Prediabetes: A study of its Prevalence and its Association with the Anthropometric Variables in Adult Population of Lucknow – A Hospital Based Cross Sectional Study

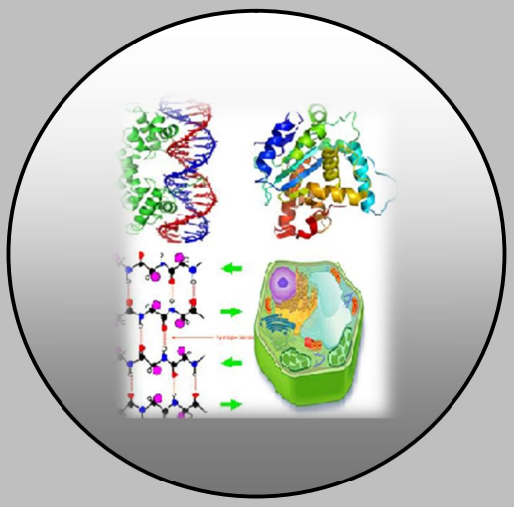
By

Abhishek Arun, Shweta Sehgal, Farah Khan, M.M. Khan, Sandeep Gupta and Shashank Tiwari

ISSN 0970-4973 (Print)
ISSN 2319-3077 (Online/Electronic)

Volume 30
No.1 (2013)

J. Biol. Chem. Research
Volume 30 (1) 2013 Pages No. 329-346



Journal of Biological and Chemical Research

(An International Journal of Life Sciences and Chemistry)

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 30, No. 1: 329-346 (2013)
(An International Journal of Life Sciences and Chemistry)

ISSN 0970-4973 (Print)
ISSN 2319-3077 (Online/Electronic)
Published by Society for Advancement of Science®

http:// www.jbcr.in
jbiolchemres@gmail.com
info@jbcr.in

RESEARCH PAPER
Received: 10/03/2013 Revised: 22/04/2013 Accepted: 23/04/2013

Prediabetes: A study of its Prevalence and its Association with the Anthropometric Variables in Adult Population of Lucknow – A Hospital Based Cross Sectional Study

Abhishek Arun,[*] Shweta Sehgal,[**] Farah Khan,[***] M.M. Khan,[**] Sandeep Gupta[****] and Shashank Tiwari[****]

[*]Department of Community Medicine, Era's Lucknow Medical College and Hospital, Lucknow, U.P. India
[**]Department of Physiology, Career Institute of Medical Sciences and Hospital, Lucknow, U.P. India
[***]Department of Prosthodontics, Kothiwal Dental College and Research Centre, Moradabad, U.P. India
[****]M.V. Hospital and Research Centre, Lucknow, U.P. India

ABSTRACT

The aim of study is to find out the prevalence of 'impaired fasting glucose' or Pre-Diabetes in a population reporting to a tertiary care center of Northern India in Lucknow and correlate it with other variables like age, weight, body mass index, waist circumference, and waist-hip ratio.

It was a cross-sectional study carried out on consecutive subjects attending the OPD of M.V. Hospital and Research Centre, a tertiary care center located in Lucknow, India. A diagnosis of impaired fasting glucose (IFG) was made as per the American Diabetes Association (ADA) guidelines. Data was analyzed using unpaired't' test and Pearson's Chi-square test to assess whether the inter-group difference was significant or not. A p - value of < 0.05 was considered significant.

The prevalence of impaired fasting glucose in the studied population was found to be 19.5%.There was minor difference between the sexes. A higher prevalence was seen with advancing age. A significantly higher prevalence was found amongst higher body weight persons, as per expectations.

Contd.....

No significant correlation was found with body mass index, but the prevalence of impaired fasting glucose increased with increasing waist circumference and showed a significant correlation with increasing waist-hip ratio.

Study showed that the prevalence of impaired fasting glucose is very high in Lucknow, India. The traditional risk factors like high total body weight and body mass index are not very good predictors for the development of Diabetes Mellitus in the rural/semi-urban populations. In fact, high total body weight might prove to be a stronger predictor of impaired fasting glucose along with high waist-hip ratio.

Key words: ***Pre-diabetes, Impaired fasting glucose, Body Mass Index, Waist-hip Ratio and High Body Weight.***

INTRODUCTION

The term Diabetes Mellitus describes a metabolic disorder of multiple aetiology characterized by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both. The effects of Diabetes Mellitus include long–term damage, dysfunction and failure of various organs. Several pathogenetic processes are involved in the development of Diabetes. These include processes which destroy the beta cells of the pancreas with consequent insulin deficiency, and others that result in resistance to insulin action. The abnormalities of carbohydrate, fat and protein metabolism are due to deficient action of insulin on target tissues resulting from insensitivity or lack of insulin (Nathan et al. 2007).

Diabetes represents a spectrum of metabolic disorders, which has become a major health challenge worldwide (Nathan et al. 2007).

It is predicted by the World Health Organization that India would contribute nearly 57 million people to the global burden of Diabetes by the year 2025 (Nathan et al. 2007). Recent reports suggest that these figures are based on conservative estimates and do not include rise in Diabetes-related risk factors like obesity and aging of the population. Hence, the original numbers projected may be too low and the actual figures may be around 80 million by the year 2030.

Diabetes is fortunately one of the most preventable of all non-communicable diseases. Primary prevention strategies can be formulated based on the known risk factors for Diabetes. However, as the risk of diabetes varies between different ethnic groups (Nathan et al. 2007 and American Diabetes Association, 2010), it is possible that the risk factors could also differ between different populations. Hence, it is necessary to have population-based data in different regions of the world to identify the risk factors for Diabetes. This forms the basis of the present study where we have attempted to determine the risk factors for diabetes in native Indians, who are considered to be at high risk for Diabetes (Boyle et al. 2001).

The Diabetes Atlas published by the International Diabetes Federation shows that India currently leads the world in number of people with diabetes and is currently home to over 40 million Diabetic subjects.

These numbers are predicted to increase to 69 million by 2025 (Nathan et al. 2007). Furthermore, India occupies the second position with respect to the number of subjects with impaired glucose tolerance (IGT) (Nathan et al. 2007). The above data has been compiled from several cross sectional studies done in various parts of India. However, to date, there is no longitudinal study on the incidence of Diabetes or IGT in India.

This paper reports on an eight year follow up study and presents the first incidence data on Diabetes and Pre-diabetes from India.

Pre-diabetes (Meigs et al. 2003) is a condition that has been projected as a precursor to Diabetes. It refers to a state of impaired glucose tolerance, or, impaired fasting glucose either singly or in combination. Pre-diabetes can be diagnosed by blood sugar test such as fasting plasma glucose (FPG)and oral glucose tolerance test (OGTT).Patients with IFG and/or IGT are referred to as having 'Pre-diabetes', recently reclassified as 'categories of increased risk for Diabetes' by the ADA position statement 'Standards of Medical Care in Diabetes', released in 2010(Shaw et al. 1999).

The purpose of this is obvious. It seeks to erase the impression of 'inevitable progression to Diabetes' associated with the term 'Pre-diabetes' and generate hope for reversibility to normo glycaemia. Hence, this group is an important target for vigorous intervention for primary prevention of Diabetes.

Pre-diabetes is a common disorder in most populations. The reported prevalence of Pre-diabetes appears to vary among populations with different ethnic background. 314 million people are currently affected with Pre-diabetes all over the world, and by 2025, it is estimated that approximately 500 million people will have Pre-diabetes(Coutinho et al. 1999).The current estimates are that up to 70% of Pre-diabetic subjects eventually get Diabetes.

Importance of pre-diabetes in India

As the prevalence of and progression to Diabetes continues to increase in India, Diabetes related morbidity and mortality have emerged as major public healthcare issues. Diabetes related damage in small blood vessels can lead to blindness, kidney failure, and amputation. Damage to larger blood vessels can result in heart disease, high blood pressure, and stroke (Sadikot et al. 1999). In fact, impaired fasting glucose and impaired glucose tolerance are also independently associated with increased risk of cardiovascular events (Ramaiya et al. 1990 and Mohan et al. 2001). The occurrence of Diabetes in Indians is almost a decade earlier than in the Western population (Mehta et al. 2009, Mohan et al. 2006 and Flegal et al. 1999-2000). Hence, most of the patients are from the economically productive age group. Moreover, the treatment cost of Diabetes in an economically backward family may drain as much as 25% of the entire income for each person with Diabetes (Dunstan et al. 2004 and Menon et al. 2006).

This information clearly dictates that clinicians must intervene at the Pre-diabetic stage to prevent development of Diabetes and a host of complications rather than ignoring Pre-diabetes. Insufficient studies on Pre-diabetes in Central India and high projected prevalence and high conversion rate of Pre-diabetes to Diabetes (70%) generates the rationale behind the research.

Aims and objectives

1**.** To determine the prevalence of Pre-diabetes.
2. To determine the risk factors associated with Pre-diabetes.
3. To suggest ways and measures to prevent development of Type 2 Diabetes Mellitus.
4. To determine the association of Pre-diabetes with BMI, Weight, WHR etc.

The progression of Pre-diabetes to type 2 Diabetes has been examined in a number of populations with varying results. In general, epidemiological studies indicate that ~ 25% of subjects with IFG or IGT progress to type 2 Diabetes in 5 years, whereas about ~ 50% remain Pre-diabetic and 25% revert to normal (Liao et al. 2001). In an 11 year follow-up study among adults with IGT in Mauritius, 46% developed Diabetes, 28% remained unchanged, and 26% reverted to normal. Those with the combination of IFG and IGT develop type 2 Diabetes at approximately twice the rate (Levitan et al. 2004) as do individuals who manifest a single abnormality. In comparison with adults who have normal glucose tolerance, people with impaired fasting glucose have a two to three fold increased prospective risk of cardiovascular events, which is most marked in younger subjects.

The first national study on the prevalence of type 2 Diabetes in India was done between 1972 and 1975 by the Indian Council Medical Research (ICMR, New Delhi). Screening was done in about 35,000 individuals above 14 yr of age, using 50 g glucose load. Capillary blood glucose level >170 mg/dl was used to diagnose diabetes. The prevalence was 2.1 % in urban population and 1.5 percent in the rural population while in those above 40 yr of age, the prevalence was 5 percent in urban and 2.8 % in rural areas (Sadikot et al. 1999).
Subsequent studies showed a rising trend in the prevalence of Diabetes across different parts of India. In 1988, a study done in a small township in South India reported a prevalence of 5 per cent (Ramaiya et al. 1990). The prevalence of impaired glucose tolerance in the same study was 2 percent. A National Rural Diabetes Survey was done between 1989 and 1991 in different parts of the country in selected rural populations. This study which used the 1985 WHO criteria to diagnose Diabetes, reported a crude prevalence of 2.8 percent (Mohan et al. 2007).The Eluru survey which looked at the prevalence of known Diabetes in four villages in Andhra Pradesh showed a prevalence of 1.5 percent. The prevalence of known Diabetes was 6.1 percent in individuals aged above 40 yr which was unexpectedly high at that time for a rural area with low socio-economic status and decreased health awareness (Mehta et al. 2009).

A study done in 1988 in Chennai reported a prevalence of 8.2 percent in the urban and 2.4 % in the rural areas (Mohan et al. 2006).

A subsequent study in the same urban area done after five years showed an age standardized prevalence of 11.6 percent indicating a rising trend in prevalence of Diabetes. A very high prevalence of 16.3 percent was reported in Thiruvanathapuram in Kerala State in the year 1999.In the same year, a prevalence of 8.2 percent was reported from Guwahati (Flegal et al. 1999-2000).

The National Urban Diabetes Survey (NUDS), a population based study was conducted in six metropolitan cities across India and recruited 11,216 subjects aged 20 yr and above representative of all socio-economic strata. An oral glucose tolerance test was done using capillary glucose and Diabetes was defined using the WHO criteria. The study reported that the age standardized prevalence of type 2 Diabetes was 12.1 percent. This study also revealed that the prevalence in the southern part of India to be higher-13.5 percent in Chennai, 12.4 percent in Bangalore and 16.6 percent in Hyderabad; compared to Eastern India (Kolkata), 11.7 percent; Northern India (New Delhi), 11.6 percent; and Western India (Mumbai), 9.3 percent. The study also suggested that there was a large pool of subjects with impaired glucose tolerance (IGT), 14 percent with a high risk of conversion to Diabetes. A study done in Western India showed age standardized prevalence of 8.6 percent in urban population (Flegal et al. 1999-2000).

A more recent study reported a high prevalence (9.3%) in rural Maharashtra. The Amrita Diabetes and Endocrine Population Survey (ADEPS), a community based cross-sectional survey done in urban areas of Ernakulam district in Kerala has revealed a very high prevalence of 19.5 percent (Dustan et al. 2004).

Further support for the rising prevalence of diabetes comes from the results obtained from the Chennai Urban Rural Epidemiology Study (CURES). This study was conducted on a representative population of Chennai. The sampling for CURES was based on the model of systematic random sampling, wherein of the 155 wards of the corporation of Chennai, 46 were selected to represent all the 10 zones. A total of 26,001 individuals were selected from these 46 wards for the Phase 1 of CURES and a fasting capillary glucose measurement was obtained in all. Phase 2 focussed on the study of complications of Diabetes in the self-reported Diabetic subjects identified in Phase 1, while Phase 3 recruited every tenth subject (n=2600) screened in Phase 1 for an oral glucose tolerance test. Phase 3 had a response rate of 90.4 percent (*i.e.*, 2350 / 2600 subjects participated).This study gave us a unique opportunity to compare prevalence rates of Diabetes in Chennai city which is the only region in India that has had repeated well-conducted epidemiology studies on prevalence of Diabetes over the past two decades. We were thus able to compare the data obtained from CURES with three earlier epidemiological studies carried out in the same city using similar methods (Menon et al. 2006).

The overall crude prevalence of Diabetes using WHO criteria in CURES was 15.5 percent (age standardized: 14.3%), while that of IGT was 10.6 percent (age-standardized: 10.2%).

From 1989 to 1995, the prevalence of Diabetes in Chennai increased by 39.8 % (8.3 to 11.6%); between 1995 to 2000 by 16.3 percent (11.6 to 13.5%) and between 2000 to 2004, by 6.0 percent (13.5 to14.3%). Thus within a span of 14 yr, the prevalence of Diabetes increased significantly by 72.3 percent (Menon et al. 2006).

Urban rural differences in the prevalence of Diabetes has been consistently reported from India. While the ICMR study reported that the prevalence was 2.1 percent in urban and 1.5 percent in rural areas, a later study showed that the prevalence was three times higher among the urban (8.2%) compared to the rural population (2.4%) (Coutino et al. 1999). A study done in Southern Kerala looked at the variations in the prevalence of type 2 Diabetes among different geographic divisions within a region. The prevalence of Diabetes was the highest in the urban (12.4%) areas, followed by the midland (8.1%), highland (5.8%) and coastal division (2.5%).The prevalence of Diabetes in India study (PODIS): This study was carried out in 108 centres (49 urban and 59 rural) to look at the urban-rural differences in the prevalence of type 2 Diabetes and glucose intolerance. Capillary blood was used to estimate glucose levels and glucose intolerance was defined according to the WHO 1999 as well as the American Diabetes Association (ADA) 1997 criteria. According to the ADA criteria, the prevalence of Diabetes was 4.7 percent in the urban compared to the 2.0 per cent in the rural population while the prevalence of Diabetes according to the WHO criteria was 5.6 and 2.7 percent among urban and rural areas respectively (Clara, 2006).

In order to obtain continuous surveillance of NCD risk factors in India, the WHO and the ICMR took up NCD Risk Factor Surveillance in five States of India, representing different geographical locations (North, South, East, West and Central India). About 40,000 individuals aged 15 to 64 yr with equal representation from urban, peri-urban (slum) and rural areas were recruited for the study. The overall frequency of self-reported Diabetes study was 4.5 percent. Urban area had the highest prevalence (7.3%), followed by peri-urban/slum (3.2%) and rural areas (3.1%) (Padmini et al. 2008).

MATERIALS AND METHODS

The study will be a cross-sectional in design, spread over a period of 3 months – October to December, 2012. We included subjects attending the Medicine Out-patient department of M.V. Hospital and Research Centre, Lucknow. This is a tertiary care centre, catering to a pre-dominantly rural and semi-urban population. 200 eligible subjects of both genders were enrolled consecutively and prospectively for the study. Fasting plasma glucose measurement was used as the screening test for the diagnosis of Pre-diabetes, as recommended by the ADA 2004 guidelines. The FPG was preferred because it was easier and faster to perform, convenient, acceptable to patients and less expensive. The oral glucose tolerance test although considered the 'gold standard, 'was more costly and time consuming than the FPG test and was less reproducible. The prevalence of impaired fasting glucose was determined using the American Diabetes Association guidelines. Weight, body mass index (BMI), waist circumference (WC), and waist-hip ratio (WHR) of all the participants were recorded.

Inclusion criteria
The subjects who are aged ≥18 years and willing to participate in the study.

Exclusion criteria
The subjects with a history of Diabetes Mellitus, tuberculosis, chronic asthma, Addison's disease, acquired adrenal insufficiency, acquired hypo pituitarism, patients on long-term corticosteroid therapy, diuretics were excluded from the study.

Sampling technique
A cross-sectional in design, spread over a period of 3 months i.e. from October to December, 2012.

Tools of investigation
We used a pre-tested questionnaire that explored demographic details, past history and family history of disorders, diet pattern, physical activity and socio-economic status. An informed written consent was obtained prior to data collection. We asked additional questions to the key informant of each household to assess the socio-economic status of the households. Anthropometric measurements and blood pressure of each participant was recorded. Trained paramedical staff collected fasting blood samples from all participants for estimation of fasting plasma glucose.
The total body weight was taken by a weighing machine with the participants wearing indoor clothes without shoes. The body mass index was calculated according to the formula: weight (in kg) / height (in metre^2). The waist circumference was measured at the level of the last rib after expiration. Hip circumference was taken at the level of maximum diameter of the hips as viewed from the side. The waist-hip ratio was calculated as waist circumference / hip circumference. After this, the subjects were motivated to come the next day to the central pathology laboratory of the hospital after overnight fasting for blood sample collection.

The American Diabetes Association (ADA) criteria for diagnosis of Pre- diabetes based on expert committee recommendations 2 are as follows:

- FPG =100 - 125 mg/dl (5.6 - 6.9 mmol/l) = impaired fasting glucose (IFG)
- 2-h post-load glucose = 140 - 199 mg/dl (7.8 - 11.1mmol/l) = impaired glucose tolerance (IGT);
- HbA1c of 5.7 - 6.4% (this has been recently added).

Obesity and abdominal obesity was defined using the revised criteria for Asian Indians:
Normal range: BMI 18.5 -24.9 Kg/m2
Underweight: BMI < 18.5 Kg/m2
Normal BMI: 18.50–24.99 Kg/m2

Overweight at risk: BMI ≥25 Kg/m2,
Pre-Obese: BMI 25 - 29.9 Kg/m2,
Obese class I: BMI 30 – 34.90 Kg/m2,
Obese class II: BMI 35 -39.90 Kg/m2,
Obese class III: BMI ≥ 40 Kg/m2 for both males and females,

Abdominal obesity - waist circumference ≥ 102 cm for males and ≥ 88 cm for females

For estimation of **blood pressure** we used mercury sphygmomanometer (Diamond Deluxe BP apparatus, Pune, India).The cuff of the BP apparatus was tied round the right upper arm with the patient in sitting posture. The cuff is inflated and then deflated to give the systolic and the diastolic BP. The measurement was repeated twice more with an interval of 5 minutes in between. Thus there were three BP recordings for each participant.
The first recording was discarded. The averages of latter two recordings were then used for calculating average systolic and average diastolic blood pressure.

JNC 7 classification for blood pressure:

Category	SBP mmHg	DBP mmHg
Normal	<120	<80 mmHg
Pre hypertension	120–139	80–89 mmHg
Hypertension, Stage 1	140–159	90–99 mmHg
Hypertension, Stage 2	≥160	≥100 mmHg

Sample size and statistical analysis

$n= (z\alpha^2 p.q/d^2)$

Where:

$z\ \alpha$ =1.96 (5 % type one error)
n=sample size
p=prevalence
q=100-p
d=allowable error i.e. X % of p

Prevalence is taken as 14.4% (13) and the value of allowable error is 20%.
Sample Size= $(1.96)^2$. (14.4). $(100-14.4)/5^2$
= 200 (including data loss)

Data processing and statistical analysis

Data was entered, compiled in the computer and analyzed using Pearson's Chi-square test and students unpaired 't' test to assess if the inter-group difference was significant or not. A p-value of < 0.05 was considered significant.

RESULTS

Out of 200 eligible subjects, all 200 subjects were actually studied (response rate: 100%).This included 50.5% males and 49.5% females.

The prevalence of impaired fasting glucose in population reporting to tertiary care centre was found to be 19.5% and 18.81% pre-diabetics were found among males and 20.2% among females. Among males, the highest percentage of pre-diabetics was found in the 50-59 years age group and lowest among 20 – 29 years age group, whereas in females the highest percentage was found in the >60 years age group and lowest among the 20 – 29 years and above 30 – 39 years age group (Table I and Fig. 1). Similarly, the highest percentage of pre-diabetics among males and females was found in the weight group 61 - 70 kg respectively. The lowest percentage among both males and females was in the weight group above 71 kg (Table II, Fig. 2).

Table 1. Prevalence of IFG according to age and sex.

Table 1.1 Prevalence of prediabetes amongst male patients attending OPD services at MVH&RC.

Age group(Males)	Males	No. of Pre Diabetics	Percentage
20-29	18	1	5.55
30-39	15	3	20
40-49	17	2	11.76
50-59	23	6	26.08
≥60	28	7	25
Total	101	19	18.81

Figure. 1

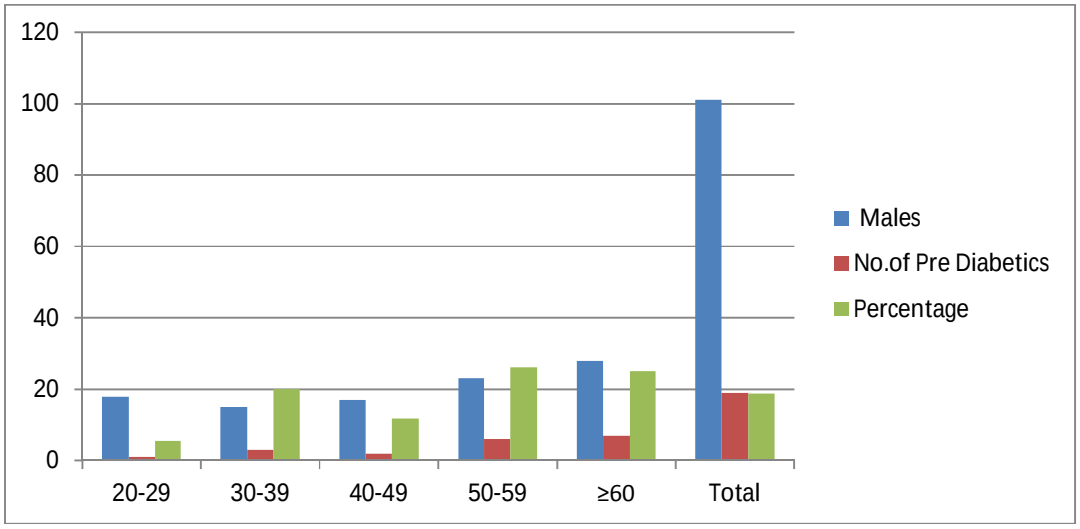


Table 1. 2. Prevalence of pre-diabetes amongst female patients OPD services at MVH&RC.

Age group	Female	No.of Pre Diabetics	Percentage
20-29	12	2	16.67
30-39	24	4	16.67
40-49	26	6	23.07
50-59	22	4	18.18
≥60	17	4	23.52
Total	99	20	20.2

Significant difference was found in the prevalence of impaired fasting glucose among subjects of weight group below 51 kg compared to subjects of weight group 51 kg and above (p value < 0.05) (Table III).

Figure. 2

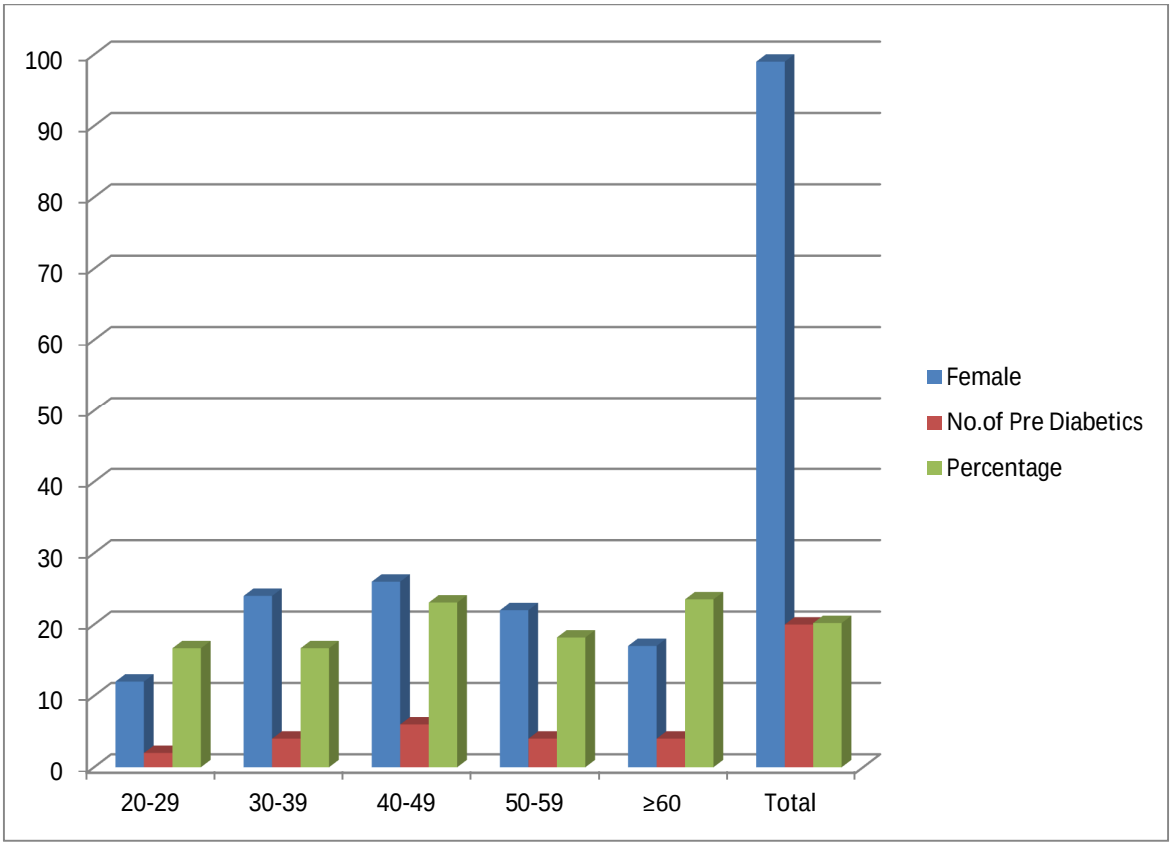


Table 2. Prevalence of IFG according to TBW (total body weight).

Table 2.1. Prevalence of IFG according to TBW (total body weight) amongst males.

Wt. in Kg	Males	No. of pre-diabetes	Percentage
31-40	8	1	12.50%
41-50	12	6	50%
51-60	28	4	14.28%
61-70	32	7	21.80%
above 71	21	1	4.76%
total	101	19	18.81%

Figure. 3

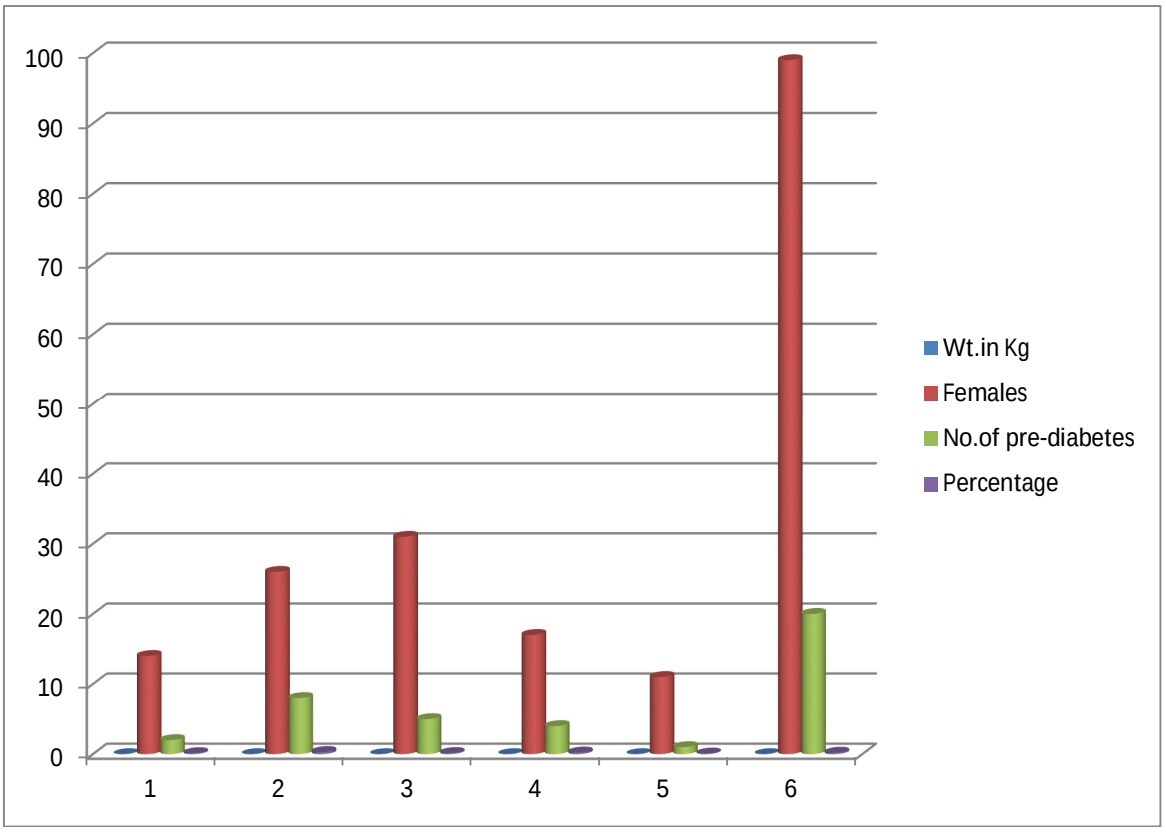


Table 2.2. Prevalence of IFG according to TBW (total body weight) amongst females.

Wt. in Kg	Females	No. of pre-diabetes	Percentage
31-40	14	2	14.28%
41-50	26	8	31%
51-60	31	5	16.12%
61-70	17	4	23.52%
above 71	11	1	9.09%
total	99	20	20.20%

Figure. 4

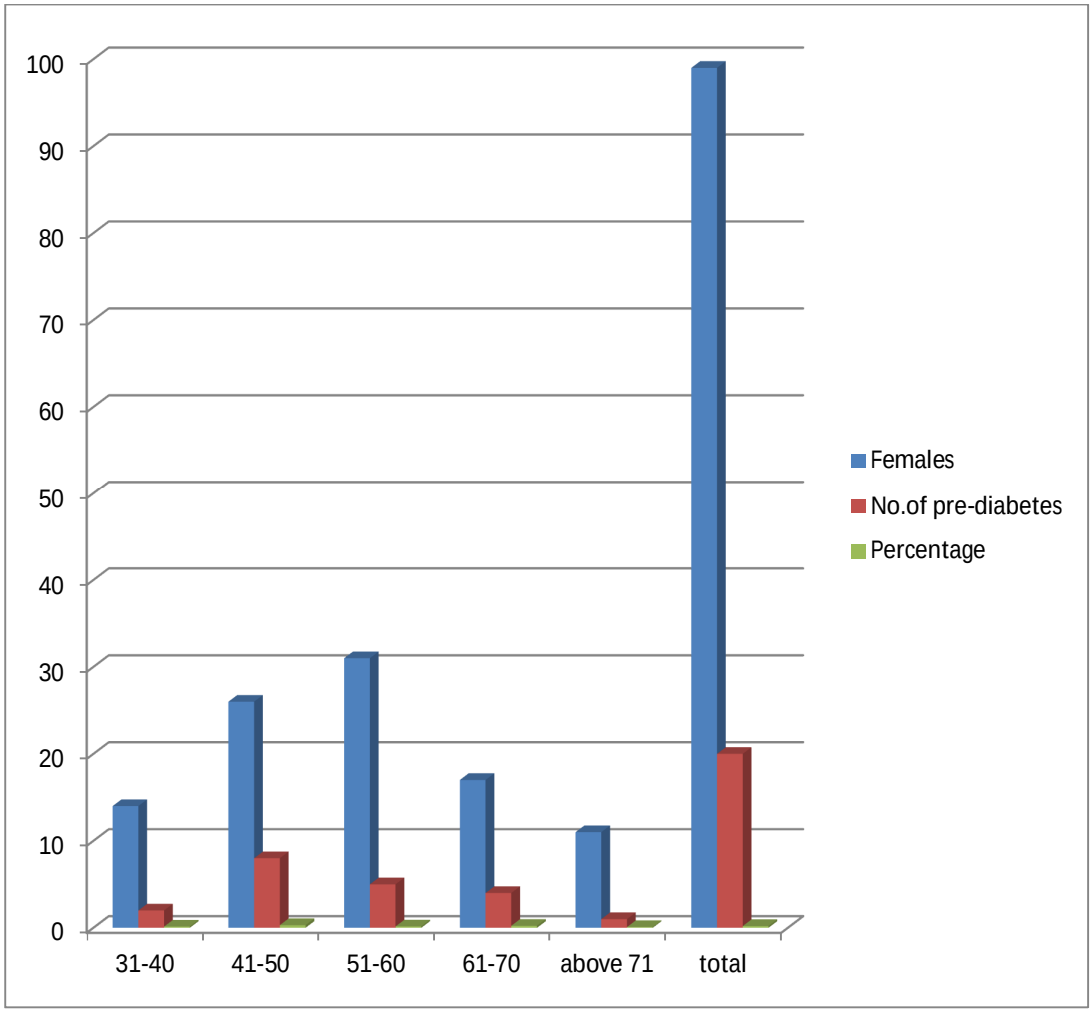


Table 3. Prevalence of IFG according to anthropometric variables.

Anthropometric Parameters	Pre-diabetics	Non pre-diabetics	p-value
MEAN BMI	19.2+2.8	20.1+2.6	0.1926
MEAN WC	82+1.6	81+1.2	0.1482
MEAN WHR	1.30+0.08	0.9+0.08	0.0234

BMI = Body mass index; WC = Waist circumference; WHR = Waist-hip ratio

Figure. 5

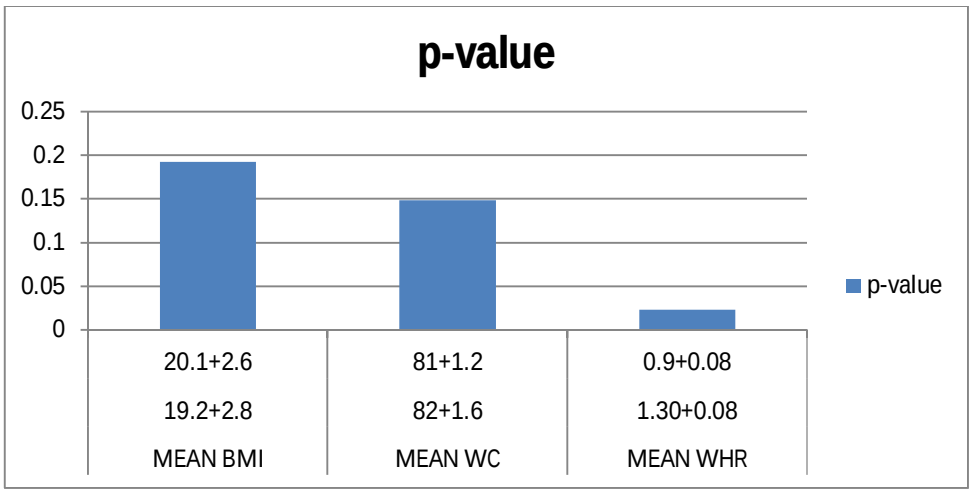


Table 4. Prevalence of IFG according to various variables.

Table 4.1. Prevalence of IFG according to weight group.

Weight group	Pre-diabetics	Non pre-diabetics
less than 51 kg	17	62
51kg and above	22	99

p-value <0.05

Table 4.2. Prevalence of IFG according to sex.

Sex	Pre-diabetics	Non pre-diabetics
Male	19	82
Female	20	79

p-value >0.05

Figure. 6

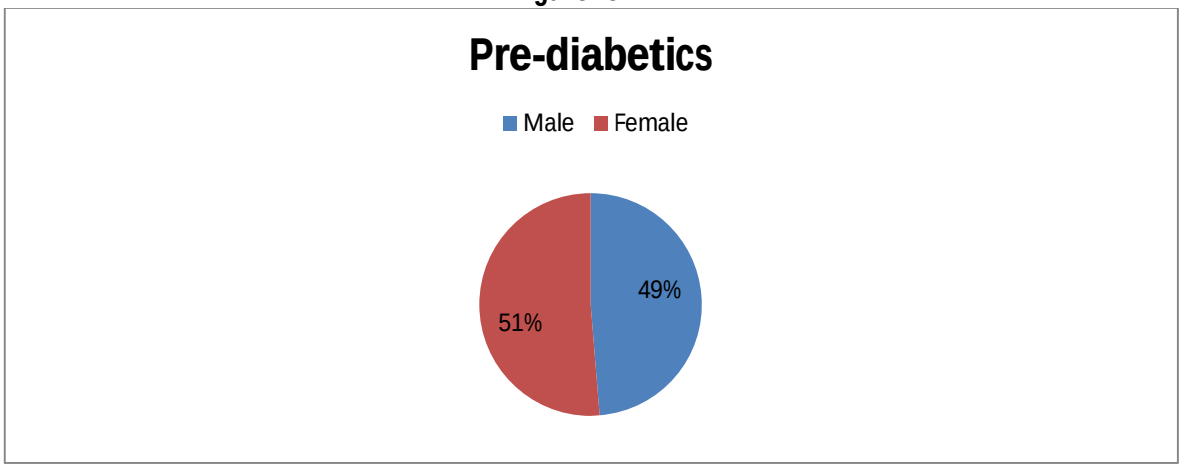


Table 4. 3. Prevalence of IGT according to age group.

Age group	Pre-diabetic	Non-pre diabetic
less than 46years	15	100
46 years and above	24	61
		p-value >0.05

No significant difference was found in the prevalence of pre-diabetics among men and women (p value > 0.05). Similarly, difference in prevalence of impaired fasting glucose (IFG) in the age group below 46 yrs compared to 46 yrs and above age group was non-significant (p-value > 0.05) (Table III). The mean BMI and mean WC were not found to be significantly different between the IFG and the normal populations. The mean WHR was found to be significantly higher in the pre diabetic population (1.30) compared to the non-Pre-diabetic population (0.9).

DISCUSSION

The prevalence of impaired fasting glucose varies from study to study throughout the world. A study from the USA indicated that the prevalence of impaired fasting glucose in an adult population was nearly 26% (Flegal et al. 2002). This was much higher than the prevalence found in our study (19.5%). The **Australian Diabetes Obesity and Lifestyle Study** (Dunstan et al. 2004) reported the prevalence of impaired fasting glucose to be 16.4%, which is slightly lower to the prevalence found in our study. As compared to our study, a lower prevalence of 11.2% was found in the **Amrita Diabetes and Endocrine Population Survey (ADEPS**) (Menon et al 2006), which was a community-based cross-sectional survey done in urban areas of **Ernakulam** district in **Kerala**.

A study in a developing rural area of **Andhra Pradesh** reported the prevalence of impaired fasting glucose (IFG) to be 15.5% which was lower as compared to our results (Clara, 2006).

The **USA study** also showed that the prevalence of impaired fasting glucose was significantly higher in males, whereas in our study we have found no significant difference in prevalence of impaired fasting glucose among males and females which is in agreement with the study of (Shaw *et al.1999*), who also reported that prevalence of impaired fasting glucose (IFG) was similar among males and females. In a study carried-out in a rural population of Tamil Nadu, the crude prevalence of IFG was 12.1% (Padmini et al, 2008), which was slightly lower than the prevalence found in our study. This is probably because of the purely rural setting against semi-urban in our study. They also found a significantly higher prevalence amongst men as compared to women. The anthropometric findings in this study were quite similar to ours. The overall body mass index was within the normal range, though there was significant rise in the prevalence of impaired fasting glucose with increasing body mass index. The waist circumference in most of the subjects was in the normal range, but waist-hip ratio was strongly correlated with rising prevalence of impaired fasting glucose, just like in our study.

The findings of our study were at variance from 'The Kolkata Policeman Study' (Kumar et al. 2008). The authors had found a prevalence of impaired fasting glucose to be only 6.2%. There was a strong correlation with waist circumference and waist-hip ratio but no significant correlation with body mass index, just like in our study. The overall body mass index in the Kolkata Policeman study was much higher (mean body mass index 23.87 ± 2.83 in IFG group) than in our study (19.2 ± 2.8). This could be because the income of policemen is significantly higher than the predominantly agrarian population studied by us. The variation in the results of different studies on impaired fasting glucose is probably due to difference in cultural factors, genetic factors, lifestyle habits, ethnic variations, rural urban variations, selection of different age groups. The notable finding in our study was the significantly higher prevalence of IFG among the low body weight population, raising the possibility of a higher prevalence of insulin deficient state than previously suspected.

The relationship between obesity and poverty is a complex one. In developing countries like India, the paradoxical finding is of underweight children and overweight adults. It has been postulated that intrauterine growth retardation leads to the acquisition of a '**thrifty gene'** which causes the small babies to have rapid weight gain in early adulthood. The fat distribution has been consistently found to be concentrated around the abdomen, even though the bony frame remains smaller.

Various studies have demonstrated that diabetes in the Indian population has several unique features (Ramachandran et al. 2006). These include a younger age of onset (almost a decade earlier than other populations), a relatively low body mass index, higher intra-abdominal fat, high rates of insulin resistance and a high prevalence of insulin deficiency as evidenced by more patients requiring insulin therapy and at a younger age.

The diabetes 'explosion' in India has been explained by the '**Thrifty Gene Hypothesis**' and the '**Yajnik Paradox'** (Yajnik et al. 2004).

Limitations of the study

The major limitation of the present study is that it was a hospital-based study and therefore may not represent the true status of the prevalence of impaired fasting glucose (IFG) in the general population. The postulated correlation of high body weight with insulin deficient state could not be confirmed in our study due to financial constraints. It would be helpful to find out the level of serum insulin in low body weight subjects showing impaired fasting glucose to predict the future development of Diabetes.

To conclude, this study revealed that the prevalence of impaired fasting glucose in northern India is high (19.5%) and is an under-diagnosed condition. 39 out of 200 individuals attending the out-patient department at M.V. Hospital are Pre-diabetics, indicating a need for greater emphasis on the early detection and timely intervention in order to effectively contain the diabetes epidemic. The traditional risk factors like total body weight and body mass index are not very good predictors for development of diabetes mellitus in the rural/semi-urban populations.

In fact, high total body weight might prove to be a strong predictor of impaired fasting glucose along with high waist-hip ratio.

So, this study showed that the prevalence of impaired fasting glucose is very high in Lucknow, India. The traditional risk factors like high total body weight and body mass index are not very good predictors for the development of Diabetes Mellitus in the rural/semi-urban populations. In fact, high total body weight might prove to be a stronger predictor of impaired fasting glucose along with high waist-hip ratio**.**

ACKNOWLEDGEMENTS

We are thankful to the Director, *M.V. Hospital and Research Centre, Lucknow,* for providing facilities for conducting work presented in this research paper.

REFERENCES

Nathan, D.M., Davidson, M.B. and Defronzo, R.A. 2007. Impaired fasting glucose and impaired glucose tolerance. *Diabetes Care*; 3:753-8.

American Diabetes Association: Standards of medical care in diabetes - 2010 (Position Statement). *Diabetes Care*; 33 (Suppl1): S11-S61.

Boyle, J.P., Honeycutt, A.A. and Narayan, K.M. 2001. Projection of diabetes burden through 2050. *Diabetes Care*; 24: 193-640.

Meigs, J.B., Muller, D.C. and Nathan, D.M. 2003. The natural history of progression from normal glucose tolerance to type 2 diabetes in the Baltimore Longitudinal Study of Aging. *Diabetes*; 52:1475-84.

Shaw, J.E., Zimmet, P.Z. and De Courten, M. 1999. Impaired fasting glucose or impaired glucose tolerance. What best predicts future diabetes in Mauritius. *Diabetes Care*; 22: 399-402.

Coutinho, M., Gerstein, H.C. and Wang, Y. 1999. The relationship between glucose and incident cardiovascular events. A Meta regression analysis published data from20 studies of 95,783 individuals followed for 12.4 years. *Diabetes Care*; 22: 233-40.

Liao, D., Shofer, J.B. and Boyko, E.J. 2001. Abnormal glucose tolerance and increased risk for cardiovascular disease in Japanese-Americans with normal fasting glucose. *Diabetes Care*; 24: 39-44.

Levitan, E.B., Song, Y., Ford, E.S. and Liu, S. 2004. Is non-diabetic hyper glycaemia a risk factor for cardiovascular disease? A meta-analysis of prospective studies. *Arch Intern Med*; 164: 2147-55.

Sadikot, S.M., Nigam, A. and Das, S. 2004. Diabetes India: The burden of diabetes and impaired glucose tolerance in India using the WHO 1999 criteria: prevalence of diabetes in India study (PODIS). *Diabetes Res Clin Pract*; 66: 301-7.

Ramaiya, K.L., Kodali, U.R. and K.G.M.M. Alberti. 1990. Epidemiology of Diabetes in Asians of the Indian Subcontinent. *Diab Metabol Rev*; 6:125-46.

Mohan, V., Sandeep, S. and Deepa, R. 2007. Epidemiology of type 2Diabetes. *Indian J Med Res*; 125: 217-30.

Mehta, S.R., Kashyap, A.S. and Das, S. 2009. Diabetes Mellitus in India: The Modern Scourge. *MJAFI*; 65: 50-4.

Mohan, V., Shanthirani, C.S. and Deepa, M. 2006. Mortality rates due to Diabetes in a selected urban South Indian population – the Chennai Urban Population Study (CUPS). *J Assoc Physicians India*; 54: 113-7.

Flegal, K.M., Carroll, M.D., Ogden and C.L., Johnson, C.L. 2002. Prevalence and trends in obesity among US adults 1999–2000. *JAMA*; 288:1723-7.

Dunstan, D.W., Zimmet, P.Z. and Wetborn, T.A. 2004. The rising prevalence of diabetes and impaired glucose tolerance: the Australian Diabetes Obesity and Lifestyle Study. *Diabetes Care*; 25: 829-34.

Menon, V.U., Kumar, K.V. and Gilchrist, A. 2006. Prevalence of known and undetected diabetes and associated risk factors in Central Kerala-ADEPS. *Diabetes Res Clin Pract*; 74: 289-94.

Clara, K. Chow. 2006. The prevalence and management of Diabetes in Rural India. *Diabetes Care*; 29: 1717-8.

Padmini, B., Kamalamma, N. and Patel, T.G. 2008. A Community-Based Diabetes Prevention and Management Education Programme in a Rural Village in India. *Diabetes Care*; 31 (6): 1097-1104.

Kumar, S., Mukherjee, S. and Mukhopadhyay, P. 2008. Prevalence of Diabetes and Impaired Fasting Glucose in a selected Population with Special Reference to Influence of Family History and Anthropometric Measurements – The Kolkata Policemen Study. *J Assoc Physicians India*; 56: 841-4.

Ramachandran, A. 2006. The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetolgia,* 49: 289-97.

Yajnik C.S. and Yudkin, J.S. 2004. The Y-Y Paradox. *The Lancet*; 363: 163.

Corresponding author: Dr. Abhishek Arun, Department of Community Medicine, Era's Lucknow Medical College and Hospital, Lucknow, India.
Email: dr.abhishekarun@gmail.com dr.muslimkhan156@gmail.com