ABSTRACT

Diabetes has emerged as the major public health problem across the globe. At the turn of millennium we had 3 million diabetics and it is projected that the prevalence would increase to about 80 million by 2020. The problem is compounded further since diabetes starts at much younger age and remains undetected in a large proportion. This would impose an enormous economic burden. We have to adopt preventive strategies on a war footing.

We know that the factors contributing to this increase in prevalence are unhealthy dietary habits and lack of physical exercise with rural to urban migration. Research in different populations has shown that emergence of diabetes in high risk populations can be prevented by regular physical exercise and dietary modification. This knowledge can be implemented in our day to day life on a universal basis.

Yogic practises have a favorable effect on correcting insulin resistance and perhaps in preserving beta cell function, the two important pathogenic mechanisms causing type 2 diabetes. Yoga can be practiced by patients of all ages and in all seasons.

Diabetes has emerged as a major public health problem across the globe. The prevalence is increasing every year at an alarming rate. In the year 2000 it was estimated that there were 200 million diabetics in the world and it is projected that it would increase to 366 million by 2030, an increase of 70%. India has the dubious distinction of having the largest number of diabetics 30 million in 2000. It is projected this figure is likely to touch 80 million by 2025. The problem is further magnified by the fact that the age of onset in our country is a decade earlier and the burden of undetected diabetes is very high.

The public health burden due to diabetes is apparent by the fact that diabetes is the leading cause of blindness, chronic renal disease and non traumatic limb amputations, more importantly diabetes is the leading cause of coronary artery disease, stroke and peripheral vascular disease. 75% of the mortality in diabetics is due to coronary artery disease and stroke. Hence the economic burden imposed by diabetes is enormous. Once established the disease is difficult to treat; there is a direct relationship to uncontrolled diabetes and the development of its long term complications. It is often difficult to achieve optimal glycaemic control. Hence it is important that we should strive hard to achieve primary prevention of type 2 diabetes.

In order to prevent a chronic disease like type 2 diabetes it is necessary to have a knowledge about its natural history including the preclinical phase, modifiable risk factors, effective and simple tools to identify high risk individuals and an effective intervention that is affordable and acceptable.

RISK FACTORS FOR THE DEVELOPMENT OF TYPE 2 DIABETES.

It is accepted that genetic predisposition and environmental factors collude to favor the development of diabetes. The environmental factors associated with increase occurrence of type 2 diabetes include obesity, physical inactivity, previous history of gestational diabetes in women, hypertension and dyslipidaemia. These risk factors interact with the genetic predisposition indicated by a family history of diabetes or high risk ethnic heritage to promote the development of diabetes such a phenomenon is clearly demonstrated in studies done in migrant Indian populations settled in South Africa, UK, USA, Fiji Islands, South East Asia. These have shown a distinct similarity in terms of very high prevalence rates ranging between 15-20% in these populations, while the prevalence among the native populations in these countries ranged between 2.5 – 4%. Hence this increased prevalence among the migrant Indians was not due to environment factors alone, but it was proposed that Indians were genetically more predisposed to develop diabetes. Studies also showed that Indians were more insulin resistant. The life style changes that contributed in them were decreased physical activity, increased food intake with fat dense calories and the stress of working in an alien place.

With industrialization and improved facilities available in our country in the past 3 decades we have a similar scenario developing in our country leading to a very similar prevalence rate of 15-20%. There is an increase in rural to urban migration, with changes in dietary habits with diets rich in saturated fats and trans fatty acids with decreased physical activity. The increased longevity is another factor among our population.
Another major change has been the increasing prevalence of obesity in childhood and adolescents. This is contributed by changing food habits due to availability of increasing number of fast food counters, consumption of large quantities of aerated drinks, lack of physical activity due to non-availability of play grounds in schools and colleges. Also an increase in hours of TV viewing or computer use. Childhood obesity in turn predisposes to the development of obesity in adulthood and early onset of type 2 diabetes, hypertension and coronary artery disease.

**RISK FACTORS FOR DEVELOPING DIABETES AND IDENTIFICATION OF HIGH RISK GROUPS**

1. **Body Fat Distribution**: It is important to recognize that type 2 diabetes is associated not only with a high body mass index but also with a particular pattern of body fat distribution. Individuals with central obesity i.e. with the android pattern of obesity are far more likely to develop type 2 diabetes than those with gynaecoid obesity. Waist hip ratio gives a good indication of central obesity and has been shown to correlate with type 2 diabetes. Insulin resistance is probably the most important link between obesity and diabetes. Hyperinsulinemia is correlated with increasing body mass index and central obesity.

In western societies, the combination of an unbalanced, excessive diet and a sedentary lifestyle has increased the prevalence of central obesity. When populations with a low risk of type 2 diabetes adopt unhealthy westernized diets and sedentary lifestyles, the risk of diabetes increases. The growing prevalence of obesity highlights the importance of insulin resistance and type 2 diabetes.

2. **Fat Intake**: There is evidence that dietary fat is the most likely component to have aetiological relationship to development of diabetes. In rats fed with high fat diets, insulin resistance tends to develop and it is possible that a similar phenomenon may occur in humans especially, with a high intake of saturated fats.

3. **Lack of Physical Activity**: This is an important risk factor for the development of type 2 diabetes. High levels of physical activity are correlated with lower levels of plasma insulin and physical training can decrease insulin resistance. In one study the prevalence of diabetes was three times higher in individuals indulging in light physical activity compared to those involved in heavy work.

4. **Smoking**: has been found to be an independent risk factor for the development of type 2 diabetes mellitus. Data from the Osaka health survey have shown that the risk for development of type 2 diabetes mellitus in current smokers is higher than in non-smokers and that the number of cigarettes smoked and the number of pack-years are positively related to the development of type 2 diabetes mellitus in a dose dependent manner.

5. **Role of Stress**: During periods of stress the body responds by secreting excess of catecholamines, cortisol, growth hormone and glucagon. These hormones increase the insulin resistance and over a period of time the increased stress may promote the development of type 2 diabetes.

6. **Genetic Background**: There is a strong genetic element in the development of type 2 diabetes and a genetic susceptibility probably predisposes individuals with changes in their lifestyle, to develop diabetes. Certain ethnic groups such as native Americans and Hispanics have a higher genetic predisposition for the development of diabetes. The same is true with Asian Indians like us.

An individual’s risk of developing diabetes is doubled if one member of their family already has the disease. The risk gets quadrupled if there are two family members with diabetes.

7. **Previous Gestational Diabetes**: Development of gestational diabetes mellitus during pregnancy indicates a significantly higher risk of developing diabetes in future. In fact the progression to type 2 diabetes is 5% per year with almost 50% of these women with gestational diabetes developing diabetes over a 10 year follow up.

Early detection of Gestational Diabetes Mellitus (GDM) by Universal screening and appropriate management can not only prevent perinatal morbidity and mortality, but also prevent the birth of either low body weight babies or large babies, both of which are associated with higher risk for development of type 2 diabetes. Exposure of the fetus to higher glycemic levels in the mother has also been associated with a greater risk of development of type 2 diabetes. Thus measures directed towards early detection and effective management of GDM can therefore ensure long term benefit over three generations and contribute to the prevention of diabetes.

**Insulin Resistance**: Insulin resistance has been demonstrated in first degree relatives of type 2 diabetic patients. Significant insulin resistance has also been reported in non diabetic, lean relatives and offspring of type 2 diabetes patients. Overall upto 50% of 1st degree relatives are insulin resistant for several years before they develop diabetes. These data suggest that insulin resistance as a metabolic precursor to type 2 diabetes and establish a rationale for interventions that improve insulin sensitivity as one strategy for preventing diabetes.

Pancreatic beta cell dysfunction leads to progressive impairment of insulin release. In a prospective study of Pima Indians this defect in the first phase of insulin secretion proved to be a critical determinant of progression from normal to IGT to type 2 diabetes. Progression from IGT to diabetes was associated with an approximately 75% decline in the acute insulin secretory response to IV glucose. A high concordance rate for impaired insulin secretion has also been reported among elderly identical twins discordant for type 2 diabetes, which suggests a genetic basis for pancreatic beta cell dysfunction.
The role of beta cell dysfunction in predicting progression to type 2 diabetes suggests that interventions that prevent the progression of decline in insulin secretion can be expected to prevent the development of type 2 diabetes.

PREVENTING PROGRESSION TO DIABETES

Early intervention in high risk individuals with modification of lifestyle factors, such as diet and exercise, have a major influence on the development and progression of impaired glucose tolerance, dyslipidaemia and insulin resistance, conditions that precede the onset of type 2 diabetes. Although not all patients with such metabolic abnormalities progress to diabetes, their risk of developing the disease is significantly increased.

Lifestyle intervention is an important clinical strategy that can help reduce obesity and reduce the risk of developing type 2 diabetes. Major clinical studies such as the Da Qing Study, The Finnish diabetes Prevention Study, and the Diabetes prevention program, have conclusively brought out the benefit of lifestyle changes in prevention or in delaying the progression of pre-diabetes (impaired fasting glucose and impaired glucose tolerance) to type 2 diabetes.

The Da Qing Study: The Da Qing study examined the effect of a 6 year diet and exercise intervention in Chinese subjects with IGT. Participants were divided into four groups: control (n=133), diet modification alone (n=130), exercise alone (n=141) and diet modification plus exercise (n=126). Diet and/or exercise interventions led to a significant decrease in the incidence of type 2 diabetes. At 6 years, the cumulative incidence of type 2 diabetes was 67.7% (95% CI 59.8 – 75.2%) in the control group compared with 43.8% (95% CI 35.5 – 52.3%) in the diet group, 41.1% (95% CI 33.4 – 49.4) in the exercise group, and 46.0% (95% CI 37.3 – 54.7%) in the diet plus exercise group (p<0.05).

The Finnish Diabetes Prevention Study: An intensive diet and exercise program reduced body weight and was associated with a 58% reduction in the risk of developing type 2 diabetes (p<0.0001). Middle-aged men (n=172) and women (n=350) who were overweight (body mass index [BMI] ≥ 25kg/m²) and had IGT were randomized to the intervention group (n=265) or to a conventional care control group (n=257). The goals of intervention in the study were:

- Weight reduction: > 5% of baseline body weight
- Fat intake: < 30% of energy intake
- Saturated fat intake: < 10% of energy intake
- Fibre intake: ≥ 15g/1000 kcal
- Endurance exercise (walking, jogging, swimming): ≥ 4h/week

After 2 years, subjects in the intervention group achieved a significantly greater mean reduction in body weight (3.5kg) compared with those in the control group (0.8kg; p<0.0001). The intervention group also had better glycaemic control, including improved glucose levels while fasting and after an oral glucose challenge. In addition, fewer subjects in the intervention group developed type 2 diabetes than in the control group during the 3.2 years of mean follow-up (27 versus 59; P<0.0001). The reduction in the risk of progression to diabetes was directly related to the magnitude of the changes in lifestyle; none of the patients who had achieved at least four of the intervention goals by year 1 developed type 2 diabetes during follow-up.

Diabetes Prevention Program: The large-scale diabetes prevention program found that lifestyle modification reduced the incidence of type 2 diabetes by 58% in overweight American adults with IGT. A total of 3234 adults (1043 men and 2191 women) were randomized to standard lifestyle recommendations plus placebo (n=1082) or metformin 850mg twice daily (n=1073), or to an intensive lifestyle modification program (n=1079). The goal was to achieve and maintain ≥ 7% reduction in body weight through a low-calorie, low-fat diet plus at least 150 minutes per week of moderately intense physical activity.

Patients in the lifestyle intervention group lost significantly more body weight (5.6kg, p<0.0001) than those in the placebo (0.1kg) and metformin groups (2.1kg). The cumulative incidence of type 2 diabetes during the follow-up period was lower in the lifestyle intervention and metformin groups than in the placebo group with incidence rates of 4.8, 7.8 and 11.0 cases per 100 person years, respectively. Thus, the reduction in diabetes incidence was greater in the lifestyle intervention group at 58% (95% CI 48-66%) than in the metformin group at 39% (95% CI 17 – 43%).

The Indian Diabetes Prevention Program (IDPP) are a preventive study based on the Diabetes Prevention Program has clearly demonstrated the importance of physical activity in the prevention of diabetes in Indians.

531 (421 men 110 women) subjects with IGT (mean age 45.9±5.7 years, BMI 25.8±3.5 kg/m²) were randomized into four groups. Group 1 was the control, Group 2 was given advice on lifestyle modification (LSM), Group 3 was treated with metformin (MET) and Group 4 was given LSM plus MET. The primary outcome measure was type 2 diabetes as diagnosed using World Health Organization criteria. After a median follow-up period of 30 months, the 3-year cumulative incidence of diabetes were 55.0%, 39.3%, 40.5% and 39.5% in Groups 1–4, respectively. The relative risk reduction was 28.5% with LSM (95% CI 20.5–37.3, p=0.018), 26.4% with MET (95% CI 19.1–35.1, p=0.029) and 28.2% with LSM + MET (95% CI 20.3–37.0, p=0.022), as compared with the control group. This study therefore showed that although progression of IGT to diabetes is high in Indians, both LSM and MET significantly reduced this progression and there was no added benefit from combining them.

Detecting and managing those at high risk for type 2 diabetes: In light of the impressive results of the Finnish Diabetes Prevention Study and the Diabetes Prevention Program, the American Diabetes Association (ADA) and the National Institute of Diabetes, Digestive and Kidney disease (NIDDK) recommended that people over 45 years with a BMI ≥ 25kg/m² should be screened.
for IGT. Patients with evidence of IGT should be given appropriate counseling on the importance of weight loss through a program of dietary modification and exercise.

Identification of subjects at high risk of type 2 diabetes is relatively easy; no biochemical or costly tests are required. From the prevention perspective, screening for type 2 diabetes is not the same as measuring blood glucose. Risk can be determined using non-invasive data, such as waist measurement and BMI. A diabetes prediction risk score has recently been developed based on the prospective study in Finland.[13]

An Indian Diabetes Risk score (IDRS) has recently been developed by Mohan et al., which uses four simple variables namely age, family history, exercise frequency and intensity and waist circumference to arrive at a risk score. (table 2). Those individuals with a score below 30 have a low risk, between 30-50 have an intermediate risk and those with a score >60 have a high risk of developing diabetes and cardiovascular disease.[14]

**ROLE OF YOGIC PRACTICES IN DIABETES PREVENTION**

The science of yoga is an ancient one. It is a rich heritage of our culture. Several older books make a mention of the usefulness of yoga in the treatment of certain diseases and preservation of health in normal individuals.

We carried out several studies to assess the effect of yogic practices in normal healthy volunteers, patients with diabetes, hypertension, asthma and obesity. These studies were both short term and long term follow up. The following observations were made.

**Effect of yogic practices on body composition:** In normal healthy volunteers the skin fold thickness was significantly reduced with increase in the lean body mass, without any significant change in the weight of the individuals. One hundred eight patients with type 2 diabetes were studied for a period of 6 months. All these patients developed a sense of well being and showed a significant fall in the glycosylated hemoglobin and the drug requirements. In these patients there was a significant decrease in the body fat and increase in the lean body mass. The reduction in body fat percentage and increase in the lean body mass helps to improve insulin sensitivity and reduce insulin resistance[15].

**Effect of yogic practices on insulin kinetics:** There was a reduction in the fasting insulin levels and a shift of the peak level of insulin to the left. There was a normalization of the I/G ratio with a reduction in the free fatty acid levels, suggesting a better peripheral utilization of insulin and reduction in insulin resistance. This was confirmed by a study of yogic practices on insulin receptors, which showed a significant rise in the insulin receptors even before glycemic control was achieved, indicating a reduction in insulin resistance and improvement in insulin sensitivity[14].

**Effect of yogic practices on CMI in type 2 diabetes:** Cell mediated immunity (CMI) is defective in patients with type 2 diabetes, particularly with poor glycaemic control. The defective cell mediated immunity predisposes the diabetics to various infections. Our studies have shown that yogic practices have a favorable effect on the lymphocyte migration test, suggesting an improvement in the cell mediated immunity. Yogic practices like Shavasana and Makrasana help in eliminating stress.

**Effect on co-morbid conditions:** Hypertension is commonly encountered in patients with diabetes and it has significant role in the development of both microvascular and macrovascular complications. Along with hypertension dyslipidemia is also equally common.

**Effect of yogic practices on hypertension:** Patients with hypertension were advised pranayama and shavasana. 20 non-diabetic patients with moderately elevated BP had reduction in both systolic and diastolic blood pressure after 3 weeks of yogic practices and the blood pressure was maintained at normal levels with significant reduction in the dosage requirement of anti-hypertensive drugs. Similar reduction in the systolic and diastolic blood pressure and the fasting and post-lunch blood

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**Table 1: Risk Factors For Type 2 Diabetes**

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Score</th>
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<tbody>
<tr>
<td>Family history of type 2 diabetes</td>
<td></td>
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<tr>
<td>Over weight / obesity</td>
<td></td>
</tr>
<tr>
<td>Physical inactivity</td>
<td></td>
</tr>
<tr>
<td>Gestational Diabetics</td>
<td></td>
</tr>
<tr>
<td>Delivery of a baby weighing more than 4 kg</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
</tr>
<tr>
<td>Dyslipidaemia</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
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<tr>
<td>Pre diabetic states IGT &amp; IFG</td>
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**Table 2: Indian Diabetes Risk Score**

<table>
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<th>Particulars</th>
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<tbody>
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<td>Age (yrs)</td>
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<tr>
<td>&lt; 35</td>
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</tr>
<tr>
<td>35-49</td>
<td>20</td>
</tr>
<tr>
<td>≥ 50</td>
<td>30</td>
</tr>
<tr>
<td>Abdominal Obesity</td>
<td></td>
</tr>
<tr>
<td>Waist &lt; 80cm (female), &lt; 90cm (male)</td>
<td>0</td>
</tr>
<tr>
<td>Waist ≥ 80-89cm(female), ≥90-99cm(male)</td>
<td>10</td>
</tr>
<tr>
<td>Waist ≥ 90 cm (female), ≥ 100 cm (male)</td>
<td>20</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
</tr>
<tr>
<td>Vigorous exercise or strenuous (manual)</td>
<td>0</td>
</tr>
<tr>
<td>Labour at home / work</td>
<td></td>
</tr>
<tr>
<td>Mild to moderate exercise or mild to moderate physical activity at home / work</td>
<td>20</td>
</tr>
<tr>
<td>No exercise and sedentary activities at home/work</td>
<td>30</td>
</tr>
<tr>
<td>Family History</td>
<td></td>
</tr>
<tr>
<td>No family history</td>
<td>0</td>
</tr>
<tr>
<td>Either parent</td>
<td>10</td>
</tr>
<tr>
<td>Both parents</td>
<td>20</td>
</tr>
</tbody>
</table>

**Interpretation of Score**

<table>
<thead>
<tr>
<th>Score</th>
<th>Low risk</th>
<th>Medium Risk</th>
<th>High risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30</td>
<td></td>
<td>30-50</td>
<td>&gt; 60</td>
</tr>
</tbody>
</table>

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sugar was observed in patients with diabetes and hypertension. The blood pressure came under control in 15 days and the effect was sustained even in studies up to 3 months. Patients were free from cerebrovascular, cardiovascular and renal problems without any adverse effects on the lipid profile.14.

Effect of yogic practices on lipid parameters: The impact on lipids was studied in the different groups of patients. The effect of yogasanas on lipoprotein profiles was studied. There was a significant decrease in the free fatty acids, low density lipoprotein and very low density lipoprotein cholesterol, with increase in high density lipoprotein cholesterol. These changes suggest improvement in the insulin sensitivity following yogic practices.14.

Studies like the UKPDS have shown that there is a progressive decline in beta cell function leading to worsening of glycemic status. Our studies in a subset of elderly diabetics aged over 65 years with yogic practices showed that they maintained good glycemic control even as long as 7 years indicating that yogic practices help in preserving beta cell function.

The improved cell mediated immunity protects individuals from infections and stress is eliminated with the practice of shavasana, which are additional factors identified as contribution to the development of type 2 diabetes. Therefore, by its influence on all these factors yogic practices, help in the prevention of type 2 diabetes. In a pilot study 80 siblings born in diabetic families were followed for a period of 5 years. 24 subjects practiced yoga regularly while the other 56 siblings did other forms of physical exercise. Only 1 out of the 24 subjects in the yoga group developed diabetes compared to 10 out of 56 in the non-yoga group.

By following the practice of yoga the following changes take place—There is an increase in the lean body mass and decrease in the body fat percentage. There is an improvement in insulin/glucose ratios, correction in the peak of insulin secretion with a shift to the left. There is an improvement in the insulin receptors, a decrease in the free fatty acid levels and triglycerides. All these lead to improved insulin sensitivity and decrease in insulin resistance which is an important forerunner in the pathogenesis of type 2 diabetes.14.

The effect on the glycaemic control and co-morbid conditions like dyslipidaemia and hypertension protects the patients from complications of diabetes. Hence yogic practices have a role both in primary and secondary prevention in diabetes.

SUMMARY AND CONCLUSIONS
To conclude the war against diabetes in our country should start focusing on school going children, by educating them on the importance of healthy lifestyle with both diet and exercise. The schools should provide facilities like playgrounds and introduce physical training and yoga classes in the curriculum. Government should create public parks and provide facilities for physical exercises. Growth of Fast food counters should be curtailed by preventing the sale of junk food in the vicinity of the schools.

REFERENCES