic syndrome three or more of five abnormalities was met: WC of >90 cm for men, or >80 cm for women; triglyceride (TG) level of ≥ 150 *mg/dl*; on treatment for low levels of HDL or low levels of HDL ≤ 40 *mg/dl* for women, ≤ 50 *mg/dl* for men; on treatment for high blood pressure or high blood pressure readings $\geq 130/85$ mm Hg; on treatment for diabetes or high plasma sugar level ≥ 100 *mg/dl* (Suastika et al., 2011).

The results of the study showed that when comparing men to women, men were found to have higher height, weight, WC and TG levels but HDL-C levels were lower in comparison to women. At large, the mean of all the measured values were within normal range. Despite the lack of differences in the nutritional status when comparing males to females, obesity was higher among females (43.4% vs. 27.5%, $p < 0.001$). By looking at the metabolic syndrome prevalence, it was found to be 18.2% (16.6% males, 20.5% females), and evaluating data by gender and villages revealed that five out of seven villages were found to have higher prevalence of metabolic syndrome especially among female participants. Furthermore, IFG was reported to be 13.1% (14.3% males, 12.4% females), and diabetes prevalence was 5.9% (6.1% males, 5.7% females). Analysis of metabolic syndrome variables showed the number of participants who met 1, 2 or 3 diagnostics

criteria for metabolic syndrome were higher than those who met 4 or 5 criteria, and this suits to both gender categories. In addition, the findings of the study showed that two villages displayed higher prevalence of abdominal obesity. However, this did not imply that they had a greater diabetes prevalence (Suastika et al., 2011).

The third study was conducted in Korea between 2002 and 2009 by Chang (2012) that explored the impact of BMI on the incidence of metabolic abnormalities in 2599 metabolically healthy men. Exclusion criteria included any participant that met the metabolic syndrome criteria or had any characteristics that could affect metabolic syndrome, and subjects with hepatic disease or any evidence of hepatic abnormality on ultrasound. Therefore, based on the set exclusion criteria 27 participants were excluded due to history of cancer; 125 participants were on lipid lowering agents; 16 participants had history of cardiovascular disease; 3031 participants who were on anti-diabetic medications or with fasting plasma glucose (FPG) $\geq 5.55 \text{ mmol/l}$; 3823 participants who were on anti-hypertensive medications or had blood pressure reading $\geq 130/85$; 6277 had high triglyceride levels $\geq 1.69 \text{ mmol/l}$; 1894 participants had low levels of HDL $< 1.03 \text{ mmol/l}$; 5053 participants had ultrasonographic changes indicating steatohepatitis; 2498 participants with daily alcohol consumption of at least 20 g; 2181 participants with homeostasis model assessment of insulin resistance (HOMA-IR) ≥ 2.5 ; 4132 participants with elevated levels of C-reactive protein (CRP) $\geq 1.0 \text{ mg/l}$; 11 participants were on anti-hepatitis treatment; 841 participants with abnormal hepatitis B or C serology and had

history of any type of documented hepatic disease or ultrasonographic evidence of any acute or chronic hepatic disease; 413 participants excluded because during the antecedent year they were on medications that could lead to hepatic abnormality, examples include anti-epileptic drugs, tetracycline, metabolic steroids and immune-suppressant drugs. In addition to the previously mentioned, an additional 824 participants were excluded because of incomplete initial data and another 258 participants due to loss of follow up. Overall, the exclusion criteria were well defined to establish the true relationship between BMI and metabolic profile (Chang et al., 2012).

The study was conducted in Kangbuk Samsung Hospital Health Screening Center, where participants had an initial and follow-up examination either yearly or twice a year. During these examinations information regarding the medical status, current medications, behaviors influencing health, physical and biochemical examination were collected. Moreover, data regarding smoking status, alcohol intake per day and per week and the frequency and intensity of physical activity per week were obtained using a questionnaire. Body weight was measured to the nearest of 0.1 kg by a digital scale wearing light clothing and without shoes. Height was measured to the nearest of 0.1 cm without shoes using an electronic scale. BMI was calculated using the standardized equation of weight in kilograms divided by height squared in meters. Blood pressure measurements in the sitting position were taken by an experienced nurse trained to use a mercury sphygmomanometer. Standardized laboratory techniques were used to analyze the blood samples collected after

more than 12 hours fasting from veins in the antecubital area. Blood samples were analyzed for the following biochemical markers: total cholesterol, LDL-C, HDL-C, glucose, TG, gamma-glutamyltransferase, aspartate-aminotransferase, alanine-aminotransferase and uric acid. An expert radiologist who was blinded to the study design and results carried out the abdominal ultrasound. A set criterion was used by the radiologist to diagnose the participants with hepatic steatosis. The modified National Cholesterol Education Program Adult Treatment III was used to diagnose metabolic syndrome. The fact that the study was carried out over eight years with a regular interval follow-up for the participants, the use of standardized anthropometric measures and laboratory techniques and the blinding strategy applied lends credibility to reported findings and is an excellent start to reduce bias (Chang et al., 2012).

The results of the study revealed that of 2955 participants, the mean age was 36.1 years, and the mean BMI was 22.3 kg/m², and for those who were not diagnosed with metabolic syndrome the average follow-up was 5.1 years. A dose response outcome was distinctly found between BMI and the following characteristics: age, systolic and diastolic blood pressure, FPG, total cholesterol, LDL-C, TG, HOMA-IR, insulin, uric acid, CRP, ongoing alcohol use and physical activity. On the other hand, smoking and HDL-C were oppositely associated with BMI. With the follow-up of 9647.1 person-years, 1673 subjects had metabolic derangement. The accumulating incidence of metabolic derangement during the first year was 4.9%, 23.6% after two years and 53.6% at five

years. Thereafter, the study showed the tendency to develop each metabolic derangement in concordance to baseline BMI. The first analysis was done by comparing BMI with each baseline category by adjusting for age, followed by adjustment for age, alcohol intake, smoking and physical activity. In both occasions, a higher BMI was positively associated with all metabolic derangement ($p < 0.05$), and the tendency to develop any metabolic derangement expanded to all BMI categories. When contrasting participants with normal weight and healthy metabolic profile to those who had an obese and healthy metabolic profile, the former had a tremendous increase in the risk of developing high TG, pre-diabetes, pre-hypertension, low HDL-C, high CRP, high HOMA-IR, and any derangement in metabolic profile and metabolic syndrome. Additionally, they studied the difference between obese individuals with healthy metabolic profile who maintained their normal profile ($n = 257$), and those who developed abnormality in their metabolic profile ($n = 72$). Those who maintained a normal metabolic profile had a favorable one at the beginning, compared with the other group who started with a baseline elevated TG and plasma glucose levels and were older too (Chang et al., 2012).

The fourth study by Gobato (2014) on metabolic syndrome and insulin resistance in obese adolescents was a cross-sectional study that took place in the Child and Adolescent Obesity Outpatient Clinic at Hospital de Clínicas da Faculdade de Ciências Médicas (School of Medical Sciences), University of Campinas, Brazil. Adolescents with a BMI $\geq 97^{th}$ percentile for gender and age

according to the WHO guidelines, were encouraged to join the study. The study included 79 female and male adolescents in the age range of 10 to 18 years and their physical, laboratory and ultrasonographic results were analyzed. Anthropometric measures were evaluated including height, weight and WC. BMI was calculated and WC was measured using a tape at halfway between the last rib and the superior margin of the iliac crest. Having a WC ≥ 75 *percentile* for sex and age was considered a risk factor. Dual energy X-ray absorptiometry was used to assess the percentage of body adiposity, the cut-off point for males was $> 25\%$ and for females was $> 30\%$. A 7.5MHz linear transducer was used to assess subcutaneous fat. The procedure was carried out by the same technician with the participant in dorsal decubitus position after fasting for 12 hours. Measurement was taken by lightly placing the transducer 1 cm above the umbilicus, then the distance between the skin and the outer surface of the rectus abdominus muscle fascia was obtained. A mercury sphygmomanometer was used to assess the blood pressure using a matching size arm cuff for the participant's arm circumference following the procedures recommended by the Brazilian Society of Hypertension. The cut-off point for a high blood pressure was ≥ 95 *th percentile* for gender, age, and height percentile. Nonetheless, it has been suggested that the use of a mercury sphygmomanometer might increase errors similarly applied to the previous study (Gobato et al., 2014).

Blood samples collection for evaluating biochemical markers was done through venous blood sampling after 12 hours of fasting. A standardized laboratory method was used to analyze FPG, lipids,

and basal insulin levels. A value of $\geq 126 \text{ mg/dl}$ was used to diagnose diabetes mellites. Values used to diagnose abnormal lipid profile were as follows: triglycerides $\geq 100 \text{ mg/dl}$, total cholesterol $\geq 150 \text{ mg/dl}$, HDL-C $< 45 \text{ mg/dl}$ and LDL-C $\geq 100 \text{ mg/dl}$. HOMA-IR, which is calculated by dividing the sum of fasting insulin (mIU/mL) and fasting glucose (mmol/L) by 22.5 was used to diagnose insulin resistance if the result was higher than 3.16. Criteria used by this study to diagnose metabolic syndrome is the presence of three or more of the following listed abnormalities: height percentile and waist circumference $\geq 90^{\text{th}}$ percentile for gender and age, systolic or diastolic blood pressure $\geq 90^{\text{th}}$ percentile for gender and age, FPG $\geq 110 \text{ mg/dl}$, triglycerides $\geq 100 \text{ mg/dl}$ and HDL-C $\leq 40 \text{ mg/dl}$ (Gobato et al., 2014).

Results included 79 subjects, of which 49.3% (39) were females, in the age range of 10 to 18 years. Percentage of body fat showed drastic differences between males and females with females having higher values than males. Likewise, plasma insulin and insulin resistance measured by HOMA-IR was notably different between males and females, with females having higher values than males.

In addition, 52.8% (29) of females and 47.2% (17) of males were diagnosed with metabolic syndrome. Patients diagnosed with metabolic syndrome demonstrated a remarkably higher BMI, LDL-C and a mean HOMA-IR. Furthermore, 29.1% (23) of participants were diagnosed with insulin resistance of which 56.5% (13) were females and 43.5 (10) were males. Participants

with insulin resistance had a higher WC mean, BMI, percentage body fat and subcutaneous fat. On the other hand, mean level of HDL-C was strikingly lower among this group. Interestingly, the association test showed that insulin resistance is associated with a suboptimal level of HDL-C. Also, there was a positive correlation of all body compositions with insulin resistance. Systolic and diastolic blood pressures were the only components with a strong correlation to BMI, subcutaneous fat, and WC. Furthermore, the correlation study showed that out of all metabolic syndrome risk factors assessed, BMI was the only significant factor. But there were no significant correlation of glucose levels and lipid profile with any barometers of body compositions. Finally, the 23.5% of insulin resistance and 36.3% of metabolic syndrome above the BMI reference values aid in the recognition of these conditions (Gobato et al., 2014).

The fifth study is by Gurka (2018) assessed the use of BMI as the marker of adiposity in a metabolic syndrome severity score. This study was conducted by using the same methodology used by Gurka (2014) that evaluated WC as the main variable as oppose to this study which used BMI and compared it with WC. They used data from non- Hispanic white and black or Hispanic Mexican/American and other Hispanic origins in the age range of 20-64 years, collected in the period of (1999-2010) from the National Health and Nutrition Examinations (NHANES), which is an annually cross-sectional survey that is done by the National center for Health Statistics (NCHS). These surveys employ randomly chosen subjects to fill in questionnaires, collect anthropometric and blood pressure measurements, and for blood sample collection. Ethical approval was obtained from the NCHS and participants consented to take part in the research.

Measurements included TG, HDL-C, and FPG, in addition to WC and blood pressure measurements using a standardized method. Phlebotomy was done after ≥ 8 hours of fasting. For each subject blood pressure was measured four times and the mean was taken. The study excluded any subject with known and unknown case of diabetes, or unknown case of diabetes but the FPG is $> 125 \text{ mg/dl}$, on hypoglycemic or lipid lowering agents, with a history of congestive heart disease, CHD, myocardial infarction (MI) or stroke and pregnant women. However, participants on blood pressure lowering therapy were not excluded, as the author stated that these medications may be used for other purposes other than lowering the blood pressure. Nevertheless, not excluding participants on blood pressure lowering agents might have an impact on the correlation with BMI (Gurka et al., 2018, Gurka et al., 2014).

With regards to the aims of their study, the first goal was to execute confirmatory factor analysis (CFA) in adults for metabolic syndrome elements using BMI as the marker for central abdominal obesity. First, they defined the CFA as a statistical method for examining how several independent variables contribute to a latent component by correlating them. Consequently, a sequence of one CFA was carried out on each of the five elements of the metabolic syndrome in adults: glucose, TG, HDL-C, systolic blood pressure and BMI. The researchers used systolic blood pressure instead of using both systolic and diastolic blood pressure due to the significant association between systolic blood pressure and insulin resistance. CFA was successfully executed all over and then specific to the gender, race and ethnicity to avoid the differences in metabolic syndrome criteria related to these variables, thereby adding strength to their findings, because it included all these possible

confounders. The second goal was to contrast their CFA using BMI to their previous CFA using WC, while the third goal was to assess concurrence between the metabolic syndrome severity scores and the final fourth goal was to use previous cohort studies to contrast metabolic syndrome severity Z-score BMI and metabolic syndrome severity Z-score WC, with regard to their future connection to disease, especially type 2 diabetes mellitus and CHD. Consequently, to achieve the fourth goal the authors used cohort studies, the Atherosclerosis Risk in Communities (ARIC) Study and the Jackson Heart Study (JHS). Subjects from both studies were (n = 19,026) and the exclusion criteria included subjects with type 2 diabetes mellitus (n = 2485), CHD (n = 973), stroke (n = 393), non-fasting when obtaining baseline labs (n = 507), subjects who lacked baseline metabolic syndrome data (n = 792) and subjects who lost out come follow-up data (n = 2992). Elements of metabolic syndrome were assessed similarly in both cohort studies. Standardized protocols for both cohorts detected incidents of CHD, fatal CHD, in hospital fatal and non-fatal MI, silent MI detected by electrocardiography or coronary angioplasty. The study concluded that when BMI was used as an indicator of adiposity in a metabolic syndrome severity Z-score, it exhibited similar influence of WC based score in the prognosis of future CHD and type 2 diabetes mellitus, and in general similar risk of metabolic syndrome predicted by both BMI and WC. Consequently, this pointed to the practicality and benefit of metabolic syndrome severity Z-score BMI in evaluating metabolic syndrome risk over the years (Gurka et al., 2018).

The sixth study by Weber (2018), tackled metabolic syndrome in German air force personnel: the prevalence and association with BMI and physical fitness. A retrospective data from the German air force center of aerospace medicine were reviewed. Participants were all white males, who had the same level of workload and stress, same socioeconomic status and from the same topographical area. A follow-up observation for the entire cohort was done throughout the period of (January 1, 1996, to December 31, 2016), during which laboratory test results were saved in the data base of the facility, and only those who were medically fit were included in the study. Medical fitness was defined as having a normal medical history, normal examination of all the body systems and normal electrocardiogram, electroencephalogram and abdominal ultrasound. Moreover, medical fitness included fasting blood sample collection for white and red blood cells, erythrocyte sedimentation rate (ESR), urine analysis, liver function test, urea nitrogen, creatinine, electrolytes, uric acid, plasma glucose level and lipids. In addition, annual examination included measuring BMI, blood pressure, HDL-C, total cholesterol level, plasma glucose level and ESR. Metabolic syndrome was defined according to the National Cholesterol Educational program 2005, the only exception to this definition was not including central obesity because the data base was lacking data related to WC (Weber et al., 2018).

The researchers of this study concluded, that BMI was strikingly higher among participants with metabolic syndrome and agility was lower when compared to healthy participants throughout the study period. Furthermore, during the observation period of the

study it was found that BMI was increasing, and agility was decreasing regardless of the participant's age. Moreover, metabolic syndrome had led to a significant incline in BMI and decline in physical agility. This is an excellent study to assess the relationship of metabolic syndrome and BMI because first of all it included healthy individuals, thus the association between metabolic syndrome and BMI was clear, and secondly the follow-up period participants was adequate, which in turn established a temporal relationship between metabolic syndrome components and BMI (Weber et al., 2018).

The last study was a prospective cohort study by Da Silva Coelho (2020), which related to the incidence of metabolic syndrome in Brazilian adults with healthy weight, normal weight obesity, and overweight/obesity. Data collection took place at three stages during the period between 1978 to 1979: at birth, then when they reached the age of 23 to 25 years and then at the age of 37 to 39 years. In regards to inclusion criteria, only singletons were included ($n = 1094$), and exclusion criteria were as follows: individuals with history of metabolic syndrome ($n = 111$), if the BMI was < 18.5 ($n = 64$) or $\geq 25 \text{ kg/m}^2$, subscapular skinfold (SSF) and triceps skinfold (TSF) measurements $\leq 90\text{th percentile}$ ($n = 111$), and finally those with missing data ($n = 21$). Consequently, the total number of participants was 787. Individuals were evaluated for metabolic syndrome at the age of 23 to 25 years and then again at the age of 37 to 39 years, with participants at the age of 23 to 25 years scoring at least three of the following criteria labels them as having metabolic syndrome: $\text{FPG} \geq 100 \text{ mg/dl}$ or on hypoglycemic agents, systolic blood

pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg or on blood pressure lowering agents, HDL-C < 40 mg/dl for men and < 50 mg/dl for females or on lipid lowering agents, TG ≥ 150 mg/dl or on lipid lowering agents and WC ≥ 90 cm for men and ≥ 80 cm for females. The same criteria for diagnosis of metabolic syndrome was applied to individuals aged 37 to 39 years, with the exception for TG, which was reported abnormal if the levels were ≥ 175 mg/dl. In addition, a questionnaire was used to evaluate for the use of medications (Da Silva Coelho et al., 2020).

Anthropometric measurements were performed by trained healthcare providers. Weight was measured with the subjects wearing light garments and without footwear with an accuracy of 100 g using a mechanical scale for the 23 to 25 years old subjects and a digital scale for the 37 to 39 years old subjects. A stadiometer with an accuracy of 0.1 cm was used to measure the height. The Lange caliber was used to assess the TSF and the SSF and the 90th percentile of the summation of both skinfolds was used to approximate normal weight obesity. Therefore, the cut-off point of high body fat was > 30 mm for males and > 39 mm for females. For measuring the WC, a fiberglass tape was placed halfway between the ribs and iliac crests at the end of normal exhalation in a standing position with a relaxed abdomen. When not feasible, WC was measured at the level of the umbilicus. Furthermore, blood pressure was measured with the subjects in sitting position and their arms at the level of the heart, three measurements were taken 15 minutes apart and the average of the last two readings was recorded. Last but not the least, 40 ml blood

samples were collected from the participants after 12 hours of fasting, and standardized laboratory methods were used for analyses (Da Silva Coelho et al., 2020).

Results showed that out of the 787 analyzed subjects, 441 (57.5%) were females. Assessment of body composition revealed that 6% were found to be normal weight obese (NWO), and 23.7% were overweight obese (OWO). In the 25- to 27-year-old cohort, individuals with a healthy weight (HWI) had the lowest plasma glucose levels (81 mg/dl) and diastolic blood pressure (67.9 mm Hg). On the other hand, OWO exhibited the highest percentage of body fat, which was 32.3% for males and 38.8% for females. In the 37-to 39-year-old cohort, OWO showed the highest plasma glucose levels (91 mg/dl) and had the same body fat percentage of OWO as the previous age group. Yet, for 42- year old female subjects NWO had the highest levels of TG (152.8 mg/dl) and lowest HDL-C levels. The overall incidence of metabolic syndrome was 35.5%. NWO and OWO individuals had the highest incidence, above normal WC, plasma glucose levels and blood pressure when contrasted with healthy weight individuals. The only difference was that high HDL-C was only observed in NWO not in OWO (Da Silva Coelho et al., 2020).

Analyzing the previous studies gave me a better, clear and more comprehensive way to conduct my research especially in regard to inclusion, exclusion criteria and the best methodology to collect relevant data to increase the accuracy of the research outcome. These studies served as an eye opener on certain categories that should be excluded from the study to eliminate

possible confounders and bias. Moreover, adopting the protocols of the implemented procedures in the above-mentioned studies will serve as a clear guidance for me throughout my data collection journey. In conclusion, the hypothesis of this study was that if BMI increased, then it will lead to metabolic abnormalities and whether such an increase would be a statistically significant predictor for metabolic derangements.

Chapter Three: Methods and Procedures

3.1 Study setting and design

3.2 Sample size and sampling techniques

3.3 Participants

3.4 Phone Interview

3.5 Research Approval

3.6 Research Tools and Measurements

3.7 Statistical Analysis

Methods and Procedures

3.1 Study setting and design

This study was a cross-sectional study and was conducted on patients in the age group of 20-65 years attending KHUH outpatient clinics of neurology, dermatology and respiratory between the fifth of August 2021 and the sixteenth of September 2021.

3.2 Sample size and sampling technique

Selection of the clinic specialty was based on convenience. Patients list was obtained from the KHUH electronic system following the instructions given by the hospital directorate. The neurology, dermatology and respiratory clinics were running three days a week, lists of patients having appointment on that givenday were obtained from the hospital system two days prior to their appointment. Then the medical record for every single patient on that list was checked to apply the inclusion and exclusion criteria. Exclusion criteria included any patient in aged below 20 or over 65, non-Bahraini's, pregnant ladies, those with previous diagnosis of type 2 diabetes mellites, hypertension or dyslipidemia, those who are on hypoglycemic or dyslipidemia agents and those with history of MI, CHF or stroke. Moreover, patients on hypertensive medications were not excluded because they could be taking these medications for other medical conditions other than hypertension. Patients who met the inclusion criteria based on their medical records were contacted by telephone and the inclusion criteria was verified once again. After thoroughly explaining the purpose of the call and the study objectives, process and the participation

requirements, verbal consent was obtained, and the patient was informed that they will be signing a written consent on the day of their appointment. The target sample size of the study was a minimum of 194 participants to achieve a 95% confidence interval and a margin of error of 5% calculated using an online sample size calculator (survey system), according to the study of

Nyangasa et al (2019). Of the 247 baseline patients listed in the clinic's lists, 194 of them met the study criteria and participated by consenting to the study, attending their appointments, checking their vital signs and having their blood investigations. In regard to the remaining 53 patients, 80% of these patients were excluded because they met the exclusion criteria, majority of them were diabetics, the second most common reason for exclusion is diabetics with cardiac comorbidities and the third reason was dyslipidemia. Then, 8% of them were excluded because of lack of communication number, 11% did not show up for their appointments or did not undergo the lab investigations and the remaining 1% declined to participate in the research.

3.3 Participants

Bahraini males and females aged 20-65 years attending KHUH outpatient dermatology, neurology and respiratory clinics were recruited.

3.4 Phone Interviews

Due to the Covid-19 pandemic, and to reduce the risk of exposure and infection among the investigators and patients, phone interviews substituted the initial plan of in person interview. A checklist was formulated by the primary investigator to ease gathering participants data and to apply the inclusion and exclusion criteria on each subject, thus only enabling eligible

subjects to proceed with the process of the research (AppendixD).

The checklist has three sections; the first section obtained demographic data like age, gender, nationality, marital status, pregnancy status for female participants, educational level, and income status. The second section included questions concerning physical activity, smoking status and dietary questions regarding the amount of fruits and vegetable intake per day. The last section aimed to assess the past medical history of the subjects, and included questions inquiring about any past history of MI, congestive heart failure or stroke and whether the subject was on any glucose or lipids lowering agents.

3.5 Research Approval

Before starting data collection and to facilitate access to, KHUH data base, patients list, clinics, instruments, and professional personnel and patients, approval from the Institutional Review Board of KHUH was acquired (Appendix A). The process of obtaining the approval involved completing and submitting of documentation, which included research proposal application, research proposal checklist, ethical issues checklist, and the informed consent template in both Arabic (Appendix B) and English (Appendix C) took place in the period of May to July 2021.

3.6 Research Tools and Measurements

Anthropometric and blood pressure measurements, in addition to blood tests were obtained at KHUH. On the appointment day, the participants signed the informed consent, had their height and weight taken, their blood pressure measured and blood samples for biochemical serum markers collected. The specially designed checklist was filled two days prior to the patient's appointment from his/her medical record and then was verified with a phone call interview by one of the KHUH interns. All the collected data was entered into an excel sheet. The height was measured using a calibrated stadiometer to the nearest of 0.1 cm. Body weight was measured using a calibrated electronic scale to the nearest of 100 g. BMI was calculated using the standardized equation of weight in kilograms divided by the square meter of the height. Moreover, participants were classified according to the WHO BMI classifications, Blood pressure was measured three times and the mean value was recorded using a digital sphygmomanometer with the right size arm cuff and the arm at the level of the heart. Measurements were taken after the patient rested for 5 minutes. All the above-mentioned procedures were conducted by trained nurses.

Blood samples were drawn after > 12 hours fasting from the antecubital veins. Biochemical serum markers measured were FPG, total cholesterol, LDL-C, high HDL-C and TG. Blood samples were analyzed in a College of American Pathologist accredited laboratory using standardized and calibrated techniques.

Diagnosis of hypertension was done according to the International Society of Hypertension Global which is a blood pressure of $< 130/85$ is normal, $130/85$ to $139/89$ is pre-hypertension and $\geq 140/90$ mm Hg is considered hypertension (Unger et al., 2020). Furthermore, diagnosis of IFG is $5.5-6.9$ mmol/l and DM if fasting ≥ 7 mmol/l. In regard to the lipids profile, the normal cutoff points were < 5.2 mmol/l for total cholesterol, <1.8 mmol/l for LDL- C, and < 1.69 mmol/l for triglycerides, in regard to HDL-C < 1.03 mmol/l is considered abnormal following the Dyslipidemia Guidelines 2019 – Bahrain.

The WHO classified nutritional status according to the BMI as underweight when the BMI is <18 , normal weight when BMI is between $18.5-24.9$, overweight when BMI is between $25.0-29.9$, obesity class I when BMI between $30.0-34.9$, obesity class II when BMI between $35.0-39.9$ and obesity class III when BMI >40 .

3.7 Statistical Analysis

Statistical Package for the Social Sciences (SPSS), version 26.0 (IBM, Chicago, USA), was used for data entry and analysis. Frequencies and percentages were computed for the categorical variables. Mean and standard deviation were computed for the quantitative variables. T-test was used to determine whether there is a significant difference in means between two independent groups. Analysis of Variance test (ANOVA) was used to determine whether there is a significant difference in means

between more than two independent groups. Chi-Square test was used to determine whether there is a significant relationship between two categorical variables. Pearson's Correlation Coefficient was used to measure the correlation between two quantitative variables. In all statistical tests, p-value of less than 0.05 was statistically considered significant.

Chapter Four: Results, Discussion, and Recommendations

4.1 Results

4.2 Discussion

4.3 Conclusion

4.4 Recommendation

Results, Discussion, and Recommendations

4.1 Results

The total number of participants was 194, majority falls in the age group of 18-30 years (44.8%) with over two-thirds (69.1%) being females. In term of marital status numbers were very close, having (53.6%) married and (46.4%) single. When asked about physical activity only (4.1%) vigorously exercised, while (52.6%) had a sedentary lifestyle. On the other side, most of the subjects were non-smokers (85.6%), with 43.3% and 47.4% of them consuming ≥ 5 servings per day of fruits and vegetables, respectively. (Table 1).

Table (1): Demographic characteristics (n= 194)

	n (%)
Age in years	
18-30	87 (44.8)
31-45	63 (32.5)
>45	44 (22.7)
Gender	
Male	60 (30.9)
Female	134 (69.1)
Marital status	
Married	104 (53.6)
Single	90 (46.4)
Educational level	
School	80 (41.2)
Higher education	114 (58.8)
Monthly income	
<450 BD	87 (44.8)
≥ 450 BD	107 (55.2)
Physical activity	
Sedentary	102 (52.6)
Light	56 (28.9)
Moderate	28 (14.4)
Vigorous	8 (4.1)
Smoking status	
Smoker	28 (14.4)

Non-Smoker	166 (85.6)
Fruit intake	
<5 servings	110 (56.7)
≥5 servings	84 (43.3)
Vegetables intake	
<5 servings	102 (52.6)
≥5 servings	92 (47.4)

Tables 2 and 3 show data regarding BMI and metabolic characteristics. Consequently, assessment of BMI among the study participants showed that 39.2% were obese, 23.2% had a normal BMI and the mean BMI was 29 ± 7.2 . In addition, only 17% of them were found to be hypertensive with a mean systolic blood pressure of 120.9 ± 13.7 and a mean diastolic blood pressure of 78.0 ± 14.9 . Moreover, the vast majority of them had a normal fasting glucose (79.4%) with a mean FPG of 5.2 ± 0.5 . Coming to the lipid profile, most of the subjects had normal levels of total cholesterol (64.9) with a mean of 4.9 ± 0.9 , normal levels of TGs (83.5%) with a mean of 1.1 ± 0.6 and normal levels of HDL-C (74.4%) with a mean of 1.3 ± 0.3 . The exception was the LDL-C, having higher percentage of participants with an abnormal level (98.5%) with a mean of 3.3 ± 0.3 .

Table (2): BMI and Metabolic characteristics (n = 194)	
	n (%)
BMI	
Underweight	9 (4.6)
Normal	45 (23.2)
Overweight	64 (33)
Obese	76 (39.2)
Blood pressure	
Normal	130 (67)
Pre-hypertension	31 (16)
Hypertension	33 (17)
Fasting blood glucose	

Normal	154 (79.4)
Pre-diabetic	39 (20.1)
Diabetic	1 (0.5)
Cholesterol	
Normal	126 (64.9)
Abnormal	68 (35.1)
Triglycerides	
Normal	162 (83.5)
Abnormal	32 (16.5)
LDL	
Normal	3 (1.5)
Abnormal	191 (98.5)
HDL	
Normal	152 (78.4)
Abnormal	42 (21.6)

Table (3): BMI and Metabolic characteristics (n = 194)

	Mean $\pm$ SD
BMI	29.0 $\pm$ 7.2
Systolic BP	120.9 $\pm$ 13.7
Diastolic BP	78.0 $\pm$ 14.9
Fasting blood glucose	5.2 $\pm$ 0.5
Cholesterol	4.9 $\pm$ 0.9
Triglycerides	1.1 $\pm$ 0.6
LDL	3.3 $\pm$ 0.9
HDL	1.3 $\pm$ 0.3

Tables 4 and 5 illustrate the of the association between demographic data and BMI, which revealed that the only statistically significant association with BMI was found with age and marital status ($P < 0.001$). The higher the age of the participant, the higher the percentage of obesity (59.1%), and married individuals were more obese (48.1%) than single individuals. On the hand there was no statistical association between BMI and the other demographic data. Furthermore, studying the association between demographic data and BMI as a quantitative variable showed a significant statistical interaction

with both age and marital status ($P < 0.001$, $P < 0.028$, respectively).

Table (4): Association between demographic characteristics and BMI

	BMI			P-value
	Underweight/Normal	Overweight	Obese	
	n (%)	n (%)	n (%)	
Age in years				
18-30	40 (46)	24 (27.6)	23 (26.4)	<0.001
31-45	13 (20.6)	23 (36.5)	27 (42.9)	
>45	1 (2.3)	17 (38.6)	26 (59.1)	
Gender				
Male	16 (26.7)	24 (40)	20 (33.3)	0.351
Female	38 (28.4)	40 (29.9)	56 (41.8)	
Marital status				
Married	16 (15.4)	38 (36.5)	50 (48.1)	<0.001
Single	38 (42.2)	26 (28.9)	26 (28.9)	
Educational level				
School	19 (23.8)	23 (28.7)	38 (47.5)	0.138
Higher education	35 (30.7)	41 (36)	38 (33.3)	
Monthly income				
<450 BD	31 (35.6)	25 (28.7)	31 (35.6)	0.090
≥450 BD	23 (21.5)	39 (36.4)	45 (42.1)	
Physical activity				
Sedentary	31 (30.4)	32 (31.4)	39 (38.2)	0.059
Light	10 (17.9)	17 (30.4)	29 (51.8)	
Moderate/Vigorous	13 (36.1)	15 (41.7)	8 (22.2)	
Smoking status				
Smoker	8 (28.6)	11 (39.3)	9 (32.1)	0.666
Non-Smoker	46 (27.7)	53 (31.9)	67 (40.4)	
Fruit intake				
<5 servings	29 (26.4)	40 (36.4)	41 (37.3)	0.520
≥5 servings	25 (29.8)	24 (28.6)	35 (41.7)	
Vegetables intake				
<5 servings	28 (27.5)	35 (34.3)	39 (38.2)	0.917
≥5 servings	26 (28.3)	29 (31.5)	37 (40.2)	

Table (5): Association between demographic characteristics and BMI

	BMI	P-value
	Mean ± SD	
Age in years		
18-30	26.4 ± 6.1	<0.001
31-45	30.3 ± 7.7	
>45	32.4 ± 6.5	
Gender		
Male	28.0 ± 6.0	0.207
Female	29.5 ± 7.6	
Marital status		
Married	30.1 ± 6.5	0.028
Single	27.8 ± 7.8	
Educational level		
School	29.7 ± 7.0	0.250
Higher education	28.5 ± 7.3	
Monthly income		
< BHD 450	28.1 ± 7.0	0.110
≥ BHD 450	29.8 ± 7.2	
Physical activity		
Sedentary	28.9 ± 7.5	0.062
Light	30.5 ± 7.3	
Moderate/Vigorous	26.9 ± 5.3	
Smoking status		
Smoker	28.3 ± 6.4	0.556
Non-Smoker	29.1 ± 7.3	
Fruit intake		
<5 servings	28.9 ± 7.4	0.851
≥5 servings	29.1 ± 6.9	
Vegetables intake		
<5 servings	28.9 ± 7.7	0.828
≥5 servings	29.1 ± 6.6	

The main objective of this study was assessed in Table (6), which is the association between BMI and metabolic profile. BMI was found to have a statistically significant association with all of the metabolic profiles. Results showed that obese participants were more hypertensive as oppose to participants with under/normal

weight BMI (28.9% and 5.6%, respectively) ($P= 0.002$). Similarly, obese participants had a higher percentage of pre-diabetic status than under/normal weight (36% and 5.6%, respectively) ($P < 0.001$). Just as importantly, obese participants had higher percentages of abnormal cholesterol (47.4%), TGs (25%) and HDL-C (31.6%) ($P=0.006$, 0.002 and 0.009 , respectively). Surprisingly, none of the obese individuals had a normal LDL-C level.

Table (6): Association between BMI and metabolic characteristics

	BMI			P-value
	Underweight/Normal	Overweight	Obese	
	n (%)	n (%)	n (%)	
Blood pressure				
Normal	45 (83.3)	44 (68.8)	41 (53.9)	0.002
Pre-hypertension	6 (11.1)	12 (18.8)	13 (17.1)	
Hypertension	3 (5.6)	8 (12.5)	22 (28.9)	
Fasting blood glucose				
Normal	51 (94.4)	55 (85.9)	48 (64)	<0.001
Pre-diabetic	3 (5.6)	9 (14.1)	27 (36)	
Cholesterol				
Normal	43 (79.6)	43 (67.2)	40 (52.6)	0.006
Abnormal	11 (20.4)	21 (32.8)	36 (47.4)	
Triglycerides				
Normal	53 (98.1)	52 (81.3)	57 (75)	0.002
Abnormal	1 (1.9)	12 (18.8)	19 (25)	
LDL				
Normal	2 (3.7)	1 (1.6)	0 (0)	
Abnormal	52 (96.3)	63 (98.4)	76 (100)	
HDL				
Normal	49 (90.7)	51 (79.7)	52 (68.4)	0.009
Abnormal	5 (9.3)	13 (20.3)	24 (31.6)	

Lastly, Tables 7 and 8 demonstrate an alternative method to study the correlation between BMI and metabolic profile as well as to assess the strength of correlation. This method showed that systolic blood pressure, FPG and LDL-C had a low positive

correlation, while diastolic blood pressure, cholesterol, TGs and HDL-C had no correlation.

Table (7): Correlation between BMI and metabolic characteristics

	BMI	
	Pearson Correlation	P-value
Systolic BP	0.330	<0.001
Diastolic BP	0.151	0.036
Fasting blood glucose	0.300	<0.001
Cholesterol	0.260	<0.001
Triglycerides	0.224	0.002
LDL	0.336	<0.001
HDL	-0.186	0.010

Table (8): Interpreting the Size of a Correlation Coefficient

Size of Correlation	Interpretation
0.90 to 1.00 (−0.90 to −1.00)	Very high positive (negative) correlation
0.70 to 0.90 (−0.70 to −0.90)	High positive (negative) correlation
0.50 to 0.70 (−0.50 to −0.70)	Moderate positive (negative) correlation
0.30 to 0.50 (−0.30 to −0.50)	Low positive (negative) correlation
0.00 to 0.30 (0.00 to −0.30)	negligible correlation

4.2 Discussion

In recent time BMI has been widely used as a practical tool by different health concerning specialties, including medical physicians, nutritionists, and personal trainers. It is a measure that physicians refer to when advising patients about lowering their plasma glucose, total cholesterol, TG, LDL-C levels and to lower their risk of cardiovascular, peripheral vascular and neurological events. Moreover, it is the cornerstone measure used by dieticians and nutritionist while establishing a nutritional plan for

maintaining, losing or gaining weight, by measuring the baseline and target BMI. Nowadays many individuals will pay to get their BMI checked at various BMI measuring machines placed in pharmacies. Consequently, the main objective of this study was to assess the credibility of BMI in predicting abnormalities related to metabolic markers like blood glucose, lipid profile and blood pressure among Bahraini individuals. The target was achieved by analyzing data collected from Bahraini patients attending dermatology, neurology and respiratory outpatient clinics at KHUH.

Data analysis showed that the overall prevalence of obesity among the study cohort of Bahrainis aged 20-65 years is 39.2% with a mean of 29 ± 7.2 . The study by Van Harmelenen (2003) which assessed the effect of BMI and age on adipose tissue cellularity and differentiation capacity in women concluded that BMI has a direct correlation with age, total number of fat and stromal cells and adipose cells size. Consequently, to evaluate whether this effect can be applied in this study, the correlation between age and BMI was studied, and the results showed that when correlating the BMI with age a dose response relationship was found. Findings revealed that obesity was 26.4% among the 18-30 years group, 42.9% among 31-45 years group and 51.1% in those above the 45 years group (Van Harmelenen et al., 2003). Upon contrasting these results with those published from a study done in Korea on subjects in the age of 30-59 years, same dose response relationship was found with a mean age of obesity at 36.5 years. This shows that although this study was

done on completely different ethnic group, BMI had the same effect on age (Chang et al., 2012).

Another previous study published in 2010 extracted its population from three large studies conducted in the years from 1917-1989 in the US, with a wide range of age groups ranging from 5-70 years, showed that obesity was higher in the age group of 45-64.9 years with a percentage of 77.9%, and participants ≥ 65 years had a 22.1% obesity rate (Wildman et al., 2010). In my opinion, it is important to compare the current study results of the effect of BMI on age with studies from a different timespan to assess whether subjects living in different circumstances with a modernized lifestyle and advanced technologies would have different outcome.

On the other hand, Weber (2018) concluded that BMI remarkably increased in metabolically abnormal individuals throughout the observation span regardless of the age. These results convey abnormal metabolic profile has a more profound effect on the BMI than age. (Weber et al., 2018) Furthermore, a recently published study in 2020 that started in 1978 that evaluated the incidence of metabolic syndrome in Brazilian adults with healthy weight, normal weight obesity, and overweight/obesity. Categorized individuals based on the BMI, TSF and SSF, defining OWO participants as having a BMI ≥ 25 kg/m² TSF+SSF > 90th percentile. Consequently, the study found that there was no difference in percentage of OWO individuals among the age group of 23-25 years and 37-39 years and in both groups the percentage was 23.7%. (Da Silva Coelho et al., 2020) The difference of that outcome from the outcome of this study might

be due to the effect of adding the TSF and SSF to the BMI, which added more credibility to the amount of adiposity and its impact on the studies variables including the age.

Another correlation was done between gender as a demographic parameter and BMI. This correlation found that females had higher percentage of obesity (41.8%) than males (33.3%), but this outcome was not statistically significant according to the Chi-square test. This result can be explained by the effect of one of the most important female sex hormones, estrogen, and its effect on fat storage priming the female body for childbearing beginning at puberty. Similarly, the study by Wildman (2010) concluded that women have higher rates of obesity than men (68.7%, 31.3% respectively) and that relationship was statistically significant. (Wildman et al., 2011) Another study by Gobato (2014) reported a similar outcome, which enrolled all adolescents that attended the Child and Adolescent Obesity Outpatient Clinic at Hospital de Clínicas da Faculdade de Ciências Médicas with a BMI $\geq$ 97th percentile, and out of the 79 obese adolescents, females constituted 49.3% of them (Gobato et al., 2014). Moreover, Suastika (2011) reported a no statistically significant difference between gender and BMI, with 19.9% of females with obesity class one, 5.8% with obesity class two, and 21.1% of males with obesity class one, and 5.7% with obesity class two. Nevertheless, a statistically significant correlation was found in term of abdominal obesity, with females having higher rates than men (43.4%, 27.5%, respectively) (Suastika et al., 2011).

With a further comparison to a study conducted in the US, a similar result to the current study done in Bahrain was found. This study enrolled male and female undergraduate students with a mean age of 19.4 years old (standard deviation= 0.87), and exploratory analysis was used to evaluate the differences in BMI scores between genders. One-way ANOVA test disclosed that the differences in BMI scores between males and females is not statistically significant (Pilafova et al., 2007).

Opposite to the above-mentioned results are the results found by a study published by D'Souza et al. (2015) on the effect of gender and lifestyle behaviors on BMI trends in a sample of undergraduate population. Showing a statistically significant correlation between gender and BMI, with a male obesity of 22.33% and female obesity of 18.29%. Similarly, the study by Saxena (2011) revealed that teenage boys had higher percentage of obesity (42.42%) in comparison to females, but females had higher percentage of under-nutrition (25.75%) in comparison to males. These last results can be due to factors related to body image that highly concerns females especially during adolescent and university years (Saxena et al., 2011).

Upon further analysis, marital status was found to have a statistically significant correlation with BMI when Chi-square test was applied, having higher percentage of obesity among married individuals compared to single participants. In contrast, there were more single individuals in the underweight/normal BMI category (42.2%) and less married individuals in this category (15.4%). According to Bahraini culture being married is

linked to overweight and obesity in both genders. This can be related to causes like stability, responsibilities, financial issues for both sexes and pregnancy for females. Moreover, other factors that can contribute to overweight might play an important role in the in-weight gain after marriage like time constraints for exercising due to family responsibilities, or the reduced ability to purchase healthy foods because of financial commitments.

Comparison of results from different studies related to marital status in a chronological manner from oldest to newest study is done, in order to assess this relationship across time. Starting with a cross-sectional study done in US by Sobel (1992), this study assessed marital status as a causative model for obesity and it revealed that marital status mainly affects men. Married men had higher risk of obesity than men who never got married or previously married even after adjusting for physical, social and demographic variables. (Sobel et al., 1992) Worth mentioning this relationship between marital status and obesity was gender and age adjusted, with younger unmarried individuals having less weight. Therefore, in relation to the current study relatively same results were found, as younger age groups had less weight as well as unmarried individuals. Consequently, if we were to combine the two variables and their effect on weight, we might find that more unmarried individuals are in younger age groups, more physically active and confining to better dietary habits and this might have contributed to effect of marriage status on weight.

Another study by Schoenborn (2004) studied marital status and health and categorized the relationship between marital status and

BMI according to age. The relatively younger age group of 18-44 years married men had higher rates of overweight and obesity (70.3%), and in middle age group married men had an obesity percentage of (75.2%). However, results related to females were different than the results of the current study. Middle age married women had lower rates of obesity (55.6%), as oppose to never married (64.4%), divorced (59.3%) and widowed (64.8%). Furthermore, there was no statistically significant difference in rates of overweight and obesity among older age women. (Schoenborn et al., 2004) In addition, another study published in the US reported similar results in regard to females, by which separated women having higher rates of overweight (76%), and by comparing married men to those who never married, married men are more likely to be overweight, and they have significant risk of being overweight than any other marital status except for cohabitating men (Hanson et al., 2007).

Newer studies were conducted first by Janghorbani (2008), and the second by Sobel (2009) both demonstrating relatively similar results to the current study. The first study conducted in Iran revealed that there is two folds increase in the prevalence of overweight among married men and women when compared to unmarried men and women, even after controlling other factors like age, educational level, smoking habits, physical activity, leisure time and place of residence. (Janghorbani et al., 2008) The second study showed that married men had higher tendency to be overweight (74%) or obese (30%). On the other hand, separated, divorced or never married individuals had significantly lower odds of being overweight than married men. But, statistically

significant lower odds of obesity were only found among divorced men. Furthermore, an effect of marital status on women was found, as they had higher rates of overweight (75%) or obesity (43%) were found among separated individuals. (Sobel et al., 2009) Furthermore, a study by Tzotzas (2010) also found a significant link between marital status and BMI. This study conveyed that the association is significant in both genders. Compared to unmarried participants, married, widowed and divorced participants had higher odds of being overweight. Leaving out widowed men by which the probability of being overweight was similar to unmarried men.

Indeed, a study that took place in Saudi Arabia tackled obesity and associated risk factors by Memish (2014), studied the marital status and BMI more rigorously, but concluded similar results to the current study. The study disclosed that higher rates of obesity were among married men (67.9%) and women (67.2%), in contrast to obesity among unmarried men (30.8%) and women (21.2%). In contrary to significantly lower percentages of obesity among separated, divorced, or widowed men (1.3%) and women (11.6%). It is worth mentioning that these results may have been affected by the fact that female respondents were more likely to be currently or previously married. (Memish et al., 2014) Last but not the least is the recent study by Lee (2020), confirmed the significant correlation between marriage and obesity. Results showed that lower overweight prevalence was observed among unmarried men or divorced/separated men and women. Also, higher prevalence of underweight was observed in unmarried men

and women than married subjects. On the other hand, widowed women had higher overweight prevalence. (Lee et al., 2020) Consequently, due to the significant effect of marital status on BMI that was found by the current study and other studies, that resulted from an interplay of many factors like gender, age, physical activity and financial status, married individuals should be targeted specifically to reduce the effect of modifiable risk factors on weight.

Upon further analysis, educational level and BMI correlation was assessed and results showed that individuals with high school degree or less had higher rates of obesity and lower rates of underweight/normal BMI in comparison to individuals with higher education. Obesity among higher educated individuals was (33.3%) and underweight/normal BMI was (30.7%). However, this correlation was not statistically significant. Studying this correlation is important to assess whether the educational level has an impact on health behaviors and attitudes, which in turn will have an influence on BMI. Through this impact future studies can be developed particularly focusing on this correlation in order to decide on the efficacy of educational campaigns targeting BMI related health programs.

In this context the cross-sectional study done in Spain by Gutierrez-Fisac (2002), that evaluated the correlation between obesity and educational level, showed that obesity prevalence was highest in Spanish participants with elementary level of education in both genders. Moreover, in 1995-1997 the implication of obesity that is associated with less than third level of education

was (55%) in women and (20%) in men in 25-64 years age group. In my opinion, analyzing results from three different studies spreading over eleven years adds a great credibility to the outcome of the correlation. (Gutierrez-Fisac et al., 2002) In a study published in 2004, Gutierrez-Fisac conducted a similar study assessing the correlation between BMI and educational level. By reevaluating this correlation, the author emphasized on the outcome obtained two years earlier, due to the that illiterate male individuals had higher prevalence of obesity (36.7%) than those with university education (30.9%). Moreover, the impact of educational level was more obvious among females, by which illiterate females were 41.8% obese and those with university education were 17.5% obese (Gutierrez-Fisac et al., 2002).

Likewise, the study by Woo (1999), found that there is significant inverse relationship between BMI and education level among Chinese women, where women with higher educational level had a lower BMI. Additionally, Wildman (2010) reached the same conclusion. Statistically significant results were found by which subjects with high school education or less (50.5%) of them were non-obese and (60.8%) of them were obese. Besides that, those with an educational level higher than high school had (49.5%) non obesity and (40%) obesity level. (Wildman et al., 2010) Moreover, Tzotzas (2010) concluded the same results. In their study, the researchers showed a statistically significant anticorrelation between educational level and BMI, revealing that subjects with primary educational level had higher obesity rates than those in university (Tzotzas et al., 2010).

In a study by Martorell (2000) that covered a wide geographical area, included 38 developing countries and the US the results conveyed truly reflected that economic status of a country can have an indirect impact on individual's health. Having said this, the results of this study showed that low socioeconomic countries had obesity clustered among women in urban areas with higher education level. On the contrary, in higher socioeconomic level countries like Latin American and the Central Eastern Europe/Commonwealth of Independent States countries obesity were more evenly distributed across the general population (Martorell et al., 2000).

In conclusion, the etiology behind higher levels of obesity in individuals with lower educational level might be due to having less knowledge and awareness about the importance of maintaining a normal BMI and the appropriate means to accomplish that, which highlights the importance of education and health awareness in programs that targets prevention of obesity and its negative health consequences.

Another important parameter that can have an impact on BMI is the financial status of the individuals. More recently this is more evident nowadays, due to the current influence that the pandemic had on the economy at the international, country and individuals' level, with most goods increasing in price, and food products especially has been affected by this rise. So, healthy, organic and weight watchers food products has been especially affected by this economic crises, because even during stable economical circumstance these products had higher prices and now it got even more expensive. On the other hand, economical inflation along

with purchasing power due to low monthly income can lower the amount of services or goods an individual would be able to purchase, and that can be applied to eating from outside and buying fast food and energy dense foods. Therefore, the current study analyzed the correlation between monthly income and BMI. Monthly income was categorized into subjects with less than BHD 450 and $\geq$ BHD 450 based on the latest statistics from the Labour Market Regulatory Authority of Bahrain median monthly wages of Bahrainis. Results showed that subjects with a monthly income below BHD 450, the equivalent of \$1,190 had higher rates of under/normal weight individuals (35.6%), less rates of overweight (28.7%) and obese (35.6%) individuals when compared to subjects with $\geq$ BHD 450 monthly income, however this correlation was not statistically significant.

The results of this study contradict the results of an earlier study by Kuntz et al. (2010) which analyzed the correlation between occupational status on BMI based on gender and reported a significant impact of income on BMI in women. Thus, women with low income had risk of obesity that is increased by a factor of 3. On the other hand, there was no correlation found between men income and the presence of obesity.

Another study by Chang (2010), had wide variation of results in accordance to monthly income. Similar correlation was found in the two extremes of income, the very low income $< \$ 723.71$ and the very high $> \$ 2171.12$ which is higher rates of obesity and lower rates of healthy individuals. It was revealed that the those with income $< \$ 723.71$, (27.2%) of them were obese and (28.8%) of them were healthy. Likewise, those with income $> \$ 2171.12$,

(18.4%) were obese and (9.3%) were health. On the other hand, subjects with income ranging from (\$723.71-\$1447.41) and (\$1447.41-\$2171.12) had higher rates of healthy individuals than obesity. For those having income of (\$723.71-\$1447), (29.8%) of them were obese and (34.2%) of them were healthy, and those having income of (\$1447-\$2171.12), (7.9%) were obese and (14.7%) were healthy (Chang et al., 2010).

Inconsistent to the present study the systematic review by Dinsa et al. (2012), which evaluated the correlation between socioeconomic status and measured obesity in low- and middle-income countries in children, men and women. reported a parallel association between income and risk of obesity. Thus, countries with lower income had lower risk or obesity compared to countries with higher level of income. On the contrary, results of another study that data from Seattle (US) and Paris (France) on the influence of food environment and SES on obesity. An inverse association was found, by which lower income in both cities were linked to increased risk of obesity. As oppose to being in higher SES, which can be related to residing in prosperous community and shopping at expensive supermarkets had a protective effect on the risk of obesity (Drewnowski et al., 2014). Similarly, the more recent study of Asp et al. (2017) reported lower percentage of obesity in individuals with high socioeconomic status (12%), as oppose to those with middle or low socioeconomic status (18% and 19% respectively). Comparably with the previous study is a study done in Massachusetts to assess the effect of household income on childhood obesity, the study concluded that there is a significant relationship between low income and increase risk of

overweight and obesity, consequently for every 1% increment in low income there was 1.17% increment in overweight/obesity. (Rogers et al., 2015) In agreement with the previous study the findings of Assari et al. (2018) supported the proved the hypothesis that family income reduces the risk of obesity and that higher income plays a protective factor role against childhood obesity.

Last but not least, based on the current study results and that from previous studies which showed that higher income and socioeconomic status impacted BMI positively, this can be attributed to healthy living circumstances, like purchasing healthy food options, ability to join the gym and hiring household helpers to have the time to exercise. This provides further evidence that improving the individual's socioeconomic status may have a direct health related benefit.

Additionally, the relationship between physical activity and BMI was evaluated, as it is a major factor determining overweight and obesity. Also, it is an important parameter frequently considered when precisely calculating the BMI to establish a weight guided dietary health plan. Moreover, physical activity is considered a successful strategy couples with calorie reduction to produce a negative energy balance for losing weight. Consequently, evaluating this parameter showed that participants with moderate/vigorous physical activity level had the lowest rate of obesity (22.2%) and the highest rate of under/normal weight (36.1). In contrast, those with sedentary level of physical activity had higher rate of obesity (38.2%) and lower rate of under/normal

weight (30.4%). Nevertheless, this correlation was not statistically significant.

In consistence with the current study outcome, the cross-sectional study on elderly Swedish population found a strong correlation between physical activity and BMI with physically inactive individuals having higher percentage of obesity than those who are physically active, and elderly with impaired physical activity being more obese than those with physical mobility (Asp et al., 2017).

Moreover, a study by Schwarzfischer et al. (2017) involving school children showed light physical activity being negatively associated with increased weight, whereas sedentary activity was positively associated with increased weight. The author concluded that there was an indirectly proportional relationship between the minutes spent per day in physical activity and BMI. Another study demonstrated the inverse correlation between physical activity and BMI (Bradbury et al., 2017). Furthermore, Da Silva Coelho et al. (2020) included physical activity as one of the variables in studying metabolic syndrome incidence in healthy weight (HWI), normal weight obesity (NOW), and overweight/obesity (OWO) and found that the percentage of HWI was higher in those with vigorous activity than those with light activity, and that the percentage of OWO was higher among those with light activity in comparison to those with vigorous activity (Da Silva Coelho et al., 2020).

Additionally, another study that assessed the effect on regular exercise training program on the BMI of Iranian type 2 diabetes

mellitus patients reported a significant impact of physical activity on the BMI compared to the control group. Also, after 8 years of regular exercise training, the intervention group had improvement in their BMI, with a linear reduction in BMI during the first six years and slight increase during the last two years. On the other side, control group had a slight persistent increase in BMI throughout the eight years follow up period (Najafipor et al.,2017).

Results from the current study provides further evidence to the significant effect of physical activity on BMI, especially that the positive effect on BMI is increasing as the intensity of exercise increases. This proves the effect of burned calories on BMI to facilitate weight loss. Consequently, moderate to high intensity physical activity should be part of comprehensive obesity prevention strategy.

As for smoking the current study showed that smokers had lower percentage of obesity than non-smokers and slightly higher percentage of under/normal weight in smokers than non-smokers. This correlation might be due to the fact that smoking may act like an appetite suppressant, raises the metabolism and energy expenditure which is the amount of energy the individual needs for daily physical functions, such as breathing, food digestion, blood circulation and physical activity.

Consistent results to the current study was reported by Lv et al. (2015), revealed that regular smoking has statistically significant negative associated with BMI in both genders. In addition, another study by Jacobs et al. (2019) concluded same results, by

which there is an inverse association between smoking and BMI for males and females. Participants who smoke had lower BMI than those who are irregular smokers or those who never smoked. Moreover, a UK cross-sectional study by Dare et al. (2015), conveyed similar results whereby participants who smoked had lower risk of being obese compared to those who never smoked. However, there was no significant correlation in individuals ≤ 40 years. Furthermore, other revealed a similar statistically significant same inverse correlation between current smoking status and BMI (Wildman et al., 2010, Chang et al., 2012).

On the contrary, Tuovinen et al. (2016). Showed that among the normal weight group heavy daily smokers were less in numbers than those who never smoked. Furthermore, similar results to the current study was found among the overweight/obese group, with higher percentages among those who never smoked and lower percentages among those with heavy daily smoking (Tuovinen et al., 2016).

By comparing the current study results to other studies, it was found that most studies reached a similar negative correlation between smoking and obesity, which might prove the effect of smoking on suppressing the appetite and increasing the metabolism. However, smoking should not be encouraged encouraging individuals to smoke in order to lose weight because of the disadvantage of smoking on health that outweighs the advantages.

The last aspect of the demographics was concerned with diet in term of the amount of fruits and vegetables intake per day. This correlation was studied to assess the international dietary recommendations in regard to the consumption of ≥ 5 servings of fruits and vegetables per day in order to improve health and prevent diseases. Results showed non-significant correlation between fruits and vegetables intake per day and BMI with slightly higher percentage of obesity among those who has ≥ 5 servings of fruits and vegetables per day compare to those who take < 5 servings of fruits and vegetables per day. This might be due to the higher calories intake that is associated with eating more servings of fruits and starchy vegetables. Besides, this insignificant correlation might due the wider multifactorial effect that food can have on BMI. In other words, diet is more than just fruits and vegetables, as other food groups may have a larger effect on the BMI and all type of diet including all food groups and the total calorie intake must be studied in relation to BMI.

In the same scope, a study by Charlton et al. (2014) involving Australian adults aged 45 years and above, showed similar results to the current study among women only. Thus overweight and obese women were more likely to meet the target intake of fruits and vegetables and had higher odds of being at the highest intake quartile for fruits and vegetables. As opposed to overweight men who were less likely to meet the target intake of fruits and vegetables and had lower odds of being at the high intake quartile.

Inconsistent results to the current study were reported by Liu (2004). Results showed that women who had higher intake of

fruits and vegetables has lower BMI, but they also were older and had higher physical activity than those who had lower intake of fruits and vegetables (Liu et al., 2004). Similarly, the study of Epstein et al. (2001), demonstrated that parents who increased their children's fruits and vegetables intake had significantly lower rates of overweight than those who decreased fat and sugar rich foods (Epstein et al., 2001).

Coming to the core aspect of this study, which is the association between BMI and metabolic characteristics like; blood pressure, fasting blood glucose and lipids profile. Starting with the blood pressure, this study found that there is significant correlation between BMI and blood pressure, by which an increase in the percentage of hypertension was observed moving from under/normal weight to overweight and obesity (5.6%, 12.5% and 28% respectively). This effect of obesity on BMI can be explained by the study of Dustan (1983), this explained the multiple physiological mechanisms that played a role in this effect. The author elaborated that there are physiological changes that happens in obesity with the increase in tissue mass, there will be increase in the oxygen consumption, thus there will be a rise in blood volume, cardiac output, and arteriovenous oxygen difference. Moreover, obesity is associated with metabolic and endocrine changes such as: increase in insulin level, insulin resistance, carbohydrates intolerance, increase in the rate of stress hormones secretion like cortisol which has a critical role in rising the blood pressure. In addition, it was found that with obesity there is increase stimulation of the sympathetic nervous system

activity, which in turns adds to the rise in blood pressure. Furthermore, the author implicated that with weight loss there will be resolution of all the above-mentioned abnormalities. (Dustan et al., 1983)

A Study by Simonds (2014) highlighted the role of leptin in explaining the association between obesity and hypertension. The study displayed results of multiple studies, one of them was done on rodent that had obesity induced by diet, this study proposed that the sympathetic nervous system has an important role in obesity induced hypertension. In addition, leptin is elevated in obese individuals because it is an adipose tissue derived hormone works by acting on the hypothalamus to decrease calorie intake and increase the burn of energy, also leads to increase stimulation of the sympathetic nervous system, thus increasing heart rate and blood pressure. This study gave a further scientific explanation to the results found by the current study. (Simonds et al., 2014)

The impact of obesity on raising the blood pressure was also reflected in a study by Wildman (2010). The study revealed that obese individuals had a higher mean systolic and diastolic blood pressure (127.6/74.9 mmHg) when compared to the mean of non-obese individuals (123.4/73.2), and this was a significant correlation. Moreover, a study by Chang (2012) revealed same effect of obesity on BMI. The results of this study showed that the mean systolic and diastolic blood pressure increases with the increase in BMI status from underweight to obesity (Wildman et al., 2010, Chang et al., 2012).

Relatively similar rise in the percentage of hypertension across the BMI categories was observed in a study by Da Silva Coelho et al. (2020), this study showed that the mean systolic and diastolic blood pressure was highest in overweight obese individuals.

Another supportive study to the current study in regard to the association between BMI and blood pressure was by Dua et al. (2014). Upon analyzing the results based on systolic and diastolic blood pressure, highest percentage of overweight males were found to have prehypertension. Similar results were found in regard to the percentage of overweight males and stage one hypertension, they are found to have the highest percentage according to the diastolic blood pressure. Similarly, among females the percentage of prehypertension was the highest among overweight females when considering systolic blood pressure and diastolic blood pressure. Furthermore, when comparing overweight/obese male individuals to normal weight, overweight/obese males had 2.82 times higher risk of prehypertension and 2.65 times higher risk of stage one hypertension and 8.98 times higher risk of stage two hypertension. Also, overweight/obese females had 2 times higher risk of prehypertension, 3.74 times higher risk of stage one hypertension and 8.98 times higher risk of stage two hypertension compared to non-obese females.

In addition, another study showed that there is significant association between higher BMI levels and the incident of developing hypertension (Chandra et al., 2014). Similarly, a study by Khera (2020) reported increase in BMI there was simultaneous increase in the mean systolic blood pressure. So, normal weight

individuals had lower mean systolic blood pressure than overweight, obese and morbidly obese individuals (Khera et al., 2020).

In conclusion, the impact of obesity on rising the blood pressure was clearly demonstrated by all the previously mentioned studies and the current study. Therefore, this clear positive correlation between BMI and blood pressure emphasizes on the importance of managing weight in order to prevent and treat elevated blood pressure. Obese patients can be confidently informed about the negative impact of their weight on their blood pressure.

FPG was the second metabolic parameter that has been examined in correlation with BMI, Results of the current study revealed that higher percentage of pre-diabetes was found among obese individuals than those with under/normal weight, and the percentage of normal FPG level was found among those with under/normal weight compared to obese individuals. This effect can be explained by the insulin resistant theory, which states that adipocytes produces adipocytes derived fatty acids that leads to resistance to insulin action exerted on the liver and muscles. In addition, this large amount of adipose tissue that is present in overweight and obese individuals secretes large amounts of leptin that has a defective action at the cellular level, and this might also be related to insulin resistance (Lazar et al., 2005).

In consistent with the current study by Khera et a. (2020) showed that the percentage of diabetes increased with the increase in BMI, and that the percentage of diabetes among normal weight participants was lowest in comparison to the overweight, obese

and morbidly obese participant. Wildman et al. (2010) also found a significant association between BMI and abnormal FPG with obese subjects having high mean level values compared to normal weight individuals.

Another study that supported the current study results is the study by Da Silva Coelho et al. (2020), this study revealed that overweight obese individuals had higher blood glucose median level than healthy weight individuals. Moreover, a study by Chang (2012) also conveyed that the mean blood glucose for overweight participants is higher than those with normal weight.

Indeed, it can be concluded that obese individuals have a significantly higher risk of elevated blood sugar pointing to the essential role of weight loss program in managing high blood sugar.

Lastly, the correlation between the lipids profile including total cholesterol, TGs, LDL-C and HDL-C and BMI was examined. This research found a significant correlation between BMI and all the lipids profile parameters, by which abnormal total cholesterol and TGs levels were higher in obese participants than under/normal weight participants. Surprisingly all of the obese individuals had abnormal LDL-C levels and lower levels of HDL-C were present in obese individuals in comparison to those under/normal weight. These results can be explained by the physiological and metabolic effect that is exerted by obesity on the body leading to the increase in the free fatty acids levels. These free fatty acids play a role in the development of insulin resistance, increasing the LDL-C, TGs, VLDL levels and

decreasing HDL-C levels. As a consequence of liver exposure to high levels of free fatty acids, high amounts of VLDL, intermediate density lipoprotein and ultimately high levels of LDL-C. Also, in support of the current study's results, Kanwar et al. (2016) demonstrated that obese participants had a higher mean of total cholesterol, TGs and LDL-C and lower mean of HDL-C compared to the non-obese participants.

The study by Wildman et al. (2010) also supported the outcome of the current study in regard to the TGs and HDL-C association to obesity. Obese individuals had higher TGs levels and lower levels of HDL-C than non-obese individuals (Wildman et al., 2010). Similar significant outcomes were conveyed by Chang et al. (2012) but including all the lipid profile parameters that was included in the current study. Results showed that the mean of total cholesterol level was inclining with the increase of BMI from normal, to overweight to obesity, identical trend was observed in the mean of LDL-C and the median of triglycerides. On the contrary the mean of HDL-C was declining with the increase in BMI from normal to overweight to obesity.

In addition, Da Silva Coelho et al. (2020) also reached similar results to the above studies in terms of TGs and HDL-C. The study showed that OWO individuals had higher median triglycerides than HWI. And in regard to HDL-C OWO individuals had lower mean than HWI.

Nevertheless, there are certain limitations to the current study. Due to the Covid-19 pandemic situation, telephone interviews substituted the in-person interviews which gives more

accessibility and provides more accurate information as they tend to last longer than phone interviews. For this particular reason, the number of variables were reduced. Finally, convenience sampling method is subject to selection bias.

4.3 Conclusion

In conclusion, results from this research established that the prevalence of obesity among Bahraini individuals aged 20-65 years is 39.2%. There was significant association between advancing age and obesity, but there was no significant difference in obesity status demonstrated between males and females. The only other demographic parameter that was significantly associated with obesity was the marital status, as married participants had higher percentage of obesity. Evidently, BMI is proven to have a significant correlation with elevated blood pressure, FPG, total cholesterol, LDL-C, TGs and low levels of HDL-C. Finally, obesity was significantly associated with abnormal metabolic profile and elevated blood pressure and normal weight was significantly associated with metabolic profile and favorable blood pressure readings,

4.4 Recommendations

- The study should be conducted on larger sample, including participants from hospitals in different areas around Bahrain in order to be more representative of Bahraini population.
- More credible sampling technique should be used to avoid sampling bias.

- Cooperation between governmental hospitals research committees is needed to establish future collaborations for future researches that includes participant from different areas with different characteristics.
- Cooperation between the main governmental hospital in Bahrain (Salmaniya Medical Complex) and the University of Bahrain is desired, as the hospital represents the whole population of Bahrain.
- Adding BMI as one of the compulsory parameters that has to be filled in every visit on the electronic health systems for the governmental hospital to make easier for future researches to evaluate the impact of BMI over time on different biochemical markers.
- Establishing a comprehensive BMI based program as part of NCD prevention, that incorporates individualized dietary and physical activity plan based on the patient's BMI and metabolic abnormality.
- Implementing an intensive BMI targeting preventative programs at schools in order to improve and maintain school age children normal BMI to enhance their future health.
- Incorporating the data of the current study to conduct a study that evaluates the risk metabolic syndrome in obese individuals.

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Appendix (A)

KING HAMAD
UNIVERSITY HOSPITAL
مستشفى الملك حمد الجامعي

07 July 2021



TO:
Co INVESTIGATORS
& SUPERVISORS:

Dr. Tahera Alnashaba
Dr. Tariq Alalwan (UoB), Dr. Jawaher Alsaqer, Dr. Abdulrahman Mahroofi & Dr. Dalal Alromaihi

FROM:

Institutional Review Board

PROJECT TITLE:

Evaluation of Metabolic Derangement Among Bahrainis in Relation to Body Mass Index

REFERENCE #:

21- 442

ACTION:

APPROVED

APPROVAL DATE:

07 July 2021

EXPIRATION DATE:

06 July 2022

REVIEW TYPE:

Expedited Review

This is to inform you that your research proposal has been reviewed by the Institutional Review Board, King Hamad University Hospital. Your application is approved as submitted. Approval is for a period of one year from 07 July 2021. If you would like to continue this research after this period, please submit for an extension (use status update form) one month prior to your expiration date of 06 July 2022.

1. Kindly note that you are expected to complete a status update report on your study every three months.
2. The Head of Scientific Research & Development should be informed in writing (email is acceptable) within twenty-four hours of any adverse event in the conduct of research involving human subjects. Please include the nature of the adverse event, the names of the persons affected, the extent of the injury or breach of security, if any, and any other information material to the situation.
3. Any aspect of your research procedure should not be changed without permission from the Head of Scientific Research & Development. Please use the status update form to request any changes.
4. Maintain all research records as detailed in the protocol.
5. Ensure that each consent form is dated and duly signed by the participant and the investigator or the designated person obtaining consent. All informed consents should also be provided to the Research Department upon completion of the study. Indicate in the header or footer of each page of your approved Informed Consent form the approval and expiration dates of the protocol as follows: "Approved from 07 July 2021 to 06 July 2022 by the KHUH IRB" (if relevant).
6. Kindly note that the KHUH IRB has the right to withhold publication of a study and/or withdraw ethical approval of a research if judged necessary.

We can assist you with data analysis and provide guidance for process of publication. Should you have any questions about the conduct of your research under this protocol, particularly about obtaining informed consent, please email: research3@khu.org.bh.

We wish you the best of success in your research.

Yours Sincerely,


Abdulla Almusafam, MA

Acting Head of Scientific Research & Development

Appendix (B)

نموذج الموافقة بالعلم لمستشفى الملك حمد الجامعي
تزود هذه الاستمارة المعلومات للمشاركة في البحث (أو ولي الامر) وإثبات الموافقة بالعلم، الموافقة
المبينة، و/ أو إذن ولي الامر.

الموافقة الشخصية بالعلم

معلومات المشروع	
عنوان مشروع البحث	تقييم اضطراب التمثيل الغذائي بين البحرينيين بالنظر إلى مؤشر كتلة الجسم
الباحث الرئيسي	طاهرة محمد النشابة

- الهدف من هذه الدراسة البحثية:

اطلب منكم المشاركة الاختيارية في مشروعنا البحثي (أطروحتي). بحثي هذا مصمم لدراسة السمنة واضطراب التمثيل الغذائي بالنظر إلى مؤشر كتلة الجسم، القياسات الأنتروبومترية، وقياس معدلات الأيض مثل مستوى الدهون (على سبيل المثال: الدهون الثلاثية، الكوليسترول، البروتين الدهني عالي الكثافة ومنخفض الكثافة)، ومستويات الجلوكوز في الدم للصائم، سوف يتم أخذ عينات الدم بعد الصيام لمدة 10 – 12 ساعة طوال الليل.

الإجراءات:

في حال المشاركة، سوف يُطلب منك الآتي:

الحضور إلى الجادة في يوم محدد لأخذ القياسات الأنتروبومترية (الطول والوزن)، ضغط الدم، وأخذ عينات الدم.

الوقت المطلوب للمشاركة:

سوف يُطلب منك الحضور للجادة في مستشفى الملك حمد الجامعي لمدة تصل في مجموعها إلى يومين، سوف يتم أخذ القياسات في اليوم الأول مع عينات الدم، أما في اليوم التالي سوف يكون لنتيجة فحص الدم. في حال حصول خلل في أخذ عينات الدم بسبب الإجراءات المخبرية، سوف يُطلب منك الحضور مرة أخرى لسحب الدم.

الآخطار المحتملة:

هناك حد أدنى من الآخطار المرتبطة بهذه الدراسة. وتتضمن هذه الآخطار الآلم الطفيف الناتج عن أخذ عينات الدم، أو فشل العملية. سوف يتم التواصل معك بشأن أي معلومات تستجد أثناء الدراسة والتي قد تؤثر على قابليتك للاستمرار في المشاركة.

ملكية وتوثيق العينات:

للتعامل مع العينة، سوف يتم اتباع الإجراءات المعتادة في مختبر مستشفى الملك حمد الجامعي وفق السياسات والإجراءات. معلومات المريض سوف يتم تحييدها وتخزينها في ملف إلكتروني آمن محمي بكلمة مرور ويمكن الوصول إليه فقط من قبل الباحثين المشاركين.

الفوائد المحتملة:

سوف يستفيد المشترك من قياس العلامات البيوكيميائية ومن العلاج الذي قد يترتب على النتائج. بالإضافة إلى ذلك، فإن تقييم قياسات المريض الأثرية قد ينقل بيانات صحية إضافية مرتبطة بالنتيجة. وكذلك فإن هذه الدراسة سوف تساعد في إثبات الفرضية التي تربط بين السمنة واضطراب التمثيل الغذائي بالنظر إلى مؤشر كتلة الجسم من أجل تسليط الضوء على مدى جنية المشكلة في منطقتنا، ما يمكنه أن يشكل حافزاً للبيئات الحكومية وغير الحكومية لتطوير وتطبيق خطط فعلية للوقاية والسيطرة على هذه السمنة والمعدلات الأيضية.

اعتبارات مالية:

لا يوجد مقلب مالي لاشتراككم في هذه الدراسة. في حال تعرضكم للجرح كنتيجة مباشرة لاشتراك في هذه الدراسة البحثية، سوف يتم توفير الخلية الطبية العاجلة من قبل الطاقم الطبي لمستشفى الملك حمد أو من خلال نقلكم إلى طبيبك الشخصي أو إلى مركز طبي. لن تتمكن () ولا الحكومة من توفير الخلية الطبية طوية الأجل أو التعويض المالي باستثناء ما هو وارد في برنامج تأمين صاحب العمل أو من خلال أي ترتيبات قانونية ممكنة.

بدائل العلاج المتوفرة:

الدراسة لا تتضمن علاجاً تجريبياً.

السرية:

هوية المشارك ومعلوماته الطبية سيتم التعامل معها بالكامل من قبل الباحثين المشاركين في هذه الدراسة، وسوف يتم تجميع المعلومات تحت أرقام تسلسلية بدلاً من الأسماء أو الأرقام الشخصية. سوف يتم الحفاظ على الخصوصية أثناء التعامل مع المشارك.



كل عينات الدم سيتم استخدامها فقط لأغراض الدراسة وسيتم التخلص منها بعد التحليل، وذلك وفقاً لبروتوكول التخلص من عينات الدم بالمستشفى. وسيتم عرض نتائج فحص الدم لكل المشاركين في زيارة منفصلة لكل منهم.

إنهاء الدراسة البحثية:

للمشارك الحرية في المشاركة في هذه الدراسة أو لا. لن تكون هناك عقوبة أو خسارة في المزايا التي يحق لك الحصول عليها إذا اخترت عدم المشاركة. سوف يتم تزويدك كمشارك بأي معلومات تستجد أثناء عقد هذه الدراسة والتي من شأنها أن تؤثر في استمرارك في المشاركة. في حال الرغبة في عدم استمرارك في المشاركة في هذه الدراسة، الرجاء إخطار () بقراركم، وذلك ليضمن لنا إنهاء مشاركتكم بانتظام. إذا قررت عدم الاستمرار في المشاركة قبل البدء بإجراءات تحليل الدم، لن يكون هناك أي عواقب. ولكن إذا كان الانسحاب من قبلكم بعد نتائج فحص الدم، فإن كل معلوماتكم الطبية سوف يتم استخدامها في الدراسة، ولكن لن يطلب منكم الحضور أكثر لمواعيد الجادة في حال حصول خلل في الفحص المبني.

بالإضافة إلى ذلك، فإن مشاركتكم في الدراسة يمكن أن يتم إنهاؤها من قبل الباحث دون أخذ موافقتكم، في حال لم يتم الالتزام من قبلكم بالتعليمات المعطاة من قبل الباحث الرئيسي بخصوص الزيارات المطلوبة للقياسات الأثروبومترية وأخذ عينات الدم.

مصادر المعلومات المتاحة:

سوف يتم الإجابة عن أي استفسار آخر بخصوص هذه الدراسة من قبل الباحث الرئيسي.

الاسم: _____ رقم الهاتف: _____

لاي استفسار لديكم عن حقوقكم كموضوع للبحث يمكننا التواصل مع:

الاسم: _____

رقم الهاتف: _____

في حال حصول طوارئ متعلقة بالدراسة، الرجاء الاتصال على:

رقم الطوارئ للنهار: _____

رقم الطوارئ لليل: _____



تقويض:

لقد قمت بقراءة وفهم استمارة الموافقة هذه، وأوافق على المشاركة في هذه الدراسة البحثية. وأدرك بأنني سأسلم نسخة من هذه الاستمارة. أهتم بالمشاركة باختيار، ولكن أدرك بأن موافقتي لا تسحب أي حقوق قانونية في حال الإهمال أو الأخطاء التقنية الأخرى لأي أحد في هذه الدراسة. وكذلك أدرك بأن لا شيء في استمارة الموافقة هذه يمكنه أن يستقبل أي قانون مطبق في الدولة.

اسم المشارك (مطبوع أو مكتوب): _____ التاريخ: _____

توقيع المشارك: _____ التاريخ: _____

توقيع الباحث الرئيسي: _____ التاريخ: _____

توقيع الشخص الحاصل على الموافقة: _____ التاريخ: _____

Appendix (C)

KHUH INFORMED CONSENT TEMPLATE

This form is used to provide information to the research participant (or parent/guardian) and to document written informed consent, minor assent, and/or parental permission.

HUMAN INFORMED CONSENT

PROJECT INFORMATION	
Research Project Title	Evaluation of Metabolic Derangement Among Bahrainis in Relation to Body Mass Index
Principal Investigator	Tahera Mohamed Alrashdan

- PURPOSE OF THIS RESEARCH STUDY:

I am asking for your voluntary participation in my research (thesis) project. My study is designed to study the obesity and metabolic derangements in relation to BMI, Assess your anthropometric measures and to Assess your metabolic parameters like lipid profile (e.g., triglycerides, cholesterol, high density lipoprotein and low-density lipoprotein), and fasting blood glucose levels, blood samples will be collected after an overnight fasting of 10-12 hrs.

PROCEDURES:

If you participate, you will be asked to:

To attend the clinic on a defined day to be evaluate your anthropometric measurements (height and weight), blood pressure and blood samples collection

Time required for participation:

You will be asked to attend the clinic in KHUH for total of two days, the first day measurements will be taken, and blood will be collected and the second time for

conveying your blood results. In case of errors in blood collection of laboratory procedures, you will be asked to come for another blood draw.

POSSIBLE RISKS OR DISCOMFORT:

There are minimal risks that is associated with the study. These risks involve mild pain associated with blood collection, or procedure failure.

Any new information developed during the study that may affect your willingness to continue participation will be communicated to you

OWNERSHIP AND DOCUMENTATION OF SPECIMENS:

Standard procedures for specimen handling will be followed by KHUH lab in accordance with policies and procedures. Patient information will be deidentified and stored in a secure electronic file that is protected by a password and only accessible by the co-investigators.

POSSIBLE BENEFITS:

The participant will benefit from assessing his/her biochemical markers and from the treatment that might be needed based on the results. In addition, evaluating the participant's anthropometric measures might will convey extra health associated data. Moreover, This study will help establishing the prevalence of obesity and metabolic derangement in relation to BMI in order to emphasize the seriousness of the problem in our region, which can motivate governmental and non-governmental agencies to develop and implement action plans for prevention and control of these metabolic parameters and obesity.

FINANCIAL CONSIDERATIONS:

There is no financial compensation for your participation in this research.

If you are injured as a direct result of taking part in this research study, emergency medical care will be provided by KHUH medical staff or by transporting you to

your personal doctor or medical center. Neither [] nor the government will be able to provide you with long-term medical treatment or financial compensation except as may be provided through your employer's insurance programs or through whatever remedies are normally available at law.

AVAILABLE TREATMENT ALTERNATIVES:

The study does not involve an experimental treatment.

AVAILABLE MEDICAL TREATMENT FOR ADVERSE EXPERIENCES:

This study involves minimal risk.

If you are injured as a direct result of taking part in this research study, emergency medical care will be provided by KHUH medical staff or by transporting you to your personal doctor or medical center. Neither [] nor the government will be able to provide you with long-term medical treatment or financial compensation except as may be provided through your employer's insurance programs or through whatever remedies are normally available at law.

CONFIDENTIALITY:

Participant's identities and medical data will be exclusively handled by the study researchers.

the data will be collected under serial numbers instead of names or CPRs.

Privacy will be practiced during participant encounter.

All blood samples will only be used for the study purposes and will be discarded after analysis, as per the hospital blood samples discarding protocol.

Blood results will be disclosed to all participants on a separate visit.

TERMINATION OF RESEARCH STUDY:

You are free to choose whether or not to participate in this study. There will be no penalty or loss of benefits to which you are otherwise entitled if you choose not to participate. You will be provided with any significant new findings developed during the course of this study that may relate to or influence your willingness to continue participation. In the event you decide to discontinue your participation in the study: Please notify () of your decision, so that your participation can be orderly terminated. If you decided to discontinue participation before the blood results procedure, there will be no consequences. But, if withdrawal was after blood results then all your medical data will be used in the study, but you will not be asked to attend further clinic appointments in case of any errors in the initial testing.

In addition, your participation in the study may be terminated by the investigator without your consent, if you failed to follow the instructions given by the principle researcher regarding the needed visits for anthropometric measurements and blood sample collections.

AVAILABLE SOURCES OF INFORMATION: Any further questions you have about this study will be answered by the Principal Investigator:

Name: Phone Number:

Any questions you may have about your rights as a research subject will be answered by:

Name: Phone
Number:

In case of a research-related emergency, call:

Day Emergency Number:

Night Emergency Number: _____

AUTHORIZATION

I have read and understand this consent form, and I volunteer to participate in this research study. I understand that I will receive a copy of this form. I voluntarily choose to participate, but I understand that my consent does not take away any legal rights in the case of negligence or other legal fault of anyone who is involved in this study. I further understand that nothing in this consent form is intended to replace any applicable country laws.

Participant Name (Printed or Typed): _____ Date: _____

Participant Signature: _____ Date: _____

Principal Investigator Signature: _____ Date: _____

Signature of Person Obtaining Consent: _____ Date: _____

Appendix (D)

Metabolic Derangement Among Bahrainis in Relation to BMI

Your Full Name:	Click here to enter text.	
CPR:	Click here to enter text.	
Age:	Click here to enter text.	
Gender:	☐ Female ☐ Male	
Nationality:	☐ Bahraini ☐ Non- Bahraini	
Marital status:	☐ Married ☐ Single	
Pregnancy status:	☐ Pregnant ☐ Non-pregnant	
Educational level:	☐ School ☐ Higher education	
Income status:	☐ Less than 450 ☐ More than 450	
Physical activity:	☐ Sedentary ☐ Low active ☐ Active ☐ Very active	
Smoking status:	☐ Smoker ☐ Non-smoker	
Diet:	Fruit intake:	☐ Less than 5 servings ☐ More than 5 servings
	Vegetable intake:	☐ Less than 5 servings ☐ More than 5 servings
Are you on	☐ Hyperglycemic agents ☐ Lipid lowering agents	

Any history of myocardial infraction or congestive heart failure or stroke?	☐ Yes ☐ No
Blood pressure	1. Click here to enter text. 2. Click here to enter text. 3. Click here to enter text.
Anthropometric measurement	Height- Click here to enter text. Weight- Click here to enter text. BMI- Click here to enter text.
Fasting glucose level	Click here to enter text.
Fasting lipid profile	Total cholesterol- Click here to enter text. Triglycerides- Click here to enter text. LDL- Click here to enter text. HDL- Click here to enter text.

ملخص البحث

الهدف: الهدف الرئيسي من الدراسة هو تقييم اضطرابات الأيض بين البالغين البحرينيين فيما يتعلق بمؤشر كتلة الجسم (بي إم أي).

الطرق: تم استخدام تصميم مقطعي لعينة مناسبة من المرضى البحرينيين من الفئة العمرية بين 20-65 عام في العيادات الخارجية بمستشفى الملك حمد الجامعي لأمراض الأعصاب والأمراض الجلدية والجهاز التنفسي بين أغسطس 2021 وسبتمبر 2021. وقد تم فحص بيانات المشاركين باستخدام سجل مرضى مستشفى الملك حمد الجامعي وتم التحقق منها من خلال مكالمات هاتفية. علاوة على ذلك، تم الاتصال بالمرضى الذين استوفوا معايير الانضمام ووافقوا على البحث في يوم الموعد المحدد لهم، وتم الحصول على قياسات الجسم وضغط الدم جنباً إلى جنب مع فحوصات الدم. وبعد ذلك تم تحليل البيانات وتفسيرها باستخدام دلالة إحصائية أقل من 0.05. تم فحص مجموعة من 194 مشاركاً لدى الانتهاء من جمع البيانات من السجلات الإلكترونية والمقابلة الهاتفية والإجراءات التي تمت خلال المواعيد. وبحسب النتائج، بلغ معدل انتشار السمنة بين المشاركين 39.2٪، مع العلم أن السن والحالة الاجتماعية هما المتغيرين الوحيدتين اللذين لهما دلالة إحصائية مع مؤشر كتلة الجسم ($P < 0.001$). ومن ناحية أخرى، تم تحقيق دلالة إحصائية لمؤشر كتلة الجسم مع جميع المتغيرات الأيضية، حيث كان هناك أقوى ارتباط بين السمنة والبروتين الدهني منخفض الكثافة (LDL-C). وقد تبين أن نسبة ارتفاع ضغط الدم بين الأفراد الذين يعانون من السمنة المفرطة كانت 28.9٪ ($P = 0.002$)، ومن يعانون من مقدمات السكري 36٪ ($P < 0.001$). وبلغت نسبة الكوليسترول الكلي غير الطبيعي 47.4٪ ($P = 0.006$) والدهون الثلاثية غير الطبيعية (TG) كانت 25٪ ($P = 0.002$) وكان والبروتين الدهني منخفض الكثافة غير طبيعي 100٪ والبروتين الدهني عالي الكثافة غير الطبيعي (HDL-C) 31.6٪ ($P = 0.009$).

الخلاصة: كشفت نتائج هذه الدراسة أن الأفراد الذين يعانون من السمنة المفرطة أظهروا نسبة أعلى من التشوهات الأيضية مقارنة بنظرائهم من ذوي الوزن المنخفض / الطبيعي. مما يوضح أن مؤشر كتلة الجسم له تأثير سلبي كبير على معايير التمثيل الغذائي التي تزداد مع ارتفاع مؤشر كتلة الجسم وتفاقمه بمرور الوقت.

جامعة البحرين

قسم علوم الحياة

كلية العلوم



تقيم اضطراب التمثيل الغذائي بين البحرينيين بالنظر الى مؤشر كتلة الجسم

اطروحة مقدمة كجزء من متطلبات الحصول على درجة الماجستير في التغذية والنظم الغذائية

إعداد :

طاهرة محمد النشايه

الرقم الجامعي: 20170044

إشراف :

د . طارق العلوان

استاذ مساعد

جامعة البحرين

مملكة البحرين

فبراير ٢٠٢٢