Role of Risk Factors in Development of Type 2 Diabetes Mellitus: A Review

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Abstract

In the present era although many remarkable achievements have been accomplished in medical sciences but still there are a number of diseases that have insufficient proof of their actual causative agents. The term "risk factor" is used to postulate the causative agent of such diseases. Diabetes Mellitus is one of them, where several risk factors both genetic and acquired have been suggested and a number of scientific studies have been conducted to verify them. In the following review paper, risk factors for Diabetes mellitus have been evaluated in the light of different scientific studies. Awareness among the people about these risk factors and their willingness to embrace corrective measures may help reduce the burden of diabetes.

Keywords: Risk factor, Diabetes Mellitus, Hyperglycemia, Insulin resistance

Introduction

Chronic diseases are considered to be the leading cause of public health problem in the developed as well as developing countries. Diabetes Mellitus has a strong contribution among them. It is a leading cause of death and disability worldwide (Aktar *et al.*, 2014). India, once acknowledged as the 'diabetes capital of the world' was home to 61.3 million patients with Type 2 DM in 2011 with predictions of 101.2 million diabetics by 2030 (Gupta *et al.*, 2015). Such a massive global burden of diabetes mellitus is attributed to the risk factors, which play a major role in the causation of the disease. Since ancient period till present age, medical science has a remarkable achievement in identifying the etiology and pathology of diseases but still there are a number of diseases with unidentified causative factors and complete profile of etiopathology. These are deliberated in terms of "risk factors".

The earliest use of "risk factor" analysis dates back to Ibn Sina (Avicenna) who has given a comprehensive account of factors that may have influence in the causation of diabetes (Goodman, 2003). Although, the term risk factor as such was first used by Dr. Thomas R. Dawber in a land mark scientific paper in 1961, where he credited heart diseases to specific condition (blood pressure, cholesterol, smoking) (http://en.wikipedia.org/wki/Risk factors)

The term risk factor is generally used at least for two meanings in preventive and social medicine: one meaning is an attribute or exposure that is significantly associated with the development of a disease. Second meaning is a determinant that can be modified by intervention thereby reducing the possibility of occurrence of disease or other specific outcome (Gupta & Pathak, 2003).

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Risk factor defined by Taber's is "an environmental, chemical, psychological, physiological or genetic element that predisposes an individual to the development of a disease" (Davis, 2001).

Risk factor can be described as a signal of possibilities or potential problem. It is like a red flag to catch our attention. It serves to alert loved ones and physician to be more alert and observant than it might otherwise be.

Types of Risk Factors

Risk factors of diabetes mellitus can be categorized in following to types:

1. Modifiable risk factors
2. Non modifiable risk factors

1. Modifiable Risk Factors:

   These can be further divided into two categories.

   a. Behavioral and Life Style Related Risk Factors: They include dietary habit, alcohol intake, smoking, physical activity, obesity, socioeconomic status, urbanization, acculturation, thinness at birth and genetic environmental interaction etc.

   b. Metabolic factors: Insulin resistance, hyper insulinemia and hyperglycemia.

2. Non Modifiable Risk Factors:

   These are also categorized into:

   a. Demographic Risk Factors: Such as age, ethnicity and gender or sex etc. These are demographic risk factors that cannot be modified.

   b. Genetic Risk Factors: These are also non modifiable risk factors such as candidate gene, family history, racial admixture, twins' history (Park, 2007).

Risk Factors and Their Associations with Diabetes mellitus:

Age

Although diabetes may occur at any age however, surveys indicate that prevalence rises steeply with age. In most population, Type 2 DM incidence is low before the age of 30 years but increases rapidly as the age advances. The prevalence of diabetes mellitus in Pima Indian aged 25-29 years is 13%, however, it is as high as that for US Non Hispanic Whites aged 60-64 years. Incidence data suggest that the relative risk of Type 2 DM in US minority group, compared with Non Hispanic Whites, is highest at age <40 years and decrease thereafter. In high risk population, susceptible persons develop Type 2 DM at an earlier age. Several

studies in India revealed that the prevalence of diabetes mellitus in Indian population is 10-12 years earlier as compared to Western population. The prognosis is worse in younger diabetic who tend to develop complication earlier than older diabetics (Park, 2007; King & Rewers, 1993).

Gender (sex)

There is little evidence that Type 2 DM risk differ between men and women when other factors are accounted for. In some countries like UK, the overall male and female ratio is about equal, but in South East Asia, an excess of diabetic males has been observed (Park, 2007).

Genetics

The general observation that Type 2 DM has a genetic component is undisputed (Vadheim & Rotter, 1992). The simplest evidence is that Type 2 DM is more frequent in certain ethnic groups and in certain families. This ethnic and familial clustering is likely to result from both shared genes and shared behavioral and environmental risk factors.

Studies of population that derive from ethnic groups differing in Type 2 DM risk provided indirect evidence for the genetic factors in Type 2 DM. For instance, Hispanics in the Southern US share genes of Native American, who have one of the highest diabetes rates in the world (West, 1978) and genes of the Caucasian who are at a much lower risk (Mann *et al*., 1983). The prevalence study of diabetes in twins showed that in identical twins who developed Type 2 DM, concordance was approximately 90%, this demonstrating a strong genetic component (Park, 2007).

Twins

Studies on twins have suggested that Type 2 DM is highly concordant among monozygotic twins and less so among dizygotic twins. A study of US veterans reported concordance rate of 58% for monozygous and 17% for dizygous twins (Newman *et al.,* 1987).

Family History

Presence of Type 2 DM in family members is an established risk factor for Type 2 DM. Pima Indian and Caucasian with at least one diabetic parent have a much higher incidence of Type 2 DM than those who were equally obese but do not have a diabetic parent (Knowler *et al*., 1981; Bairde, 1973).

A strong familial aggregation in the Indian diabetic population reported by a study which revealed that nearly 75% of Type 2 diabetic patients have first degree familial

history of diabetes (Ramchandran *et al*., 2002). In DESI report, 16.9% subjects were found with positive family history and in this report prevalence was significantly higher in those with positive family history (29.1%) than (11.4%) in those without positive family history (Ramchandran *et al*., 2001).

Diet

Diet has been considered a possible cause of diabetes for centuries. Total caloric intake as well as several components of diet including carbohydrate and fats has been considered to be causative factors. Studies of severe food shortage during war provide ecological evidence that diabetes mortality and morbidity abruptly declined with decreased caloric intake (Himsworth, 1935).

The development of DM is characterized by chronic insulin resistance and a progressive fall in *B*-cell compensation for insulin resistance (Cnop*et al*., 2007). Severe, short-term calorie restriction has been shown to improve insulin sensitivity and enhance *B*-cell function (Chen *et al*., 2014). Several studies demonstrated that calorie restriction reduces Insulin resistance, improves glucose tolerance, and delays or prevents the onset of Type 2 diabetes (Larson-Meyer *et al*., 2006).

Dietary Carbohydrate and Fiber

Studies of dietary carbohydrate intake have given variable results. A 12 years prospective study of diet and Type 2 DM found no relationship to any dietary component, including main source of carbohydrate and fiber. Apart from this several other studies also reported, no relationship between dietary factors and Type 2 DM (Lundgren *et al*., 1989; Medalie *et al*., 1975).

A study in a small sample of Pima Indian women reported that higher total and complex carbohydrate intake was associated with higher Type 2 DM incidence (Pozza, 1984). Four years of follow up of elderly subjects found a positive association between development of glucose intolerance and carbohydrate intake. Thus prospective studies have reported mixed result concerning dietary carbohydrate or fiber and the risk of Type 2 DM (Feskens*et al*., 1991). But certain controlled experimental studies have revealed that high intake of dietary fibers reduced blood glucose and insulin level in people with Type 2 DM and impaired glucose tolerance. Thus the evidence for protective effect of dietary fibers appears strong (Park, 2007).

Dietary Fat

A high saturated fat intake has been associated with a higher risk of impaired glucose tolerance, and higher fasting glucose and insulin level. Higher proportion of saturated fatty acid in serum lipid or muscles phospholipids also associated

with higher fasting insulin, lower insulin sensitivity and higher risk of Type 2 DM. Poly unsaturated fatty acid and higher unsaturated fatty acid from vegetable sources were found to reduce the risk of Type 2 DM (Park, 2007).

A 40 gm/day higher dietary fat intake increases diabetes risk seven folds (Marshal & Hamman, 1988). Consistent result was reported from a study of Japanese American (Tsunehara *et al*., 1991). Several other studies also suggested that high fat intake, increases risk of Type 2 DM. But such properties and preliminary human data suggest that higher intake of Omega-3-fatty acids might protect people from developing Type 2 DM. Omega-3-fatty acids appear to reduce serum lipid and lipoprotein, platelet aggregation, blood pressure and insulin resistance (Marshal *et al*., 1991).

Physical Activity

Lack of exercise may alter the interaction between insulin and its receptors and subsequently lead to Type 2 DM (Park, 2007).

Ecological Studies suggested that the prevalence of type 2 DM is consistently lower in population with higher level of habitual physical activity (Wicking *et al*., 1981). Lower prevalence of Type 2 DM at higher level of physical activity has also been consistently found in cross sectional and retrospective studies (Harris, 1991). A prospective study has also revealed that each 500 Kcal of increased energy expenditure in leisure time activity per week lowered the risk of Type 2 DM by 10%. This effect was also greatest in more obese men (Helmrich *et al*., 1991).

It has been postulated that this protective effect of physical activities on development of Type 2 DM is due to the prevention of insulin resistance (Bauchard *et al*., 1990). So it seems reasonable to conclude that increased level of physical activities decreases the risk of Type 2 diabetes mellitus.

Obesity

Obesity is recognized as a major health problem in both developed and developing countries. In India, obesity is emerging as an important health problem. The major health consequences associated with overweight and obesity are Type 2 DM, CHD, hypertension etc.

Total body adiposity has been recognized as being associated with diabetes for long. A positive association between overweight or obesity, and risk of Type 2 DM has been established repeatedly in many cross sectional and prospective studies. It was shown that the risk conformed by obesity for developing diabetes was higher by 40 times in obese women compared to those who remained slim and the risk of Type 2 DM should reduce significantly with weight loss. It was shown

for Indian urban population that at a BMI of >23 kg/m^2 the risk for diabetes was significantly higher for both genders. Therefore, the healthy BMI for an Indian is definitely below 23 kg/m^2. This has been confirmed by studies from other parts of India and in migrant Indians (Anonymous, 2004).

Level and duration of obesity with the location of body fat are strong risk factor for Type 2 DM. Several studies have reported that the risk increases proportionately with the duration of obesity, and it is now recognized that rather than the degree of obesity, the distribution of body fat is a more important determinant of Type 2 DM, upper body (central, abdominal) obesity increases the risk of diabetes, it has been suggested by several cross sectional and prospective studies (Ramchandran *et al*., 2002).

Parity Effect

It has been suggested that increasing parity increases the risk of Type 2 DM in women. Several studies have found both positive and no association with diabetes mellitus.

The effect of pregnancy operates through weight gain while the number of birth has no independent effect itself (Ressanen *et al*., 1991). A positive association between increased parity may have an effect beyond that of obesity (Kritz*et al*., 1989). In contrast, a prospective study is consistent with the view that increased risk of Type 2 DM is secondary to obesity (Manson *et al*., 1992).

Thinness at Birth

It has been proposed that persons who are thin at birth or at age 1 year are at an increased life time risk of Type 2 DM. Association between low birth weight and traits related to insulin resistance were reported in several studies (Valdez *et al*., 1994). The explanation of this association may be given that poor fetal nutrition leads to poor development of *â* cells and dysfunction in later life. Another explanation is that low birth weight and low ponderal index at birth reflects a latent â cell defect. It remains to be elucidated however that how a latent *â* cell defect could lead to insulin resistance or hyper insulinemia.

Socio-economic Status (SES)

Socioeconomic environment influences occupation, life style and nutrition of social classes which in turn would influence the prevalence and profile of glucose intolerance and diabetes complication. A number of studies have addressed this issue in western countries (Ramchandran *et al*., 2002).

Prevalence of diabetes was found to be lower in the low socio economic group living in urban areas compared to the high income group (12.6% vs. 24.6% in

subject ≤ 40 years) in India. Lower prevalence of diabetes has been reported in the low income group as compared with middle income group in South India (Ramchandran *et al*., 2002).

The finding of lower prevalence of diabetes in the socially deprived urban Indians was in contrast to the positive association of diabetes and social deprivation in western countries (Ramchandran *et al*., 2002).

Urbanization

Urbanization has brought several changes in the life style in most areas in India. These changes include consumption of excess calories, reduction in complex carbohydrates with increased consumption of simple sugar and fat. Moreover availability of energy saving method of transport and labour has resulted in severely reduced physical activities. A recent study has shown that the total activity level considering the activity at work and during leisure time was very low, especially in women. Sedentary life style was one of the significant factors associated with diabetes in the population. Studies from different part of India also reported that urban residents have higher rate of Type 2 DM than rural dwellers, due to a number of life style factors implicated in the etiology of type 2 diabetes mellitus (Ramchandran *et al*., 2002).

Stress

Mental stress is associated with urban life and modernization. The role of stress as a possible risk factor for Type 2 DM has some support in studies of the neuro endocrine system, especially the sympathetic nervous system. In a study from Kolkata, self-reported stress, history of trauma and history of surgery were found to increase the risk of Type 2 DM. It has been suggested that chronic moderate stress leads to development of Type 2 DM (Dutt *et al*., 2004).

Alcohol Consumption

Alcohol consumption has been suggested as a possible independent Type 2 DM risk factor, either because of its effect on the liver and pancreas, or simply because of additional calories result in increased weight and abdominal adipose tissue (Colditz *et al*., 1991).

Studies exploring the association between alcohol intake and the risk for Type 2 DM have reported conflicting results. Several large scale epidemiological studies have reported an increased association between moderate alcohol consumption and reduced risk for Type 2 DM, while others have suggested nil association.

Several studies indicate that apparently healthy men who self-selected for light to moderate alcohol consumption have a decreased subsequent risk for Type 2

DM. This inverse association between regular low to moderate consumption of alcohol and the risk of developing Type 2 DM are consistent with reports from other large prospective cohort studies (Ajani *et al*., 2000).

American who reported high use of alcohol ≤ 176 gm/week had twice the incidence of Type 2 DM, when compared with men who drank less alcohol, although the later had lower rates of Type 2 DM than those who reported drinking no alcohol (Holbrook *et al*., 1990).

In certain studies from India, alcohol consumption was identified as significant risk factor for Type 2 DM (Dutt *et al*., 2004).

Gestational Hyperglycemia

Abnormal glucose tolerance first detected during pregnancy is a risk factor for later development of both Type 1 and Type 2 DM (Helmrich *et al*., 1991). After pregnancy, 5-10% of women who had gestational diabetes mellitus (GDM) are found to develop Type 2 DM. Women who have had GDM have a 20-50% chances of developing diabetes in the next 5-10 years following pregnancy, and in another pregnancy, they have 40% chances of GDM also (http://wnhs.health.wa.gov.all).

Smoking

A positive association between smoking habit and the risk of Type 2 DM emerged from many prospective studies carried out in Europe and Japan (Rimm*et al*., 1995). A large prospective study showed that current smoking was associated with a 20 to 40% increased risk of diabetes mellitus of which 99% was Type 2 DM among men, and 40-50% increased risk for both age sub groups (40-59 years and 60-79 years) among women (Sairennchi *et al*., 2004). Therefore, it can be stated, conclusively that smoking is associated with increased risk of Type 2 DM among all age group of men and women.

Conclusion

It can be concluded that sedentary lifestyle, urbanization, obesity and high socio economic status are mutually related and that the above risk factors along with smoking and stress are co relationally related with the Type 2 DM. Several Scientific studies have suggested their potential role of causing Type 2 DM. On the other hand fibrous diet has protective effect in controlling the blood sugar. Although the health care facilities are playing an important role in control and prevention of DM, the prevalence of diabetes is increasing day by day. Hence it is necessary to impart awareness and educate common people regarding modifiable risk factors of DM especially in the areas where lack of awareness and scarcity of health care facilities persist, so that burden of diabetes can be reduced to an extent.

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