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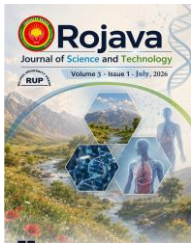

Assessing the Impact of Overweight and Obesity on Cardiovascular Health Among Syrian Population Living in North and East Syria: A Cross-Sectional Study

Shima Mustafa Ali[1], Haidar Saify Nabiabad[1], Eman Elbassuoni[2*]

[1] Department of Physiology, Institute of Science and Modern Technology, Rojava University, North and East Syria

[2] Department of Physiology, Faculty of Medicine, Minia University, Egypt

Abstract

As the global prevalence of overweight and obesity continues to rise, understanding their impact on cardiovascular health is crucial for developing effective interventions and healthcare policies. Cardiovascular diseases (CVD), including heart disease and stroke, remain the leading causes of death worldwide. Addressing this issue begins with assessing the prevalence of overweight and obesity and evaluating their effects on CVD risks, as demonstrated in the population of North and East Syria. A total of 167 participants (47.5% males, 40.4% females) with a mean age of 49.4 years were assessed. The average BMI was 27.9, with overweight and obesity rates of 34.2% and 35.3%, respectively. High waist circumference was observed in 49.7% of participants, with a significant gender difference, as 63.4% of females exhibited this condition compared to 36.5% of males. The mean systolic blood pressure was 132.1 mmHg, and the mean diastolic blood pressure was 85.3 mmHg. Hypertriglyceridemia was the most obesity prevalent risk factor (61.7%), followed by high waist circumference (49.7%), hypertension (32.9%), and hyperglycemia (32.3%). Hypercholesterolemia had the lowest prevalence (9.6%). A significant association was found between age and waist circumference, mean arterial pressure, fasting blood glucose, and cardiometabolic syndrome development. Gender differences extended to lifestyle and educational factors. Smoking and alcohol consumption were significantly higher among males (58.8% and 18.8%, respectively), while females had lower education levels (36.6% uneducated). Being overweight and obese was strongly associated with a history of hypertension, a family history of CVD, and a lack of education. This study highlights the significant burden of obesity and its associated health risks in North and East Syria. It emphasizes the need for targeted public health interventions focusing on education, lifestyle modification, and early detection of obesity-related conditions to mitigate the rising prevalence of cardiometabolic disorders in the region.

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*Corresponding Corresponding Author: Eman Elbassuoni, eman.abdelhameed@mu.edu.eg

1. Introduction

Overweight and obesity, characterized by excessive fat accumulation due to an imbalance between energy intake and expenditure, are major global health concerns (Pereira-Lancha et al. 2010). Epidemiological evidence links obesity to increased incidence and mortality from cardiovascular disease (CVD), with its effects varying based on obesity duration and individual fitness levels (Ortega, Lavie, and Blair 2016). Physical fitness can moderate some cardiovascular risks even in obese individuals (Ashraf and Baweja 2013).

Excess body weight negatively affects the cardiovascular system, increasing the risks of hypertension, dyslipidemia, insulin resistance, and structural heart changes. Additionally, obesity is associated with chronic inflammation, with elevated proinflammatory cytokines contributing to insulin resistance, plaque activation, myocardial hypertrophy, and CVD progression (Ellul et al. 2017). Inflammatory changes in adipose tissue also impair vascular function (Oikonomou and Antoniades 2018).

Obesity significantly contributes to heart failure. Each unit increase in BMI raises the incidence of heart failure by 5% in men and 7% in women. Increased blood volume and cardiac workload can lead to left ventricular hypertrophy, ultimately causing heart failure. Obesity is also a key component of metabolic syndrome, further elevating CVD risk (Oberman and Bhardwaj 2022).

In 2022, approximately 16% of adults worldwide were obese, with obesity prevalence more than doubling since 1990. An estimated 2.5 billion adults were overweight, including over 890 million classified as obese. This accounted for 43% of adults aged 18 years and older (43% of men and 44% of women), a significant increase from 25% in 1990. Overweight prevalence varied by region, ranging from 31% in the WHO Southeast Asia and African Regions to 67% in the Americas (World Health Organization 2024).

Obesity is a major risk factor for numerous health conditions, worsening comorbid illnesses, reducing quality of life, and increasing mortality risk. In the United States alone, over 111,000 deaths annually are linked to obesity (Flegal 2005). Epidemiological studies show that obesity contributes to higher incidence and mortality from multiple cancers, including those of the colon, breast (postmenopausal women), endometrium, kidney, esophagus, gastric cardia, pancreas, gallbladder, and liver. Overall, 15%–20% of all cancer-related deaths in the U.S. are attributed to overweight and obesity (Calle et al. 2003).

The main objectives of this research project are to assess the prevalence of overweight and obesity in a defined population in Syria, and to provide a comprehensive understanding of its impact on cardiovascular health, revealing the underlying mechanisms and potential interventions.

2. Materials and methods

2.1 Study Design

The study was an observational cross-sectional study conducted in North and East Syria from December 2023 to June 2024.

2.2 Study Population and Sampling Technique

All Syrian residents living in North and East Syria were invited to participate in the study. The required sample size calculated based using EPI-INFO version 3, considering the prevalence of obesity in Syria (18.9 %) (Zlatko Nikoloski 2023), a confidence interval of 95%, and a maximum acceptable error of 5%. Accordingly, the minimum sample size needed was 150 members. A total of 167 members were included in the study. The study was conducted at the outpatient clinics and internal medicine in the following hospitals:

- Afrin Hospital in Fafin, Al-Shahba District, Aleppo
- Tal Rifaat Hospital, Al-Shahba District, Aleppo
- Yassin Hospital, Sheikh Maqsoud neighborhood, Aleppo
- Kobani Hospital, Kobani city, East of Euphrates

- Amal Hospital, Kobani City, East of Euphrates

Official permissions were obtained from the Rojava University administration and the university's scientific ethical committee. The study protocol was approved by the Ethics Committee of Rojava University.

2.3. Research Strategy

Data was collected after explaining the study and obtaining written consent from participants. Interested participants were screened for eligibility and scheduled for data collection. All samples were analyzed at the hospitals' accredited laboratories.

All participants underwent thorough history-taking and clinical examinations.

1. Questionnaire including:

• Socio-Demographic Characteristics: age, sex, physical activity, smoking/alcohol habits, dietary habits, educational level

• Medical History: hypertension, diabetes mellitus, CVD, or any chronic disease, family history of hypertension, diabetes mellitus, or CVD.

2. Anthropometric Measurements:

• Body Weight (kg): Measured with a digital scale to the nearest 0.1 kg.

• Height (cm): Measured with stretch-resistant tape to the nearest 0.5 cm. Participants removed shoes and bulky clothing.

• Waist circumference (in centimeters): measured at the midpoint between the lower rib margin and the iliac crest (WHO, 2008). Threshold values: ≥88 cm (women), ≥102 cm (men).

• Body Mass Index (BMI): Calculated as: BMI=Weight in kilograms / Height in meters^2

BMI was classified according to World Health Organization guidelines (World Health Organization 2024): underweight (<18.5), normal (18.5–24.9), overweight (25–29.9), and obese (30–39.9).

3. Clinical Examination: Brachial blood pressure was measured using standard mercury sphygmomanometers after participants rested for at least five minutes. Categories were based on American College of Cardiology/American Heart Association guidelines (Carey and Whelton 2018):
   - Normal: Systolic <120 mmHg, Diastolic <80 mmHg.
   - Elevated: Systolic 120–129 mmHg, Diastolic <80 mmHg.
   - Hypertension: Systolic ≥130 mmHg, Diastolic ≥80 mmHg.

4. Laboratory Investigations:

• Fasting Blood glucose (mg/dl): Measured after overnight fasting. Levels were categorized as normal (<100 mg/dL), prediabetes (100–125 mg/dL), and diabetes (≥126 mg/dL) (Mayo Clinic 2017).

• Cholesterol and triglyceride levels are classified per standard clinical thresholds (Grundy et al. 2018).

- Normal total Cholesterol (mg/dL) (<200), borderline high (200–239), and high (≥240).
- Triglyceride Classification (mg/dL) into: Normal (<150), Mild High (150–199), Moderate High (200–499), and Severe High (≥500).

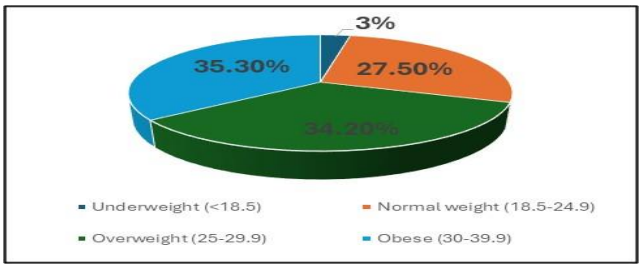
2.4. Statistical Methods

Data was analyzed using IBM SPSS version 27. Quantitative data were expressed as mean ± SD, and categorical data as numbers and percentages. Relationships between variables and outcomes were tested using the chi-square or Fisher's exact test for categorical data and independent sample t-tests and ANOVA for numerical data.

3. Results

3.1. The prevalence of different BMI categories

In the studied population, underweight represents 3% of the participants, normal weight represents 27.5% of the participants, overweight represents 34.2% of the participants, obese represents 35.3%of the participants



(figure 1).

Figure 1: The prevalence of different BMI categories

3.2. The mean and prevalence of some health risks related to overweight and obesity

- A total of 167 participants were included in the present study. The mean BMI was 27.9, while the mean waist circumference was 94.9 cm. The mean arterial blood pressure was 100.9 mmHg, and the mean fasting blood glucose level was 107.8. The mean cholesterol level was 165.5, while the mean triglyceride level was 195.8 (Table 1).

- Hypertriglyceridemia was the most prevalent risk factor, with a prevalence of 61.7%, followed by high waist circumference (49.7%). In comparison, hypertension had a prevalence of 32.9%, while hyperglycemia was observed in 32.3% of participants. The least prevalent risk factor was hypercholesterolemia, with a prevalence of 9.6% (Figure 2).

Table 1: Main characteristics of the population studied

	Total (Number = 167) Mean ± SD
BMI (kg/m^2)	27.9 ± 5.3
Waist circumference (cm)	94.9 ± 13.7
MAP (mmHg)	100.9 ± 15.7
Fasting blood glucose (mg/dl)	107.8 ± 45.2
Cholesterol (mg/dl)	165.5 ± 34.5
Triglycerides (mg/dl)	195.8 ± 98

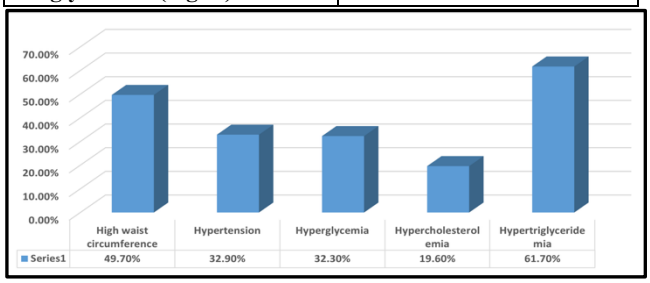


Figure 2: The prevalence of some health risks related to overweight and obesity.

3.3. SEM Correlation between age and BMI and some health risks related to overweight and obesity

Statistical analysis found a positive correlation between age and waist circumference, mean arterial pressure, fasting glucose level, and cardiometabolic syndrome (CMS) development (Table 2).

Table 2: Correlation between age and BMI and some health risks related to overweight and obesity

Correlation	Age (year)	
	R	p-value
BMI	0.128	0.100
Waist circumference	0.241 **	0.002
MAP	0.213 **	0.006
Fasting blood glucose	0.184 *	0.017
Cholesterol	0.139	0.073
Triglycerides	0.028	0.722
CMS	0.243 **	0.002

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

3.4. The relation between BMI, and some medical and lifestyle risk factors related to overweight and obesity

- Analysis of the present results showed that there was a significant association between overweight and obesity and high waist circumference, high MAP, high triglycerides, and the presence of CMS (p-value < 0.05) (table 3).

- The present results showed that there was a significant association between overweight & obesity and history of hypertension, family history of CVD, and no education (p-value < 0.05) (table 3).

3.5. The distribution of BMI, some related health risk factors, and some medical and lifestyle risk factors related to overweight and obesity according to gender

- Statistical analysis showed that the participants' gender was significantly associated with high waist circumference and BMI (p<0.05). About 63.4 % of female participants have a high waist circumference, compared to 36.5% for males. About 45.1% of female participants were obese, compared to 25.9% for males (figure 3).

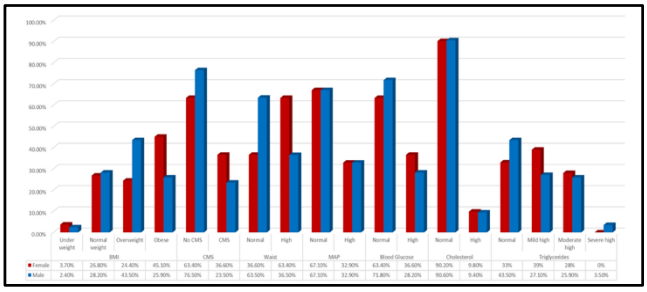


Figure 4: *The distribution of BMI and some medical risk factors related to overweight and obesity according to gender*

- On the other hand, the gender of the participants was significantly associated with educational level, smoking, and alcohol intake (p<0.05). About 36.6% of female participants have not been educated, compared to 16.5% of males. 73% of males have low education, compared to 52.4% of females. 58.8% of males were smokers, compared to 35.4% for females. 18.8% of males take alcohol, compared to 2.4% for females (figure 4).

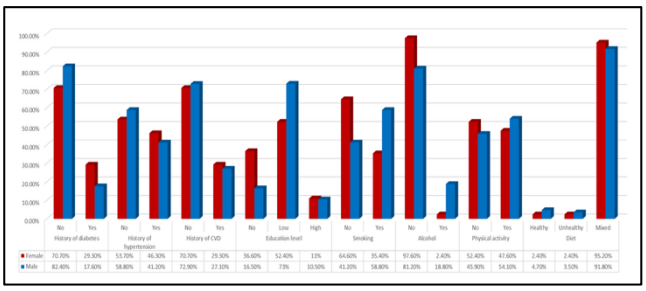


Figure 3: *The distribution of BMI and some lifestyle risk factors related to overweight and obesity according to gender*

Table 3: *The relation between BMI and some medical and lifestyle risk factors related to obesity*

		BMI			Test	p-value
		Normal (N=51)	**Overweight (N= 57)**	**Obese (N=59)**		
Waist Circumference	- Normal - High	41 (80.4%) 10 (19.6%)	33 (57.9%) 24 (42.1 %)	10 (16.9%) 49 (83.1%)	X^2 46.040	<0.001
MAP	- Normal - High	44 (86.3%) 7 (13.7%)	35 (61.4%) 22 (38.6%)	33 (55.9%) 26 (44.1%)	X^2 *12.658*	0.002
Fasting blood glucose	- Normal - High	37 (72.5%) 14 (27.5%)	41 (71.9%) 16 (28.1%)	35 (59.3%) 24 (40.7%)	X^2 2.907	0.234
Total cholesterol	- Normal - High	47 (92.2%) 4 (7.8%)	53 (93%) 4 (7%)	51 (86.4%) 8 (13.6%)	X^2 1.688	0.430
Triglycerides	- Normal - Mild high - Moderate high - Severe high	30 (58.8%) 15 (29.4%) 6 (11.8%) 0 (0%)	20 (35.1%) 18 (31.6%) 18 (31.6%) 1 (1.8%)	14 (23.7%) 22 (37.3%) 21 (35.6%) 2 (3.4%)	X^2 17.795	0.007
CMS	- No - Yes	46 (90.2%) 5 (9.8%)	41 (71.9%) 16 (28.1%)	30 (50.8%) 29 (49.2%)	X^2 20.336	<0.001
History of diabetes	- No - Yes	44 (86.3%) 7 (13.7%)	41 (71.9%) 16 (28.1 %)	43 (72.9%) 16 (27.1%)	X^2 3.817	0.148
Family history of diabetes	- No - Yes	32 (62.7%) 19 (37.3%)	31 (54.4%) 26 (45.6%)	26 (44.1%) 33 (55.9%)	X^2 3.875	0.144
History of hypertension	- No - Yes	38 (74.5%) 13 (25.5%)	28 (49.1%) 29 (50.9%)	28 (47.5%) 31 (52.5%)	X^2 9.941	0.007
Family history of hypertension	- No - Yes	26 (51%) 25 (49%)	19 (33.3%) 38 (66.7%)	21 (35.6%) 38 (64.4%)	X^2 4.096	0.129
History of CVD	- No - Yes	41 (80.4%) 10 (19.6%)	42 (73.7%) 15 (26.3%)	37 (63.8%) 21 (36.2%)	X^2 3.817	0.148
Family history of CVD	- No - Yes	37 (72.5%) 14 (27.5%)	35 (61.4%) 22 (38.6%)	26 (44.1%) 33 (55.9%)	X^2 9.416	0.009
Education level	- No - Low - High	10 (19.6%) 29 (56.9%) 12 (23.5%)	15 (26.3%) 39 (68.4%) 3 (5.3%)	19 (32.2%) 37 (62.7%) 3 (5.1%)	X^2 13.296	0.010
Smoking	- No - Yes	22 (43.1%) 29 (56.9%)	30 (52.6%) 27 (47.4%)	36 (61%) 23 (39%)	X^2 3.508	0.173
Alcohol	- No - Yes	47 (92.2%) 4 (7.8%)	51 (89.5%) 6 (10.5%)	51 (86.4%) 8 (13.6%)	X^2 0.935	0.627
Physical activity	- No - Yes	24 (47.1%) 27 (52.9%)	25 (43.9%) 32 (56.1%)	33 (55.9%) 26 (44.1%)	X^2 1.813	0.404
Diet	- Healthy - Unhealthy - Mixed	2 (3.9%) 2 (3.9%) 47 (92.2%)	3 (5.3%) 3 (5.3%) 51 (89.4%)	1 (1.7%) 0 (0%) 58 (98.3%)	X^2 4.197	0.380

p-value less than 0.05 indicates a significant association between the variable

4. Discussion

In the present study, obesity affected 35.3% of participants, while 34.2% were overweight, meaning over two-thirds faced increased non-communicable disease risks related to obesity. Globally, obesity has nearly tripled since 1975, with the Middle East showing higher rates than the world average (El-Sahli 2023). Syria's conflict-driven economic instability, food insecurity, and stress-induced hormonal imbalances contribute to this trend (Messer and Cohen 2023).

Only 27.5% of participants had a normal BMI, aligning with global declines in normal-weight populations. Underweight prevalence was just 3%, highlighting Syria's dual burden of malnutrition—nutritional deficiencies alongside rising obesity (Selimian, Nassr, and Sen 2022). Unlike conflict-affected Low- and Middle-Income Countries (LMICs) facing caloric deficits, Syria's food insecurity results in poor-quality, high-calorie diets (Ismail et al. 2019).

Limited income forces reliance on processed, energy-dense foods, while cultural and environmental factors—including high carbohydrate intake, low physical activity, and restricted healthcare access—exacerbate obesity (Katoue et al. 2022). Conflict-related stress further drives weight gain through cortisol dysregulation and insulin resistance (Yitshak-Sade et al. 2020).

This study highlights the significant burden of obesity-related health risks in North and East Syria. Hypertriglyceridemia (61.7%) was the most prevalent risk factor, followed by high waist circumference (49.7%), hypertension (32.9%), and hyperglycemia (32.3%). Hypercholesterolemia was least common (9.6%), reflecting global and regional trends influenced by Syria's socio-economic conditions.

Triglyceride levels averaged 195.8 mg/dL, with mild elevations in 33% of participants, moderate in 26.9%, and severe in 1.8%. Elevated triglycerides, associated with metabolic syndrome, result from dietary habits, physical inactivity, and genetic predisposition. Globally, hypertriglyceridemia is on the rise, especially in LMICs where diets are increasingly high in carbohydrates and low in fiber (Misra and Khurana 2008).

Hypertriglyceridemia exceeds 50% in the Middle East due to high sugar and processed food consumption (Algoblan, Alalfi, and Khan 2014). In Syria, economic constraints and reliance on low-cost, high-glycemic foods contribute to elevated triglycerides, compounded by poor access to lipid-lowering therapies ("Global Food Security Index (GFSI)" 2022).

Central obesity (≥102 cm in men, ≥88 cm in women), a key risk factor for metabolic syndrome. Urbanization and sedentary lifestyles drive its increase worldwide, with similar trends observed in Saudi Arabia and the U.S. (Borlaug and Reddy 2016; Wang et al. 2024).

The high mean arterial pressure observed in 32.9% of participants, indicating a significant prevalence of hypertension, aligns with global trends where over 1.28 billion adults are affected (World Health Organization 2023). In the Middle East, hypertension prevalence ranges from 26% to 44%, influenced by genetic factors, sedentary lifestyles, and high-sodium diets (Okati-Aliabad et al. 2022). In Syria, additional factors such as high salt intake, limited healthcare access, and stress from prolonged conflict contribute to elevated blood pressure (Alhaffar and Janos 2021).

The study also found a high fasting blood glucose level of 107.8 mg/dL, with 32.3% of participants affected, indicating a high prevalence of prediabetes and diabetes. Globally, diabetes cases have surged to 537 million in 2021, driven by obesity, urbanization, and sedentary lifestyles (International Diabetes Federation 2021). The Middle East has some of the highest diabetes rates, with Gulf countries like Saudi Arabia and Kuwait exceeding 20% (Okati-Aliabad et al. 2022). In Syria, disrupted food supply chains, reliance on low-cost, high-calorie foods, and reduced healthcare access have worsened glycemic control, while conflict-related stress has further impaired glucose metabolism (Algoblan, Alalfi, and Khan 2014;

"Food Security & Conflict in Syria," 2019). Diabetes prevalence in Syria has nearly tripled since 1980, with more than 1 in 10 Syrians affected ("WHO Helps Diabetes Patients in Syria," 2016).

The mean cholesterol level of 165.5 mg/dL was within normal limits, with only 9.6% of participants exhibiting high cholesterol. Globally, hypercholesterolemia remains a major concern, particularly in LMICs, where dietary shifts toward fat-rich foods and reduced physical activity have increased cholesterol levels (Misra and Khurana 2008). In the Middle East, rising cholesterol levels are attributed to greater consumption of animal fats and processed foods (Borlaug and Reddy 2016). However, in Syria, economic difficulty may have reduced access to such foods, explaining lower cholesterol levels ("Food Security & Conflict in Syria," 2019).

Aging correlated with increased BMI, waist circumference, and cardiometabolic risks, aligning with global patterns where reduced metabolism, hormonal shifts, and muscle loss contribute to obesity, diabetes, and hypertension (Hruby & Hu 2015). Urbanization and sedentary lifestyles further intensify these risks, particularly in the Middle East, where dietary habits and cultural standards discourage physical activity (Musaiger 2011; Lee et al. 2019).

Gender differences in obesity were notable, with 63.4% of women having high waist circumference versus 36.5% of men. Obesity affected 45.1% of women compared to 25.9% of men, mirroring regional trends where social patterns limit female mobility and physical activity (Hruby & Hu 2015; Musaiger 2011). Conflict has worsened these disparities by restricting women's access to education, employment, and healthcare (Welchman 2023). Low educational level was more prevalent among women, further contributing to higher obesity rates due to reduced health knowledge and economic constraints (UNICEF 2018).

Smoking and alcohol consumption were also gendered, with men engaging more due to cultural customs. In Syria, stress from conflict has likely increased male smoking rates, while traditional restrictions keep female smoking lower ("Syrian Arab Republic | Tobacco Atlas" 2019).

This study found strong links between overweight/obesity and some key risk factors related to obesity, including hypertension, family history of CVD, and low education levels.

Obesity is a major driver of hypertension worldwide, increasing vascular resistance and cardiac output (Fox et al. 2019). In the Middle East, obesity-related hypertension is widespread due to high-calorie diets and sedentary lifestyles, with studies in Saudi Arabia showing 60% of hypertensive individuals are overweight or obese (Okati-Aliabad et al. 2022). In Syria, economic instability and limited healthcare access worsen these risks.

The family history of CVD further increases obesity-related risks, as excess weight accelerates atherosclerosis and insulin resistance (Misra & Khurana 2008). In the Middle East, high obesity rates amplify these genetic risks (Algoblan et al. 2014). Syria's conflict exacerbates these issues by increasing stress, food insecurity, and reliance on unhealthy diets (Roba Gaafar 2021).

Low education was also strongly associated with obesity, limiting awareness of healthy lifestyles and access to nutritious food (Hruby & Hu 2015). In the Middle East, gender disparities in education contribute to higher obesity rates, particularly among women (Musaiger 2011). Syria's ongoing conflict has further widened these gaps, reducing opportunities for health education and reinforcing unhealthy behaviors (Qaddour & Husain 2022).

5. Conclusion

This study highlights the alarming prevalence of overweight and obesity in North and East Syria, with over two-thirds of participants affected, significantly increasing their risk for non-communicable diseases. Key risk factors, including hypertension,

hypertriglyceridemia, central obesity, and diabetes, were strongly linked to excess weight, reflecting hormonal imbalances further exacerbate these risks, while limited healthcare access and reliance on low-cost, high-calorie diets contribute to poor cardiometabolic health. Gender disparities and low educational levels, particularly among women, reinforce obesity-related challenges. Overweight and obesity, especially when excess fat accumulates around the abdomen, may increase the risk of numerous health problems. However, reaching and maintaining a healthy weight can help prevent these complications, slow their progression, or even eliminate them. Addressing obesity in Syria requires urgent interventions targeting healthcare accessibility, nutrition education, and lifestyle modifications to mitigate long-term health consequences in conflict-affected populations.

regional and global trends. Conflict-driven economic instability, food insecurity, and stress-induced

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