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*Original Article*

# A comparative study of body mass index (BMI) in diabetic and non-diabetic individuals in Nepalese population

**Shah A[1], Parthasarathi D[2], Sarkar D[3], Saha CG[4]**
[1]MSc Student, [2]Assistant Professor, [3]Professor, [4]Prof. and Head, Department of Physiology, Manipal College of Medical Sciences, Pokhara, Nepal

**Abstract**

**Introduction and Objectives:** Diabetes Mellitus (DM) is the most common endocrine disorder world-wide. The prevalence of diabetes mellitus is increasing. In the present study an attempt has been made (i) to examine the relation between obesity and diabetes mellitus in Nepalese people, (ii) to find out whether BMI cut-off points for determining over weight and obesity as per WHO criteria are applicable in Nepalese study population.

**Materials and methods:** The present study was carried out in Manipal College of Medical Sciences (MCOMS) and Manipal Teaching Hospital (MTH), Pokhara. The Diabetic patients of Pokhara and surroundings who attended the 'Diabetic Clinic' and Out Patient Department (OPD) during August 2004 to November 2004 at Manipal Teaching Hospital were included in the present study. The number of diabetic patients was two hundred (200), out of which, one hundred and fourteen (114) were male and eighty six (86) were female. In addition one hundred (100) non-diabetic subjects who attended the OPD at MTH were taken for comparison with the diabetic patients, of which, forty seven (47) were male and fifty three (53) were female. Age, height and weight were recorded for every subject. BMI was calculated by the standard formula. In the present study, body mass index (BMI) of the diabetic subjects was found to be more than that of non-diabetic subjects. BMI of non-diabetic males and females were found to be around 22 kg/m$^2$ which is within normal range as per WHO recommendations. On the other hand, diabetic subjects' BMI were found to be around 25 kg/m$^2$, which denotes borderline obesity. It is clear from the present study that 51.5% of the diabetic subjects were within the normal range (BMI 18.5-24.9 kg/m$^2$). More diabetic subjects were found in over-weight (25-29.9) category than non-diabetic subjects. As per WHO criteria 56% of the non-diabetic subjects were within the normal BMI range (BMI 18.5-24.9 kg/m$^2$). It is also evident that when BMI in the range of 25.0-29.9 kg/m$^2$ is considered as over-weight, only 33% were found to be over-weight in diabetic subjects. But when BMI ≥23 kg/m$^2$ (as recommended for Asians) is taken as the determining factor for overweight, 64% of overweight male subjects and 72.09% of overweight female subjects were found to be diabetic.

**Conclusion:** According to the observations of the present study on Nepalese it can be concluded that BMI cut-off points for determining over-weight and obesity should be lowered to 23 kg/m$^2$ or less which can provide an adequate basis of taking action on risks related to overweight and obesity in Nepal.

**Key words:** Diabetes, Nepalese Population, BMI, Obesity

Diabetes Mellitus (DM) is the most common endocrine disorder. It is a group of metabolic disorders of carbohydrate metabolism characterised by glucose underutilization and hyperglycemia[1].

The increase in prevalence of obesity[2] and sedentary life style[3] are also key contributors to the rising prevalence of DM in the United States and throughout the world. The assessment of body fat represents a major challenge for both researchers and clinicians. The main storage sites of adipose tissue are located in the subcutaneous and intra-abdominal (visceral) regions, considerable amount of fat may also accumulate within muscles, especially among elderly individuals. The Quetlet's Index or Body Mass Index (BMI) is the most frequently used indicator of total body adiposity in epidemiological studies[4].

**Correspondence**
Prof C.G. Saha
Professor & Head
Department of Physiology
Manipal College of medical Sciences, Pokhara, Nepal
E mail: cgasaha@yahoo.com

The association between degree of obesity, body fat distribution and weight gain with subsequent consequence of Type II diabetes have been examined in several perspective studies. *BMI* and *both waist to hip ratio* (WHR) and *waist circumference* (WC) are now well established independent risk factors for the development of Type II diabetes and has been shown to have a direct association with overall mortality in both men and women[5-10].

Recently a WHO expert consultation addressed the debate about interpretation of recommended body mass index (BMI) cut-off points for determining over-weight and obesity in Asian populations, and considered whether population-specific cut-off points for BMI are necessary. They came to an opinion that the proportion of Asian people with a high risk of Type II diabetes and cardio-vascular disease is substantial at BMIs lower than the existing WHO cut-off points for over-weight ($\geq$ 25 kg/m$^2$). The cut-off points for observed risk varies from 22 kg/m$^2$ to 25 kg/m$^2$ in different Asian populations and for high-risk group it varies from 26 to 31 kg/m$^2$. Although the WHO consultation agreed that the present BMI cut-off points should be retained as the international classification, they recommended for the purpose of public health action, cut off points 23.0, 27.5, 32.5, and 37.5 kg/m$^2$ to be considered and proposed methods by which countries could make decisions for redefining obesity for the purpose of taking public health action in their population[11].

Recently it has been shown that the prevalence of diabetes mellitus in Nepal is increasing[12]. The present study is an attempt i.) To examine the relation between obesity and diabetes mellitus in Nepalese people, and ii.) To find out whether BMI cut-off points for determining over-weight and obesity as per WHO criteria are applicable to the population studied.

## Materials and methods

### *Selection of the subjects*

All the subjects selected in the present study were inhabitants of Pokhara and its surroundings. Pokhara is a valley with a cool weather situated in the western region of Nepal. Most of the subjects of this study were from middle class families. The study was carried out in Manipal College of Medical Sciences (MCOMS) and Manipal Teaching Hospital (MTH), Pokhara. The Diabetic patients of Pokhara and surroundings who attended the 'Diabetic Clinic' and Out Door Patient (OPD) during August 2004 to November 2004 at Manipal Teaching Hospital was included in the present study. The number of diabetic patients was two hundred (200), out of which, one hundred and fourteen (114) subjects were male and eighty-six (86) subjects were female. In addition one hundred (100) non-diabetic subjects who attended the OPD at MTH were taken for comparison (control subject) with diabetic patient, out of which, forty seven (47) subjects were male and fifty three (53) subjects were female (Table 1).

Out of all diabetic patients some were newly diagnosed and some were suffering from diabetic for approximately 10 months to 30 years. Those patients who were attending OPD other than the diabetic clinic were found not suffering from diabetes.

All the subjects included in the present study were grouped into diabetic and non-diabetic. Diabetic patients were diagnosed clinically by the specialists in diabetic clinics. After that each group of subjects were again divided into male and female for comparison (Table 1).

### *Calculation of BMI*

Height and weight were measured for every individual and body mass index (BMI) was calculated by following formula:
Body Mass Index (BMI) = weight in kilograms divided by the square of the height in meters (kg/m$^2$).

### *Statistical Analysis*

Data analysis was performed using the statistical package for the social sciences (SPSS Version 9.0). Mean, standard deviations (SD), minimum value, maximum value were obtained for all the selected variables of diabetic and non-diabetic subjects. One way ANOVA was conducted to examine any difference between the variables in each group. Pearson's products moment bivariate correlation coefficient was performed to examine the relationship of age and BMI.

## Results

The mean age of the non-diabetic and diabetic male and female subjects was within the range of 45-56 years. The height and weight of non-diabetic and diabetic male subjects were found to be 162.9 $\pm$ 5.80 cm and 60 $\pm$ 13.00 kg and 161.2 $\pm$ 6.50 cm and 63.8 $\pm$ 10.10 kg respectively. Height and weight of non-diabetic and diabetic female subjects were 151.4$\pm$ 6.70 cm and 52.7 $\pm$ 4.00 kg and 154 $\pm$ 6.53 cm and 60.9 $\pm$ 10.27 kg respectively.

The mean BMI of non-diabetic male and female were 22.2$\pm$4.00 and 22.4$\pm$9.20 kg/m$^2$ respectively which are within the normal range as per WHO

recommendations[13]. Mean values of BMI of diabetic male and female subjects were 24.5±3.60 and 25.6 ± 4.11 respectively, which are borderline obese[14].

The comparisons of physical characteristics (including BMI) of diabetic and non-diabetic male and female subjects are presented in Table 6. In both sexes, the mean BMI were higher in diabetic than non-diabetic subjects but these were not statistically significant.

The correlation coefficient (r, 0.22) between age and BMI in all combined subjects of the present study was found to be statistically significant ($p<0.01$) i.e. BMI is increased with the advancement of age. Besides, in both non-diabetic and diabetic subjects BMI is positively related with age but this is not statistically significant. However, BMI of diabetic subjects are more positively correlated with age than non-diabetic subjects (in non-diabetic r, 0.06; in diabetic *r*, 0.10) (Table 7).

Classification of over weight and obesity by BMI as per WHO criteria[13] was done for all subjects. Comparison of number and percentage of subjects (male and female) in non-diabetic and diabetic in various BMI groups are presented in Table 8. 56% of the non-diabetic subjects were within the normal BMI range (BMI 18.5-24.9 kg/m$^2$). In both male and female, more diabetic subjects were found in over-weight (BMI 25-29.9 kg/m$^2$) category than non-diabetic subjects. Obese Grade I (BMI, 30-34.9 kg/m$^2$) were also found more in diabetic female subjects than non-diabetic female but this trend is just the reverse in male subjects. When BMI of ≥ 23 kg/m$^2$ is considered for determining over-weight as recommended for Asians (WHO, 2002), 64 % of male subjects and 72.09% female subjects were found diabetic (Table 9).

**Table 1:** Number of non-diabetic and diabetic and sex distribution.

| Sex | Non-diabetic | Diabetic | Total |
|---|---|---|---|
| Male | 47 | 114 | 161 |
| Female | 53 | 86 | 139 |
| Total | 100 | 200 | 300 |

**Table 2:** Descriptive characteristics of non-diabetic male subjects (n=47)

| Variable | Mean | SD | Minimum value | Maximum value |
|---|---|---|---|---|
| Age (yrs) | 45.4 | ±16.60 | 15.0 | 79.0 |
| Height (cm) | 162.9 | ±5.80 | 150.0 | 178.0 |
| Weight (kg) | 60.0 | ±13.00 | 22.0 | 84.0 |
| BMI (kg/m$^2$) | 22.2 | ±4.00 | 16.0 | 31.0 |

SD, standard deviation; BMI, body mass index; yrs, years

**Table 3:** Descriptive characteristics of diabetic male subjects (n=114)

| Variable | Mean | SD | Minimum value | Maximum value |
|---|---|---|---|---|
| Age (yrs) | 56.5 | ±10.90 | 26.0 | 84.0 |
| Height (cm) | 161.2 | ±6.50 | 16.7 | 33.3 |
| Weight (kg) | 63.8 | ±10.10 | 147.0 | 179.0 |
| BMI (kg/m$^2$) | 24.5 | ±3.60 | 41.0 | 94.0 |

SD, standard deviation; BMI, body mass index; yrs, years

**Table 4:** Descriptive characteristics of non-diabetic female subjects (n=53)

| Variable | Mean | SD | Minimum value | Maximum value |
|---|---|---|---|---|
| Age (yrs) | 43.7 | ±13.70 | 17.0 | 74.0 |
| Height (cm) | 151.4 | ±6.70 | 136.0 | 173.0 |
| Weight (kg) | 52.7 | ±4.00 | 37.0 | 79.0 |
| BMI (kg/m$^2$) | 22.4 | ±9.20 | 17.0 | 38.0 |

SD, standard deviation; BMI, body mass index, yrs, years

**Table 5:** Descriptive characteristics of diabetic female subjects (n=86)

| Variable | Mean | SD | Minimum value | Maximum value |
|---|---|---|---|---|
| Age (yrs) | 52.2 | ±11.00 | 27.0 | 78.0 |
| Height (cm) | 154.2 | ±6.53 | 143.0 | 170.0 |
| Weight (kg) | 60.9 | ±10.27 | 37.0 | 79.0 |
| BMI (kg/m$^2$) | 25.6 | ±4.11 | 16.2 | 35.1 |

SD, standard deviation; BMI, body mass index, yrs, years

**Table 6:** Comparison of physical characteristics of non-diabetic and diabetic male and female subjects

| Variable | Male | | Female | |
|---|---|---|---|---|
| | Non-diabetic (n=47) | Diabetic (n=114) | Non-diabetic (n=53) | Diabetic (n=86) |
| Age (yrs) | 45.4±16.60 | 56.5±10.90$^{ns}$ | 43.7±13.70 | 52.2±11.00$^{ns}$ |
| Height (cm) | 162.9±5.80 | 161.2±6.50$^{ns}$ | 151.4±6.70 | 154.2±6.50$^{ns}$ |
| Weight (kg) | 60.0±13.0 | 63.8±10.10$^{ns}$ | 52.7±4.00 | 60.9±10.27$^{ns}$ |
| BMI (kg/m$^2$) | 22.2±4.00 | 24.5±3.60$^{ns}$ | 22.4±9.20 | 25.6±4.11$^{ns}$ |

Values are mean ±standard deviation; 't' test is performed to see the level of significance between the groups; ns, not significant; BMI, body mass index

**Table 7:** Correlation coefficients between age and body mass index

| | Age/BMI |
|---|---|
| Non diabetic and diabetic male and female (n, 300) | 0.22** |
| Non diabetic male and female (n, 100) | 0.06$^{ns}$ |
| Diabetic male and male (n, 200) | 0.10$^{ns}$ |

ns, not significant * * P< 0.01, BMI, body mass index

**Table 8:** Comparison of diabetic and non-diabetic male and female subjects according to BMI groups

| BMI groups (kg/m$^2$) | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Non-diabetic | | Diabetic | | Non-diabetic | | Diabetic | |
| | No. | % | No. | % | No. | % | No. | % |
| Normal (18.5-24.9) | 23 | 48.93 | 63 | 59.64 | 33 | 38.37 | 40 | 46.51 |
| Overweight (25-29.9) | 12 | 25.53 | 38 | 33.33 | 9 | 10.46 | 28 | 32.55 |
| Obese Grade I (30-34.9) | 13 | 27.65 | 9 | 7.89 | 2 | 2.32 | 15 | 17.44 |
| Obese Grade II (35-39.9) | 0 | 0 | 0 | 0 | 1 | 1.16 | 1 | 1.16 |

No., number of subjects; %, percentage

**Table 9:** Number (no) and percentage (%) of non-diabetic and diabetic subjects (both male and female) those were BMI ≥ 23 kg/m$^2$ as over weight recommended for Asians[14]

| BMI | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| ≥ 23kg/m$^2$ | Non-diabetic (n, 47) | | Diabetic (n, 114) | | Non-diabetic (n, 53) | | Diabetic (n, 86) | |
| | Number | % | Number | % | Number | % | Number | % |
| | 18 | 38.29 | 73 | 64.03 | 21 | 39.62 | 62 | 72.09 |

**Discussion**

The association between degree of obesity, body fats distribution and weight gain with subsequent occurrence of Type II diabetes has been examined in several prospective studies. Increased BMI is now a well established independent risk factor for the development of Type II diabetes[9, 10].

In the present study, body mass index (BMI) of the diabetic subjects was found to higher than non-diabetic subjects (Table 2-5 and Fig. 1 and 2). However, BMI of non-diabetic male and female were found to be around 22 kg/m$^2$ which is within normal range as per WHO recommendations[14]. On the other hand, in diabetic subjects BMI was found to be around 25 kg/m$^2$, which fall in borderline of obesity.

In the present study the diabetic subjects' BMI were found to be around 25 kg/m$^2$, which denotes borderline obesity[14]. Obesity accounts for 64% of cases of diabetes in men and 74% in women, though many cases of diabetes were observed in relatively lean individuals[15, 16]. BMI was described as the strongest predictor of type II diabetes. It is clear from the present study that BMI increases with age and BMI of diabetic subjects is positively correlated with age more than that in non-diabetic subjects (Table 7). An Indian study showed that diabetes has a positive and independent association with age and BMI[17].

In the present study, the diabetics were not classified separately by their types, so it is not possible to comment about relation between obesity and type II diabetes specifically. But obesity is mostly related to Type II diabetes[4, 9, 18]. Obesity, in particular abdominal or central obesity, is closely linked with insulin resistance. Among obese individuals, enhanced lipolysis and release of free fatty acids inhibits insulin stimulated peripheral glucose uptake in dose dependent manner while simultaneously inhibiting insulin secretion[9].

As per WHO BMI criteria[14] the non-diabetic subjects of the present study approximately 50% of total subjects were within the normal BMI range (BMI 18.5-24.9 kg/m$^{2)}$. It is also evident that considering BMI in between the range of 25.0-29.9 kg/m$^2$ as over-weight only 33.33% of male and 32.55% female were found over-weight in diabetic subjects. But when BMI ≥23 kg/m$^2$ is considered for determining overweight, 64% of male and 72.09% females were found diabetic. So, from this result we recommend that BMI cut off value of 23 or less should be taken as the determining factor for denoting over-weight in Nepalese population to be used as public health action points.

The risk of developing type II diabetes and cardiovascular diseases is high at relatively low BMI values in subjects who is originating from South East Asian countries and as compared to white population[19, 20, 21, 22]. Other studies from northern parts of India had also shown that the normal BMI for an Indian was < 22 kg/m$^2$ [23, 24]. The relationship of Diabetes and impaired glucose tolerance (IGT) for BMI value of >22 kg/m$^2$ had been established in Asian countries[25, 26, 27]. So it is likely that the South Asian people have BMI cut-off value lower than Westerners. BMI might not correspond to the same body fat in different populations because of variations in body proportions, which can be the reason for lower BMI in Asians[28]. Recently it has been observed that normal cut-off value for BMI in Asian Indian adults is <23 kg/m$^2$ [29].

In 2002 WHO expert consultation was made to recommend body mass index (BMI) cut-off points for determining over-weight and obesity in Asians populations. They noted that the number of Asians with a high risk of Type II diabetes and cardio-vascular disease is substantial at BMIs lower than 25 kg/m$^2$. The cut-off points for observed risk varies from 22 kg/m$^2$ to 25 kg/m$^2$ in different Asian populations and for high risk it varies from 26 kg/m$^2$ [to 31] kg/m$^2$ [11]. WHO consultation proposed that further study is required in different Asian countries to find

out BMI cut-offs to assess potential risk in overweight population for diabetes and cardiovascular diseases[11].

In respect with the observations of the present study it can be concluded that i) when the present WHO criteria are used no significant relation between Diabetes Mellitus and overweight or obesity was seen, ii) But when the recommended lower public health action points of 23 $kg/m^2$ is taken then it was found that substantial number of overweight people have Diabetes. However, in the present study data was only taken from Nepalese Population in Pokhara. So, further extensive study is required among all others regions of Nepal to make a final conclusion for BMI cut-off points to assess the potential risk for diabetes in Nepal.

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