ABSTRACT

Syndrome X is distinguished by the co-occurrence of determinants that are unquestionably linked to an increase in the chance of experiencing chronic illnesses like adult-onset diabetes and coronary artery disease. Addressing modifiable lifestyle factors, including dietary habits, is essential in preventing and managing metabolic syndrome (MetS). This study investigated the evaluating the effectiveness of dietary interventions on MetS risk factors among a sample of adults. The research involved a six-month dietary intervention program conducted on fifty adults aged from 20 to 60 years targeting high-risk individuals with MetS. An individualized balanced diet was tailored, and anthropometric assessments biochemical analyses, and routine medical examinations were conducted. Most of the studied sample were Class 3 (high-risk) obesity with mean Body Mass Index (BMI) (40.1 ± 6.7), an increase in Total cholesterol (TC), fasting blood sugar (FBG), triglycerides (TG), and Low-density lipoprotein-cholesterol (LDL-c) levels and decrease in High-density lipoprotein-cholesterol (HDL-c) levels. The intervention program resulted in considerable alterations in MetS and its criteria among participants. There was a notable reduction in factors such as FBG, TC, LDL-c, and TG, accompanied by elevated HDL-c levels. In conclusion, dietary intervention can improve MetS and associated risk factors in adults.

Keywords: Metabolic Syndrome, Dietary Intervention, Metabolic Risk Factors, Adults.
INTRODUCTION

The International Diabetes Federation has developed a description of the criteria of MetS including having a waist circumference of more than 94 and 80 centimeters for males and women respectively, as well as the presence of more than two or equal of the subsequent circumstances: FBG levels above 100 milligrams per deciliter (mg/dl) or confirmed diabetes, levels of HDL-c for men 40 mg/dl and 50 mg/dl for females, or drug to cure low HDL-c, 150 mg/dl of blood TG or medication therapy for high TG and Blood pressure greater than 130/85 millimeters of mercury (mmHg) or hypertension (HTN) medication (Alberti et al., 2009).

In comparison with individuals without MetS a total of 8,494 deaths were noted during 16.71 years of follow-up through a prospective cohort study conducted by the National Health and Nutrition Examination Survey involving 36,414 adults (Li et al., 2023).

Among obese Egyptian college students, the prevalence of metabolic syndrome was 24.37% in a study involving eight hundred obese participants with (BMI >30Kg/m2) their ages ranged from 18 to 24 years old from October 6th, Cairo and Misr University for Science and Technology universities conducted from April 2011 to April 2013 (Ahmed et al., 2014). While a study by Mahrous et al., illustrated that the prevalence of insulin resistance syndrome was 16.7% among 455 of 18–25 years old Students of Menoufia University and it was more common among female students.

Restricting calories can lead to weight loss and an improvement in peripheral lipid profile and cytokine, which could potentially reduce coronary artery disease (Montefusco et al., 2021).

As evidenced by recent research, modifiable lifestyle factors particularly eating behaviors correlate with both the prevalence and prevention of dysmetabolic syndrome (Fahed et al., 2022).

AIM OF THE STUDY

This survey's purpose is to investigate and assess the impact of
specific dietary changes on the risk factors correlated with Syndrome X in a sample of adults. The ultimate goal is to provide evidence-based strategies for the management and prevention of Mets, contributing to improved public health outcomes.

**METHODOLOGY**

Fifty persons between the ages of 20 and 60 participated in this trial, which focused on high-risk MetS patients. An individualized balanced diet was tailored for the six months. The Scientific Research Ethics Committee, in GOTTI, accepted the search by a Review and Approval Certificate (RAC). The study will be conducted through the year when the (IN 000149) Ethics Committee number was valid.

*Subjects exposed at the onset of intervention and the end to:*

1. **Anthropometric assessment:** It was conducted (Height, hip, weight, BMI, and waist measurements). Quetelet Index was computed by dividing the weight of an individual in kilograms by the square of their height in meters. *(Jelliffe, 1966).* BMI was used according to *(WHO, 2000).* Hip and Waist circumference *(Dalton et al., 2003).*

2. **Biochemical analysis:** Serum lipid profile (TG, total, HDL-c, and LDL-c cholesterol) and fasting blood sugar were made according to the method described by *(Raba and Mottola 1995; Kumari and Kanwar 2012; Lopes-Virella et al., 1977; Martin et al., 2013; Fossati and Prencipe 1982).*

3. **Routine Medical examination:** Blood pressure: While sitting with the right hand, the arm supported at heart level, and the feet flat on the floor, the systolic and diastolic blood pressures were taken *(Owusu et al., 2015).*

4. **Dietary assessment:** 24-hour recall was conducted. The recalls were used to calculate the intake of food types as well as energy and nutrients. The Egyptian food composition tables were used to calculate the consumption of energy and nutrients.
National Nutrition Institute, 2006). By comparing the calorie and nutrient intake with Raymond and, Morrow's (2022) recommended dietary allowances (RDA) the adequacy of the diet was evaluated.

The criteria for exclusion:
• Gravid or nursing mothers
• Whom is on a restrictive diet
• People who suffer from serious diseases such as cancer, liver or heart problems, or are unable to engage in physical activity

Statistical Analysis:
Version twenty-one of the Statistical Package for the Social Sciences (SPSS) was used to analyze the data. Percentages and mean ±SD of the results were reported. Compare the means (paired-samples T-test) was used to assess the outcomes. Significant statistically were taken into consideration at P < 0.05. (Snidecor and Cokhran 1967)

OUTCOMES

Table one shows that the examined group was morbidly obese before intervention with BMI (40.1 ± 6.7) and a significant decrease to obesity class II with BMI (35.1 ± 5.6).

Table (2) demonstrates the highly significant decline in FBG, TC, and LDL-c with a highly considerable increase in HDL-c cholesterol.

Table three and Figure one shows how many metabolic syndrome criteria there are before intervention all intervention samples had criteria of MetS however after intervention (28%) became had less than 3 factors only.

Table (4) shows a highly significant improvement in dietary intake decrease in Kcal, protein, fat, and Carbohydrate, and a non-significant increase in fiber.

Table (5) shows that there is a high reduction in sodium consumption and a strong rise in calcium, magnesium, and potassium consumption.

Table (6) shows that there is a highly significant increase in intake of vitamins A, C, B1, and B2 after intervention.

DISCUSSION

After Six months of dietary intervention with an
individualized balanced diet, there was a noticeable lowering in every anthropometric parameter as well as clinical parameters (table 1) and this was associated with improvement in all laboratory parameters with a very notable decline in FBG, LDL-c and TC as well as a significant elevation in HDL-c (table 2). This reduced the percentage of patients with metabolic syndrome by 28% (table 3 and Fig. 1). This is comparable with the Van Namen et al., (2019) study in which lifestyle intervention led to a 39% lowering in the spread of MetS.

As regards macronutrient analysis for 24-hour recall, there was a highly significant improvement in dietary intake decrease in Kcal, Protein, fat, and carbohydrate, and a significant increase in fiber (table 4). Also (table 1) showed that participants were morbidly obese before intervention with a BMI (of 40.1 ± 6.7) and a significant decrease to obesity class II with a BMI (of 35.1 ± 5.6) the findings of Chao et al., (2021) are in agreement with These results as they reported in Certain scientific research and meta-analyses have demonstrated that low low-caloric regimen compared to a higher calorie diet consistently resulted in more short-lived (<6 months) weight loss, with the decreasing of this benefit over longer periods (>12 months). Proceed in progress dietary commitment, which is substantial to both long-short run weight losses, may arise from increased attempts to find metabolic and behavioral characteristics in dieters.

Also, there was a considerable decrease in sodium consumption and a notable rise in calcium, magnesium, and potassium consumption (table 5). These results agree with those of Filippini et al., (2021) who discovered an almost linear association between a reduction in SBP as well as DBP and sodium consumption across the whole range of sodium intake from dietary sources. Also, these findings in linear with a systematic review conducted by Gonçalves, and Abreu (2020) that suggested that the risk of CVD is correlated with a reduced sodium-to-potassium ratio and rise in potassium levels.
The outcomes of Piuri et al., (2021) agree with the results as they reported that following a proper dietary pattern which includes the right intake of magnesium can improve Mets, by lowering hypertension, high blood glucose, and hypertriglyceridemia. This occurs, through the positive impact on the structure of the gut microbiome and the B1 and D vitamin metabolism as well as modification of gene regulation and protein expression profile and protein signature.

Additionally, the outcomes are consistent with Woo et al., (2020) which demonstrated that the incident risk of MetS and each component was inversely correlated with dietary calcium consumption, even intake from vegetables. The inverse association was more distinguished through individuals with two components of MetS at baseline.

Also, there was a highly significant decrease in iron and zinc consumption but they were still within RDA (table 5). These results may be inverse with Zhu et al., (2018) who reported that there was a positive correlation between insulin resistance syndrome and its criteria in adult people and dietary iron consumption. But maybe agree with these findings if we take into consideration that their consumption level is still within RDA.

The results are consistent with Ding et al., (2022) who found a negative correlation between the consumption of zinc from dietary sources and Dysmetabolic syndrome in a meta-analysis of observational studies.

As mentioned in (table 6), There is a considerable rise in vitamin C, B1, and B2. Liu and Park, (2022) discovered that a low dietary ascorbic acid ingestion may raise the chance of developing syndrome X and associated metabolic character-eristics, particularly high blood sugar. To improve glycemic control, adults should be advised in a setting of therapy to ingest 100 mg of vitamin C daily through their diet. This may illustrate that the studied sample had insufficient V.C. consumption before inter-vention and took an acceptable range after this.

In addition, the results go in parallel with Ponce et al., (2019) who concluded that orange juice with a diet that is balanced resulted
in improvement in MetS features, especially insulin and insulin resistance.

The findings are in harmony with Wong and others., (2020); and Dludla etc., (2022) who observed that it has been supposed that Anti-inflammatory and antioxidant advantages are positive consequences of ascorbate intake. They also findings highlighted the significance of vitamin C intake for metabolic syndrome patients via supplementations, drinks, and foods to preserve its level of concentration in the bloodstream and maybe reverse MetS.

Also, our results go in parallel with Ashor et al., (2019) who reported that the pathophysiology of cardiac disease may be impacted and altered by increased ascorbic acid intake from food, particularly from vegetables and fruits due to the physiological functions of vitamin C including epigenomics regulation, antioxidant activity, and collagen formation.

The findings of Wu et al., (2020) are in agreement with the results as they reported that increased consumption of vitamins B1 and B2 has been linked to a lower incidence of metabolic syndrome.

The results are consistent with Nguyen and Kim (2022) as they reported that Adults with comorbidities showed a substantial 7% reduction in syndrome X when their daily B1 intake was doubled.

**CONCLUSION:**

In conclusion, this study demonstrates the significant improvements in metabolic risk factors after the dietary intervention with a significant amelioration in dietary intake, including a decrease in calories, protein, fat, and carbohydrates and a non-significant increase in fiber. Also, there is an obvious decline in sodium consumption and a notable rise in intake of calcium, magnesium, and potassium consumption. While there is a highly significant rise in A, C, Thiamine, and B2 vitamins. According to these results, adults' risk of developing metabolic syndrome may be effectively decreased by dietary interventions.
RECOMMENDATIONS:
Consuming a healthy, balanced diet to maintain a healthy weight, physical activity, and optimal sleep. Decrease salt consumption as follows: Choose the lowest content packaged products of sodium, Pick fresh poultry and vegetables instead of packaged ones. And use condiments, spices, and vinegar to add flavor to foods instead of salt, increase consumption of fresh vegetables and fruits, increase consumption of dairy products specially fermented products, increase consumption of water instead of soft drinks, and use healthy oils to decrease the consumption of saturated fatty acids.

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Table (1): anthropometric and clinical data before and after the intervention.

<table>
<thead>
<tr>
<th>Anthropometric and clinical data</th>
<th>Pre N= 50</th>
<th>Post N= 50</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometric data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (yrs.)</td>
<td>42.9±9.4</td>
<td>42.9±9.4</td>
<td>0.000</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>108.1±20.4</td>
<td>94.8±17.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Height (Cm)</td>
<td>164.1±7.2</td>
<td>164.1±7.2</td>
<td>-</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>40.1±6.7</td>
<td>35.1±5.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Waist (Cm)</td>
<td>115.2±13.8</td>
<td>105.3±12.5</td>
<td>0.000</td>
</tr>
<tr>
<td>Hip (Cm)</td>
<td>123.8±14.1</td>
<td>116.1±13.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Waist to Hip ratio (Cm)</td>
<td>0.93±0.08</td>
<td>0.91±0.09</td>
<td>0.002</td>
</tr>
<tr>
<td>Waist to Height ratio (Cm)</td>
<td>0.70±0.07</td>
<td>0.64±0.06</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Clinical data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>141.4±25.2</td>
<td>127.8±10.8</td>
<td>0.000</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>92.0±12.8</td>
<td>85.0±6.3</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The results are significant when the P value ≤0.05
Table (2): Descriptive Statistics for and laboratory parameters before and after the intervention

<table>
<thead>
<tr>
<th></th>
<th>Cut points</th>
<th>Pre N= 50</th>
<th>Post N= 50</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>FBG (mg/dl)</td>
<td>&lt; 100</td>
<td>113.7 ± 36.8</td>
<td>95.9 ± 12.6</td>
<td>0.011</td>
</tr>
<tr>
<td>TC (mg/dl)</td>
<td>&lt; 200</td>
<td>226.0 ± 74.9</td>
<td>176.0 ± 43.3</td>
<td>0.000</td>
</tr>
<tr>
<td>TG (mg/dl)</td>
<td>&lt; 150</td>
<td>169.9 ± 63.2</td>
<td>123.0 ± 46.7</td>
<td>0.000</td>
</tr>
<tr>
<td>HDL-c (mg/dl)</td>
<td>&gt; 40</td>
<td>39.2 ± 6.5</td>
<td>43.6 ± 11.7</td>
<td>0.029</td>
</tr>
<tr>
<td>LDL-c (mg/dl)</td>
<td>&lt; 100</td>
<td>119.8 ± 43.2</td>
<td>92.1 ± 27.8</td>
<td>0.000</td>
</tr>
</tbody>
</table>

FBG = fasting blood glucose  
TC = total cholesterol  
TG = triglyceride  
HDL-c = high-density lipoprotein-cholesterol  
The results are significant when the P value ≤ 0.05  
LDL-c = low-density lipoprotein-cholesterol

Table (3): distribution of Risk factors before and after the intervention

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Pre N= 50</th>
<th>Post N= 50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
</tr>
<tr>
<td>1 factor</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 factors</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 factors</td>
<td>8</td>
<td>16.0</td>
</tr>
<tr>
<td>4 factors</td>
<td>36</td>
<td>72.0</td>
</tr>
<tr>
<td>5 factors</td>
<td>6</td>
<td>12.0</td>
</tr>
</tbody>
</table>
Effect of Dietary Intervention on Metabolic Syndrome Risk Factors among Adults
Mohammed H Haggag; El-Sayed M Hammad; Eman A Sultan; Hanaa A El-Wahab and Akram H Salem

**Table (4):** dietary intake from energy, fiber, and macronutrient

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>RDA range</th>
<th>Pre</th>
<th>Post</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ±SD</td>
<td>% of RDA</td>
<td>Mean ±SD</td>
</tr>
<tr>
<td>Calories (Kcal)</td>
<td>1500 – 2500</td>
<td>2921.7 ±942.4</td>
<td>146 %</td>
<td>1627.6 ±383.7</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>21 – 35</td>
<td>10.4 ± 3.8</td>
<td>37.14 %</td>
<td>18 ± 2.0</td>
</tr>
<tr>
<td>Protein(g)</td>
<td>56.25 – 93.8</td>
<td>104.4 ± 33.1</td>
<td>139.2%</td>
<td>79.0 ± 22.3</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>50 – 83.3</td>
<td>102.5 ± 48.2</td>
<td>153.8%</td>
<td>46.3 ± 23.9</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>206.25-343.8</td>
<td>394.6 ± 122.4</td>
<td>143.5%</td>
<td>215.6 ± 42.4</td>
</tr>
</tbody>
</table>

*Source of RDA: Raymond and Morrow 2022. The results are significant when the P value ≤0.05*
Table (5): Dietary intake from minerals before and after the intervention

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>RDA range</th>
<th>Pre</th>
<th>Post</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>% of RDA</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>1300 – 1500</td>
<td>4164.0 ± 1894.9</td>
<td>297.4 %</td>
<td>1707.2 ± 616.2</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>4700 – 4700</td>
<td>2432.3 ± 969.2</td>
<td>51.8 %</td>
<td>2816.2 ± 603.9</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1000 – 1200</td>
<td>550.9 ± 256.0</td>
<td>50 %</td>
<td>860.0 ± 464.2</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>700 – 700</td>
<td>1017.2 ± 268.7</td>
<td>145.3 %</td>
<td>1060.0 ± 401.5</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>310 – 420</td>
<td>146.7 ± 66.8</td>
<td>40.2 %</td>
<td>203.9 ± 77.3</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>8 – 18</td>
<td>16.7 ± 5.1</td>
<td>128.5 %</td>
<td>12.8 ± 3.7</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>8 – 11</td>
<td>12.4 ± 3.6</td>
<td>130.5 %</td>
<td>9.5 ± 3.2</td>
</tr>
</tbody>
</table>

Source of RDA: Raymond and Morrow 2022. The results are significant when the P value ≤0.05

Table (6): Dietary intake from vitamins before and after the intervention

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>RDA range</th>
<th>Pre</th>
<th>Post</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>% of RDA</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Vitamin A (µg RE)</td>
<td>700 – 900</td>
<td>213.8 ± 103.3</td>
<td>26.7 %</td>
<td>527.4 ± 251.0</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>75 – 90</td>
<td>35.6 ± 16.8</td>
<td>43.2 %</td>
<td>110.3 ± 48.1</td>
</tr>
<tr>
<td>Vitamin B1(mg)</td>
<td>1.1 – 1.2</td>
<td>0.8 ± 0.4</td>
<td>69.6 %</td>
<td>1.0 ± 0.3</td>
</tr>
<tr>
<td>Vitamin B2 (mg)</td>
<td>1.1– 1.3</td>
<td>0.8 ± 0.4</td>
<td>66.7 %</td>
<td>1.2 ± 0.5</td>
</tr>
</tbody>
</table>

Source of RDA: Raymond and Morrow 2022. RE= Retinol Equivalent
The results are significant when the P value ≤0.05
Effect of Dietary Intervention on Metabolic Syndrome Risk Factors among Adults
Mohammed H Haggag; El-Sayed M Hammad; Eman A Sultan; Hanaa A El-Wahab and Akram H Salem

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