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The Interplay of Diet, Lifestyle, and Metabolic Risk Among Saudi Adults with Metabolic Syndrome

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Abstract

Metabolic syndrome (MetS) is a multifactorial condition characterized by central obesity, hypertension, dyslipidaemia, and hyperglycaemia, predisposing individuals to cardiovascular disease and type 2 diabetes. This cross-sectional study investigated the relationship between dietary intake, sociodemographic factors, and components of MetS among Saudi adults aged 30 years and older attending King Abdulaziz University Hospital. Fifty-three participants meeting MetS diagnostic criteria were assessed through anthropometric measurements, biochemical markers, and two-day dietary recalls analyzed using MyFood24 software. Descriptive and correlation analyses were conducted using SPSS 26.0. The majority of participants (73.6%) were aged over 50 years, were obese (75.5%), and exhibited a high waist circumference (94.3%). Low fibre (6.6 g/day) and high fat (41.8 g/day) intake patterns were evident. Salt intake showed a significant inverse correlation with systolic blood pressure ($\rho = -0.36$, $p < 0.01$), potentially reflecting under-reporting or dietary adjustments following diagnosis. Higher BMI correlated positively with waist circumference and diastolic pressure, while frequent physical activity correlated negatively with these parameters. These findings emphasize the influence of diet and lifestyle on metabolic risk and underscore the need for culturally tailored interventions promoting balanced macronutrient intake, increased fibre consumption, and enhanced physical activity to mitigate MetS prevalence among Saudi adults.

Keywords: metabolic syndrome; dietary intake; obesity; hypertension; hyperglycaemia; dyslipidaemia; physical activity; fibre

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1. Introduction

Metabolic syndrome (MetS) is a cluster of metabolic abnormalities, including central obesity, hypertension, dyslipidaemia, and hyperglycaemia, that significantly increase the risk of cardiovascular disease and type 2 diabetes. The prevalence of MetS is rising globally, with particularly high rates observed in Middle Eastern countries, including Saudi Arabia, due to rapid lifestyle and dietary transitions [1,2]. The prevalence of MetS in Saudi Arabia is among the highest globally, with recent studies reporting rates as high as 39.8% in adults, and highlighting a particularly high burden among young adults and older individuals [3]. Diet is a modifiable risk factor, and numerous studies have demonstrated that specific dietary patterns, such as those high in saturated fats, simple carbohydrates, and processed foods, are associated with an increased risk of MetS and its individual components, while

diets rich in fruits, vegetables, whole grains, and lean proteins are linked to a reduced risk [4–7].

Sociodemographic factors, including age, sex, income, education, and marital status, also influence both dietary behaviours and the risk of developing MetS. For example, higher income and education levels have been associated with lower MetS prevalence, while marital status and smoking are linked to an increased risk of developing MetS [1]. Sex differences in dietary intakes and their metabolic consequences have been observed, with men and women exhibiting distinct associations between specific dietary behaviours and MetS risk [8–10].

Common dietary behaviours contributing to the progression of MetS include the frequent consumption of highly processed, energy-dense foods, a high intake of saturated fats and sugars, and a low intake of fibre-rich foods. These behaviours are often shaped by sociodemographic context and cultural practices [11,12]. Cross-sectional studies in diverse populations have consistently shown that unhealthy dietary habits are correlated with a higher prevalence of MetS and its components, while healthy dietary choices are protective [7,11–14]. Conversely, diets rich in vegetables, fruits, coffee, whole grains, fish, and unsaturated fats are linked to a reduced MetS risk [1]. However, most evidence is observational, from cross-sectional studies, limiting the causal inference from such types of studies, and there is a need for more nuanced experimental analyses of specific dietary components and their direct links to individual MetS criteria [15–17].

There is considerable variation in the dietary assessment methods and the definitions of dietary patterns used across different studies. This lack of standardization complicates direct comparisons and hinders the synthesis of evidence into a cohesive body of knowledge, and the impact of emerging dietary behaviours, such as meal timing and snacking, and recent societal shifts, including those induced by the COVID-19 pandemic, require further investigation [18].

Given the high burden of MetS in Saudi Arabia and its unique sociodemographic landscape, it is essential to investigate the correlations between dietary intake, sociodemographic factors, and MetS components in this population. Such research can inform targeted interventions and public health strategies to curb the rising prevalence of MetS and its associated complications.

This cross-sectional study aims to explore the relationship between dietary intake and metabolic syndrome components, investigate how dietary intakes vary with sociodemographic factors, and identify dietary behaviours linked to the progression of metabolic syndrome to support culturally tailored prevention strategies.

2. Materials and Methods

2.1. Study Population and Design

The main cross-sectional study received approval from the Biomedical Ethics Research Committee at King Abdulaziz University in Jeddah, Saudi Arabia (No. 619-23, 20 November 2023). This subsample of fifty-three volunteers reflects only those participants who completed the two-day, 24 h dietary recall component. As not all participants completed the dietary recall, the subsample used in this analysis is smaller than the originally calculated sample size, although the original sample size calculated using G*Power 3.1.9.7 software, was larger to account for the objectives of the main study. This limitation, including its potential impact on statistical power, has been acknowledged in the discussion section. The main study, which examined the association between coffee consumption and metabolic syndrome components among Saudi adults, was previously published [2], with oral consent acquired from participants prior to starting the interview, before attending the doctor's session, and before verifying their medical information in the system. Oral consent was

also used for participants who were illiterate, in accordance with the approved ethical procedures. The data collection was conducted over three months duration, with participants being selected from King Abdulaziz University Hospital (KAUH). The inclusion criteria encompassed Saudi adults aged thirty years and older, both men and women, who satisfied a minimum of three criteria for a diagnosis of metabolic syndrome (MetS). Participants who successfully completed anthropometric assessments, a two-day, 24 h dietary recall, and had relevant lab values in their medical records were included. The exclusion criteria comprised the following: individuals of non-Saudi nationality; those lacking sufficient data pertinent to a MetS diagnosis, such as blood lipid profiles or blood glucose levels; and women who were either pregnant or breastfeeding. The sample size was determined utilizing Power version 3.1.9.7, resulting in a total of approximately ninety participants. Data was collected from participants through a self-administered questionnaire and face-to-face interviews.

2.2. Anthropometric Measurements and Definition of MetS

Nurses from KAUH executed anthropometric evaluations, documenting weight (kg) and height (cm), while a certified dietitian measured waist circumference (WC) within the designated screening room. Height (cm) and weight (kg) assessments were conducted using a Seca stadiometer scale (Seca, Hamburg, Germany). These evaluations were generally performed on a single occasion unless discrepancies were observed. Blood pressure was assessed via employing a SureSigns VS4 vital signs monitor (Philips, MA, USA) subsequent to participants having rested in a seated posture for a minimum duration of five minutes. Two measurements were obtained at intervals of 1–2 min, and the mean of the two closest readings was documented. Waist circumference was gauged utilizing a non-elastic measuring tape at the midpoint between the inferior rib and the iliac crest, with two measurements taken and averaged to yield the final value.

Body mass index (BMI) was also computed, and weight status was assessed using the WHO cut-off points: underweight (<18.5 kg/m^2), normal ($\geq$18.5 and <24.9 kg/m^2), overweight ($\geq$25 and <29.9 kg/m), and obese ($\geq$30 kg/m), including obese class I (30 to 34.9 kg/m^2), obese class II (35 to 39.9 kg/m^2), and obese class III ($\geq$40 kg/m^2). Biochemical measurements were taken from KAUH medical records, including hemoglobin A1c (HbA1c), high-density lipoproteins cholesterol (HDL-C), high-density lipoproteins cholesterol (LDL-C), total cholesterol (TC), and triglycerides (TGs). In accordance with the Harmonizing Definition developed by the American Heart Association, the International Diabetes Federation (IDF), and the National Heart, Lung, and Blood Institute (AHA/NHLBI), MetS was defined as occurring if at least three of the following five metabolic abnormalities were present: (1) a waist circumference of 94 cm for men and 80 cm for women, as defined for the Middle East population until new data are available; (2) TGs of 150 mg/dL or elevated TGs due to medication; (3) a HDL-C level of less than 40 mg/dL in men or less than 50 mg/dL in women; (4) a systolic BP of $\geq$130 mmHg or a diastolic BP of $\geq$85 mmHg or on antihypertensive drug treatment in a patient with a history of HTN; and (5) a fasting blood glucose (FBG) level of $\geq$100 mg/dL or taking drug treatment for elevated FBG [19].

2.3. Dietary Intake Assessment

Dietary intake was measured by a previously measured, two-consecutive-day, 24 h recall. MyFood24 software was utilized to analyze food and drink intake from 24 h recall, providing detailed information on total energy intake, as well as carbohydrates, protein, fat, saturated fat, fibre, sugar, and sodium.

2.4. Assessment of Other Covariates

Age, sex, nationality, educational attainment, marital status, occupation, and socioeconomic status were among the demographic information we collected via a questionnaire.

Along with their smoking habits, direct and indirect exposure, and levels of physical activity, ranging from never to more than five times per week, the participants' lifestyle characteristics were also recorded. Less than seven hours per day, seven to eight hours per day, and more than eight hours per day were the categories used to classify sleep patterns. The medical health information included family history, current medications, frequency of multivitamin or mineral supplement use, and the presence of specific medical conditions. In addition to conventional lipid parameters, the atherogenic index of plasma (AIP) was calculated as $\log_{10}(\text{triglycerides/HDL cholesterol})$, where TG and HDL-C are expressed in mmol/L. AIP was selected as an integrated marker of atherogenic dyslipidaemia, as higher values reflect a predominance of small, dense LDL particles and have been associated with increased cardiovascular risk in diverse populations.

2.5. Data Analysis

Data collected were tabulated and analyzed using SPSS (Statistical Package for Social Science) version 26.0 on an IBM-compatible computer. The main types of statistical analysis were performed: (1) Descriptive statistics, which were used to give a general descriptive summary for data. The main types of descriptive statistics used in this analysis were frequency distribution, mean, and standard deviation. (2) Correlation analysis: two types of correlation coefficients were used, namely, Pearson's r and Spearman's rho. (3) Multiple linear regression, which was used to check for the possible influence of intake variables (for some nutrients) on the MetS component variables, while controlling for some covariates/confounders. (4) the Shapiro–Wilk test, which was used to check for data normality. A p-value of <0.05 was considered statistically significant.

3. Results

3.1. Participant Characteristics

A total of 53 participants were included in the study, with a balanced sex distribution (49.06% male, 50.94% female). The majority were aged 50 years or older (73.58%), married (81.13%), had a family income of at least SAR 6000 (66%), were obese (75.47%), and had high waist circumference (94.34%). Regarding educational status, 58.5% held a diploma or bachelor's degree, while 33.96% had attained a master's degree. Employment status was distributed as follows: 24.53% were employed, 43.4% unemployed, and 32.08% were retired (Table 1).

Table 1. Demographic statistics.

Variable	Categories	Frequency (N = 53)	%
Sex	Male	26	49.06
	Female	27	50.94
Age (years)	30–35	1	1.89
	36–40	8	15.09
	41–45	0	0.00
	46–49	5	9.43
	50+	39	73.58

Table 1. *Cont.*

Variable	Categories	Frequency (N = 53)	%
Marital status	Single	2	3.77
	Married	43	81.13
	Divorced	4	7.55
	Widowed	4	7.55
Education	Undergraduate	18	33.96
	Diploma	9	16.98
	Bachelor	4	7.55
	Master	18	33.96
	PhD	4	7.55
Employment status	Employed	13	24.53
	Unemployed	23	43.40
	Retired	17	32.08
Monthly income (USD)	<267	1	1.89
	267–800	7	13.21
	800–1600	8	15.09
	1600–2667	13	24.53
	>2667	22	41.51
BMI (kg/m^2) M = 33.65, SD = 6.09	Normal	5	9.43
	Overweight	8	15.09
	Obese	40	75.47
High WC M = 107.12, SD = 12.04	No	2	3.77
	Yes	50	94.34

3.2. Lifestyle and Medical Factors

Approximately 37.25% of participants reported almost never engaging in physical activity (PA), with varying degrees of participation among the remainder; among those practicing PA regularly, 92.31% reported 1–2 h per session. Of the sample, 28.3% were current smokers. More than half (56.6%) reported less than seven hours of sleep per night (Table 2).

Table 2. Lifestyle statistics.

Variable	Categories	Frequency	%
PA (days) *	Almost never	19	37.25
	Once a week	8	15.69
	3 times a week	10	19.61
	5+ times a week	14	27.45
PA (hours/day) *	1–2	24	92.31
	3–5	2	7.69

Table 2. *Cont.*

Variable	Categories	Frequency	%
Smoking	Almost never	38	71.70
	Few times a week	3	5.66
	Few times a day	2	3.77
	All day	10	18.87
Sleeping hours	<7	30	56.60
	7–8	19	35.85
	>8	4	7.55

* For the PA variable, the total frequency is 51 (rather than 53) due to missing information for two participants. In addition, among those who practice PA regularly (n = 32), 26 have reported the hours spent per PA session (six participants did not provide this information).

The majority reported a family history of chronic disease (82.69%), most commonly including more than one type of condition. Most participants (92.45%) exhibited at least one chronic medical condition, with frequent medication use for diabetes (56.6%), hypertension (52.83%), or hypercholesterolemia (43.4%). The regular use of multivitamin or mineral supplements was reported by 66%, with most of the participants using these daily.

3.3. Metabolic Syndrome Components and Laboratory Results

The assessment of metabolic syndrome (MetS) components showed a high prevalence of abnormal levels: 94.34% had a larger waist circumference, 60.38% had elevated blood pressure, 57.14% had high fasting blood glucose, 54.72% had low HDL cholesterol, and 20.75% had increased triglycerides. Elevated LDL, total cholesterol, and HbA1c were present in 9.80%, 11.54%, and 46.15% of participants, respectively (Table 3). The mean AIP in the study sample was 0.45 ± 0.24, with 32% of participants classified in the high atherogenic risk category (AIP $\geq$ 0.22), 20% as intermediate risk (AIP 0.11–0.21), and the rest classified as low risk.

Table 3. Medical/Health-related statistics.

Variable	Categories	Frequency	%
Frequency of multivitamins or minerals' ingestion	Almost never	18	33.96
	Once a week	6	11.32
	Few times a week	7	13.21
	Daily	22	41.51
Medications taken	DM	30	56.60
	Cholesterol	23	43.40
	HTN	28	52.83
	Pain killers	3	5.66
	Thyroid	4	7.55
	Depression	1	1.89
	Heart	2	3.77
	Weight loss	4	7.55
	Prostate	2	3.77
	Other	2	3.77

Table 3. *Cont.*

Variable	Categories	Frequency	%
Family history (no. of diseases)	None	9	17.31
	1	11	21.15
	2+	32	61.54
Medical conditions	None	4	7.55
	1	11	20.75
	2+	38	71.70
FBG M = 7.34, SD = 3.85	Normal/borderline	6	42.86
	High *	8	57.14
TG M = 1.52, SD = 0.78	Normal/borderline	42	79.25
	High *	11	20.75
PB SBP: M = 131.42, SD = 14.84 DBP: M = 70.3, SD = 10.93	Normal/borderline	21	39.62
	High *	32	60.38
HDL M = 1.14, SD = 0.28	Normal/borderline	24	45.28
	Low	29	54.72
LDL M = 2.85, SD = 0.91	Normal/borderline	46	90.20
	High *	5	9.80
TC M = 4.54, SD = 1.03	Normal/borderline	46	88.46
	High *	6	11.54
HbA1c M = 6.71, SD = 1.42	Normal/borderline	28	53.85
	High *	24	46.15

* High FBG (≥100 mg/dL); high TG (≥150 mg/dL); high PB (SBP ≥ 130 mmHg or DBP ≥ 85 mmHg); high HDL (<40 mg/dL in men or <50 mg/dL in women); high LDL (≥160 mg/dL); high TC (≥240 mg/dL); and high HbA1c (≥117 mg/dL).

3.4. Dietary Intake

The mean daily caloric intake was 1152.9 kcal (SD 444.3). Mean (SD) daily consumption for selected nutrients was as follows: carbohydrates 148.4 (67.5) g, sugar 51.5 (33.9) g, protein 54.5 (23.3) g, total fat 41.8 (19.4) g, saturated fat 13.3 (6.9) g, salt 3.5 (1.8) g, and fibre 6.6 (4.5) g (Table 4).

Table 4. Mean and SD of daily consumption of some food elements.

Element	M ± SD	% Daily Value [a]
Calories (kcal/d)	1152.9 ± 444.29	57.6
Protein (g/d)	54.5 ± 23.31	-
Fat (g/d)	41.8 ± 19.4	2.1
Sat. fat (g/d)	13.3 ± 6.88	0.7
Carb (g/d)	148.4 ± 67.46	7.4
Sugar (g/d)	51.5 ± 33.86	2.6
Salt (g/d)	3.5 ± 1.75	70 [b]
Fibre (g/d)	6.6 ± 4.51	26.4 [c]

[a] based on 2000 kcal/day, [b] based on RDA for salt as 5 g/d, [c] based on RDA for fibre as 25 g/d.

3.5. Correlation and Regression Analyses

Spearman and Pearson correlation analyses indicated that salt intake was moderately correlated with systolic blood pressure (SBP) ($p < 0.05$). Total fat intake also demonstrated a

near-significant inverse correlation with SBP; however, this did not meet the conventional threshold for statistical significance ($p > 0.05$) (Supplementary Figures S1–S5).

In the Pearson correlation analysis, several socio-demographic and lifestyle factors were found to be significantly associated with metabolic syndrome components. Higher body mass index (BMI) demonstrated a strong positive correlation with waist circumference (r = 0.478) ($p < 0.01$), and a moderate significant positive association with diastolic blood pressure (DBP; r = 0.344) ($p < 0.05$). Educational attainment showed a moderate negative relationship with HDL (r = −0.333) ($p < 0.05$) indicating higher HDL among less educated participants. More frequent physical activity (five times a week) was inversely correlated with WC (r = −0.372) ($p < 0.01$), systolic blood pressure (SBP; r = −0.362) ($p < 0.01$), and DBP (r = −0.380) ($p < 0.01$). In contrast, a higher frequency of medication use was positively correlated with SBP (r = 0.341), while a history of multiple chronic conditions in the family was positively correlated with DBP (r = 0.385). Higher AIP values were significantly associated with greater waist circumferences and fasting blood glucose, and with lower HDL-C concentrations ($p < 0.05$), whereas no significant associations were observed with systolic or diastolic blood pressure (Supplementary Tables S1–S4).

4. Discussion

The findings of this study contribute to the growing body of evidence highlighting the high prevalence and multifactorial nature of metabolic syndrome (MetS) among Saudi adults [1]. Consistent with national and regional reports, most participants were aged 50 years or older and exhibited high rates of abdominal obesity, hypertension, and hyperglycaemia, reflecting patterns observed in prior Saudi and Middle Eastern studies [3]. The predominance of MetS among older adults underscores the cumulative effect of prolonged exposure to obesogenic environments characterized by energy-dense diets, sedentary lifestyles, and a rapid nutritional transition toward Westernized food habits [20]. Furthermore, the unemployment rate was higher among MetS participants because most participants were older adults or elderly. These age groups are more likely to be retired or affected by age-related functional limitations.

The mean daily caloric intake among participants was lower than that reported in other Saudi cohorts (1152.9 ± 444.3 kcal/day), which may reflect under-reporting, particularly among overweight and obese individuals. Despite the lower total energy intake, the macronutrient distribution revealed suboptimal patterns, namely a relatively high total and saturated fat consumption (41.8 ± 19.4 g/day and 13.3 ± 6.9 g/day, respectively), moderate protein intake (54.5 ± 23.3 g/day), low carbohydrate consumption (148.4 ± 67.5 g/day), and a particularly low mean fibre intake (6.6 ± 4.5 g/day). The observed insufficiency in dietary fibre aligns with previous national surveys indicating inadequate fruit, vegetable, and whole grain intake among Saudi adults [21,22]. Low fibre consumption has direct implications for insulin sensitivity, lipid metabolism, and body weight regulation—all key determinants of metabolic risk [23–25].

While major nutrient correlations with MetS components did not reach statistical significance, a noteworthy association emerged between salt intake and systolic blood pressure. Interestingly, higher sodium consumption was inversely correlated with systolic blood pressure ($\rho = -0.36$, $p < 0.01$) a finding contrary to physiological expectations. Given the well-known positive relationship between sodium intake and blood pressure, this inverse association is unlikely to reflect physiological effects. This could stem from reporting bias, dietary modification following hypertension diagnosis, or the limitations of the two-day self-reported recall data. Such discrepancies have been observed in prior, small sample studies regarding underestimated nutrient intake, which emphasize the challenge of accurately assessing dietary intake [26,27]. Nevertheless, the high mean salt intake

(3.5 g/day) remains concerning given its established role in elevating blood pressure and cardiovascular risk.

This study provides insight into how sociodemographic and lifestyle factors shape metabolic health. A strong positive correlation between BMI and waist circumference reflects the central obesity that characterizes MetS, while elevated diastolic pressure among individuals with higher BMI underscores the synergistic relationship between adiposity and hypertension. Sedentary behaviour was common, as 37% of participants reported almost never engaging in physical activity, mirroring national data indicating low adherence to physical activity guidelines [28–30]. The WHO 2020 guidelines recommend that adults, including those with metabolic syndrome, undertake at least 150 to 300 min of moderate-intensity aerobic physical activity or 75 to 150 min of vigorous-intensity activity weekly, supplemented by muscle-strengthening activities two or more days per week. Conversely, participants who reported exercising five times per week exhibited significantly lower waist circumference, systolic, and diastolic blood pressure levels, highlighting the protective role of regular movement in regulating body composition and vascular health [14]. Despite most physically active participants reporting sessions of 1–2 h, the overall low frequency of activity emphasizes insufficient adherence to WHO recommendations, underscoring the need for targeted interventions to promote active lifestyles and reduce sedentary behaviour among individuals with metabolic syndrome.

These findings indicate that both lifestyle behaviours and sociodemographic factors are significant determinants of metabolic risk factors in the studied population. Recent meta-analyses have demonstrated that combined healthy lifestyle factors including physical activity, diet, and smoking cessation are associated with a marked reduction in the risk of metabolic syndrome, with healthier lifestyle scores correlating with a 40–60% lower incidence. Furthermore, anthropometric factors such as being overweight and obesity substantially increase the odds of metabolic syndrome by approximately fivefold, underscoring the central role of body composition in its pathogenesis. Sociodemographic variables such as age, sex, socioeconomic status, and education also independently influence metabolic syndrome risk, likely through both biological and behavioural pathways. Collectively, these data emphasize the multifactorial etiology of metabolic syndrome and the necessity of integrated interventions targeting behavioural modification alongside the social determinants of health to effectively mitigate cardiometabolic risk. Interestingly, educational attainment demonstrated an inverse association with HDL cholesterol levels, as less educated participants exhibited higher HDL. While unexpected, this finding may reflect complex interactions between socioeconomic status, occupational activity, and dietary habits. Some evidence suggests that higher-educated individuals in urban Saudi settings may have more sedentary occupations and greater access to processed convenience foods, despite having greater health literacy [31,32]. Such findings underscore the context-specific nature of the social determinants of metabolic risk and indicate that public health interventions should consider both education and occupational context rather than assuming linear associations. By incorporating the atherogenic index of plasma, this study extends the conventional MetS lipid profile to capture the combined impact of elevated triglycerides and low HDL-C on atherogenic risk. The generally elevated AIP values observed in this cohort are consistent with the high prevalence of abdominal obesity and low HDL-C, suggesting a substantial burden of atherogenic small dense LDL particles among Saudi adults with MetS [1,3].

The high prevalence of obesity (75%) and elevated waist circumference (94%) in this study underscores the critical need for targeted obesity prevention strategies. Central adiposity contributes to insulin resistance, dyslipidaemia, and systemic inflammation, forming the core of the MetS pathophysiology [7]. The observed metabolic disturbances hyperglycaemia in 57% of participants and the low HDL in 55% reflect early yet serious metabolic

derangements that heighten cardiovascular risk. Recent studies from Saudi Arabia demonstrate that central obesity and low HDL are the most prevalent MetS components compared to elevated TG. This metabolic pattern is influenced by abdominal adiposity, dietary habits, and the use of lipid-lowering medications, which may reduce the observed prevalence of high TG [1,3]. Comprehensive interventions emphasizing weight management, balanced macronutrient intake, and increased physical activity could attenuate these trends. Moreover, incorporating culturally adapted dietary models, such as modified Mediterranean or DASH patterns emphasizing whole grains, legumes, nuts, and olive oil, could enhance acceptability and adherence [33,34]. Given that AIP is responsive to lifestyle modification, including weight reduction, increased physical activity, higher fibre intake, and a reduced intake of refined carbohydrates and saturated fat, it may represent a practical secondary target in interventions aiming to improve cardiometabolic risk beyond traditional MetS components [32].

The cross-sectional design precludes causal inference; thus, the observed relationships represent associations rather than directional effects. The modest sample size (n = 53) and the reliance on two-day dietary recalls limit statistical power and generalizability. Furthermore, two-consecutive-day, 24 h dietary recalls are widely used but they have some well-documented limitations. They may not fully capture habitual diet, especially food consumed infrequently. Nevertheless, two-consecutive-day, 24 h recalls still provide acceptable reliability at the group level for estimating average intake. Future research employing larger, nationally representative samples and objective biomarkers of dietary intake such as urinary sodium and plasma fatty acid profiles would strengthen causal interpretation. Longitudinal and interventional designs are also warranted to determine the impact of dietary modification on individual MetS components over time. Furthermore, refining dietary assessment to capture evolving behavioural dimensions such as meal timing, snacking frequency, and the consumption of ultra-processed foods could offer deeper insights into emerging risk patterns, particularly in post-pandemic contexts where lifestyle disruptions remain prevalent [18].

5. Conclusions

Overall, this study underscores the substantial metabolic burden among Saudi adults and the multifaceted role of diet, lifestyle, and sociodemographic factors in shaping risk. The convergence of high obesity rates, inadequate fibre intake, and physical inactivity calls for urgent, evidence-informed public health action. Interventions integrating dietary education, community-based physical activity promotion, and behavioural counselling could yield significant benefits. Addressing these modifiable risk factors is essential not only for the prevention of metabolic syndrome but also for mitigating its long-term cardiovascular and metabolic sequelae.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/obesities5040091/s1. Figure S1: Scatterplot of the Association between Salt Intake (X) and SBP (Y). Figure S2: Histogram of Residuals (in Model 1). Figure S3: Histogram of Residuals (in Model 25). Figure S4: Scatterplot of Predicted Values (X) and Residuals (Y) (in Model 1). Figure S5: Scatterplot of Predicted Values (X) and Residuals (Y) (in Model 25). Table S1: Logistic Regression of MetS (or any of its components) on Coffee Consumption. Table S2: Multiple* Linear Regression for the Association between All Possible Pairs of IV (nutrient intake variables) and DV (MetS—component variables). Table S3: Normality of the Main Study Variables. Table S4: *p*-Values for the Pearson Correlation between the Possible Covariates and MetS—Component Variables.

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Data Availability Statement: Data are available on request from the authors.

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Abbreviations

MetS, metabolic syndrome; BMI, body mass index; BP, blood pressure; WC, waist circumference; FBG, fasting blood glucose; HbA1c, hemoglobin A1c; TG, triglyceride; TC, total cholesterol, LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

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