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Theoretical studies of prevalence of obesity and type 2 diabetes mellitus

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Abstract
Diabetes is a metabolic condition in which the body does not produce sufficient insulin to regulate blood glucose levels or where the insulin produced is unable to work effectively. There are two main types of diabetes: Type 1 diabetes is an auto-immune condition in which the cells that produce insulina are destroyed so lifelong treatment with insulin is required to prevent death. About 10% of people with diagnosed diabetes have type 1 diabetes. Type 2 diabetes accounts for at least 90% of all cases of diabetes. It occurs when the body either stops producing enough insulin for its needs or becomes resistant to the effect of insulin produced. The condition is progressive requiring lifestyle management at all stages. Over time most people with type 2 diabetes will require oral drugs and or insulin. Type 2 diabetes may remain undetected for many years. Obesity is only associated with type 2 diabetes and this paper does not cover type 1 diabetes, which has no association with obesity or other lifestyle factors, or other forms of diabetes such as gestational diabetes.

Keywords: obesity, type 2 diabetes.

1. Introduction
International Scenario: According to WHO MONICA study (1989), the prevalence of obesity has increased by about 10-40% in most of the European countries in the past decade. It escalated in the UK, where the prevalence has doubled during this period (Seidell and Flegal, 1997) [1]. Similarly, in UK in 2003, 60% of women and 68% of men were overweight or obese (Fisher, 2005) [2]. In Germany, 70% of men and 50% women were found to be obese (Mensink *et al*, 2005) [3]. In Spain, the prevalence of obesity has been reported 14.5% in one study (Carraro and Cebrian, 2003) [4] and 13% in another study (Martinez *et al*., 2004) [5]. A 1994 analysis in Denmark showed the prevalence of obesity to be 12% in men and 11% in women. In a study in Poland, in 2003, 15% of women and 6.5% of men were reported obese. In 2003, in Canada, 15.2% individuals were found obese. A study in South Australia found that obesity rates (BMI≥ 30 to < 35) increased significantly from 8.7% in 1991 to 14.1% in 2003 and sever obesity (BMI≥ 35) increased significantly from 2.6% in 1991 to 5.3% in 2003 Obesity levels also vary depending on ethnic origin. In the USA, particularly among women, there are large differences in the prevalence of obesity between populations of the different ethnic origins within the same country. In Malaysia, the National Morbidity Survey of 1996 reported an overall nationwide prevalence of overweight among adults of 20.7% and of obesity of 5.8%. It was further reported that the Indian ethnic group had the highest prevalence of overweight (24.9%). As per, in Malaysia, as compared to the obesity prevalence of 4.4% in adults aged 18 years and above reported in the Second National Health and Morbidity Survey in 1996, in 2004 obesity prevalence was reported 280% higher than that in 1996. Current obesity levels range from below 5% in China, Japan and certain African nations, to over 75% in urban Samoa. It is further projected that even in relatively low prevalence countries like China, rates are almost 20% in some cities. The WHO has stated "the growth in the number of severely overweight adults is expected to be double that of underweight during 1995-2025" and further crude projections, from Extrapolating existing data, suggest that by the year 2025, Levels of obesity could be as high as 45-50% in the USA, between 30-40% in Australia, England and Mauritius and over 20% in Brazil. In developing countries, in terms of regional trends, the highest rates of obesity occur in the Pacific region while the lowest rates are found in South Asia. In terms of intra- regional trends, with in South Asia, Pakistan has the highest rates of obesity followed by India.

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Based on current trends, it is predicted that the levels of obesity will continue to rise unless action is taken now. The WHO (1998) has projected that the growth in the number of severely overweight adults is expected to be double that of underweight during 1995-2025.

National Scenario

In developed countries which are in the phase of nutrition transition, the increase in obesity is blamed on both increased access to cheap high fat, high energy foods and simultaneously reduction in physical activity. Thus, obesity is often viewed as a disease of rich people. But, according to, as obesity is becoming more and more common in middle class and neo-rich class in India also, it is no more the disease of high class society or the disease of the rich. It is assumed that there are about 1.5 million people in India who are coming into the group requiring surgical intervention.

Obesity in India has reached epidemic proportions in the 21st century and is following a trend of other developing countries that are steadily becoming more obese. In countries like India, where there is high prevalence of under nutrition, overweight and obese now coexist with the undernourished in noteworthy proportions. Obesity is a major chronic disorder, affecting 20%-40% adults in India. The prevalence of obesity is higher among women and also in economically better off individuals and who live in urban areas. Women in higher socio-economic status experience the greater risk for being pre-overweight, overweight and obese.

There has been a rise in prevalence of obesity and lifestyle diseases in India in the aftermath of the economic boom in the last few years. According to, 24.5% of males and 30.2% of females of Jaipur were obese (BMI $\geq$27 kg/m2). On the other hand, reported that the prevalence of overweight or obesity (BMI $\geq$25 kg/m2) in men and women of Punjabi Bhatia family of Jaipur was 54.0% and 69.4%, respectively, whereas, severe obesity (BMI>30 kg/m2) was observed in 20.8% of men and 32.3% of women. According to reports of National Family Health Survey (NFHS)- III (2005-06), in India, Punjab ranks one with 33.9% of population being obese, followed by Kerala (29.1%), Goa (23.9%), Tamilnadu (22.1%) and Andra Pradesh (20.9%). Das and Bose (2006) reported 58% of Marwari population of West Bengal as overweight and obese, whereas, reported 17.45 % of Bengalee Hindu women as obese. studied the prevalence of obesity among women in Tangkhul Naga tribe of Manipur. The prevalence of overweight and obesity among the Tangkhul Naga women was found to be 27.1% when BMI was assessed using recommended cut-off points for Asians and when BMI was assessed using the WHO International Classification of adult overweight and obesity, the prevalence of obesity observed was 9.8%. has reported the prevalence of obesity as 47.4% among men and women of Chennai. reported that 34.4% of males and 31.3% of females of Gwalior as either obese or overweight, whereas, obesity accounted for 80.00% and overweight for 14% of the individuals of Bengali Kayastha Population of North Bengal. In rural Kerala, 18% of those in age 20-29 years were reported obese or overweight which rose to 41.7% of those in 40-49 years and 41.9% of those in 50-59 years.

Prevalence

Data from the Third National Health and Nutrition Examination Survey (NHANES III) indicate that two thirds of adults, both men and women, had BMI values >27 kg/m2. The prevalence of T2DM parallels the increasing prevalence of obesity. The World Health Organization (WHO) projects that there are currently 2.3 billion overweight people aged 15 years and above, and that there will be over 700 million obese people worldwide in 2015 [http://www.who.int/mediacentre/factsheets/fs311/en/]. The prevalence of diabetes is increasing in the United States, and the diagnosed diabetes increased from 0.9% in 1958 to 6.3% in 2008. In 2008, 18.8 million people had diagnosed diabetes, compared to only 1.6 million in 1958 [http://www.cdc.gov/diabetes/statistics/slides/long_term_trends.pdf.].

According to the International Diabetes Federation (IDF), it is estimated that approximately 285 million people worldwide, or 6.6%, in the age group 20-79, will have diabetes in 2010 [http: //www.diabetesatlas.org/map], some 70% of whom live in low- and middle-income countries. This number is expected to increase by more than 50% in the next 20 years if preventive programs are not put in place. By 2030, some 438 million people, or 7.8% of the adult population, are projected to have diabetes. T2DM is the predominant form of diabetes worldwide and constitutes 85% - 95% of all diabetes. Obesity and overweight currently affect 15% and 20% of Spanish children, respectively. The NHANES study noted that with increasing overweight and obesity class, there is an increase in the prevalence of diabetes, from 2.4% for normal weight to 14.2% for obesity class 3. With normal weight individuals as a reference, individuals in obesity class 3 had an adjusted odds ratio of 5.1 (95% CI 3.7 to 7.0) for diabetes.

Impact of Obesity on Type 2

Diabetes The relative risk of T2DM increases as BMI increases above 23, and the association was found to be stronger in younger age groups in this study from the Asia-Pacific region. Weight gain in early adulthood is related to a higher risk and earlier onset of type 2 diabetes than is weight gain between 40 and 55 years of age. The risk of diabetes increases linearly with BMI; the prevalence of diabetes increased from 2% in those with a BMI of 25 to 29.9 kg/m2, to 8% in those with a BMI of 30 to 34.9 kg/m2, and finally to 13% in those with a BMI greater than 35 kg/m2. Although the prevalence of diagnosed diabetes has increased significantly over the last decade, the prevalence of undiagnosed diabetes and impaired fasting glucose (IFG) has remained relatively stable. More than generalized obesity, the risk of central obesity increases with increase in waist circumference (WC), waist-to-hip ratio, visceral adiposity, or abdominal obesity. In a review of 17 prospective and 35 cross-sectional studies in adults aged 18 - 74 years, either BMI or WC predicted or was associated with T2DM independently. Increase in BMI is a better predictor of diabetes than increase in weight. Prospective studies in non-diabetic overweight adults noted a 49% increase in the incidence of diabetes in 10 years for every 1 kg/year increase in body weight and similarly each kg of weight lost annually over 10 years was associated with a 33% lower risk of diabetes in the subsequent 10 years. Similar studies in Pima Indians reported that weight gain was significantly related to diabetes incidence only in those who were not initially overweight (BMI less than 27.3 kg/m2). Similarly, in the Behavioral Risk Factor Surveillance System (BRFSS) for 1991-1998, reported that every 1 kg increase in average self-reported weight was associated with a 9% increase in the prevalence of diabetes. Visceral fat seems to be strongly associated with an abnormal metabolic profile rather than

upper body subcutaneous fat. The National Institutes of Health uses WC to identify those at increased risk. Though both visceral adiposity (VAT) and subcutaneous fat are associated with adverse cardio metabolic risk factors, VAT remains more strongly associated with these risk factors.

Type 2 Diabetes Mellitus
International Scenario
T2DM, another obesity related disorder, is rapidly emerging as a global health care problem that threatens to reach pandemic levels very soon. According to and Third Report of National Cholesterol Education Programme (NCEP- III, 2001), as part of the metabolic syndrome, hypertension and diabetes are closely associated with obesity and frequently occur together in an individual. But little information exists on the relationship of BP levels with the subsequent development of T2DM. According to, T2DM, which is more prevalent (more than 90% of all diabetes cases) and the main driver of the diabetes epidemic, now affects 5.9% of the world's adult population with almost 80% of the total in developing countries. WHO has projected that the global prevalence of T2DM will become more than double from 135 million in 1995 to 300 million by the year 2025. Similar reports are also given by Wild *et al*. (2004) [6] stating that diabetes prevalence will be more than double from 171 million in 2000 to 366 million by 2030 with the prevalence rate of 4.4%. have estimated the world prevalence of diabetes among adults in the age group 20-79 years to be 6.4%, affecting 285 million adults. It is estimated to increase to 7.7%, affecting 439 million adults by 2030.

India, China and the United States had the highest respective prevalence of diabetes in 2000, and these three countries are also predicted to maintain their respective prevalence ranking in 2030. India will stand at number one with 79.4 million diabetic cases in 2030 as compared to the estimated 31.7 million in the year 2000. China had 20.8 million cases of diabetes in 2000 and is expected to have 42.3 million diabetic cases by the year 2030. In United States, the rate of diabetes will increase from 17.7 million in 2000 to 30.3 million in 2030. After India, China and United States, will come Indonesia occupying the same position in 2030 as occupied in the year 2000. There were 8.4 million people living with diabetes in 2000 and this number is expected to increase to 21.3 million in the year 2030. Pakistan was ranked at position six among the first 10 countries with the highest diabetic rates in the year 2000 but is expected to rank five after Indonesia in 2030 (Wild *et al*., 2004) [6]. With rapidly developing economies, India and china are likely to face an increasing health care burden related to diabetes as the prevalence of diabetes often rises dramatically with the economic development coupled with concomitant rise in obesity and sedentary life style (Hu, 2003: Charansonney and Despres, 2010) [7, 8]

National Scenario
India is the diabetes capital of the world with 41 million Indians having diabetes, every fifth diabetic in the world is an Indian (Joshi, 2005) [9]. According to the WHO estimates, India had 32 million diabetic subjects in the year 2000 and this number would increase to 80 million by the year 2030 (Wild *et al*., 2004) [6]. The International Diabetes Federation (IDF) also reported that the total number of diabetic subjects in India was 41 million in 2006 and that this would rise to 70 million by the year 2025 (Sicree *et al*., 2006) [10]. There is wide variation in the prevalence of diabetes in India. From the available region wise population based studies it is clear that in the last two decades, there has been a marked increase in the prevalence of diabetes among both urban as well as the rural Indians, with southern India having the sharpest increase. also confirmed the high prevalence of diabetes in urban south India.

An increasing trend in prevalence of diabetes is observed in the northern part of India since late 1960's, which has escalated from 2.9% in Chandigarh during 1966 to 23.5% in Jaipur during JHW-4. The crude prevalence of T2DM in southern Kerala was reported as 5.9%. They further reported that that the prevalence was highest in the urban (12.4%), followed by midland (8.1%), highland (5.8%), and coastal (2.5%) regions. The National Urban Diabetes Survey (NUDS) was a population based study conducted in six large cities from different regions of India. This study was done on 11,216 subjects aged over 20 years from all socio-economic strata. The WHO criterion was used for diagnosis diabetes after an Oral Glucose Tolerance Test using capillary blood. The study showed that the age standardized prevalence of T2DM was 12.1%. The prevalence was the highest in Hyderabad (16.6%), followed by Chennai (13.5%), Bengaluru (12.4%), Kolkatta (11.7%), New Delhi (11.6%) and Mumbai (9.3%) (Ramachandran *et al*., 2001). A prevalence of 10.3% has been reported in a slum area in Delhi, where 11.2% of males and 9.9% of females were diabetic. A prevalence of 4.58% in males and 2.66% in females of Mysore has been reported.

Types of Diabetes
The most common classes of diabetes are the type 1 and type 2 diabetes. Other forms of diabetes such as gestational, impaired glucose tolerance and diabetes related to malnutrition are relatively rare.

Type 1 Diabetes
It is also called as insulin dependent diabetes mellitus. It is an autoimmune disorder, in which there is loss of pancreatic beta cells, resulting in insulin deficiency. Approximately 10% of the diabetic cases are affected by type 1 diabetes. It is also termed as juvenile diabetes, because the onset of type 1 diabetes occurs at an early age, specifically affecting children. Patients with type 1 diabetes are supplemented daily with insulin in order to control the blood glucose level.

Type 2 Diabetes
It is also called as non-insulin dependent diabetes mellitus which accounts for more than 90% of the diabetic cases. It is often associated with obesity in which the cells do not respond to the insulin action. Type 2 diabetes was believed to have its onset only after 40 years, but recent studies have diagnosed it in young people too. Insulin administration is not mandatory in type 2 diabetic patients for survival, but they may become insulin dependent at advanced stages of the disease (Bennett, 2000).

Results
Assessment of Overweight and Obesity
In the present study, prevalence of overweight and obesity in pre- and postmenopausal women was computed using WHO (2000) criteria of BMI. Subjects having BMI less than 23 kg/m2 were considered as non-obese and those with BMI above 23 kg/m2 as overweight/obese. The distribution of subjects according to BMI classification has been presented in Table 1. In pooled data of 595 subjects, 14.29% females

were non-obese and 85.71% were overweight and obese. Out of 330 (55.46%) premenopausal women, 17.58% (58) were non-obese and 82.42% (272) were overweight and obese. Similarly, out of 265 (44.54%) postmenopausal women, only 10.20% (27) women were non-obese, whereas, 89.81% were overweight and obese. On comparison between pre- and postmenopausal women, it was observed that the prevalence of overweight/obesity was significantly higher ($\chi2$ =6.55, df =1, p>0.05) in post-menopausal woman as compared to premenopausal women.

Table 1: Percentage Prevalence of Overweight/ Obesity in Non-Obese and Overweight/Obese Premenopausal (Pre-M) and Postmenopausal Women (Post-M)

Category	No. of subjects	Non-Obese	Overweight / Obese
Pre-M	330	17.58(58)	82.42(272)
Post-M	265	10.20(27)	89.81* (238)
Total	595	14.29 (85)	85.71 (510)

*Chi Square ($\chi2$)=6.55, df=1, p<0.05

Assessment of Type 2 Diabetes Mellitus
Table 2 present the percentage prevalence of Type 2 Diabetes Mellitus (T2 DM) in the pre- and postmenopausal women. In the pooled data (595), 11.26% (67) women were observed as diabetic and 88.74% (528) as non-diabetic. When assessed separately, it was noticed that in premenopausal women, 8.48% (28) subjects were diabetic, whereas, 91.51% (302) as non-diabetic. Similarly, in postmenopausal women, the proportion of diabetic and non-diabetic subjects was observed as 14.72% (39) and 85.28% (226), respectively. It is evident from this table that the prevalence of diabetic subjects was 6.24% higher in postmenopausal women as compared to premenopausal women and difference between the two groups was statistically significant ($\chi2 = 5.18$, df=1, p<0.05).

Table 2: Percent Prevalence of Type 2 Diabetes Mellitus in Premenopausal (Pre-M) and Postmenopausal Women (Post-M)

Category	Diabetes	Non-Diabetes	Chi Square
Pre-M (330)	8.48(28)	91.51 (302)	5.18
Post-M (265)	14.72 (39)	85.28 (226)	df=1, p<0.05
Total	11.26 (67)	88.74 (528)	

Conclusion
Obesity is one of the most serious public health problems of the 21st century. It is a complex multifactorial disorder prevalent in both developed and developing countries that affect children and adult alike. Indeed, overweight and obesity are now so common that in many environments they are replacing more traditional public health concerns such as under nutrition and infectious diseases as among the most significant causes of ill health. Even in countries like India which are typically known for high prevalence of under nutrition, significant proportion of overweight and obesity now co-exist with the under nurished. At all ages and throughout the world, women are generally found to have a higher mean body mass index (BMI) and higher rates of obesity than men for biological reasons. Literature reports that obesity, an increasingly prevalent and difficult-to-treat condition, affects more women than men, particularly postmenopausal women. The prevalence of obesity and related co-morbidities like hypertension and type 2 diabetes mellitus (T2DM) become higher after menopause. It is evident from literature that numerous hormones and cytokines play a key role in the pathogenesis and complications of obesity in adults.

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