



University of Bahrain

College of Science - Department of Biology

**Metabolic Syndrome among Bahraini Adults:
Association with Dietary Patterns and Prognostic
Factors**

Layla Habib Ahmed Hammad

A Dissertation submitted in partial fulfillment of the
Requirements for degree of M.Sc. in Nutrition and Dietetics

June 2021



جامعة البحرين

قسم العلوم - كلية الأحياء

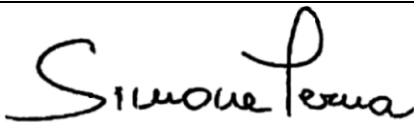
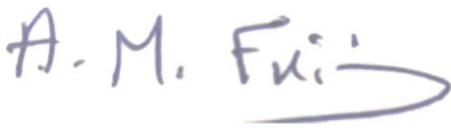
متلازمة التمثيل الغذائي بين البالغين البحرينيين وعلاقتها بالنمط الغذائي والعوامل التكهنية

ليلى حبيب احمد حماد

أطروحة مقدمة في إطار الوفاء الجزئي بمتطلبات درجة الماجستير في التغذية والنظم الغذائية

يونيو 2021

Thesis Committee Members:

1. Thesis Supervisor	Dr. Simone Perna
Title	Associate Professor – Department of Biology
Institution	University of Bahrain
Signature	
Date	19 th of May 2021
2. Internal Examiner	Prof. Afnan Mahmood Freije
Title	Professor – Department of Biology
Institution	University of Bahrain
Signature	
Date	19 th of May 2021
3. External Examiner	Dr. Ghufraan Ahmed Jassim
Title	Associate Professor in Family Medicine
Institution	Royal College of Surgeons in Ireland
Signature	
Date	19 th of May 2021

ABSTRACT

Background: The relationship between metabolic syndrome (MetS) risk and diet is not fully understood and has not been thoroughly investigated and defined yet. The motivation and objective of this study is to examine the relationship between biochemical biomarkers with MetS among Bahraini adults and the possible association between metabolic syndrome (MetS) and dietary pattern.

Method: A cross-sectional study involving adults aged from 18 to 65 years old (n = 151) with a history of metabolic syndrome (MetS) was conducted. Blood pressure, anthropometric measurements, sociodemographic information and fasting blood samples were collected. Eighty Participants completed an online food frequency questionnaire (FFQ), an international physical activity questionnaire (IPAG), and other lifestyle questions. Multiple regression analysis was used to evaluate the associations of dietary patterns and biochemical biomarkers with MetS and its risk factors.

Results: One hundred fifty-one participants were recruited in the study. The mean age of the participants was 53.8 ± 8.3 years old, 89 (58.9%) were females while 62 (41.1%) were males diagnosed with MetS.

Regarding the association between the main MetS risk factors and specific foods consumed in Bahrain, this study highlights that there was a positive association between the increase of BMI and the increase of processed meat consumption ($B=3.83$, $p=0.001$) and negative relationship with beef ($B=-4.66$, $p=0.001$), legumes ($B=-2.70$, $p=0.04$), hamburgers ($B=-5.93$, $p=0.01$), and sambosa ($B=-4.7$, $p=0.01$). The increase of systolic blood pressure was negatively associated with rice, bread, and pasta frequency of consumption ($B=-5.60$, $p=0.03$). Also, a positive relationship was found between glucose increase and the increase of lamb consumption ($B=1.86$, $p=0.01$), as well as falafel sandwiches ($B=1.55$, $p=0.02$) and negative association with dates ($B=-0.85$, $p=0.04$). Triglycerides were positively associated with the consumption of low-fat dairy products ($B=0.76$, $p=0.01$). Moreover, a negative association was observed between HDL and increase of chicken consumption ($B=-3.44$, $p=0.02$), cheddar cheese ($B=-3.89$, $p=0.04$), ricotta and goat cheese ($B=-6.29$, $p=0.01$), chips ($B=-3.89$, $p=0.39$) and positive association was found with falafel sandwiches ($B=3.67$, $p=0.034$).

Regarding the main biochemical markers associated with the MetS risk factors, this study highlights that a statistically significant positive association between glucose fasting with HbA1c

($B = 0.472$, $p = 0.01$) and negative correlation with sodium ($B = -0.3$, $p = 0.04$) were observed. In addition, negative association between triglyceride and the following biomarkers (HbA1c ($B = -0.29$, $p = 0.003$), AST ($B = -0.06$, $p = 0.009$), ESR ($B = -0.02$, $p = 0.014$)) and there was a positive correlation between triglyceride and the following biomarkers (Cr ($B = 0.01$, $p = 0.005$) and GGT ($B = 0.013$, $p = 0.001$)). Also, Positive associations were noted between HDL and ESR ($B = 0.103$, $p = 0.02$). Regarding blood pressure, SBP was positively correlated with amylase ($B = 0.135$, $p = 0.04$) and vitamin B9 ($B = 0.665$, $p = 0.02$) while DBP was positively correlated with ALT ($B = 0.051$, $p = 0.04$).

Conclusion: Multiple dietary patterns are closely associated with MetS risk factors among Bahraini adults and some biochemical biomarkers are associated with MetS components which may use as early indicators to be addressed to minimize the risk of MetS.

Keywords: metabolic syndrome; adults; dietary pattern; food; biochemical biomarkers

خُلاصة البحث

الخلفية: ان العلاقة بين خطر متلازمة التمثيل الغذائي والنظام الغذائي ليست مفهومة بالكامل ولم يتم التحقيق فيها وتحديدها بدقة الى الآن. الدافع والهدف من هذه الدراسة هو فحص العلاقة بين بين متلازمة التمثيل الغذائي والنمط الغذائي بين البالغين البحرينيين والعلاقة المحتملة بين المؤشرات الحيوية الكيميائية ومتلازمة التمثيل الغذائي.

الطريقة: أجريت دراسة مقطعية شملت بالغين تتراوح أعمارهم بين 18 و 65 عامًا (ن = 151) لديهم تاريخ في متلازمة التمثيل الغذائي. تم جمع عينات ضغط الدم والقياسات البشرية والمعلومات الاجتماعية الديموغرافية وعينات الدم أثناء الصيام. أكمل ثمانون مشاركاً استبيان تواتر الغذاء عبر الإنترنت ، واستبيان النشاط البدني الدولي ، وأسئلة أخرى حول نمط الحياة . تم استخدام تحليل الانحدار المتعدد لتقييم ارتباطات الأنماط الغذائية والعلامات الحيوية الكيميائية الحيوية مع متلازمة النمط الغذائي وعوامل الخطر الخاصة به .

النتائج: تم تجنيد مائة وخمسين مشاركاً في الدراسة. كان متوسط عمر المشاركين 53.8 ± 8.3 سنة ، 89 (58.9%) من الإناث بينما 62 (41.1%) من الذكور تم تشخيصهم بمتلازمة النمط الغذائي .

فيما يتعلق بعوامل خطورة متلازمة النمط الغذائي والأغذية المحددة المستهلكة في البحرين ، تسلط هذه الدراسة الضوء على وجود ارتباط إيجابي بين زيادة مؤشر كتلة الجسم وزيادة استهلاك اللحوم المصنعة (ب = 3.83 ، ع = 0.001)

وعلاقة سلبية مع كل من لحم البقر (ب = -4.66 ، ع = 0.001) ، البقوليات (ب = -2.70 ، ع = 0.04) ، الهامبرغر (ب = -5.93 ، ع = 0.01) و السميوسة (ب = -4.7 ، ع = 0.01). كما ان ارتفاع ضغط الدم الانقباضي ارتبط سلبياً مع تكرار استهلاك الأرز والخبز والمعكرونة (ب = -5.6 ، ع = 0.03)

كما وجدت علاقة موجبة بين زيادة الجلوكوز مع كل من زيادة استهلاك الضأن (ب = 1.86 ، ع = 0.01) وسندويشات الفلافل (ب = 1.55 ، ع = 0.02) ووجود علاقة سلبية مع التمر (ب = -0.85 ، ع = 0.04) . وارتبطت الدهون الثلاثية بشكل إيجابي مع استهلاك منتجات الألبان قليلة الدسم (ب = 0.76 ، ع = 0.01). علاوة على ذلك ، لوحظ ارتباط سلبي بين البروتين الدهني العالي الكثافة مع كل من زيادة استهلاك الدجاج (ب = -3.44 ، ع = 0.02) ، جبنة الشيدر (ب = -3.89 ، ع = 0.04) ، جبنة قريش و جبنة الماعز (ب = -6.29 ، ع = 0.01)، رقائق الشبس (ب = -3.89 ، ع = 0.039) ووجود ارتباط ايجابي مع سندويشات الفلافل (ب = 3.67 ، ع = 0.034).

فيما يتعلق بالعلامات البيوكيميائية الرئيسية المرتبطة بعوامل خطر متلازمة التمثيل الغذائي ، تسلط هذه الدراسة الضوء على وجود علاقة ايجابية بين صيام الجلوكوز والهيموغلوبين السكري (ب = 0.472 ، ع = 0.01) وعلاقة سلبية مع الصوديوم (ب = -0.3 ، ع = 0.04) . بالإضافة إلى ذلك ، هناك ارتباط سلبي بين الدهون الثلاثية والعلامات الحيوية التالية (الهيموغلوبين السكري (ب = 0.29 ، ع = 0.003) ، مستوى انزيم ناقله امين الاسبارتات (ب = -0.06 ، ع = 0.009) ، معدل سرعة ترسيب الخلايا الحمراء (ب = -0.02 ، ع = 0.014) ووجود ارتباط ايجابي بين الدهون الثلاثية مع العلامات الحيوية التالية (الكرياتينين (ب = 0.01 ، ع = 0.005) ، انزيم ناقله الببتيد غاما غلوتاميل (ب = 0.001 ، ع = 0.013).

أيضاً لوحظ وجود علاقة ايجابية بين البروتين الدهني العالي الكثافة مع معدل سرعة ترسيب الخلايا الحمراء (ب = 0.103 ، ع = 0.02) . فيما يتعلق بضغط الدم ، هناك ارتباط ايجابي بين ضغط الدم الانقباضي و انزيم الاميليز (ب = 0.135 ، ع = 0.04) و فيتامين ب 9 (ب = 0.665 ، ع = 0.02) ، وعلاقة ايجابية بين ضغط الدم الانبساطي مع انزيم ناقله امين الألانين (ب = 0.051 ، ع = 0.04) .

الخلاصة: ترتبط الأنماط الغذائية المتعددة ارتباطاً وثيقاً بعوامل خطر متلازمة التمثيل الغذائي بين البالغين البحرينيين وترتبط بعض المؤشرات الحيوية الكيميائية الحيوية بمكونات متلازمة التمثيل الغذائي التي قد تستخدم كمؤشرات مبكرة يجب معالجتها لتقليل مخاطر متلازمة التمثيل الغذائي .

الكلمات الرئيسية: متلازمة التمثيل الغذائي؛ الكبار؛ نمط غذائي غذاء؛ المؤشرات الحيوية البيوكيميائية .

DEDICATION

I would like to dedicate this dissertation to my family whom with their support and motivation I could only complete this work.

ACKNOWLEDGEMENT

I would like to express my deep appreciation and gratitude to those who in a way or another contributed and assisted through the journey of preparing and completing this study.

I am heartily thankful to my supervisors at University of Bahrain, Dr. Simone Perna, Assistant Professor, for his devoted time, patience, encouragement, guidance and all the support I received from him from the initial to the final levels of this work

A special thanks go to King Hamad University (KHU) for their cooperation and support throughout the course of this research.

Finally, I wish to express my deep gratitude and appreciation to my husband, my father, and mother for their support, advice, prayers and encouragement throughout my study.

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Abbreviations

AST	Aspartate aminotransferase
1,25-dihydroxyvitamin D	Calcitriol
AKI	Acute kidney injury
ALT	Alanine transaminase
apoB	apolipoprotein B
ATPase	Adenosine triphosphatase
BAD	Bipolar Affective Disorder
BF	Body fat weight
BF%	Body fat percentage
BMI	Body Mass Index
BUN	Blood urea nitrogen
Ca	Calcium
CBC	Complete blood count
CIMT	Carotid intima-media thickness test
Cl	Chloride
CLIA	Chemiluminescence Immunoassay system
CRP	C-reactive protein
CVD	Cardiovascular Diseases
DBil	Direct bilirubin
DBP	Diastolic Blood Pressure
DLP	Dyslipidemia

DM II	Type 2 Diabetes Mellitus
DPs	Dietary patterns
ESR	Erythrocyte sedimentation rate
FBG	Fasting Blood Glucose
Fe	Iron
FFA	Free Fatty Acid
FFM	Fat free mass
FFQ	Food Frequency Questionnaire
FFQ	Food Frequency questionnaire
FG	Fasting Glucose
FGF-23	Fibroblast growth factor-23
G/dL	Grams per deciliter
G/L	Grams per liter
GCC	Cooperation Council for the Arab States of the Gulf
GFR	Glomerular Filtration Rate
GGT	γ -glutamyl transferase
GI	Glycemic Index
GnRH	Gonadotropin–releasing hormone
GOD-POD	Glucose oxidase per oxidase
H	Height
Hb	Hemoglobin
HbA1c	Glycated hemoglobin

HC	Hip Circumference
HCT	Hematocrit
HDL-C	High Density Lipoprotein Cholesterol
HG	Hyperglycemia
HTN	Hypertension
IBil	Indirect bilirubin
IDF	International Diabetes Federation
IFG	Impaired fasting glycaemia
IL-6	Interleukin-6
IPAQ	International physical activity questionnaire
IR	Insulin Resistance
IR	Insulin resistance
K	Potassium
LDL-C	Low Density Lipoprotein Cholesterol
LH	Elevated luteinizing hormone
LPL	Lipoprotein Lipase
LTPA	Leisure time of physical activity
M/uL	Million per microliter
MAU	Microalbuminuria
METs	Metabolic equivalents of task
MetS	Metabolic Syndrome
Mg/l	Milligrams per liter
MK	Megakaryocyte

Mm/hr	Millimeters per hour
mm Hg	Millimeters of mercury
Mmol/L	Millimoles per liter
MUFA	Monounsaturated Fatty Acids
Na	Sodium
NALFD	Non-alcohol fatty liver disease
NCD	Non-communicable diseases
NCEP	National Cholesterol Education Program
Ng/mL	Nano grams per milliliter
NIH	National institute of health
NPN	N-protein nitrogenous
OR	Odd Ratio
PA	Physical Activity
PCOS	Polycystic ovary syndrome
Pg/ml	Picograms per milliliter
PLT	Platelets
PTH	Parathyroid hormone
RBC	Red blood cell
RDW	Red blood cell distribution width
SA	Serum Albumin
SBP	Systolic Blood Pressure
SOC	Standard of care
SUA	Serum Uric acid

TBil	Total bilirubin
TBW	Total body water
TC	Total cholesterol
TG	Triglycerides
TP	Total protein
U/L	Units per liter
UAE	Urinary albumin excretion
μmol/L	Micromole per liter
W	Weight
WC	Waist Circumference
WHO	World health organization
WHR	Waist hip ratio

Chapter 1

1.1 Introduction

Metabolic syndrome (MetS) is defined as a multifactorial condition characterized by a complex interrelation between genetic and environmental factors (Kaur, 2014). In addition, the quality of dietary pattern plays a big role in MetS development and unhealthy dietary pattern which is high in fat, red meat, and added sugar increases risk of MetS (Rodríguez-Monforte et al., 2016). The National Institutes of Health (NIH) outlines metabolic syndrome (MetS) as “A cluster of conditions characterized by the presence of three of the following five factors: central obesity (≥ 102 cm in men and ≥ 88 cm in women), elevated blood pressure (systolic blood pressure (SBP) ≥ 130 mm Hg), diastolic blood pressure (DBP ≥ 85 mm Hg), reduced high-density lipoprotein-cholesterol (HDL-C) (< 40 mg/dL in men and < 50 mg/dL in women), elevated blood serum triacylglycerol (TG) (≥ 150 mg/dL), and elevated fasting plasma glucose (FPG) (≥ 100 mg/dL) (NIH, 2001).”

The frequency rate of MetS has considerably risen globally in the last decades. Kaur (2014) reported that the occurrence of metabolic syndrome has been outlined to be between 10% and 84% globally determined by the age, sex, and ethnicity of the population. In children, the prevalence of MetS whole populations was 3.3% (Friend et al., 2013) while in adults it is approximately 25% worldwide (Nolan et al., 2017). In addition, according to world health organization (WHO), the occurrence of MetS in an elderly population ranged from 11% to 43% (median 21%) (Denys et al., 2009).

MetS affects around fewer than 10% of people in their 20s and 40% of people in their 60s (Damiri et al., 2018). In the United States, it was found that the overall prevalence of MetS was 33% with 35.6% in women who were considered at higher prevalence compared to men with 30.3% and MetS prevalence was increasing with

age as found that among those aged 20 to 39 years, the prevalence rate was 18.3% and it rose to reach 46.7% among those aged 60 years or older with more than 50% higher prevalence among women (Aguilar et al., 2015). It was found that 12–37% of the Asian population and 12–26% of the European population experience MetS and its effects (Ranasingh et al., 2017).

In Saudi Arabia, 40% of population have MetS. Approximately 34.4% in men and 29.2% in women. This percentage is categorized Saudi Arabia as one with the top prevalence of MetS (Al-Rubeaan et al., 2018).

The main observable predisposing factors of MetS are aging, physical inactivity, and the Western diet (Agodi et al., 2018). The pathogenesis of the metabolic syndrome is complex and not well agreed and there are variations of different factors that participate in metabolic syndrome development that includes physiological, biochemical, clinical, genetic, metabolic, and environmental factors (Rochlani et al., 2017) .

Hardy et al. (2012) and Dunkley et al. (2012) showed that central obesity or weight accumulation in the midriff area as being resistant to insulin and the primary cause of MetS, which is a significant determinant of cardiovascular diseases (CVDs).

Studies suggest that lifestyle and diet play a big role as a cause and the most important components that considered one of the risk factors that trigger the metabolic syndrome (VanWormer et al., 2017; Sekgala et al., 2018) . Unhealthy diet has been correlated with all risk factors related to MetS, including hypertension, impaired fasting glucose, dyslipidemia, and obesity (Al-Qawasmeh & Tayyem, 2018). Also, physical activity has been revealed to lessen cardiovascular mortality risk, diabetes, hypertension, and all mortality causes. International data showed that physical activity may avert MetS and its risk factors (Aljuhani et al., 2020).

Moreover, age is the trigger factor that tends to increase the prevalence of MetS development (Al Zenki et al., 2012; Yasein & Masa'd, 2006) and gender is believed to be a vital factor of MetS and its outcomes (Pradhan, 2014).

Most of the studies used the method of evaluating single nutrients effects instead of assessing the whole nutritional patterns. Although individuals consume meals that consist of different types of food with a variety combination of nutrients, not just a single nutrient. Consequently, using the comprehensive dietary approach that focuses on assessing the dietary pattern was suggested to be recommended (Naja et al., 2011).

Also, in current years, Boachie et al. (2020) and Zhao et al. (2019) have indicated that there is a link between metabolic syndrome and biochemical markers and other parameters. Boachie et al. (2020) indicated presence of low vitamin B12 among adult MetS patients. In addition, Yang (2016) reported raised prevalence of nonalcoholic fatty liver disease (NAFLD) among adults in his study which was approximately 53.7% of the patients. Zhao et al. (2019) reported the concentration of alanine transaminase (ALT), serum Uric acid (SUA), low density lipoprotein cholesterol (LDL-C), C-reactive protein (CRP) were identified at a higher level in the children with MetS compared with other children and high-density lipoprotein cholesterol (HDL-C) concentration was found at a lower level in MetS children. Yki-Järvinen (2014) reported presence proof that supports the linkage between NAFLD and metabolic syndrome.

1.2 Research problem

In the Kingdom of Bahrain, even though the risk of MetS is developing into a major public health issue, limited studies including Jahrami and Khalil (2018) ; Khalil et al. (2019) explored the prevalence of MetS among psychiatric patients in case control studies while no studies are found to examine the different variables

that lead to the prevalence of MetS and that investigate the extent of correlation between food patterns and MetS and the relationship between biochemical biomarkers and MetS. Khalil et al. (2019) studied the prevalence of MetS among bipolar patients as a case-control study and the results indicated that the prevalence of MetS among cases was 34.8% in comparison to 31.8% controls. In addition, Jahrami and Khalil (2018) studied the prevalence of MetS among schizophrenic patients as a case-control study and among cases was 48% in comparison to 34% controls.

The lack of knowledge on food habits and awareness could lead to a rise in the prevalence of metabolic syndrome as most health services focus on curative procedures for chronic diseases rather than preventive measures.

1.3 The signs and symptoms of the problem

It has been reported worldwide that metabolic syndrome is an intermediate outcome preceding disability and death from various related diseases such as diabetes mellitus (DM) and cardiovascular diseases (CVD) (Aekplakorn et al., 2015). In the study of Saklayen (2018) highlighted those non-communicable diseases (NCD) have become the main reason for illness and death in both urbanized and underdeveloped countries. Metabolic syndrome had been the most aggressive and devastating non-communicable disease worldwide. In another research, Musaiger et al. (2014) found that the overall prevalence of overweight and obesity ranged from 15.7% to 28.9% among males and from 21.1% to 30.7% among females and this considers a concern as that obesity during childhood is a huge influence attributed to having a high percentage of obesity among Bahraini adults suffering from cardiovascular diseases, hypertension, and diabetes. Also, Musaiger et al. (2014) indicated that modern day lifestyle and recent trends in

eating habits, a more sedentary lifestyle and routine have a huge negative impact on Bahrain's public health potential.

1.4 Research questions

It is expected that this study will answer the subsequent questions:

- What is the dietary pattern that is associated positively and negatively with MetS risk factors?
- Is there any association between metabolic syndrome and biochemical markers profile?
- What are the social demographic characteristics of the population under study?
- Is there any association between social-demographic characteristics and dietary patterns?
- What is the common physical activity level among subjects who have MetS?
- Is there any impact of lifestyle elements including sleep, smoking, alcohol consumption, and physical activity on MetS risk factors?
- Is there any association between the presences of other diseases like non-alcoholic fatty liver disease (NAFLD) or polycystic ovarian syndrome (PCOS) with metabolic syndrome?

1.5 Research objectives

The key points of this study include the following:

1.5.1 General objectives:

- To identify whether there are associations between the metabolic syndrome and the major dietary patterns among Bahraini adults who are aged between 18 years to 65 years old.

- To establish whether there is an association between metabolic syndrome and biochemical markers profile among Bahraini adults who are aged between 18 years to 65 years old.

1.5.2 Specific objectives:

1. To identify whether there is an association between sociodemographic characteristics with the values of specific dietary patterns.
2. To establish whether there is an association between selected sociodemographic characteristics with the MetS.
3. To investigate whether there is an association between metabolic syndrome and lifestyle factors (smoking, physical activity, sleep) and alcoholic consumption.
4. To establish whether there is an association between MetS and comorbidities (fatty liver, polycystic ovary syndrome)

1.6 Research hypothesis

It is hypothesized that there is a relationship between specific food patterns and the likelihood of developing MetS among Bahraini adults between 18 years to 65 years old in the Kingdom of Bahrain.

1.6.1 Research significance

To the researcher's knowledge, this is the first study in the Kingdom of Bahrain to examine the association between dietary patterns and metabolic syndrome (MetS) among Bahraini adults who are aged over 18. The research outcomes will shed light on the most common food types and any correlation with the risk of metabolic syndrome in the sample population. This study will emphasize the current condition of public health in the Kingdom of Bahrain with the view to initiating policy changes regarding the nutrition content of food products.

The study is significant as it will provide specific data on metabolic syndrome and associated dietary patterns to inform policymakers of the extent of the problem and serve as a helpful guide to set appropriate nutritional and health programs for the community.

1.6.2 Research terminology

1.6.2.1 Dependent Variable: Metabolic syndrome

Metabolic syndrome indicated by the manifestation of 3 out of 5 risk factors includes waist circumference (WC), fasting plasma glucose (FPG), triglycerides (TG), and HDL cholesterol, and blood pressure (SBP and DBP).

Metabolic syndrome: There is a wide range of criteria variation that is used for diagnosing metabolic syndrome. The criteria used in this research is according to the National Institutes of Health guidelines which defines metabolic syndrome as the presence of three or more of the following factors: WC (≥ 102 cm in men and ≥ 88 cm in women), TG (≥ 150 mg/dL), HDL cholesterol (< 40 mg/dL in men and < 50 mg/dL in women), SBP (≥ 130 mm Hg, DBP ≥ 85 mm Hg); and FG (≥ 100 mg/dL) (NIH, 2001).

Features of metabolic syndrome:

1.6.2.1.1 Blood pressure (BP)

Blood pressure is an important clinical measure intended to evaluate health risks. It measures the pressures on the walls of the arteries while the heart propels blood through the body. It consists of two readings which are systolic pressure, indicating blood pressure when the heart contracts while diastolic pressure is the blood pressure between heartbeats (Renna, 2013).

1.6.2.1.2 Body mass index (BMI)

Body mass index is used for categorizing weight and it is a parameter used to determine the extent of obesity if the person is classified as obese, overweight, or

normal weight. WHO 2008 determines BMI cutoff points indicating for underweight ($\text{BMI} < 18.5$), normal ($18.5 - 24.9$), overweight ($25 - 29.9$), and obese class ($\text{BMI} \geq 30$). BMI is the person's weight in kilograms divided by the square of the height in meters (Hassan et al., 2016).

1.6.2.1.3 Waist circumference (WC)

Waist circumference is an important indicator of central abdominal obesity and a significant predictor that correlates with the health risk of developing chronic disease (Fujibayashi et al., 2016). Waist circumference is a superior visceral obesity measurement to BMI as WHO guideline indicates. WC measurement is taken using a flexible tape measure at the center between the lower border of the last tangible rib in the midaxillary line and the upper of the iliac crest. The measurement must be taken after consecutive natural breaths. The cutoff points indicated 94 cm in men and 80 cm in women (Hassan et al., 2016). It is as the vital sign and the most frequent element of metabolic syndrome (Gierach et al., 2014) and it is linked to insulin resistance (Fujibayashi et al., 2016).

1.6.2.1.4 Dyslipidemia (DLP)

Dyslipidemia consists of three main components correlated with the metabolic syndrome. It is characterized by disturbance in the structure, metabolism, and biological activities of both atherogenic lipoproteins and antiatherogenic. It includes abnormal lipids amounts in Apo lipoprotein B (apoB), elevated triglycerides (TGs), increased low-density lipoprotein (LDL), and low levels of high-density lipoprotein (HDL). Fat distribution in the body has a big impact on metabolic and cardiovascular risk factors. It is considered to be a major factor that increases susceptibility to morbidity and mortality in most countries (Kaur, 2014).

1.6.2.1.5 HDL cholesterol (HDL-C)

Low HDL is a component of metabolic syndrome (Ali et al., 2012). HDL is produced in the liver and the intestines and synthesized through triglyceride-rich lipoproteins lipolysis. HDL are responsible for providing atheroprotective effects and are considered as good cholesterol and the main function of HDLs is removing cholesterol from the bloodstream, carrying it back to the liver for excretion (Girona et al., 2019). Low concentrations of HDL are an indicator of developing risk of cardiovascular events (März et al., 2017).

1.6.2.1.6 Triglycerides (TG)

This is a common type of dyslipidemia and it is a part of a lipid profile measure of the number of triglycerides in your blood. (Zhang et al., 2018). High TG levels are considered an important biomarker of CVD risk (Toth, 2016). It is usually asymptomatic until triglycerides reach more than 1000–2000 mg/dl (Zhang et al., 2018).

1.6.2.1.7 Fasting blood sugar (FBG)

It is a major glucose disorder and type of prediabetes correlated with a greater risk of diabetes. FBG is a measure of blood sugar levels after fasting for at least 8 hours to determine diabetes diagnosis (Sinnott et al., 2015).

Impaired fasting glycemia (IFG) is defined if the fasting glucose level is between 6.1mmol/l and 6.9mmols/l and considered above normal levels. It reflects the low efficiency of the body to regulate glucose. Lately, IFG has taken worldwide consideration as an important measure for preventing diabetes and cardiovascular diseases. Continuous abnormal blood glucose for a prolonged period raises cardiovascular disease, stroke, and metabolic syndrome risk development (Chen & Yeh, 2013).

1.6.2.2 Independent Variables (X's):

Factors linked with a high risk of MetS

1.6.2.2.1 INDEP VAR 1: Dietary intake

The daily eating patterns of an individual that consist of consumption of specific foods and calories by considering the quantity. It estimates using different dietary assessments such as food frequency questionnaire (Leech et al., 2015).

1.6.2.2.2 INDEP VAR 2: Biochemical biomarkers

Including total protein, creatinine (Cr), Blood urea nitrogen (BUN), serum albumin (SA), uric acid (UA). White blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), hematocrit (HCT), platelets (PLT), Iron (Fe), sodium (NA), potassium (K), chloride (Cl), calcium (C), blood amylase, bilirubin, AST, ALT, γ -glutamyl transferase (GGT), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), vitamin D, folic acid (B9), vitamin B12.

1.6.2.2.2.1 Total protein (TP)

This is a test that measures the complex mixture of total protein. The normal range for adults is 64 g/L to 83 g/L (Chien et al., 2017).

1.6.2.2.2.2 Serum Albumin

Serum albumin (SA) is the greatest abundant circulatory protein which is responsible for multiple physiological functions including preserving oncotic pressure and sustaining microvascular integrity, managing metabolic and vascular roles, besides, it has high antioxidant properties and anticoagulant actions. Normal albumin levels in serum is between 3.5–5.0 g/dL and hypoalbuminemia referred to the level of concentration less than 3.5 g/dL (Chien et al., 2017).

1.6.2.2.2.3 Blood urea nitrogen and creatinine

Blood urea nitrogen (BUN) and serum creatinine (Cr) have been used to diagnose acute kidney injury (AKI). BUN is a final result of protein metabolism.

Breaking down protein results amino acids and deaminating process lead the to synthesis of ammonia which is converted to urea through liver enzymes. BUN is named as a non-protein nitrogenous (NPN) waste product. The normal range is between 7 to 20 mg/dL (2.5 to 7.1 mmol/L). Creatinine results from creatine and phosphocreatine breakdown. Creatine is formed in the liver, pancreas, and kidneys from the amino acids (arginine, glycine, and methionine) Transamination. It is also considered a NPN waste product. The standard range for creatinine is 60 to 110 micromoles per liter ($\mu\text{mol/L}$) (0.7 to 1.2 milligrams per deciliter (mg/dL) for men and 45 to 90 $\mu\text{mol/L}$ (0.5 to 1.0 mg/dL) for women (Salazar, 2014).

1.6.2.2.2.4 Liver enzymes: AST & ALT

AST and ALT are liver function enzymes used as biomarkers to detect liver injury and damage (Weng et al., 2015). Increasing ALT reflects cell damage and the presence of plasma membrane disruption (McGill, 2016).

GGT

GGT means γ -glutamyl transferase which is a liver injury test to detect the presence of any liver dysfunction, bile duct conditions, and alcohol consumption. Also, raised GGT was used as an indicator for correlation with risk of coronary heart disease, type-II diabetes (T2D), and stroke. The main GGT function of GGT empowers glutathione and glutathionylated xenobiotics metabolism. However, increased GGT levels lead to prooxidant activity in the presence of iron or copper. The standard range for GGT is between 9–48 (U/L) (Koenig & Seneff, 2015).

1.6.2.2.2.5 Inflammatory markers: CRP & ESR

C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) are considered as non-specific markers of inflammation rather than infection. Their roles are important in detecting the severity and the progression of the disease.

CRP is manufactured essentially in liver hepatocytes, also, in other sites like smooth muscle cells, macrophages, endothelial cells, lymphocytes, and adipocytes. Normal plasma levels of CRP are <10 mg/L. Plasma levels are raised during the presence of inflammatory conditions such as rheumatoid arthritis, some cardiovascular diseases, and infection (Sproston & Ashworth, 2018). It increases within 4-6 hours after the initial acute stage of injury and keeps elevating many folds within 24-48 hours. CRP returns to a normal level after recovery. The normal range of ESR is between 0 to 22 mm/hr for men and 0 to 29 mm/hr for women (Samraj et al., 2013).

1.6.2.2.2.6 Uric acid

Uric acid (UA) is a result of purine breaking down. It has been linked with several disorders such as obesity, metabolic syndrome, diabetes mellitus, hypertension, endothelial dysfunction, cardiovascular disease, and chronic kidney disease. The normal value for uric acid is 2.4-6.0 mg/dL in females and 3.4-7.0 mg/dL in male (Spiga et al., 2017).

1.6.2.2.2.7 Bilirubin

Bilirubin is a metabolite result of heme-containing protein breakdown that possesses an anti-inflammatory property and antioxidative capacity focusing on oxidization suppression of both lipids and lipoproteins. It is the major part of bile linked to its characteristic color. Raised serum bilirubin has been shown the high antioxidative capacity and protects against oxidative stress-induced diseases (Li et al., 2017).

1.6.2.2.2.8 Amylase

Amylase is a digestive enzyme produced mainly from the pancreas and salivary glands. It is used as a test as abnormal levels indicate pancreatitis or another problem with the pancreas. Amylase is responsible mainly for catalyzing the

hydrolysis of starch into sugars. The normal range is between 19 U/L and 86 U/L (Ismail & bhayana, 2017; Akinfemiwa, 2020).

1.6.2.2.2.9 HbA1c

HbA1c is glycated hemoglobin in the blood which gives an indicator for average blood glucose levels in the previous two to three months. It is considered a standard of care (SOC) as recommended for type 2 diabetes testing and checking and it is the essential test used for diabetes management (Park et al., 2012). The cut-point for diagnosing diabetes is $\geq 6.5\%$. Besides, HbA1c provides prediction related to the half-life of red blood cells (RBCs) (Sherwani et al., 2016).

1.6.2.2.2.10 Complete blood count (CBC)

RBC

Red blood cells (RBCs) are known erythrocytes that are biological cells consisting of hemoglobin, a protein present inside RBC. It has an important functional part of transferring O₂ gas from the lung to the tissues, removing CO₂ gas from the body, delivering it to the lungs for exhalation and preserving acid/base equilibrium (Kuhn et al., 2017). The normal range of RBC for men is between 4.7 to 6.1 M/uL, for women is between 4.2 to 5.4 M/uL and for children is between 4.0 to 5.5 M/uL (Mesarec et al., 2019)

WBC

White blood cells (WBCs) are known leukocytes which are considered a highly important in related to the immune system as their main function is protecting against illness and disease, fighting viruses, bacteria, and defending against infection. The normal concentration is between 4,000 and 11,000 M/uL (King et al., 2018).

PLT

Platelets are non-nucleated cells produced by megakaryocyte (MK) that present primarily in the bone marrow, lungs, and peripheral blood. PLT is approximately ($\sim 4 \mu\text{m}$) which indicates small size and the quantity is roughly ($\approx 200\,000/\mu\text{L}$) in humans blood (Holinstat, 2017). PLT plays a major role in hemostasis and thrombosis. It is activated after injury and inflammatory responses (Şahin et al., 2012).

HCT

Hematocrit (HCT) is defined as a measure of red blood cell (RBCs) volume percentage in total blood. Raised HCT level has been demonstrated to be correlated with raised the possibility of cardiovascular disease (Kishimoto et al., 2020). HCT is a ratio without any unit. It is calculated by dividing the lengths of the packed RBC layer by the length of total cells and plasma. For accurate value, it is required to multiply the ratio by 100. A normal HCT ratio for a male adult is between 40% to 54% and for a female adult is between 36% to 48% (Mondal and Budh, 2020).

Hb

Hemoglobin (Hb) is a protein present in the erythrocyte. It consists of four polypeptide globin chains. The main functions consist of transporting oxygen to the body tissues, removing carbon dioxide from the body, and delivering it to the lungs for exhalation. The normal concentrations in men are between 13.5–18.0 g/dL and 11.5–16.0 g/dL in women (Thomas & Lumb, 2012).

1.6.2.2.2.11 Potassium (K)

It is the greatest predominant cation in intracellular fluid. The main function of potassium is maintenance of the acid-base balance, managing osmotic pressure, stimulating nerve impulse transmission and muscle contraction especially the

cardiac muscle, cell membrane role and $\text{Na}^+/\text{K}^+-\text{ATPase}$. The normal range for K is between 3.5-5 mmol/L (Soetan et al., 2010).

Calcium (Ca)

It is a mineral component that is important for bones and teeth and responsible for multiple functions such as muscle contraction, stimulating the transmission of nerve impulses, playing a role in blood coagulation by activating the transformation of prothrombin to thrombin. Also, adenosine triphosphatase (ATPase), succinic dehydrogenase, lipase is activated by calcium. The normal range for Ca is 2-2.6 mmol/L (Soetan et al., 2010).

Sodium (Na)

Sodium is a major cation in extracellular fluids. It is responsible for adjusting plasma volume and acid-base balance, preservation of body fluids osmotic pressure, cell permeability and is necessary for muscle function and nerve impulses transmissions and involving in $\text{Na}^+/\text{K}^+-\text{ATPase}$. The normal range for Na in the body is 135-145 mmol/L (Soetan et al., 2010).

Chloride (Cl)

Chloride is the main anion in extracellular fluid and constitutes over 60% of the anions in this fluid. It is involved in multiple important functions such as maintenance of acid-base balance and adjustment of extracellular osmotic pressure and gastric acid production. The normal range for Cl is between 96 to 106 mmol/L (Soetan et al., 2010).

Iron (Fe)

Fe is a vital component of succinate dehydrogenase and a portion of the heme of hemoglobin (Hb), myoglobin, and the cytochromes.

It is present mainly as hemoglobin in the erythrocytes and as transferrin in the plasma. It has several functions related to oxygen transporting, being a coenzyme for neurotransmitters production and packaging. It has a role in myelination of the spinal cord and white matter of cerebellar folds in the brain. The normal range of iron for men is 13.5 to 17.5 g/dL and for or women is between 12.0 to 15.5 g/dL. (Soetan et al., 2010).

1.6.2.2.2.12 B9

It is a vitamin called folic acid. It is very important for various metabolic roles. Biosynthesis of RNA and DNA and fixing DNA and methylation of DNA processes. Besides, it plays major role in rapid cell division and growth in pregnancy. The normal range for folic acid is between 6.12 to 38.52 (nmol/L) (Milman, 2012).

Vitamin B12

Vitamin B12, also called cobalamin, consists of cyano-, methyl-, deoxyadenosyl- and hydroxy-cobalamin forms. It is highly important for DNA production. The normal range for B12 is between 160 to 950 picograms per milliliter (pg/mL) (O'Leary & Samman, 2010).

Vitamin D

Vitamin D is a fat-soluble vitamin type. It is absorbed in dietary fat from both the gut, and the skin. Vitamin D3 (also known as cholecalciferol) and vitamin D2 (ergocalciferol) are considered the most common forms. The main function is the responsibility for increasing the intestinal absorption of calcium, magnesium and phosphate (Boucher, 2012). The normal range is between 30 and 50 ng/mL (Boucher, 2012; Selamet et al., 2018).

1.6.2.2.3 INDEP VAR 3: Socio-economic and demographic variables

Age

Age is considered a factor that has effect on metabolic syndrome. Aging is considered as a biological process manifested by a cumulative decline in physiological functions and metabolic processes that leads to morbidity and mortality (Bonomini et al., 2015).

Gender

Gender is an important non-modifiable factor that influences metabolic syndrome outcomes as gender difference plays a big role in presence differentiation in metabolism and MetS components and its characteristics. Studies indicated that MetS prevalence depends on gender differences (Beigh & Jain, 2012).

Education and income

Education and income are the main socio-economic factors that affect metabolic syndrome development. Education is considered a powerful health anticipator. Level of education may have an impact on lifestyle behaviors, psychosocial attitude, and accessibility to health services (Zhan et al., 2012).

Marital status

Marital status is a significant predictor of metabolic syndrome. The study demonstrated that married men had a lower death rate due to cardiovascular diseases compared to unmarried, separated, divorced, or widowed men. These interrelated links that justify the higher prevalence of metabolic syndrome among the widowed group than other groups are due to lower household income struggling with financial burdens, lower education level, and a higher proportion of smokers (Jung et al., 2018).

1.6.2.2.4 INDEP VAR 4: Lifestyle factors

Physical activity (PA)

Sedentary PA is a modifiable predisposing factor of metabolic syndrome (Al-Qawasmeh & Tayyem, 2018). PA has a big role in the prevention of disease and death and is considered one of the major and powerful strategies that implement to reduce developing MetS. PA effectiveness amount depends on several parameters depending on the PA type, duration, and intensity (Huang et al., 2017).

Smoking

Smoking habit has a big effect in increasing the morbidity and mortality in the working-age population. This means it poses a big public health threat. Smoking is considered a common modifiable risk factor for developing non-communicable diseases 2, consisting of cardiovascular disease (CVD) and type 2 diabetes mellitus (DM2) The underlying physiopathology that explains the relationship between smoking and MetS is due to the main findings in smoking individuals such as decrease in peripheral insulin sensitivity, lipoprotein metabolism change, and endothelial dysfunction (Bermudez et al., 2018).

Alcohol consumption

Alcohol consumption is considered a part of the unhealthy lifestyles that lead to health impact. Heavy alcohol consumption is a risk factor that has a negative impact in contributing to metabolic syndrome. It is proposed that alcohol disturb lipoprotein production by reducing the HDL level and hepatic Apo lipoproteins class-A production. In addition, it leads to disruption of hepatic gluconeogenesis and hinders the process of lactate oxidation to pyruvate in carbohydrate breakdown (Kim et al., 2017).

Sleep

Sleep is a lifestyle element and one of the prime preventive measures which is used as an indicator to evaluate current health status. Sleep plays a vital role as a modulator of metabolic homeostasis. Studies showed that chronic sleep restriction and poor sleep quality have a big impact on changing the metabolic functions and are correlated with a great possibility to develop obesity, IR, and the MetS. The underlying biological mechanism of sleep duration and MetS remains ambiguous. Various endocrinologic, immunologic, and metabolic processes have been revealed. Insufficient sleep period of fewer than 7 hours may lead to mutual changes in leptin and ghrelin circulation levels which stimulate appetite, increase caloric intake, decrease energy expenditure, increase in waist circumference, and obesity. In addition, as shown in clinical studies, poor sleep leads to an increase of high-sensitivity CRP and Interleukin-6 (IL-6) during, markers, and elevate cortisol level which affects in raising fasting glucose levels (Koren et al., 2016).

1.6.2.2.5 INDEP VAR 5: Comorbidities

Including non-alcohol fatty liver disease (NAFLD) and polycystic ovary syndrome (PCOS). Presence of some conditions such as fatty liver, gallstones, sleep disorders, cardiovascular disease, and polycystic ovary syndrome tends to increase the MetS risk.

Non-alcohol fatty liver disease (NAFLD)

NAFLD is one of the most common chronic liver diseases spreading in developed countries and it is associated with the global obesity epidemic. NAFLD raises the liver risk of morbidity, mortality, and other comorbidities such as type 2 diabetes and cardiovascular disease (Caldwell & Argo, 2016).

This term is used as an umbrella for several liver conditions and it is one of the manifestations of metabolic syndrome that has been identified. It defines as the accumulation of fat in hepatocyte with the lack of excessive alcohol consumption

and it is significantly correlated with obesity, insulin resistance, and metabolic syndrome (Souza et al., 2012). The exact mechanisms that explain the links between metabolic syndrome and fatty liver are not yet fully explored (Souza, et al., 2012). However, insulin resistance linked to metabolic syndrome is the major trigger with other genetic, humoral, hormonal, and lifestyle factors lead to NAFLD development (Caldwell & Argo, 2016)

Polycystic ovary syndrome (PCOS)

PCOS is a reproductive endocrine disorder and a main reason that leads to infertility among women. According to Rotterdam criteria, it is characterized by presence two of the following three manifestations: raised androgen levels, irregular menstrual cycle, and/or enlarged ovaries each consisting of at least 12. It can be either morphologically related to polycystic ovaries or mostly biochemically related to hyperandrogenemia. Raised luteinizing hormone (LH) and gonadotropin-releasing hormone (GnRH) levels, and unchanged follicular-stimulating hormone (FSH) levels are common signs of PCOS while the main clinical hallmark is hyperandrogenism. This causes hindrance in follicular development, micro cysts in the ovaries, anovulation, and menstrual changes (Ndefo et al., 2013).

PCOS affects approximately 8-10% of women at reproductive age (Spinedi & Cardinali, 2018). The underlying pathophysiology assumes the present faults in the hypothalamic-pituitary axis, insulin secretion and action, and ovarian function. (Ndefo et al., 2013).

It is proposed that insulin resistance is considered a major sign of this syndrome. Also, overweight and obesity (especially central obesity) is a very common feature (Spinedi & Cardinali, 2018). There is a rise probability of MetS development in

women suffering of PCOS and it was demonstrated to a rise about 14-times in patients with obesity (Yao et al., 2017).

Studies indicate that MetS is more prevalent (2-3 times) among PCOS women (Moran et al., 2010). This is due to the presence of insulin resistance, hyperinsulinemia, and hyper adiposity in PCOS women. Also, sleep disturbance is more common in PCOS women and is estimated to be twice more than women without PCOS (Spinedi & Cardinali, 2018).

1.6.2.3 Pathophysiology

The underlying mechanism of MetS pathophysiology is ambiguous. However, IR and central obesity are considered and expected to have the major role in the pathophysiology. These factors increase the risk of other metabolic factors such as hyperglycemia, DLP, and hypertension (HTN). According to Al-Qawasmeh and Tayyem (2018) the following explanation interprets the MetS pathophysiology.

1.6.2.4 Insulin resistance (IR)

Beta cells are responsible for secreting the normal level of insulin hormone. IR happens when there is a defect in the target tissue of the liver, skeletal muscle, and adipocyte which reduces the ability to respond well to uptake glucose inside the cells, and this decreased responsiveness to normal insulin levels leads to developing type 2 diabetes (DM II). Due to that as a compensatory mechanism to maintain the glucose level, β cells secrete additional amounts of insulin. In skeletal muscle, insulin resistance leads to glycogen synthesis reduction and glucose transport reduction. In the liver, it leads to reduction of the effectiveness of insulin signaling pathways (Al-Qawasmeh and Tayyem , 2018).

1.6.2.5 Obesity & abdominal obesity

Obesity is a term that reflects the presence of excessive fat accumulation that raises health risk. Abdominal obesity is considered a high predisposing factor

linked to insulin sensitivity, impaired glucose tolerance, elevated blood pressure, and DLP present in the MetS. Overweight and obesity are correlated with raising the risk of developing CVD, HTN, DM II, cancers, and other disorders. Adipose tissue is responsible for releasing the extra fatty acids and cytokines that lead to insulin resistance. Excessive free fatty acid (FFA) releasing leads to lipotoxicity which means that lipids and the metabolites cause oxidative stress to the endoplasmic reticulum and mitochondria. FFA reduces the utilization of insulin-stimulated muscle glucose, causing additional hyperglycemia. Due to that, lipotoxicity reduces the secretion of pancreatic β -cell insulin, which leads to β -cell collapse. Obesity is conducted to excessive consumption of cheap, calorie-dense food, and low physical activity level. Adipose tissue is comprised of a various mix of adipocytes, stromal preadipocytes, immune cells, and endothelium. This tissue responds in a rapid dynamic way toward nutrient excess through adipocytes hypertrophy and hyperplasia (Al-Qawasmeh and Tayyem , 2018). There are some factors associated with obesity such as:

Leptin: It is an adipokine which responsible for the satiety and energy intake regulation process. Leptin receptors are present in the hypothalamus and the brain stem. Leptin levels in the plasma increase in obesity and decrease during losing weight (Al-Qawasmeh and Tayyem , 2018).

CRP: increased CRP levels are correlated with increased waist circumference, insulin resistance, BMI, and hyperglycemia and are increased with the number of MetS components (Al-Qawasmeh and Tayyem , 2018).

1.6.2.6 Oxidative stress and metabolic syndrome

Chronic low-level inflammation and oxidative stress are considered another level of the underlying pathophysiology explanation of MetS. Oxidative stress takes a vital part in the pathogenesis of vascular alterations by effecting the

biochemical processes accompanying the metabolic syndrome (Al-Qawasmeh and Tayyem , 2018).

1.6.2.7 Inflammatory and oxidative mediators

IL-6 is a powerful inflammatory cytokine that has a big part in insulin resistance pathogenesis and types 2 diabetes. Raised IL-6 levels have been measured in adipose tissue of patients with diabetes mellitus, obesity, and in MetS patients (Al-Qawasmeh and Tayyem , 2018).

Chapter 2

Literature review

MetS is emerging as a pandemic worldwide (Saklayen, 2018). People with MetS have an expanded danger of cardiovascular morbidity and mortality and at risk for diabetes 2 and stroke development (Sigit et al., 2020).

Different studies reveal that there is dissimilarity in metabolic prevalence in each country but show a definite correlation between diet and MetS with variable results (Khalil et al., 2019; Jahrami & Khalil, 2018; Syed et al., 2020; Al-Lawati et al., 2003).

The prevalence rate increase in metabolic syndrome worldwide is due to the consequence of spreading obesity. The rate of prevalence of MetS has grown substantially in Mideast region and the reason for this is attributed to the rapid growth in the socio-economic standard and the resulting lifestyle changes (Sliem et al., 2012).

2.1 Prevalence of MetS in different countries

In general, as illustrated in Table 1, the prevalence of MetS rose with age (Al Zenki et al., 2012; Yasein & Masa'd, 2006). In Bahrain it was found that the prevalence of MetS among bipolar and schizophrenia patients in case control study was (case 34.8%, control 31.8%) and (case 48%, control 34%) respectively (Khalil et al., 2019; Jahrami & Khalil, 2018).

The highest recorded prevalence in Cooperation Council for the Arab States of the Gulf (GCC) was in Qatar with approximately 48.8% among adults. Findings showed that MetS was more prevalent among the 40–49 year age group which was 50.3% of the population. Also, men had higher prevalence than women with (56.7%, 42.5%) respectively (Syed et al., 2020). In contrast, Oman was recorded

as the lowest MetS prevalence in GCC and it was 19.5% among men and 23.0% among women (Al-Lawati et al., 2003).

Al-Rubeaan et al. (2018) studied the prevalence of metabolic syndrome and identified the risk factors among the adult Saudi population. The results showed that nearly 40% of the population suffered from MetS. While lifestyle changes due to urbanization and socio-economic growth were factors, dietary patterns and smoking were found to have a high negative impact on MetS risk factors.

The notable finding was that living in urban areas and low educational levels were demonstrated to be considerable predisposing factors that tend to increase the likelihood of metabolic syndrome in Saudi Arabia. Thus, urbanization exposes people to a sedentary lifestyle and poor diet that trigger the development of hypertension, obesity, and dyslipidemia which are considered risk factors of metabolic syndrome. As we note in this study, they did not highlight dietary pattern, mentioning only that poor diet is one of the factors that indirectly associates with metabolic syndrome (Al-Rubeaan et al., 2018).

Al Zenki et al. (2012) studied MetS prevalence among Kuwaiti adults. Results indicated high prevalence of MetS which varies according to standards. It was estimated 37.7% in females and 34.2% in males by National Cholesterol Education Program (NCEP) standards, and 40.1% in females and 41.7% in males according to International Diabetes Federation (IDF) standards. The significant findings reflect that prevalence of MetS rose with age and females had greater prevalence than males.

Moreover, among Arabic countries particularly in Jordan, 37.4% of population suffered from MetS and women showed higher prevalence compared to men (41.0%, 31.7%) respectively (Yasein & Masa'd, 2006). The observed point was

that prevalence rose with age in both sexes and the prevalence in Jordan was higher compared to Lebanon which was 34.6 % (Naja et al., 2011).

Further, Khan et al. (2018) conducted his study among an Indian population and the results indicated that the prevalence of MetS was 40.9% and as found in previously mentioned studies, women showed higher prevalence compared to men (59%, 26.2 %) respectively. Also, Miccoli et al. (2005) studied the Italian adult population and his finding showed that 18% of women had MetS and 15% in men and it rose with age.

Table 1. Studies performed on the prevalence of MetS among different countries worldwide.

Authors	Country	Main Theme	Target Populations	Study Design	Methodology	Main Findings
Al-Lawati et al. (2003)	Oman	Evaluating prevalence of MetS among Omani population	1,419 adults aged ≥ 20 years In Nizwa city	Cross sectional	- Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG	The MetS prevalence was 19.5% among men and 23.0% among women.
Miccoli et al. (2005)	Italy	Examining the prevalence of MetS Among Italian population	2100 adults	Cohort	- Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG	- The prevalence of MetS was estimated at 18% in women and 15% in men. - The prevalence rose with age as found increasing from 3% among group aged 20-29 years to 25% in the group aged ≥ 70 years
Yasein and Masa'd, (2006)	Jordan	Exploring the percentage of MetS	730 patients aged ≥ 25 years.	Cross sectional	- Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG	"37.4% of population had MetS"

Naja et al. (2011)	Lebanon	“Evaluating the percentage of metabolic syndrome (MetS) among Lebanese”	323 Lebanese adults ≥ 18 years	Cross sectional	- Sociodemographic information was collected 61-item food frequency questionnaire was administered - Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG - International Physical Activity Questionnaire (IPAQ) was administered to assess physical activity level	The MetS prevalence was 34.6 %
Al Zenki et al. (2012)	Kuwait	Assessing the prevalence of MetS and its components among Kuwaiti adults	1,830 Kuwaiti adults Aged ≥ 20 years	Cross sectional	- Anthropometric measurements including W, H, WC BF% ,BF , FFM, TBW were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG	The prevalence of MetS was 37.7% in females and 34.2% in males by NCEP criteria, whereas was 40.1% in females and 41.7% in males according to IDF criteria. Females had a higher prevalence than males
Al-Rubeaan et al. (2018)	Saudi Arabia	Evaluating the prevalence of MetS among Saudi population	12,126 Saudi subjects	Cross sectional	- Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG	40% of the population suffered from MetS

Khan et al. (2018)	India	Estimating the prevalence of MetS and assessing the demographic profile of MetS	420 patients 232 males and 188 females	Cross-sectional	- Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG	- The prevalence of MetS was 40.9% - Females were more prevalent in having MetS with 59% compared to 26.2% in males.
Jahrami and Khalil (2018)	Bahrain	Assessing the prevalence of MetS among Bahraini Schizophrenia patients.	50 patients with schizophrenia (cases) and 50 age- and sex-matched healthy (controls)	Case-control	- Anthropometric measurements including W, H, WC and HC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG	The prevalence of MetS among cases was 48% while 34% in controls
Khalil et al. (2019)	Bahrain	Estimating prevalence of (MetS) among BAD patients	66 adults patients diagnosed with BAD and 66 healthy control 1:1 match sex and age	Case-control	- Anthropometric measurements including W, H, WC and HC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG	The prevalence of MetS among cases was 34.8 while 31.8% in controls
Syed et al. (2020)	Qatar	Examining the prevalence of MetS and determining the factors of MetS	127,941 Individuals aged ≥ 18	Cross sectional	Demographic (age, gender and Nationality) and diagnostic data (TG, TC, LDL-C, HDL-C, and FBG, WC) were collected from the electronic medical records	- The prevalence of MetS was 48.8% - MetS was more prevalent among 40–49 year age group - Men had a higher prevalence than women with (56.7, 42.5%) respectively.

2.2 Association between dietary patterns and MetS and its risk factors

As shown in Table 2, in Lebanon, Naja et al. (2011) identified the high rate of urbanization and westernization of lifestyle, the sharp drop in fertility and mortality rates, and increased life expectancy as complex challenges that face the healthcare sector in this country. The study investigated the dietary habits in ≥ 18 years. The main results from this study found that the people who consumed fast food and desserts were more susceptible to components associated with the MetS, which included hypertension and hyperglycemia. As for those whose diet was rich in the Mediterranean or traditional Lebanese cuisine were not associated with the MetS. While, Al-Daghri et al. (2013) conducted his study among Saudi Arabian adults. Results indicated an association between lower carbohydrate, protein intake, vitamin A, C, E, K, calcium, zinc and MetS risk.

In Japan, Arisawa et al. (2014) studied men and women aged between 35-70 years. As findings, four food patterns were identified: prudent diet, Western, bread and dairy products; and seafood patterns. Prudent diet pattern was adversely associated with lower HDL-C and elevated BP. Bread and dairy products pattern were linked with a lower WC and high FG. The Western pattern was adversely associated with IR.

In a study conducted among Korean women, the results indicated the socio-economic variable was found to have a close association with MetS among these women, where it was more prevalent among older and single adults and the less educated and lower-income groups. Besides, strong links were established between dietary patterns and MetS. A prudent diet rich in fruit, dairy products, nuts, bread, and milk had an adverse correlation with the risk of MetS, whereas a traditional Korean diet did not present a significant risk factor for MetS (Choi et

al., 2015). Similarly, in Thailand, Aekplakorn et al. (2015) reported participants aged ≥ 30 –59 years were enrolled in the study. Three dietary patterns were determined: meat pattern, healthy pattern, and high carbohydrate pattern. The carbohydrate pattern with leisure-time physical activity (LTPA) were adversely associated with MetS.

Also, In the United States, Gadgil et al. (2015) studied South Asians free from CVD. He found a positive link between animal protein, fried snacks, sweets, and high-fat dairy patterns and MetS risk factors including higher BMI, WC, TC and LDL cholesterol While a negative significant correlation was observed between fruits, vegetables, nuts, and legumes pattern and MetS risk factors including reducing hypertension and MetS.

Besides, Wei et al. (2018) studied Chinese adults aged 45–59 years and results revealed that traditional Chinese pattern correlated negatively with MetS risk factors while animal food pattern showed a positive association with MetS risk factors. Moreover, in a study in Taiwan, adults aged ≥ 35 years were enrolled in this study. It was found that changes in the population demography and lifestyle are included in the etiology of MetS. Also, when examining the dietary patterns among the population, consuming a diet rich in complex foods with several nutrients has a more pronounced and positive impact than consuming a diet that has a single nutrient or includes diet food items. Besides, results indicate that high consumption frequency of meat and instant dietary pattern that is rich with saturated fat, sodium, and food additives demonstrated a positive association with MetS predisposing factors and CRP. In contrast, the high consumption frequency of seafood, cereal and dairy products showed a negative correlation with MetS components and CRP. This may be attributed to the fact that these dietary patterns rich in dietary fiber,

vitamins, minerals, and unsaturated fat, antioxidants, phytochemicals, complex carbohydrates, prebiotics, and probiotics (Syauqy et al., 2018)

In addition, Kelishadi et al. (2018) studied Iranian students. He demonstrated that three food patterns were identified: Healthy, Western, and Sweet. Sweet was positively linked to WC, elevated BP, and MetS .

Czekajło et al. (2018) in Poland, studied individuals aged 35–70 years. Findings found that fruit & vegetable dietary pattern (DP), was inversely correlated with MetS and its risk factors with lower BP and TG. Western' and 'traditional' DPs were positively correlated with higher risk of MetS and greatest risk of abnormal FG level, TG, HDL-C, WC. Traditional was adversely correlated with MetS .

Furthermore, Ramírez-López et al. (2019) studied Mexican adolescents. The results indicated that there was a correlation between the dietary pattern which consisted of higher energy, carbohydrate, sucrose, fructose, and alcohol intake and lower protein intake and MetS, hypertriglyceridemia, and insulin resistance. In addition, there was a relationship between dietary pattern which consist of higher intake of protein, cholesterol, saturated fats, sodium, dietary fiber, vitamins, and minerals, and abdominal obesity.

Tayyem et al. (2019) studied Jordanian adults aged between 20-55 years and found three dietary patterns: fast food, Mediterranean, and high-protein dietary pattern. Also, a significant association was found between MetS and fast-food while no significant associations were found between the Mediterranean and high-protein patterns with MetS components.

Table 2. Studies on the association between dietary patterns and MetS components

First Author	Country	Main Theme	Target Populations	Study Design	Methodology	Main Findings
Naja et al. (2011)	Lebanon	Assessing the correlation between dietary patterns and the metabolic syndrome (MetS) and its metabolic abnormalities	323 Lebanese adults ≥ 18 years	Cross sectional	- Sociodemographic information was collected 61-item food frequency questionnaire was administered - Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG - International Physical Activity Questionnaire (IPAQ) was administered to assess physical activity level	- Fast Food/Dessert dietary pattern was positively correlated with MetS risk factors hypertension and hyperglycemia. - High protein dietary pattern showed a positive association with hypertension. Traditional dietary pattern demonstrated no correlation with MetS components
Al-Daghri et al. (2013)	Saudi Arabia	Assessing the association between selected dietary nutrient intakes and the prevalence of MetS in the adult population	185 adult Saudis aged between 19 - 60 years	Cross sectional	- Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG - Two 24-h dietary were conducted	Lower carbohydrate, protein intake, vitamin A, C, E, K, calcium, zinc and magnesium was associated with increase MetS risk
Arisawa et al. (2014)	Japan	Evaluating the correlation between dietary patterns and MetS and its risk factors	513 men and women aged between 35-70 years 422 with-out	Cross sectional	- Sociodemographic information and lifestyle data were collected - Food frequency questionnaire was administered - Anthropometric measurements	Four food patterns were recognized: prudent diet, Western, bread and dairy products and seafood patterns. Prudent diet pattern was adversely correlated with lesser

			MetS 91 with MetS		including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG	HDL-C and raised BP. Bread and dairy products pattern were linked with a lower WC and high FG. The Western pattern was adversely associated with IR.
Aekplakorn et al. (2015)	Thailand	Identifying the dietary patterns of and the correlation with MetS	5,872 participants aged ≥ 30 –59 years	Cross sectional	- Sociodemographic information was collected - Food frequency questionnaire was administered - Anthropometric measurements including W, H, WC were taken Blood pressure was measured - Fasting blood samples were collected for TG, HDL-C, and FBG - International Physical Activity Questionnaire (IPAQ) was administered to assess physical activity level	- Three dietary patterns were determined: meat pattern, healthy pattern and high carbohydrate pattern - The carbohydrate pattern with a low level of LTPA was adversely associated with MetS.
Gadgil et al. (2015)	United States	Identifying dietary patterns and their correlations with MetS risk factors	892 South Asians aged between 40–84 y free from CVD	Cross sectional	- Sociodemographic information was collected - Lifestyle information was gathered - Food frequency questionnaire was administered - Anthropometric measurements including W, H, WC were taken - Blood pressure was measured - Fasting blood samples were collected for TG, TC, LDL-C, HDL-C, and FBG - International Physical Activity Questionnaire (IPAQ) was administered to assess physical activity	- Three dietary patterns were obtained: - Animal protein - Fried snacks including sweets, and high-fat dairy; - Fruits, vegetables, nuts, and legumes - Positive significant association were found between animal protein and the fried snacks, sweets, and high-fat dairy patterns and MetS risk factors - Negative significant correlation was observed between the fruits, vegetables, nuts, and legumes

					level	pattern and MetS risk factors
Czekajł o et al. (2018)	Poland	Examining the link between DPs and the prevalence of MetS components	1634 individuals aged 35–70 years	Cross sectional	• FFQ was administered • WC was measured • Blood pressure was measured • Fasting blood samples were collected for TG, HDL-C, and FBG	• Western and traditional dietary pattern was positively correlated with increased risk for MetS and increased risk of abnormal FG level, TG, HDL--C, WC.
Wei et al. (2018)	China	Identifying dietary patterns and their correlations with MetS risk factors	1918 Chinese adults aged 45–59 years.	Cross sectional	• Face-to-face interviews were implemented • Validated semi-quantitative FFQ was administered • Anthropometric measurements including W, H, WC were measured • Blood pressure was measured • Fasting blood samples were collected	• Traditional Chinese pattern was correlated negatively with MetS risk factors
Syauqy et al. (2018)	Taiwan	Assessing the impact of dietary habits on MetS and inflammation	26,016 subjects aged ≥35 years	Cross sectional	• FFQ was administered • WC was measured • Blood pressure was measured • Fasting blood samples were collected for TG, HDL-C, and FBG	• High consumption frequency of meat -instant dietary pattern demonstrated a positive association with MetS risk factors and CRP. • High consumption frequency of vege–seafood dietary pattern and cereal–dairy dietary pattern was showed a negative correlation with MetS components and CRP
Kelisha di et al. (2018)	Iran	Evaluating the correlation of dietary patterns with (MetS) risk factors in children and	4200 students aged 7–18 years	Case– control Multi- stage cluster sampling	• Data collected through interviews with students respond in schools • The data includes 1. Socioeconomic data Lifestyle data 2. Anthropometric measurements	• Sweet dietary pattern was positively associated with WC ,elevated BP and MetS • No clear correlation was found between Healthy, Western DPs and MetS and its risk factors

		adolescents.		design	3. Blood pressure measurement Fasting blood samples were collected for TG, HDL-C, and FBG	
Ramírez-López et al. (2019)	México	Assessing the association of dietary patterns with MetS and its components	654 adolescents	Cross sectional	Validated semi-quantitative FFQ was administered Anthropometric measurements including W, H, WC were measured Blood pressure was measured Fasting blood samples were collected for TG, HDL-C, and FBG	- Three dietary patterns were identified: “DP1”, characterized by lower energy intake and lower cholesterol consumption “DP2”, characterized by higher intake of protein, cholesterol, saturated fats, sodium, dietary fiber, vitamins, and minerals, “DP3”, characterized by higher energy, carbohydrate, sucrose, fructose, and alcohol intake and lower protein intake. - There was a correlation between “DP3” and MetS, hypertriglyceridemia and insulin resistance - There was a relationship between “DP2” and abdominal obesity
Tayyem et al. (2019)	Jordan	Examining macro- and micronutrient intake of MetS cases and control	154 adults aged between 20-55 years (77 MetS cases and	Case-control	Face-to-face interview was applied to gather dietary data	- Fast food, Mediterranean and high-protein dietary pattern was identified - Significant association was found between MetS and

			77 control)			fast-food pattern ($p = 0.001$). • No significant associations were found between the Mediterranean and high-protein patterns with MetS components
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2.3 Association between biochemical biomarkers and MetS and its risk factors

As demonstrated in Table 3, Huang et al. (2018) implemented their cross-sectional study in China among men and women. The purpose was to assess the correlation between erythrocyte parameters and MetS. Results indicated that the relationship between erythrocyte parameters and MetS depends on the sex. RBC and Hb were found as MetS risk factors in women while Hb and Red blood cell distribution width (RDW) were risk factors in men. Likewise, another study was conducted in Ethiopia with a similar purpose. Men and women adults with metabolic syndrome participated. Findings showed that Hematologic parameters (Hb, HRT and RBCs) demonstrated a direct relationship with MetS factors. These findings reflect the presence of strong evidence and the importance of taking into consideration the hematological markers as early detectors for MetS risk (Nebeck et al., 2012).

Also, Al-Dabhani et al. (2017) examined the relationship between vitamin D deficiency and MetS among Qatari participants aged between 18-80 years old. A correlation between lower 25(OH) D levels and MetS was noted. MetS risk factors including high WC and raised TG were correlated negatively with serum 25(OH) D levels while raised HDL levels were adversely linked to 25(OH) D levels. On the other hand, Veronese et al. (2014) concluded that no association was found between vitamin D and MetS.

Another study was carried out among Indian adults aged 40. It intended to evaluate the correlation of serum ferritin levels with metabolic syndrome and insulin resistance. Results indicated that there was correlation between high serum ferritin levels and metabolic syndrome (Padwal, 2015).

Additionally, a systematic review was conducted to evaluate the relationship between serum sodium levels and MetS and it revealed a significant connection between MetS subjects and higher levels of sodium. (Soltani et al., 2017).

Moreover, Kim and Han (2018) studied a Korean population to investigate the association between AST, ALT, and MetS and it was noted that there was a significant correlation between ALT and AST with MetS. Also, Xu et al. (2019) studied adult Chinese to assess the correlation between microalbuminuria (MAU) and MetS. It was found that MAU and mean 24-hour UAE were significantly raised and in correlation MetS components: BP, TG HDL-C, and HG but not for the high WC.

Furthermore, Ali et al. (2020) conducted their study among Bangladeshi adults which aimed to assess the association of SUA with MetS and its risk factors. It was found that the mean SUA concentration was remarkably higher in the MetS group. Another study was conducted in Sudan among Sudanese adults aged 18-75 years. The study intended to identify the association between MetS and its elements with hyperuricemia. Results showed that 60% of MetS demonstrated hyperuricemia and it associated positively with BMI, triglyceride, and cholesterol (Ismail et al., 2018).

Besides, Boachie et al. (2020) studied adult patients in Turkey. They noted the presence of low vitamin B12 among MetS patients.

Table 3. Studies on the association between biochemical biomarkers and MetS and its risk factors

First Author	Country	Main Theme	Target Populations	Study Design	Methodology	Outcomes	Main Findings
Nebeck et al. (2012)	Ethiopia	Evaluating the correlation between hematological parameters and MetS risk factors	1868 working Ethiopian adults with MetS (1131 men and 737 women)	Cross-sectional	- Socio-demographic and lifestyle information were collected - Physical measurements were taken - Blood samples for CBC including WBC, RBC, PLT, HB, and HCT were taken	HB, HCT, RBC, WBC	- Hematologic parameters (HB, HCT, and RBC) were demonstrated an adverse relationship with MetS risk factors ($P < 0.05$). - WBC was adversely correlated with both BMI and waist circumference ($P < 0.05$). - RBC was showed a positive relationship with DBP in men ($P < 0.05$) and women ($P < 0.001$)
Padwal (2015)	India	Assessing the correlation of serum ferritin levels in relation to MetS and IR	90 participants (50 MetS cases and 40 controls)	Prospective	- Anthropometric data including W, H and WC were measured - Blood glucose was measured using two ml fasting serum and plasma samples through GOD-POD - method - CLIA was used for estimation of serum ferritin and insulin	Fe level	High serum ferritin levels within the normal range were significantly correlated with MetS and IR
Al-Dabhani et al. (2017)	Qatar	Examining the prevalence of vitamin D	1205 Qataris and non-Qatari's	Cross-sectional	- Health, lifestyle and diet Questionnaires were applied - Anthropometric data including	25(OH)D level	MetS were correlated with lower 25(OH)D levels

		deficiency and its relationship with MetS and its risk factors	participant included 702 women and 503 men aged between 18 -80 y		W, H, WC, HC, BMI were measured • BP was measured • Blood and saliva biological samples were collected • 66 clinical biomarkers related to bone and joint markers, coagulation tests, diabetes tests, differential white cell count, full blood count, sex steroid hormones, lipid profile, minerals and vitamins were measured		• MetS risk factors including high WC and raised TG were correlated negatively with serum 25(OH)D levels while raised HDL levels were adversely linked to 25(OH)D levels
Soltani et al. (2017)	Iran	Assess association between serum sodium level and MetS	66,274 participants	17 observational studies published until June 2017 in PubMed, EMBASE, Scopus and Google Scholar were analyzed	Urinary sodium levels were measured	Na level	• MetS subjects have higher levels of sodium
Huang et al. (2018)	China	Investigating the correlation between erythrocyte parameters and MetS	4672 subjects (2161 men and 2511 women)	Cross-sectional	• Self-reported questionnaires were applied • Anthropometric parameters • WC, H, W were measured and BMI was calculated • SBP and DBP were measured • Venous blood samples for • TG, TC, HDL-C, LDL-C, FPG, • UA, WBC, PLT, RBC, HCT,	RBC, HB, RDW	• 35.2 %of women and %26.7 of men were had MetS which is as appear more MetS was more prevalent among women • RBC and HB were associated positively with MetS in women while Hb and RDW was correlated adversely with MetS as risk factors in men.

					Hb, RDW, ALT, AST, GGT, ALB and HbA1c were collected		.
Ismail et al. (2018)	Sudan	Identifying the relationship between MetS and its components with hyperuricemia	219 Sudanese participants aged between 18 – 75 y	Descriptive cross sectional	Anthropometric, clinical and biochemical measurements included: H, W, BMI, BP, lipid profile, FBG and SUA were taken	SUA	60% of MetS demonstrated hyperuricemia and it associated adversely BMI ($r=.226$, $p=.001$), triglyceride ($r=.247$, $p=.000$), and cholesterol ($r=.184$, $p=.007$).
Kim and Han (2018)	Korea	Assessing the relationship between ALT and AST with MetS	11,587 Korean adults aged _30 years	Cross-sectional	- WC was measured - BP measurement was taken - Fasting blood samples were collected for TG, TC, , glucose and ALT and AST levels	ALT and AST	Raised ALT and AST (aOR) = 7.90, levels (aOR) = 3.81 were both significantly correlated with MetS.
Xu et al. (2019)	China	Evaluating relationship between MAU and 24-hour UAE with MetS risk factors.	2261 participants aged between 18–69 y	Cross-sectional observational	- The data were collected through face-to-face interview and it included: - Socioeconomic data - Lifestyle data - Anthropometric measurements - Blood pressure measurement - Fasting blood samples were collected for TG, TC, HDL-C, LDL-C, FBG and MA	MAU	9% was estimated as the prevalence of MAU (M 24-hour UAE was 18 mg/d) - MAU and mean 24-hour UAE were significantly raised and in correlation MetS components: BP, TG, HDL-C and HG but not for the high WC
Boachie et al. (2020)	Turkey	Evaluating the relationship	976 patients with a mean age of 35.9	Review	Searching was done through done MEDLINE/PubMed and Global Health (CABI) databases. using	vitamin B12	Presence of low vitamin B12 among MetS patients

		between vitamin B12 and obesity, IR, and MetS.			vitamin B12 deficiency, insufficiency of B12, vitamin B12 or cobalamin keywords		
Ali et al. (2020)	Bangladesh	Examining the association of SUA with MetS and its risk factors	420 participants aged ≥ 18 years without severe chronic diseases	Cross-sectional	- Demographic and lifestyle information were collected through a questionnaire - Anthropometric data including W, H, WC, HC, WHR, BMI were recorded and calculated - SBP and DBP were measured - Blood samples were collected after an overnight fast (SUA), (FBG), (TC), (TG), (HDL-C), (LDL-C) were analyzed	SUA	There was a significant rise in SUA mean concentration was in MetS group compared to the non-MetS group ($p < 0.05$).

From this literature review, the outcomes reveal high benefits that impacted us as to give us brief background regarding how to implement our study by taking into consideration the systemic required elements of how to establish the methodology and required tools. Also, knowing the results of these studies assist us in establishing the hypothesis.

The remarkable notable point is that there are no studies found investigating the diet and biochemical biomarkers impact on MetS in Bahrain. Also, only one study in the Gulf area highlighting the link between nutrients and risk of MetS in Saudi Arabia (Al-Daghri et al., 2013) and only one study was done in GCC focused on assessing the association of the biochemical biomarker with MetS in Qatar (Al-Dabhani et al., 2017), which means there is no intensive highlighting regarding the topic of association of MetS with common dietary patterns in the Gulf area. Due to urbanization and dramatic nutrition transition in the Gulf area which leads to a sedentary lifestyle and fast-food consumption, the dietary part needs more attention for further studies to explore the association between dietary patterns and MetS.

Chapter 3

Methods and procedures

3.1 Setting

This study was conducted at King Hamad University Hospital (KHUH) which is located in Muharraq. KHUH offers high-quality services to all citizens of Muharraq. This study will analyze the data of patients followed in the endocrinology outpatient clinics.

3.2 Study design and participants

This study is a cross-sectional study, conducted among the Bahraini population. The approval was obtained from KHUH in Bahrain and the ethics committee of the Department of Biology, University of Bahrain. The study was carried out from May to July 2020.

3.3 Inclusion and exclusion

The study sample was selected from a section of the population that has metabolic syndrome and fits within the inclusion criteria (Bahraini nationals of both genders over the age of 18 to 65 years without any psychiatric disease) and exclusion criteria (non-Bahraini nationals, those aged below 18 years and more than 65 years old with a psychiatric disease). A written consent form was sought from each participant after providing them with a detailed clarification of the framework and purpose of this study.

3.4 Sample size

The required sample size is calculated to be at a confidence level of 95% and a margin of error of 5%. The sample size was determined using an online sample size calculator (and using this equation, $\text{Sample size} = N = 4Z\alpha^2S^2/W^2$ and estimated to be 150-190 subjects (Al-Daghri et al., 2013).

3.5 Sampling technique

The sampling was performed through the hospital electronic medical records system in KHUH. Data were obtained by going through patient records of those who have visited the endocrinology outpatient clinics and who have hyperlipidemia, diabetes, and hypertension. The selection was implemented on categorized patients who meet the National Institutes of Health guidelines for metabolic syndrome (NIH, 2001) and diagnosed with three components of metabolic syndrome which made by the endocrinology consultants in KHUH .

3.6 Materials, data collection methods, instruments used, and measurements

First, the hospital electronic medical records system in KHUH (Hope) was utilized to get information regarding the last lab results and another data for categorized patients who meet the National Institutes of Health guidelines for metabolic syndrome. The data that was collected from medical records by a team consisting of the researcher and four consultants.

- 1) Demographic data: age, gender and education levels (school levels and university).
- 2) Blood pressure measurements: systolic and diastolic blood pressure were measured after 5 minutes of rest using a standard mercury sphygmomanometer.
- 3) Anthropometric measurements: weight (W) was measured with light clothing without shoes using a digital scale and height (H) was measured using a stadiometer. The body mass index (BMI) was calculated.
- 4) Biochemical profiling: the last lab results were taken for study subjects' blood samples after 12-hours overnight fasting that included the concentrations of fasting blood glucose (FBG), triglycerides (TG), and total cholesterol (TC), HDL, LDL. Total protein (TP) , creatinine, albumin, nitrogen, uric acid. WBC,

RBC, Hb, HCT, PLT, Iron, sodium, potassium, chloride, calcium, blood amylase, bilirubin, AST, ALT, GGT, GLIC, ESR, CRP, vitamin D, folic acid, vitamin B12.

5) Echography: used to identify participants with a fatty liver diagnosis.

Secondly, categorized patients with metabolic syndrome were contacted to take their consent to participate in filling the questionnaire (dietary and lifestyle patterns in metabolic syndrome patients in the Kingdom of Bahrain). Arabic and English questionnaire versions were created through “Survey Monkey” and was distributed online for them to follow. Interviewing the patients through phone was conducted and clear explanation for questionnaire parts was implemented.

The data collected from the questionnaire are:

A. Dietary assessment

Food consumption data were gathered using a Food Frequency Questionnaire (FFQ) that measures food consumption over the previous year as a reference period. FFQ consisted of a list of 31 common food items. The participants reported their consumption frequency of each food. For each food item listed on the FFQ, six frequency choices were given (Naja et al., 2011). The questionnaire is prevalidated with minimal changes were introduced (Jahrami et al., 2017)

B. The short version of the International Physical Activity Questionnaire (IPAQ)

Physical activity was evaluated using the IPAQ short version. It measures physical activity among categorized patients with metabolic syndrome. According to metabolic equivalents of task (MET) - min/week, three types of physical activity (low, moderate, and high) were allocated after calculating the scoring (Craig et al., 2003).

Physical activity level criteria were classified according to the below criteria:

- **High physical activity level**

- I. Forceful-intensity activity on minimum of 3 days with minimum total of (1500 MET-min/week)
- II. Or 5 or more days of activities, a grouping of walking, moderate-intensity or forceful-intensity activities with completing a minimum total of (3000 MET-min/week)

- **Moderate physical activity level**

- I. Forceful activity on 3 or more days with a minimum 20 min per day
- II. Or 5 or more days of moderate-intensity activity or walking no less than 30 min duration per day
- III. Or 5 or more days of activities combining walking, moderate-intensity or vigorous-intensity activities with achieving a minimum of a complete of (600 MET-min/week)

- **Low physical activity level**

Not meeting the criteria requirements of moderate or high levels of physical activity

- I. Other lifestyle factors: Including sleep status by identifying the number of sleep hours during the day and smoking status: if the respondent smokes or not.
- II. Current medications and duration of taking the medication (less than 3 months, 3-6 months, more than 6 months).

III. Other Data: Including metabolic syndrome family history, polycystic ovarian syndrome.

- **Diagnosis criteria for the metabolic syndrome**

MetS was categorized using the National Institutes of Health guidelines as indicated below.

The individual has to have three or more of the following factors:

- I. Large waist circumference: ≥ 102 cm (40 inches) in men and ≥ 89 cm (35 inches) in women.
- II. Raised triglycerides levels (≥ 150 mg/dL), (≥ 1.7 mmol/L)
- III. Decreased HDL cholesterol: < 40 mg/dL in men (1.04 mmol/L) and < 50 mg/dL (1.3 mmol/L) in women
- IV. Raised blood pressure including systolic blood pressure (≥ 130 mm Hg) and diastolic blood pressure (≥ 85 mm Hg)
- V. Raised fasting blood glucose (≥ 100 mg/dL), (≥ 5.6 mmol/L)

3.7 Outcomes

The primary outcomes were to evaluate the influence of food intake association on metabolic syndrome factors and change in biomarkers with metabolic syndrome. The secondary outcomes included the impact of sleep, smoking, physical activity, PCOS, and fatty liver on metabolic syndrome factors.

3.8 Statistical analysis

The collected data was analyzed. The raw data from the responses of each participant was coded numerically. Following this, the data were analyzed using the Statistical Package for Social Sciences (version 21) (SPSS Inc., Chicago, IL,

USA). Statistical tests were accomplished to examine the validity and reliability of the questionnaire.

The descriptive statistics were computed. The mean, median, and percentiles were calculated for continuous data including age, body mass index (BMI), and biochemical biomarkers. The frequency and proportions were calculated for categorical data including gender, education, smoking, sleep, physical activity, fatty liver, food frequency consumption. Multiple linear regression was used to test the relationship between biochemical biomarkers and MetS components and between biochemical biomarkers themselves. The correlation coefficient was used to assess the relationship between dietary patterns and MetS risk factors and the association between MetS and lifestyle factors. Two-tailed $P < 0.05$ was reflected statistically significant for dietary patterns while two-tailed $P < 0.01$ was reflected to show the statistical significance for biochemical biomarkers.

Scatter plots were generated in SPSS to indicate the relationship between numerical variables. Bar charts were generated in Gamovi used to interpret the results and the difference between categorical variables.

Chapter 4

4.1 Results

4.1.1 Characteristics of the study population

151 participants were involved in the analysis. The demographic and lifestyle descriptive characteristics are illustrated in Table 4. The mean age of study participants was 53.8 ± 8.3 years. Approximately more than half of the sample (58.9%) were female while (41.1%) were male diagnosed with MetS.

Table 4. The demographic descriptive characteristics

		n (%)
Gender	Male	62(41.1%)
	Female	89 (58.9%)
Education	Below Secondary School Certificate	26(17.2%)
	Secondary School Certificate	29(19.2%)
	Diploma Degree	10(6.6%)
	Bachelor's Degree (BSc)	7(4.6%)
	Master's Degree (MSc)	1(0.7%)
	Doctorate (PhD)	1(0.7%)
	Non-respondents	77(51%)
Metabolic Syndrome Family History	Yes	12(7.9%)
	No	37(24.5%)
	Do not know	25(16.6%)
	Non-respondents	77(51%)
Fatty Liver	Yes	54(36%)
	No	7(4.7%)
	Not examined	89(59.3%)
Polycystic Ovary Syndrome	Yes	7(4.6%)
	No	41(27.2%)
	Male	26(17.2%)
	Non-respondents	77(50.5%)

80 out of 151 participants answered the online questionnaire. Findings found that the most of samples in our study were mainly of a low level of education categorized as below secondary school certificate and secondary school certificate educational level and women constitute the majority of a less-educated group compared to men (Figure 1).

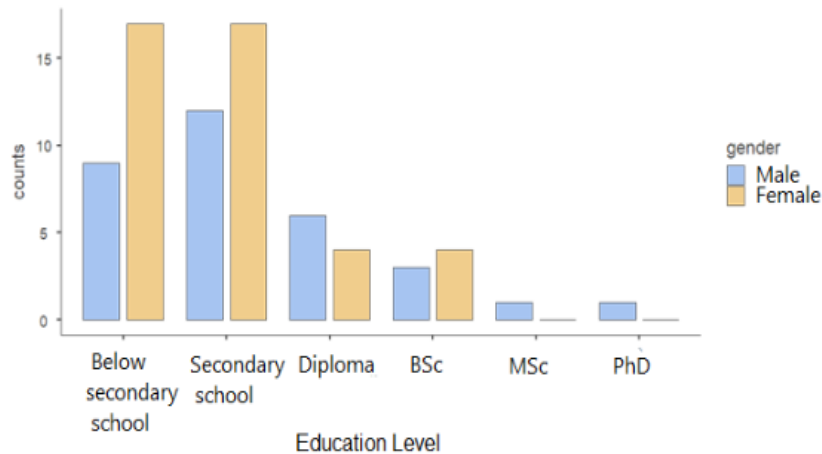


Figure 1. Education levels within the sample size

Females showed that only 4.6% have polycystic ovary syndrome while the majority do not have. Approximately a third of the participant (36%) had a fatty liver. The number of women who suffered from fatty liver was higher than men (Figure 2). Also, there was no observable relationship between metabolic risk factors and other variables including smoking, sleep, alcohol drink, and other associated diseases included fatty liver (Figure 3). The only association found was between PCOS and DBP ($B = 0.386$, $P = 0.001$) which reflects a positive relationship.

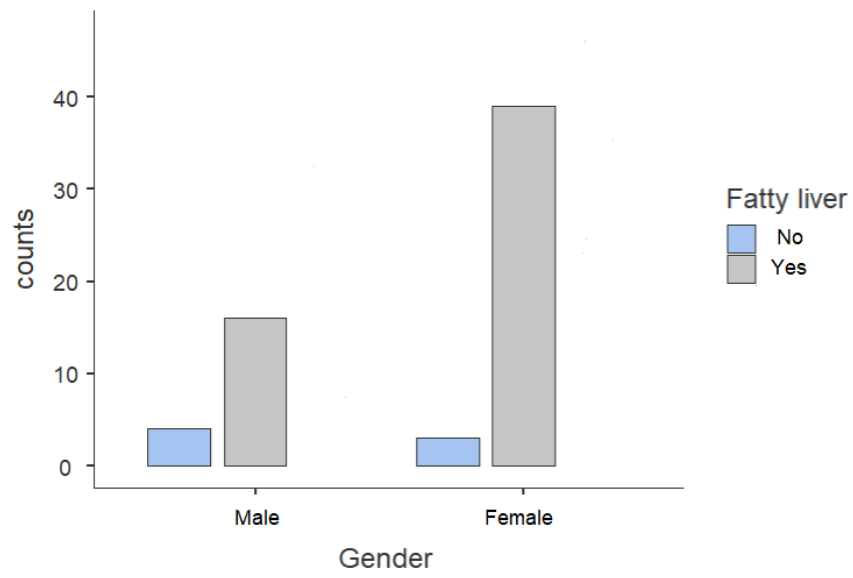


Figure 2. Fatty liver counts in male and female

As clear in Figure 3, no association were found between fatty liver and MetS risk factors as all $P > 0.05$).

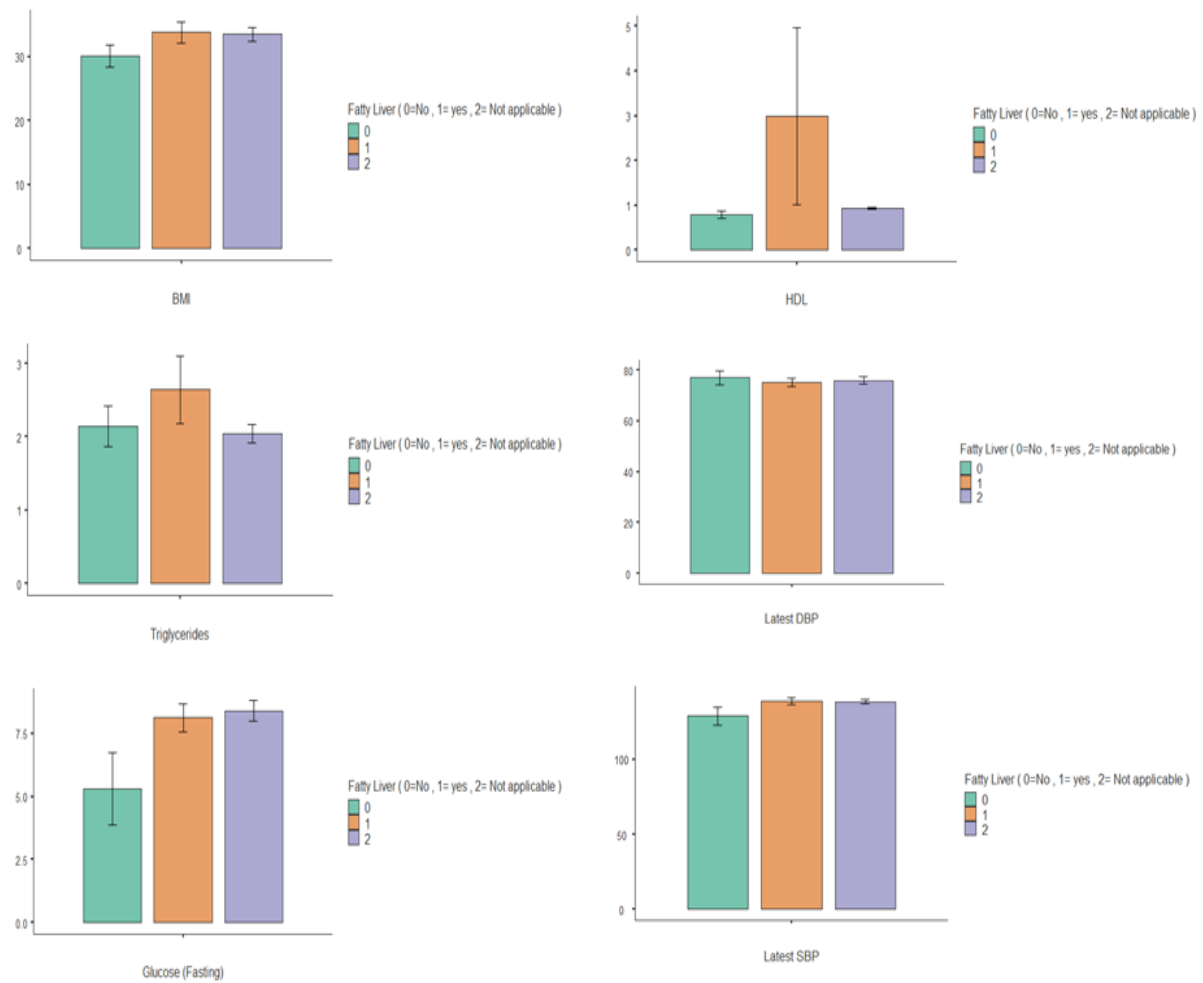


Figure 3. an illustration for the interaction between MetS risk factors and fatty liver.

4.1.2 Biochemical biomarkers

As shown in Table 5, The studied MetS population of 151 participants demonstrated mean TG of 2.26 mmol/L, mean GBF of 8.18 mmol/L, mean BMI of 33.49 kg/m² which related to obesity class I and mean BP of 138.5 / 75.9 mmHg. All of these MetS components mean were found to be high above the normal range while the mean of HDL was 1.66 mmol/L in acceptable range. In addition, as shown the level of Fe, vitamin B9 and vitamin D were low. Moreover, CRP and GGT mean levels were high as noted. Further, all other remaining mean biomarkers were in normal range.

Table 5. The descriptive statistics of biochemical biomarkers including the mean, median, percentiles and standard deviation

Variable	Mean (SD)
Age (years)	53.8 ±8.3
SBP (mmHg)	138.51±15.63
DBP (mmHg)	75.88±12.33
W (kg)	92.25±20.39
H (cm)	153.76±10.47
BMI (kg/m ²)	33.49±6.11
TC (mmol/L)	4.96±8.71
HDL (mmol/L)	1.66±1.05
TG (mmol/L)	2.26±2.22
GBF (mmol/L)	8.18±4.06
HbA1c (%)	7.49±1.94
TP (g/L)	71.6±8.80
Cr (μmol/L)	86.49±60.45
BUN (mmol/L)	4.8±35.64

SA (g/L)	37.05±9.28
AUA (umol/L)	254.02±150.23
WBC (×10 ⁹ /L)	7.29±3.32
RBC (×10 ¹² /L)	4.47±1.47
HB (g/dL)	11.73±3.85
HCT (%)	36.38±11.76
PLT (×10 ⁹ /L)	252.50±106.20
Iron (μmol/L)	3.38±5.35
Na (mmol/L)	138.35±11.67
K (mmol/L)	4.52±0.60
Cl (mmol/L)	102.45±8.74
Ca (mmol/L)	1.80±0.93
Amylase (U/L)	8.19±23.95
TBil (umol/L)	8.56±8.72
IBil (umol/L)	2.60±4.70
AST (U/L)	21.72±11.70
ALT (U/L)	39.71±5-.98
GGT (U/L)	66.78±98.22
ESR (mm/hr)	16.78±25.82
CRP (mg/l)	25.47±141.84
Vitamin D (ng/ml)	18.23±12.68
Vitamin B9 (ng/ml)	1.12±5.80
Vitamin B12 (pg/ml)	294.53±360.34

4.1.3 Dietary assessment

Food frequency intake for previous year was examined for the participants. Eighty participants responded to fill FFQ. The frequency intake of local common food is illustrated in Table 6. As clear, results indicated that 14.5% of participants were consuming fruits 3-6 times /week while 17.1% of participants were found to be consuming vegetables once daily. In addition, 13.2% were consuming full dairy products once daily while 15.9% reported never and rarely consuming of low dairy products. Also, 20.5% were found to be consuming fish 1-2 times /week while 24.5% were consuming processed meat rarely.

Table 6 .The consumption frequency of different foods on food groups

n (%)		
Meat and its substitutes group consumption		
Fish	Twice or more a day	3(2%)
	Once daily	4(2.6%)
	3-6 times per week	8(5.3%)
	1-2 times per week	31(20.5%)
	1-3 times per month	13(8.6%)
	Never or Rarely	11(7.3%)
	Non respondents	81(53.7%)
Chicken	Twice or more a day	4(2.6%)
	Once daily	5(3.3%)
	3-6 times per week	31(20.5%)
	1-2 times per week	21(13.9%)
	1-3 times per month	3(2%)
	Never or Rarely	6(4%)

	Non respondents	81(53.7%)
Processed Meat	Twice or more a day	2(1.3%)
	Once daily	4(2.6%)
	3-6 times per week	2(1.3%)
	1-2 times per week	13(8.6%)
	1-3 times per month	12(7.9%)
	Never per Rarely	37(24.5%)
	Non respondents	81(53.7%)
Beef	Twice or more a day	0
	Once daily	3(2%)
	3-6 times per week	4(2.6%)
	1-2 times per week	10(6.6%)
	1-3 times per month	23(15.2%)
	Never or Rarely	30(19.9%)
	Non respondents	81(53.7%)
Lamb	Twice or more a day	0
	Once daily	4(2.6%)
	3-6 times per week	4(2.6%)
	1-2 times per week	12(7.9%)
	1-3 times per month	18(11.9%)
	Never or Rarely	32(21.2%)
	Non respondents	81(53.7%)
Legumes	Twice or more a day	1(0.7%)
	Once daily	8(5.3%)
	3-6 times per week	12(7.9%)
	1-2 times per week	25(16.6%)
	1-3 times per month	18(11.9%)
	Never per Rarely	6(4%)

Eggs	Non respondents	81(53.7%)
	Twice or more a day	4(2.6%)
	Once daily	16(10.6%)
	3-6 times per week	15(9.9%)
	1-2 times per week	27(17.9%)
	1-3 times per month	3(2%)
	Never or Rarely	5(3.3%)
	Non respondents	81(53.7%)

Grains group consumption

Rice, Bread and Pasta	Twice or more a day	13(8.6%)
	Once daily	24(15.9%)
	3-6 times per week	20(13.2%)
	1-2 times per week	10(6.6%)
	1-3 times per month	2(1.3%)
	Never or Rarely	1(0.7%)
	Non respondents	81(53.7%)

Dairy and fat groups consumption

Full Fat Dairy	Twice or more a day	8(5.3%)
	Once daily	20(13.2%)
	3-6 times per week	12(7.9%)
	1-2 times per week	12(7.9%)
	1-3 times per month	6(4%)
	Never or Rarely	12(7.9%)
	Non respondents	81(53.7%)
Low Fat Dairy	Twice or more a day	4(2.6%)
	Once daily	11(7.3%)

	3-6 times per week	6(4%)
	1-2 times per week	17(11.3%)
	1-3 times per month	8(5.3%)
	Never or Rarely	24(15.9%)
	Non respondents	81(53.7%)
Ricotta, Goat Cheese	Twice or more a day	0
	Once daily	2(1.3%)
	3-6 times per week	2(1.3%)
	1-2 times per week	6(4%)
	1-3 times per month	11(7.3%)
	Never or Rarely	49(32.5)
	Non respondents	81(53.7%)
Cheddar Cheese	Twice or more a day	3(2%)
	Once daily	7(4.6%)
	3-6 times per week	5(3.3%)
	1-2 times per week	13(8.6%)
	1-3 times per month	12(7.9%)
	Never or Rarely	30(19.9%)
	Non respondents	81(53.7%)
Cream Cheese	Twice or more a day	3(2%)
	Once daily	8(5.3%)
	3-6 times per week	10(6.6%)
	1-2 times per week	11(7.3%)
	1-3 times per month	11(7.3%)
	Never or Rarely	27(17.9%)
	Non respondents	81(53.7%)
Butter, Mayonnaise	Twice or more a day	0
	Once daily	1(0.7%)

	3-6 times per week	4(2.6%)
	1-2 times per week	9(6%)
	1-3 times per month	8(5.3%)
	Never or Rarely	48(31.8%)
	Non respondents	81(53.7%)
Vegetable oil	Twice or more a day	0
	Once daily	0
	3-6 times per week	14(9.3%)
	1-2 times per week	8(5.3%)
	1-3 times per month	5(3.3%)
	Never or Rarely	24(15.9%)
	Non respondents	81(53.7%)

Vegetables and fruits groups consumption

Fruits	Twice or more a day	18(11.9%)
	Once daily	15(9.9%)
	3-6 times per week	22(14.5%)
	1-2 times per week	8(5.3%)
	1-3 times per month	6(4%)
	Never or Rarely	1(0.7%)
	Non respondents	81(53.7%)
Vegetables	Twice or more a day	15(9.9%)
	Once daily	26(17.1%)
	3-6 times per week	19(12.6%)
	1-2 times per week	6(4%)
	1-3 times per month	3(2%)
	Never or Rarely	1(0.7%)
	Non respondents	81(53.7%)

Olives	Twice or more a day	5(3.3%)
	Once daily	5(3.3%)
	3-6 times per week	11(7.3%)
	1-2 times per week	12(7.9%)
	1-3 times per month	13(8.6%)
	Never or Rarely	24(15.9%)
	Non respondents	81(53.7%)
Nuts and dried fruits	Twice or more a day	6(4%)
	Once daily	9(6%)
	3-6 times per week	8(5.3%)
	1-2 times per week	19(12.6%)
	1-3 times per month	19(12.6%)
	Never or Rarely	9(6%)
	Non respondents	81(53.7%)
Dates	Twice or more a day	7(4.6%)
	Once daily	14(9.3%)
	3-6 times per week	18(11.9%)
	1-2 times per week	11(7.3%)
	1-3 times per month	11(7.3%)
	Never or Rarely	9(6%)
	Non respondents	81(53.7%)

Sweets and snacks consumption

Dessert: Chocolate, Cakes, Biscuits and Ice Cream	Twice or more a day	2(1.3%)
	Once daily	6(4%)
	3-6 times per week	5(3.3%)
	1-2 times per week	17(11.3%)

	1-3 times per month	16(10.6%)
	Never or Rarely	24(15.9%)
	Non respondents	81(53.7%)
Traditional Sweets: kunafa, halwa, aseeda ,balaleet and gaimat	Twice or more a day	0
	Once daily	1(0.7%)
	3-6 times per week	1(0.7%)
	1-2 times per week	11(7.3%)
	1-3 times per month	25(16.6%)
	Never or Rarely	32(21.2%)
	Non respondents	81(53.7%)
Chips	Twice or more a day	1(0.7%)
	Once daily	4(2.6%)
	3-6 times per week	5(3.3%)
	1-2 times per week	17(11.3%)
	1-3 times per month	14(9.3%)
	Never or Rarely	29(19.2%)
	Non respondents	81(53.7%)
Other foods consumption		
Hamburger	Twice or more a day	0
	Once daily	0
	3-6 times per week	1(0.7%)
	1-2 times per week	12(7.9%)
	1-3 times per month	26(17.2%)
	Never or Rarely	31(20.5%)
	Non respondents	81(53.7%)
Shawarma	Twice or more a day	0

	Once daily	0
	3-6 times per week	2(1.3%)
	1-2 times per week	8(5.3%)
	1-3 times per month	30(19.9%)
	Never or Rarely	30(19.9%)
	Non respondents	81(53.7%)
Pizza and Pies	Twice or more a day	0
	Once daily	0
	3-6 times per week	3(2%)
	1-2 times per week	5(3.3%)
	1-3 times per month	30(19.9%)
	Never or Rarely	32(21.2%)
	Non respondents	
Falafel Sandwiches	Twice or more a day	1(0.7%)
	Once daily	1(0.7%)
	3-6 times per week	2(1.3%)
	1-2 times per week	14(9.3%)
	1-3 times per month	21(13.9%)
	Never or Rarely	31(20.5%)
	Non respondents	81(53.7%)
French Fries	Twice or more a day	0
	Once daily	1(0.7%)
	3-6 times per week	1(0.7%)
	1-2 times per week	14(9.3%)
	1-3 times per month	24(15.9%)
	Never or Rarely	30(19.9%)
	Non respondents	81(53.7%)
Sambosa	Twice or more a day	0

	Once daily	1(0.7%)
	3-6 times per week	1(0.7%)
	1-2 times per week	11(7.3%)
	1-3 times per month	23(15.2%)
	Never or Rarely	34(22.5%)
	Non respondents	81(53.7%)

Drinks consumption

Carbonated beverages and juices	Twice or more a day	3(2%)
	Once daily	7(4.6%)
	3-6 times per week	3(2%)
	1-2 times per week	9(6%)
	1-3 times per month	15(9.9%)
	Never or Rarely	33(21.9%)
	Non respondents	81(53.7%)
Alcoholic drinks	Twice or more a day	0
	Once daily	0
	3-6 times per week	0
	1-2 times per week	1(0.7%)
	1-3 times per month	0
	Never or Rarely	69(45.7%)
	Non respondents	81(53.7%)
Hot drinks tea and coffee	Twice or more a day	21(13.8%)
	Once daily	23(15.2%)
	3-6 times per week	13(8.6%)
	1-2 times per week	4(2.6%)
	1-3 times per month	2(1.3%)

Never or Rarely	7(4.6%)
Non respondents	81(53.7%)

4.1.4 Relationship between biochemical biomarkers and MetS components

Multiple linear regression models were implemented to examine the link between metabolic syndrome risk factors included BMI, DBP, SBP, TG, FG, HDL, and biochemical biomarkers ($p < 0.05$). As shown in table 7, results indicated that there was a negative association between triglyceride and the following biomarkers (HbA1c ($B = -0.29$, $p = 0.003$), AST ($B = -0.06$, $p = 0.009$), ESR ($B = -0.02$, $p = 0.014$)) and there was a positive correlation between triglyceride and the following biomarkers (Cr ($B = 0.01$, $p = 0.005$) and GGT ($B = 0.013$, $p = 0.001$)). Also, Positive associations were noted between HDL and ESR ($B = 0.103$, $p = 0.02$). Besides, a statistically significant positive association between glucose fasting with HbA1c ($B = 0.472$, $p = 0.01$) and negative correlation with Na ($B = -0.3$, $p = 0.04$) were observed. Regarding blood pressure, SBP was positively correlated with Amylase ($B = 0.135$, $p = 0.04$) and vitamin B9 ($B = 0.665$, $p = 0.02$) while DBP was positively correlated with ALT ($B = 0.051$, $p = 0.04$). No correlation was found between main MetS components (Figure 4)

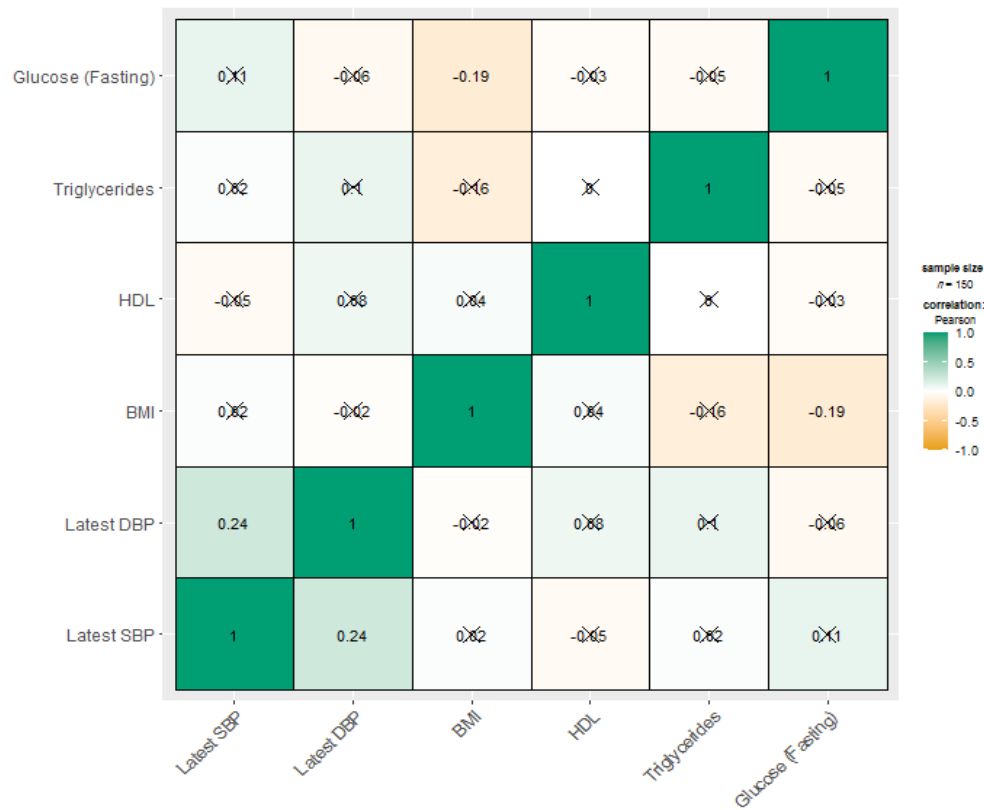


Figure 4. Correlation matrix among the main MetS risk factors

The chart demonstrates that there is no relevant correlates among investigated biomarkers

Table 7. Multiple linear regression between biochemical biomarkers and MetS risk factors

	Triglycerides		HDL		Glucose Fasting		SBP		DBP		BMI	
	B	Sig	B	Sig	B	Sig	B	Sig	B	Sig	B	Sig
Age	-0.01	0.61	-0.01	0.97	0.024	0.62	0.305	0.1	-0.371	0.006	0.075	0.22
SBP	-0.01	0.39	-0.01	0.88	0.019	0.44			0.409	0.001	0.037	0.25
DBP	0.005	0.78	0.063	0.47	-0.03	0.33	0.409	0.001			-0.073	0.09
Weight	0.004	0.77	0.06	0.39	0.016	0.56	-0.158	0.13	0.149	0.06	0.27	0.001
Height	-0	0.66	0.029	0.49	-0.02	0.22	-0.064	0.31	0.113	0.01	0.161	0.001
BMI	-0.01	0.72	-0.15	0.44	0.015	0.84	0.337	0.25	-0.366	0.09		
Total Cholesterol	0.017	0.54	0.01	0.95	0.087	0.11	-0.021	0.92	0.117	0.46	-0.031	0.66
HDL	0.016	0.42			0.036	0.34	-0.022	0.88	0.078	0.47	-0.037	0.44
LDL	0.077	0.68	0.647	0.49	-0.53	0.14	2.189	0.12	0.192	0.85	-0.203	0.66
Triglycerides			0.391	0.42	0.046	0.8	-0.63	0.39	0.151	0.78	-0.088	0.72
Glucose (Fasting)	0.013	0.8	0.244	0.34			0.297	0.44	-0.275	0.33	0.025	0.84
HBA1C	-0.29	0.003	-0.05	0.92	0.472	0.01	-0.3	0.68	0.832	0.12	0.064	0.79
Total protein	0.001	0.95	-0.05	0.64	0.086	0.03	0.188	0.22	0.014	0.9	-0.075	0.14
Creatinine	0.01	0.005	-0.01	0.45	0.005	0.44	0.042	0.12	0.014	0.5	0.006	0.51
BUN	0.001	0.88	-0.01	0.77	0.013	0.25	-0.03	0.5	0.024	0.45	-0.005	0.71
Albumin	0.005	0.81	-0.01	0.91	0.029	0.41	-0.142	0.32	-0.032	0.76	0.029	0.53
Uric Acid	0.002	0.12	-0	0.87	-0	0.26	-0.006	0.6	0.006	0.47	0.004	0.29
WBC	-0.14	0.09	0.002	1	0.12	0.44	0.621	0.31	-0.273	0.54	-0.261	0.19

RBC	-0.13	0.77	-0.35	0.88	1.356	0.11	-0.012	1	-0.911	0.72	0.201	0.86
HB	0.2	0.55	-2.23	0.18	1.154	0.07	3.977	0.11	-1.01	0.58	-1.445	0.08
HCT	-0.05	0.73	0.612	0.38	-0.53	0.05	-1.54	0.14	0.576	0.46	0.511	0.14
PLT	0.003	0.25	0.02	0.09	-0.01	0.11	0.022	0.23	-0.006	0.64	-0.003	0.62
Iron	-0.05	0.19	-0.07	0.7	-0.02	0.82	-0.061	0.83	-0.377	0.06	-0.141	0.12
Sodium	-0.08	0.27	0.124	0.74	-0.3	0.04	0.638	0.26	0.279	0.5	0.138	0.46
Potassium	0.169	0.7	-3.22	0.14	0.263	0.75	6.115	0.06	-4.472	0.06	0.291	0.79
Chloride	0.068	0.51	-0.06	0.91	0.466	0.02	-1.11	0.15	-0.324	0.57	-0.273	0.28
Calcium	-0.09	0.72	-0.05	0.97	0.741	0.11	-0.971	0.6	1.05	0.44	0.217	0.72
Amylase	0.013	0.14	0.01	0.82	-0.02	0.36	0.135	0.04	-0.016	0.74	-0.029	0.19
Total Bilirubin	0.065	0.38	-0.23	0.54	0.15	0.29	0.017	0.98	-0.059	0.89	-0.284	0.12
Direct Bilirubin	-0.15	0.28	0.387	0.57	-0.27	0.3	-0.491	0.63	-0.055	0.94	0.513	0.13
AST	-0.06	0.009	0.136	0.2	-0.02	0.66	0.085	0.6	-0.18	0.13	-0.05	0.34
ALT	0.002	0.62	-0.01	0.62	0.009	0.31	0.017	0.63	0.051	0.04	-0.002	0.87
GGT	0.013	0.001	-0.02	0.17	0	0.77	0.014	0.47	0.001	0.96	3.67E-05	1
ESR	-0.02	0.014	0.103	0.02	-0.02	0.26	-0.076	0.25	-0.031	0.53	0.018	0.41
CRP	0.002	0.75	0.005	0.87	0	0.89	-0.061	0.13	5.84E-05	1	0.017	0.20
Vitamin D	-0.01	0.52	0.025	0.75	-0.04	0.16	-0.086	0.46	0.054	0.53	-0.002	0.96
Folic Acid	-0.01	0.74	-0.03	0.87	-0.06	0.42	0.665	0.02	-0.386	0.06	-0.004	0.96
Vitamin B12	0	0.46	0	0.27	0.001	0.48	0.003	0.43	-0.001	0.82	-0.001	0.31

4.1.5 Relationship between food consumption and MetS risk factors

Linear regression analysis was applied to explore the link between food patterns and their association with MetS components ($p < 0.05$). As indicated below, Table 8 illustrates the association between food consumption and MetS predisposing factors. Findings indicated that there was a positive association between BMI and consumption of processed meat ($B = 3.83$, $p = 0.001$) and inversely associated with beef ($B = -4.66$, $p = 0.001$) legumes ($B = -2.70$, $p = 0.04$), hamburgers ($B = -5.93$, $p = 0.01$), and sambosa consumption ($B = -4.7$, $p = 0.01$). SBP was negatively associated with rice, bread, and pasta frequency consumption ($B = -5.60$, $p = 0.03$). Also, positive relationship was found between glucose and lamb ($B = 1.86$, $p = 0.01$), falafel sandwiches ($B = 1.55$, $p = 0.02$) and adverse association with Dates ($B = -0.85$, $p = 0.04$) alcoholic drinks consumption ($B = -7.30$, $p = 0.01$). Triglycerides were positively associated with the intake of low-fat dairy products ($B = 0.76$, $p = 0.01$). Moreover, a negative association was detected between HDL and chicken consumption ($B = -3.44$, $p = 0.02$), cheddar cheese ($B = -3.89$, $p = 0.04$), ricotta and goat cheese ($B = -6.29$, $p = 0.01$), chips ($B = -3.89$, $p = 0.39$) and presence positive association with falafel sandwiches ($B = 3.67$, $p = 0.034$).

No links were observed between traditional foods intakes like (qaimat, halwa, aseeda, balaleet, and kunafa) and fat products like (mayonnaise, butter, vegetable oil) with any MetS components.

Table 8. Multiple linear regression between dietary patterns and MetS risk factors

Model	Triglycerides		HDL		Glucose Fasting		SBP		DBP		BMI	
	B	Sig	B	Sig	B	Sig	B	Sig	B	Sig	B	Sig
Gender (M=0, F=1)	-0.65	0.47	1.43	.065	0.628	0.58	-0.841	0.87	-9.24	0.02	1.005	0.7
Fish	-0.76	0.1	1.055	0.5	0.94	0.11	0.221	0.93	0.883	0.66	-1.352	0.32
Chicken	-0.46	0.28	-3.44	0.02	-0.796	0.15	1.343	0.58	-1.204	0.53	-1.388	0.27
Processed Meat	0.018	0.97	0.42	0.78	-0.527	0.35	-0.627	0.8	-0.817	0.67	3.833	0.01
Beef	-0.7	0.23	1.161	0.56	-0.596	0.42	-4.655	0.16	3.576	0.17	-4.663	0.01
Lamb	-0.02	0.96	0.945	0.55	1.858	0.01	4.395	0.1	-3.273	0.12	0.291	0.83
Legumes: lentil, peas, beans	-0.06	0.89	0.092	0.95	-0.487	0.39	1.544	0.54	1.813	0.36	-2.699	0.04
Eggs	0.177	0.69	-2.212	0.13	0.456	0.42	-1.712	0.5	-0.086	0.96	0.707	0.59
Rice, bread, pasta	0.541	0.21	-2.248	0.13	-0.587	0.28	-5.598	0.03	5.157	0.01	-1.395	0.27
Dairy products (Full fat)	0.053	0.88	1.541	0.21	-0.27	0.55	1.369	0.5	-2.616	0.1	0.347	0.74
Dairy products (Low fat)	0.763	0.01	1.613	0.09	-0.08	0.82	2.625	0.1	-0.081	0.95	-1.21	0.14
Ricotta or goat cheese	0.208	0.68	-6.292	0.01	-1.074	0.1	-2.985	0.3	-1.044	0.64	1.24	0.41
Cheddar cheese	0.331	0.37	-3.887	0.04	-0.573	0.23	-1.164	0.58	0.703	0.67	-0.709	0.52
Cream cheese	0.099	0.77	2.257	0.05	-0.44	0.32	-0.314	0.87	1.649	0.27	0.599	0.55
Butter / Mayonnaise	-0.25	0.66	4.992	0.06	1.118	0.13	2.086	0.52	-0.912	0.71	-2.431	0.15
Vegetable oil	0.088	0.78	-0.505	0.64	0.38	0.34	-0.955	0.59	0.406	0.77	-0.345	0.71
Olives	0.148	0.67	0.853	0.47	-0.661	0.14	0.428	0.83	1.253	0.42	0.605	0.55

Fruits	-0.15	0.72	1.331	0.35	0.519	0.33	1.154	0.62	-2.478	0.18	-1.46	0.23
Vegetables	-0.68	0.26	-2.397	0.25	0.015	0.98	5.927	0.09	-0.431	0.87	-1.36	0.44
Nuts and dried fruits	-0.29	0.4	-0.842	0.47	0.504	0.25	0.108	0.96	0.517	0.73	1.277	0.21
Dates	0.203	0.51	-0.049	0.96	-0.845	0.04	1.899	0.28	-1.378	0.31	-1.334	0.15
Desserts:	0.64	0.08	0.119	0.92	0.569	0.22	-2.801	0.18	0.36	0.82	-0.481	0.65
Traditional sweets:	0.509	0.45	-3.741	0.11	-0.216	0.8	2.695	0.48	-0.721	0.81	3.904	0.05
Chips	-0.01	0.98	-3.345	0.04	0.588	0.32	-0.899	0.73	1.618	0.43	0.139	0.92
Hamburgers	-0.84	0.27	2.528	0.33	1.802	0.07	-6.145	0.16	2.717	0.42	-5.928	0.01
Shawarma	0.483	0.6	3.697	0.23	-1.662	0.17	-3.091	0.56	0.191	0.96	-3.501	0.21
Pizzas and pies	1.397	0.19	-1.139	0.75	-0.086	0.95	8.611	0.16	-2.468	0.59	3.205	0.31
Falafel sandwiches	-0.31	0.54	3.668	0.03	1.554	0.02	1.826	0.53	-3.188	0.15	-2.915	0.06
French fries	-0.07	0.91	-0.239	0.92	1.359	0.11	-1.417	0.7	0.088	0.98	2.247	0.24
Sambosa	-0.9	0.14	-2.912	0.17	0.051	0.95	2.779	0.43	-4.906	0.08	-4.7	0.01
Carbonated beverages and juices	-0.39	0.27	-0.091	0.94	-0.536	0.24	2.998	0.14	-0.146	0.93	0.742	0.48
Alcoholic drinks	-0.47	0.81	-4.558	0.51	-7.299	0.01	2.777	0.81	6.583	0.46	10.16	0.09
Hot drinks: tea, coffee	0.224	0.49	-1.086	0.33	-0.632	0.13	-0.495	0.79	-0.878	0.54	0.11	0.91

4.1.6 Lifestyle characteristics of the study population

The lifestyle descriptive characteristics are illustrated in Table 9. Most of the participants were non-smokers (38.4%) while only 9.9% were smokers. The sleep status of the majority of them (23.2%) and (17.2%) was distributed between (7-8) sleep hours (23.2%) and (4-6) hours /day respectively. IPAQ scoring for physical activity showed that most of the participants (32.2%) had a low level of physical activity, 13.2% demonstrated moderate physical activity while only minor numbers (2.6%) were participating regularly in high physical activity. Women exhibited less physical activity levels compared to men (Figure 5). Findings showed no significant association between metabolic risk factors and other variables including smoking, sleep and physical activity.

Table 9. The lifestyle descriptive characteristics

		n (%)
Smoking	Yes	15(9.9%)
	No	58(38.4%)
	Non respondents	78(51.7%)
Sleep (hours /day)	4-6	26(17.2%)
	7-8	35(23.2%)
	Less than 4	7(4.6%)
	More than 8	5(3.3%)
	Non respondents	78(51.7%)
Physical Activity Level	Low	49(32.2%)
	Moderate	20(13.2%)
	High	4(2.6%)
	Non respondents	78(52%)

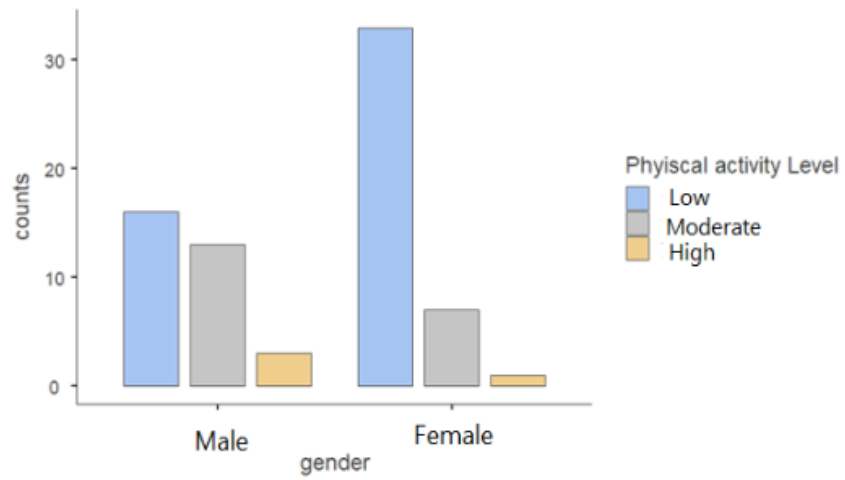


Figure 5. illustrates number of males and females in each 3 categories of physical activity

4.2 Discussion

This study examined the association between dietary patterns and MetS elements and highlighted the relationship between MetS risk factors and biochemical biomarkers among Bahraini adult population the findings in the present study revealed the association between MetS risk factors and some food. Furthermore, MetS components showed association with some biochemical markers, while there was no significant association between metabolic risk factors and lifestyle factors of sleep, smoking, and physical activity. The findings in the present study revealed presence association between MetS risk factors and some food. Furthermore, MetS components showed association with some biochemical markers, while there was no significant association between metabolic risk factors and lifestyle factors of sleep, smoking, and physical activity.

As first, we observed that consumption frequency of selected common foods in Bahrain partly follow previous reports (Rouhani et al.,2014; Sajjadi et al.,2014). As mentioned in the results part regarding the dietary patterns, findings reveal the presence of a negative association between BMI and the frequency of consumption of some types of foods such as legumes. This is supported and in agreement with Sajjadi et al. (2014); and Garcia-Bailo et al. (2018) findings which concluded that legumes consumption was negatively correlated with BMI and MetS. The probable explanation of this is that legumes are one of the healthy patterns which are associated with lower energy intake and rich in key nutrients such as fiber, protein, folate, iron, calcium, magnesium, and potassium. In addition, processed meat is found to be positively associated with BMI and our finding is consistent with Rouhani et al. (2014) which demonstrated that increasing processed meats consumption was associated with increasing BMI and WC and this goes in line

with the fact that processed meat contains a high saturated fatty acids (Drake et al., 2018; Luan et al., 2020) and high amounts of sodium and heme iron (Becerra-Tomás et al., 2016) which participate in raising the risk of MetS.

Besides, Yeo et al. (2017) findings concluded that fast-food intake including hamburgers was positively correlated with MetS risk factors. This could be attributed to fast food containing a high level of fat which raises the LDL and fat body percentage resulting in obesity. This is inconsistent with our finding, although the target and average age group were approximately the same but some differences were observed that may contribute to that inconsistency in results such as the sample size as in our study sample is 3 times less as compared to the study of Yeo et al. (2017). In addition, the consumption frequency of these food among Bahraini population as found was rare and may that due to the cultural differences between the Bahraini population and the Korean population which play a role in this food type consumption.

“Higher consumption of starchy foods including rice, bread, and pasta showed beneficial effects on lowering blood pressure which is supported by Sakurai et al. (2018) findings which was consistent with our results. This is probably due to the fact that rice, bread and pasta are rich in potassium which has a big role in decreasing blood pressure.”

“In addition, dates consumption was shown to have a lowering effect on blood glucose. This is supported by Alalwan et al. (2020); Al-Mssallem et al. (2020) which concluded that consumption of dates daily in moderation had no effects on increasing HbA1c and this attributed to the fact that dates are considered low GI food which is rich source of dietary fiber particularly insoluble fiber and antioxidant. Also, a falafel sandwich showed positive association with glucose which is in agreement with Naja et al. (2011) and this attributed to that falafel

sandwich is considered as fast food which is high in saturated fats, sugars and is low in fiber.

Moving to the effects of dietary patterns on triglycerides MetS risk factor, our findings presented that there is a positive relationship between low-fat dairy consumption and triglycerides and this is inconsistent with prior systematic reviews and meta-analyses that stated that total dairy food consumption was associated with a lower risk of MetS components (Lee et al., 2018). Besides, Merino et al. (2013) described that there is an association between low-fat dairy products intake and lesser triglyceride concentrations in a Spanish hypertriglyceridemic. Also, Babio et al. (2015) found a negative relationship between intake of low-fat dairy products, yogurt (total, low-fat, and whole-fat yogurt), and low-fat milk and risk of MetS at high cardiovascular disease risk individuals from a Mediterranean population. The possible mechanisms describing the beneficial consequence of dairy foods have been proposed. Milk and yogurt contain multiple nutrients such as Ca and dairy proteins, which play an important role in health. Ca get together with fatty acids and bile acids in the intestine and led to rise fecal fat excretion and/or hindering fat reabsorption. In our study there is a contrast with these findings that may attributed to unknown quantity of low-fat consumption. In addition, Cheddar cheese and ricotta and goat cheese were associated inversely with HDL which is in agreement with findings of Hostmark and Tomten (2011) and this is attributed to that cheese in general rich with saturated fat which lead to increase bad LDL and decrease good HDL.

Further, our results are in agreement partly with earlier studies regarding the association between MetS risk factors and biochemical biomarkers. Park et al. (2012) concluded that metabolic syndrome components BP, TC, TG and FBG were

associated positively with HbA1c and HDL was correlated negatively with HbA1c. These results were consistent with our findings in some MetS components including FPG which was indicated the positive relationship with HbA1c. This could be attributed to the fact that HbA1c is considered as long-term glycemic control indicator which monitors the cumulative glycemic history and it used to give an overall picture of the population who have diabetes and due to the fact that HbA1c is a potent marker for FPG and taking attention to this it will improve and address this FBG risk factor of MetS (Berwick et al., 2015)

Besides, Kim and Han (2018) found that elevated levels of ALT and AST were associated with MetS components. These results are supported by our study in some points of the presence of a positive relationship between triglycerides and HDL with liver enzymes.

Moreover, Oh et al. (2015) reported that there was a positive relationship between sodium excretion and all MetS components which is in some agreement with our study in the part of a positive association between FBG and sodium.

Also, Narang et al. (2016) showed that metabolic syndrome components associated with have a high level of homocysteine and folic deficiency among Indian patients which is considered as disagreement with our results of presenting a positive association between SBP and folic acid.

It is clear that some biochemical markers were positively associated with metabolic risk factors indicating that these variables are potential biomarkers reflecting early detection cues for MetS which means the nasserites of taking intensive attention in addressing these biomarkers to minimize the risk of MetS.

The relationship between metabolic syndrome and lifestyle factors was not significant. In a study implemented in the United States among African Americans

Babio et al. (2015) results indicated that there was no significant correlation between MetS and modifiable lifestyle factors which supports our findings, while in other studies physical activity findings were in disagreement with our study. In Saudi Arabia, a study was implemented among Saudi men, results reflect the presence of a significant relationship between physical activity and MetS risk factors which found 10 mins of MVPA and LPA were correlated with elevated HDL, and LPA was correlated with low TG (Alkahtani et al., 2015).

As regards the association between socioeconomic data and MetS, studies showed that increasing age and low level of education were significantly associated with metabolic syndrome and a high prevalence of MetS in individuals, 73% with lower educational level (Moreira et al., 2015). This result is consistent with our study which reported that most of the participants with MetS were in low level of education. Besides Kuk and Ardern (2010) showed MetS were more common twice in the older population (> 65 years old) than younger (aged equal or <65 years) with a prevalence percentage of (55%, 26%) respectively. This reflects that MetS risk is increasing with age increasing.

Amiri et al. (2020) reported that PCOS women in productive ages were more common to have hypertension more than others. This could be attributed to the PCOS women have excess of androgen which correlated with elevated carotid intima-media thickness test (CIMT) and this led to development of hypertension.

4.2.1 Strengths and limitations

The study has several strengths. The major strength is giving unique valuable information and contributing on the data related to metabolic syndrome from Bahrain as no previous studies were done to highlight on dietary patterns and the correlation between biochemical biomarkers and MetS in Bahrain.

The remarkable feature of our study is using a comprehensive approach in collecting data.

Some limitations of our study should be taken into consideration. Sample size is one of the limitations and low response for online questionnaire is considered an additional limitation. A self-report questionnaire method was used to examine the food frequency intake and international physical activity questionnaire which may have some recall bias. The study is cross-sectional design, and it hinders assessing causality. Also, the impact of dietary patterns on MetS is not fully understood and it is possible that MetS diagnosis may influence and change the dietary patterns of the patients after diagnosing. Moreover, some data like WC was not collected due to time insufficiency and improper circumstances. The PCOS information was subjective and some fatty liver information were missed. In addition, lack of comparison between MetS adults and non-MetS adults was present. Moreover, test-retest reliability has not been done since interviewing each patient was done only one time.

4.3 Recommendations

Biochemical markers values are potential baseline standards with high importance in association with MetS risk factors. Routine screening of biochemical biomarkers should be considered and take more attention as it may aid early detection of MetS and to limit the disease progress.

Besides, there is a strong desire of implementing positive reinforcement and spreading awareness and education through immediate actions and intensive efforts that must be directed through public health to reduce and prevent the MetS risk among Bahraini by explaining the benefits of diet modifications on minimizing and prevention of the MetS risk factors while emphasizing the role of diet, type of food, amount, and calories. In addition, indicating the benefits of addressing and

intervening the biochemical biomarkers as early indicators for population. Additional future studies should be conducted and further attention toward MetS as the studies related to MetS in Bahrain are very limited and more investigations are strongly needed to reveal and confirm our findings.

4.3.1 Conclusion

Dietary patterns and some food consumptions are closely associated with MetS risk factor among Bahraini adults. It is proposed to educate and increase people's awareness toward healthy dietary patterns as early steps to prevent MetS. In addition, some biochemical biomarkers are associated with MetS components which may be used as early indicators to be addressed to minimize risk of MetS.

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Appendix

Table 10. Frequency of medications using and compliance

Medications	n (%)
Taking Metformin Glucophage medications	
(yes) take it currently for over 6 months	34(22.4%)
(yes) take it for 3 to 6 months	3(2%)
(yes) take it for under 3 months	1(0.7%)
(yes) take it and stopped	15(9.9%)
No	9(5.9%)
I do not know	6(3.9%)
Taking Crestor Lipitor Zocor medications	
(yes) take it currently for over 6 months	31(20.4%)
(yes) take it for 3 to 6 months	1(0.7%)
(yes) take it for under 3 months	2(1.3%)
(yes) take it and stopped	1(0.7%)
No	14(9.2%)
I do not know	19(12.5%)
Taking Lipid medications	
(yes) take it currently for over 6 months	2(1.3%)
(yes) take it for 3 to 6 months	0
(yes) take it for under 3 months	0

	(yes) take it and stopped	3(2%)
	No	24(15.8%)
	I do not know	39(25.7%)
Taking Lipid medications	(yes) take it currently for over 6 months	2(1.3%)
	(yes) take it for 3 to 6 months	0
	(yes) take it for under 3 months	0
	(yes) take it and stopped	3(2%)
	No	24(15.8%)
	I do not know	39(25.7%)
Taking Finofibrate Lipanthyle medications	(yes) take it currently for over 6 months	1(0.7%)
	(yes) take it for 3 to 6 months	1(0.7%)
	(yes) take it for under 3 months	0
	(yes) take it and stopped	0
	No	30(19.7%)
	I do not know	36(23.7%)
Taking Victoza Saxenda medications	(yes) take it currently for over 6 months	5(3.3%)
	(yes) take it for 3 to 6 months	0
	(yes) take it for under 3 months	1(0.7%)

		(yes) take it and stopped	4(2.6%)
		No	25(16.4%)
		I do not know	33(21.7%)
Taking medications	Xenical	Orlistat (yes) take it currently for over 6 months	0
		(yes) take it for 3 to 6 months	0
		(yes) take it for under 3 months	0
		(yes) take it and stopped	2(1.3%)
		No	29(19.1%)
		I do not know	37(24.3%)
Compliance in the consumption of medications	Metformin	Glucophage Yes	38(25%)
		No	7(4.6%)
		I do not take this medication	23(15.1%)
Compliance in the consumption of medications	Crestor	Lipitor Yes	37(24.3%)
		No	4(2.6%)
		I do not take this medication	27(17.8%)

Compliance in the consumption of Lipid medications		
	Yes	
		4(2.6%)
	No	8(5.3%)
	I do not take this medication	56(36.8%)
Compliance in the consumption of Finofibrate Lipanthyle medications		
	Yes	
		2(1.3%)
	No	9(5.9%)
	I do not take this medication	57(37.5%)
Compliance in the consumption of Victoza Saxenda medications		
	Yes	
		7(4.6%)
	No	7(4.6%)
	I do not take this medication	54(35.5%)
Compliance in the consumption of Xenical Orlistat medications		
	Yes	
		2(1.3%)
	No	9(5.9%)
	I do not take this medication	57(37.5%)

Questionnaire (English version)

Do you agree to participate in filling the questionnaire?

- ☐ Yes
- ☐ No

First section

1- Does anyone in your family have metabolic syndrome?

- ☐ Yes
- ☐ No
- ☐ I do not know

2- Answering this question for female only, do you have Poly Cystic Ovarian Syndrome?

- ☐ Yes
- ☐ No

Second section

1- Physical activity (international physical activity questionnaire)

Think about all physical activities you spent in the last 7 days

Activity Level	Duration (mins)	Frequency (number of days / week)
Vigorous (physical Activities like heavy lifting, digging, aerobics, or fast bicycling		
Moderate (physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis)		
Walking slowly		

Sitting (sitting at a desk, watch television)		
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2- How many hours you sleep during the day?

- ☐ Less than 4 hours
- ☐ 4-6 hours
- ☐ 7-8 hours
- ☐ More than 8 hours

3- Do you smoke?

- ☐ Yes
- ☐ No

4- Food Frequency Questionnaire

Please put a tick in the box to indicate how often on average you have eaten the specified amount of each food during the past year:						
	Never / rarely	1-3 times /month	1-2 times /week	3-6 times /week	Once daily	Twice or more day/
Hamburger						
Shawarma						
Pizza and pies						
Falafel						
Sandwiches						
French fries						
Sambosa						
Mayonnaise						
Butter						
Dairy products full fat						
Dairy products low fat						
Ricotta or goat cheese						
Cheddar cheese						
Cream or glass cheese						
Olives						

Fruits						
Vegetables						
Nuts and dried Fruits						
Dates						
Legumes: lentil, peas, beans						
Grains: rice, bread, pasta						
Breakfast cereal						
Eggs						
Fish						
Chicken						
Processed meat						
Beef						
Lamb						
Vegetable oil						
Desserts: chocolate, cakes, biscuits, ice cream						
Traditional Sweets: kunafa , Halwa , Aseeda , Balaleet , qaimat						
Chips						
Carbonated Beverages and juices						
Alcoholic drinks						
Hot drink :tea , coffee						

Third section

Medications

Did you ever take any of the following medications?								
Medication	No	If Yes:				I don't know	Are you compliant?	
		Took it and stopped	taking it currently for under 3 months	taking it currently for 3-6 months	taking it currently for over 6 months		Yes	No
Metformin								
Glucophage								
Crestor								

Lipitor Zocor								
Lopid								
Fenofibrate Lipanthyl								
Victoza Saxenda								
Xenical Orlistat								

الاستبيان (النسخة العربية)

هل انت موافق على المشاركة في اجابة هذا الاستبيان ؟

- ☐ نعم
☐ لا

الجزء الأول:

المعلومات الشخصية

1- هل يوجد أحد من العائلة يعاني من متلازمة التمثيل الغذائي ؟

- ☐ نعم
☐ لا
☐ لا اعلم

2- اجابة هذا السؤال للإناث فقط ، هل تعانيين من متلازمة تكيس المبايض ؟

- ☐ نعم
☐ لا

الجزء الثاني :

1-النشاط البدني – استبانة النشاط البدني الدولية
فكر في جميع الأنشطة البدنية التي قمت بعملها في آخر 7 أيام.

مستوى النشاط	المدة (بالدقائق)	التكرار (عدد الأيام بالأسبوع)
أنشطة قوية مثلا رفع الأثقال الثقيلة، حفر، الجري، أو ركوب الدراجات السريعة		
الأنشطة المعتدلة مثلا رفع الأثقال الخفيفة، ركوب الدراجات بوتيرة منتظمة أو التنس المزدوج		
المشي بشدة منخفضة		
الجلوس (على سبيل المثال الجلوس على المكتب ، مشاهدة التلفزيون)		

2- نمط النوم
كم عدد ساعات نومك المعتادة في اليوم الواحد؟

☐ أقل من 4 ساعات

☐ 4 - 6 ساعات

☐ 7-8 ساعات

☐ أكثر من 8 ساعات

3- هل تدخن في العادة؟

☐ نعم

☐ لا

4- استبانة تواتر الغذاء

ضع علامة على كيفية استهلاكك غالبا للأطعمة التالية خلال السنة الماضية :

مرتا ن أو أكثر اليو م	1 مرة/ يوم	3-6 مرات/ أسبوع	1-2 مرات/ أسبوع	1-3 مرات/الشهر	أبدا/ نادرا
					البرغر
					الشاورما
					البيتزا والفطائر
					سندويشات الفلافل
					البطاطا المقلية
					السمبوسة
					المايونيز
					الزبدة
					منتجات الألبان كامل الدسم
					منتجات الألبان قليل الدسم
					جبنة الماعز او جبنة قريش
					جبنة الشيدر
					جبين كاسات أو جبين كريم
					الزيتون
					الفواكه الطازجة
					الخضراوات الطازجة
					المكسرات والفواكه المجففة
					التمر / الرطب
					البقوليات : العدس ، الفول
					منتجات الحبوب : الأرز ، الخبز ، الباستا
					حبوب الإفطار
					البيض
					السمك
					الدجاج
					اللحوم المصنعة
					لحم البقر
					شرائح لحم الضأن أو الماعز
					زيت الخضراوات
					الحلويات : الشوكولاته ، الكيك ، البسكوت ، الآيس كريم
					الحلويات المحلية : الكنافة ، الحلوى ، العصيدة ، البلاليط ،

