MILLETs in metabolic syndrome- time to tap the potential
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ABSTRACT

BACKGROUND

The prevalence of metabolic syndrome, which consists of a group of metabolic abnormalities associated with increased cardiovascular risk has been on the rise in India. Unbalanced dietary habits have contributed to this. The cereal millets have been thought to have beneficial properties in combating this illness. Hence, this study set out to compare the effect of millet versus non-millet-based diets on the parameters of metabolic syndrome.

METHODS

This was a cross sectional study where adults with metabolic syndrome, diagnosed in accordance with the International Diabetes Federation (IDF) criteria were enrolled. Anthropometric data and blood pressure measurements were recorded, followed by determination of fasting (FBS) and postprandial blood sugars (PPBS) and fasting lipid profile. All participants answered a questionnaire regarding their dietary patterns and accordingly were divided into the 'millet based diet group' and 'non-millet-based diet group'.

RESULTS

Of the 142 participants in the study, the millet-based diet group consisted of 69 patients and non-millet-based diet group had 73 patients. The millet based diet group had significantly lower body mass index (26.78 vs. 28.99 Kg/m², p = 0.08), systolic BP (130.8 vs. 137.8 mmHg, p= 0.023), FBS (113.2 vs. 152.2 mg/dl, p= 0.001), PPBS (122.7 vs. 214 mg/dl, p= 0.001), total serum cholesterol (170.1 vs. 211.2 mg/dl, p= 0.001), serum Low Density Lipoproteins (99.1 vs. 121.1 mg/dl, p= 0.001) and serum triglyceride levels (114.2 vs. 179.8 mg/dl, p= 0.001) and significantly higher HDL (40.7 vs. 36.6 mg/dl, p= 0.021) levels compared to the non-millet based diet group.

CONCLUSIONS

Findings in this study demonstrate the potential benefits of millet consumption and suggest that their incorporation into the diet may help to curb the ever-growing metabolic syndrome pandemic.


BACKGROUND

It is common knowledge that the incidence of 'lifestyle related disorders' such as type 2 diabetes mellitus, hypertension, dyslipidaemia and obesity have been on the rise in India. There have been tremendous changes in the patterns of physical activity and diet in our country during the past few decades and these have contributed to outbreak of such non-communicable disease 'pandemics'. It is therefore the need of the hour to take action on a large scale in order to reduce the occurrence of these disorders in the general population as well as to enhance the control of these conditions in patients already suffering from them via not just pharmacotherapy, but by promoting healthy lifestyle practices.

Metabolic syndrome (MS) is a condition characterized by increased insulin resistance and visceral adiposity. The rise in the incidence of metabolic syndrome has been attributed to lifestyle changes such as sedentary habits, increased psychological stress and dietary indiscretion. Changes in dietary patterns may be the one of the most important factors contributing to the increase in the incidence of metabolic syndrome in Asia.¹ In the southern states of India, the staple diet has been based on the cereal rice for many centuries. It is hypothesized that Asians have a higher glycaemic response than Caucasians to processed white rice.² Over the past several generations, when the main form of occupation was rigorous farming practice, traditional diets had been low on total caloric intake in which simple carbohydrates served as the main source of fuel. But in modern times, a shift towards a less physically active lifestyle coupled with easy availability and consumption of these main rice-based diets may have contributed to the high load of metabolic syndrome patients in India.

There has been growing interest regarding millet-based diet and their positive impact on health in the recent years. The health benefits associated with millet consumption have been known for several years but their impact on metabolic syndrome in the Indian population has been unclear. Hence
in this study, we set out to compare the parameters of metabolic syndrome in patients who consume millet-based diet and in those consuming non millet-based diet.

**METHODS**

**Study Design**
Cross sectional study.

**Inclusion Criteria**
Adults aged 18 years or more of both sexes attending the Ramaiah medical college hospital medicine out-patient department diagnosed to have metabolic syndrome according to International Diabetes Federation (IDF) guidelines after taking informed consent. According to IDF criteria, patients were diagnosed to have MS by the presence of:

- Waist circumference in Men ≥ 90 cm & Women ≥ 80 cm (thresholds for south Asians)

Plus

- at least two of the following:
  1. Triglycerides ≥150 mg/dL or treatment for elevated triglycerides.
  2. High density lipoprotein (HDL) cholesterol <40 mg/dL in men or <50 mg/dL in women, or treatment for low HDL.
  3. Systolic blood pressure ≥130 mm Hg, diastolic blood pressure ≥85 mm Hg, or treatment for hypertension.
  4. Fasting blood sugar (FBS) ≥100 mg/dL or previously diagnosed type 2 diabetes mellitus.

**Exclusion Criteria**
1. Pregnant women.
2. Pre-existing chronic illnesses associated with anorexia or mal-absorption.
3. Conditions interfering with body weight measurement such as ascites or oedema.

All participants were given a questionnaire regarding their dietary intake patterns in the local language. Clinical examination was done to record their weight, height, body mass index (BMI) and Waist–Hip ratio (WHR). Investigations including Fasting (FBS) and postprandial blood sugar levels (PPBS) by hexokinase method and fasting serum lipid levels by enzymatic colorimetric method were performed. Based on their dietary pattern determined by a food frequency questionnaire, people consuming at least three millet-based meals per week for at least the past 2 years were classified as millet-based diet group and the rest of the participants constituted the non-millet-based diet group.

The study was conducted after obtaining Ethical Committee approval. Qualitative data was analysed by using chi square test while quantitative data was analysed using independent t test using the SPSS 20.0 software.

**RESULTS**
A total of 142 participants diagnosed to have metabolic syndrome participated in this study and were in turn divided into 2 groups based on their dietary patterns. The group with millet-based diet comprised of 69 patients whereas the non-millet-based diet group had 73 patients. The different characteristics for the participants of the two groups are shown in table 1. The predominant millet in the diet of millet based diet group was ragi (finger millet) in the form of ‘mudde’ (lumps) or malt, followed by jowar (sorghum) and fox-tail millet, whereas rice followed by wheat (‘chapatis’) were the basis of diet in members of the non-millet group.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (Standard Deviation)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>Millet</td>
<td>Non-Millet</td>
</tr>
<tr>
<td>Males</td>
<td>50.06</td>
<td>51.3</td>
</tr>
<tr>
<td>Males</td>
<td>39</td>
<td>37</td>
</tr>
<tr>
<td>Low HDL</td>
<td>59</td>
<td>55</td>
</tr>
<tr>
<td>Elevated Triglycerides</td>
<td>14</td>
<td>42</td>
</tr>
<tr>
<td>Hypertension</td>
<td>48</td>
<td>54</td>
</tr>
<tr>
<td>Type 2 Diabetes Mellitus</td>
<td>61</td>
<td>58</td>
</tr>
</tbody>
</table>

| Table 1. Characteristics of The Two Groups |

Most participants were residents of rural areas from agricultural background and none of them followed a dedicated physical exercise regime.

In accordance with the IDF criteria for diagnosis of metabolic syndrome, all the selected participants had a high waist circumference, along with presence of at least 2 additional criteria – impaired blood glucose, elevated BP, low HDL and elevated triglycerides or were already being treated for these. The two groups did not differ significantly in these respects with the exception of the number of patients with hypertriglyceridemia that was seen to be significantly higher in the non-millet-based diet group (42 vs. 14, p = 0.000).

**Comparison of the two groups with respect to the various parameters of metabolic syndrome revealed that the participants from the millet based diet group had significantly lower BMI (26.78 vs. 28.99 Kg/m², p = 0.08) although there was no significant difference between their waist to hip ratios, neither in males (0.942 vs. 0.909, p = 0.138) nor in females (0.910 vs. 0.901, p = 0.141). The millet based diet participants also had lower readings for systolic BP (130.8 vs. 137.8 mm Hg, p = 0.023), fasting blood glucose (113.2 vs. 152.2 mg/dl, p = 0.001), total serum cholesterol (170.1 vs. 211.2 mg/dl, p = 0.001), serum LDL (99.1 vs. 121.1 mg/dl, p = 0.001) and serum triglyceride levels (114.2 vs. 179.8 mg/dl, p = 0.001) as well as having higher HDL values (40.7 vs. 36.6 mg/dl, p = 0.021) compared to the non-millet based diet participants, and these differences were found to be statistically significant. These are Highlighted in table 2.
**Table 2. Comparison of The Two Groups with Respect to Components of Metabolic Syndrome**

<table>
<thead>
<tr>
<th>Parameters of Metabolic Syndrome</th>
<th>Millet Based Diet Mean (± Std. deviation)</th>
<th>Non-Millet Based Diet Mean (± Std. deviation)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMI (Kg/m²)</strong></td>
<td>26.78 (±5.37)</td>
<td>28.99 (±5.13)</td>
<td>0.08</td>
</tr>
<tr>
<td>Waist/Hip Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>0.942</td>
<td>0.909</td>
<td>0.138</td>
</tr>
<tr>
<td>Females</td>
<td>0.910</td>
<td>0.901</td>
<td>0.141</td>
</tr>
<tr>
<td>Total Cholesterol (md/dl)</td>
<td>170.1 (±33.7)</td>
<td>211.2 (±43.8)</td>
<td>0.001</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>84.43 (±9.84)</td>
<td>86.7 (±10.1)</td>
<td>0.097</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>130.8 (±18.2)</td>
<td>137.8 (±22.0)</td>
<td>0.023</td>
</tr>
<tr>
<td>Serum HDL (mg/dl)</td>
<td>40.7 (±10.4)</td>
<td>36.6 (±12.0)</td>
<td>0.021</td>
</tr>
<tr>
<td>Serum LDL (mg/dl)</td>
<td>99.1 (±28.9)</td>
<td>121.1 (±38.0)</td>
<td>0.001</td>
</tr>
<tr>
<td>FBS (mg/dl)</td>
<td>113.2 (±31.4)</td>
<td>152.2 (±56.2)</td>
<td>0.001</td>
</tr>
<tr>
<td>PPBS (mg/dl)</td>
<td>122.7 (±40.2)</td>
<td>214 (±107)</td>
<td>0.001</td>
</tr>
<tr>
<td>Serum Triglycerides (mg/dl)</td>
<td>114.2 (±50.8)</td>
<td>179.8 (±86.7)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The fasting and post prandial blood glucose levels were also significantly lower in the millet-based diet group. Previous studies have described the effect of millets in helping to lower not only the post prandial,\textsuperscript{4,5,11} but also the fasting blood glucose\textsuperscript{6,12} levels. Millets like finger millets have been proposed to lower glycaemic effect due to the presence of ‘anti-nutrients’ which reduce starch digestibility and absorption. Finger millet seed coat phenolics and dietary fiber content act as inhibitors decreasing the postprandial hyperglycaemia by blocking the action of enzymes (amylose, alpha-glucosidase) needed for hydrolysis of complex carbohydrates.\textsuperscript{13-16} It has also been suggested that intake of millets increases leptin concentrations, which could reduce appetite. Low-grade inflammation characterized by elevated tumour necrosis factor (TNF) a and interleukin (IL) 6 levels, is a common feature in subjects with T2DM that interferes with insulin signalling pathways. It is said that this mild inflammation in diabetics decreases due to the anti-oxidant activity of millets thereby enhancing insulin sensitivity.\textsuperscript{5} The reduction in both appetite and inflammation are possibly the factors that help to reduce fasting blood glucose levels.

Finally, the levels of all the serum lipids were significantly better in the millet-based diet group. But the impact of dietary millets on serum lipids has been inconsistent in previous studies.\textsuperscript{4,5,17} We also observed that the number of participants with high serum triglyceride levels at inclusion were significantly higher in the non-millet based diet group. Soluble dietary fiber component of the grain reduces reabsorption of bile acids and decrease the LDL cholesterol. Fermented finger millet is said to be a source of metabolites, like statin and sterol. Statin acts as an enzyme inhibitor of the cholesterol biosynthetic pathway whereas dietary sterol helps in reducing serum LDL level without affecting HDL.\textsuperscript{18}
The limitations of this study include the fact that the sample size of both groups was small and that this study was conducted on patients seeking medical attention at the hospital rather than on the general population at a community level. Also, the influence of a number of confounding factors for instance physical activity and compliance to medications was difficult to eliminate, something that a study with a larger sample size in the future may better address.

CONCLUSIONS
In today’s age, where there is an ever-growing burden of non-communicable diseases, there is a need for measures to be employed on a large scale for the prevention and control of metabolic syndrome. The cereal crop millet holds great potential to be powerful nutraceuticals in combating the metabolic syndrome pandemic.

REFERENCES