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Original Research Article

An Observational Cross Sectional Study to Evaluate Association between BMI and Severity of Diabetes Mellitus.

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Abstract

Aim: The aim of the present study was to investigate the association and quantify the relationship between BMI and severity of diabetes mellitus.

Material & Methods: This analytic cross-sectional study was performed in the department of Medicine IPD of Lord Buddha Koshi Medical College, Saharsa, Bihar, India for one year. The final sample included 500 individuals who had a baseline BMI ≥18.5 kg/m2 (200 cases and 300 controls).

Results: Compared with control individuals, the case individuals had higher baseline BMI values (mean ± standard deviation: 32.8 ± 8.2 kg/m2 vs. 28.2 ± 6.4 kg/m2, $p < 0.01$). Cases were more likely to be younger, male, and to have higher healthcare resource use as measured by costs during the 12-month pre-index period than controls. Cases were also more likely to have experienced comorbidities related to diabetes and/or obesity and used medications related to diabetes or obesity during the 12-month pre index period than controls. The relative risks displayed a similar pattern: the relative risk was 1.5 (95%CI: 1.4–1.6) for overweight adults, 2.5 (2.3–2.6) for adults in Obesity Class I, 3.6 (3.4–3.8) for adults in Obesity Class II, and 5.1 (4.7–5.5) for adults in Obesity Class III. We found that the change in the magnitude of the ORs from one BMI category to the next was larger for individuals in higher BMI categories than individuals in lower BMI categories, as illustrated by the increasing slope of the lines connecting the ORs and, to a lesser degree, the lines connecting the relative risks. These patterns of ORs and relative risks imply that individuals in higher BMI categories were increasingly more likely to be diagnosed with T2D than individuals in lower BMI categories ($p < 0.05$).

Conclusion: The present study concluded that that not only is BMI strongly and independently associated with the risk of being diagnosed with T2D, but also that the magnitude of this positive association is larger for higher BMI values.

Keywords: Body mass index . Type 2 diabetes mellitus

Introduction

Type 2 diabetes mellitus (T2DM) is one of the most important leading causes of disability, quality of life reduction and premature mortality in the world. [1,2]

Diabetes, the most common metabolic disorder, is associated with substantial disease burden, including increased mortality risk and significant long-term morbidity. [3,4] Type 2 diabetes mellitus (T2D) comprises about 90%–95% of all diabetes cases, [5,6] and its prevalence has been steadily increasing. [7] Overweight and obesity, where rising rates worldwide are strikingly evident in the young, [8] is associated with several types of cancer, cardiovascular disease and type 2 diabetes. [9]

Obesity, classified as body mass index (BMI) ≥30 kg/m2, is a known predictor of T2D and has become a major public health problem. An association has been shown between the duration of obesity as well as weight gain during puberty and risk of type 2 diabetes, indicating early-onset obesity as an important risk factor, [10,11] although attenuated when adjusting for adult BMI. [12,13] Type 2 diabetes is associated with risk of microvascular complications, mortality and cardiovascular events, where low age at diagnosis, poor glycemic control and presence of cardiovascular risk factors are associated with poorer prognosis. [14,15]

The association between BMI in adolescence and the risk of subsequent type 2 diabetes and second, to assess the association between early BMI and risk factor control - metabolic control, blood pressure, blood lipids, and microalbuminuria − among those who were diagnosed with type 2 diabetes during their adulthood. Several studies have reported a strong association between excess weight and increased risk of death, placing the overweight group at a 40% higher and the obese group at up to 300% higher risk of death than individuals whose BMI is normal (18.5 ≤ BMI < 25). [16,17] Excess weight and physical inactivity are also associated with an increased risk of developing various diseases, particularly type 2 diabetes. [12,18] Since excess weight is an important predictor of type 2 DM, the term "diabesity" was proposed by Astrup and Finer in 2000 (23). Specifically, In comparison to women with normal BMI, overweight, obese class I and II (30 ≤ BMI < 39.99), and class III (BMI ≥ 40) individuals face increased risks of developing type 2 DM with 7.6%, 20.1% and 38.8% greater risk respectively. [19] Individuals with DM are also 17 times more likely to have an amputation due to peripheral vascular disease, and are at an increased risk of developing nephropathy, retinopathy, and coronary heart disease among other adverse outcomes. [20]

Hence, the purpose of this study was to investigate the association and quantify the relationship between BMI and severity of diabetes mellitus.

Material & Methods

This analytic cross-sectional study was performed in the department of Medicine IPD of Lord Buddha Koshi Medical College, Saharsa, Bihar, India for one year .The final sample included 500 individuals who had a baseline BMI ≥18.5 kg/m2 (200 cases and 300 controls).

Information concerning the age, gender, duration of diabetes, HbA1c, medication, previous history of stroke or myocardial infarction (MI) and cigarette smoking status was obtained from the patients 'medical records. Blood pressure (BP) was measured by standard methods using a sphygmomanometer with the patient in a sitting position. Three measurements were made in all subjects at 5-min intervals, and the average of the second and third measurements was used in the analysis. Hypertension was defined as a systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg or taking antihypertensive medications.

Anthropometric measurements including weight and height measurements were obtained using standardized techniques. Height was measured in centimeters using a wall mounted measuring tape to the nearest centimeter. Subjects were requested to stand upright without shoes with their back against the wall, heels together and eyes directed forward. Weight was measured in kilograms using a digital scale that was kept on a firm horizontal surface. [21] Subjects were asked to wear light clothing and weight was recorded to the nearest 0.5 kg. BMI was calculated as weight in kilograms divided by height in meters squared (Kg/m2). The guideline of the United States National Institute of Health (NIH) use the following BMI classification: BMI < 18.5 kg/m2, underweight; BMI 18.5 to 24.9 kg/m2, normal weight; BMI 25.0– 29.9 kg/m2, overweight; BMI 30–34.9 kg/m2, obesity class I; BMI 35–39.9 kg/m2, obesity class II; and BMI ≥ 40.0 kg/m2, obesity class III. [22]

Statistical analyses

Data were analyzed using the SPSS version 20.0 for windows computer software package (SPSS Inc., Chicago, IL, USA). Frequency, percent, mean and standard deviation were used for population description. The normal distributions of data were checked and t test, spearman correlation, analysis of variance (ANOVA) and Chi-square test ($\chi 2$) were used for analytic analysis. Multivariate logistic regression was used to estimate the odds ratio with a 95% confidence interval (CI) for the risk of Diabetes. Statistical significance was accepted at the $p < 0.05$ level. Data are expressed as mean ± SD values when referred to in the text.

Results

Table 1: Demographic and Clinical Characteristics

	Cases (With T2D) N = 200	Controls (Without diabetes) N = 300	P value
BMI (mean ± SD, kg/m2)	32.8 ± 8.2	28.2 ± 6.4	<0.01
BMI category (%)			<0.01
18.5–24.9 kg/m2	15	24	
25.0–29.9 kg/m2	22	36	
30.0–34.9 kg/m2	25	24	
35.0–39.9 kg/m2	20	10	
40+ kg/m2	18	6	
Male	44	46	0.252
Age (mean ± SD)	54 ± 14.6	56 ± 16.4	<0.01
Age group (%)			<0.01
18.5–24.9	26	26	
25.0–29.9	44	34	
30.0–34.9	18	20	
35.0–39.9	10	16	
40+	2	4	
Smoking status (%)			0.425
Never smoke	50	48	
Former smoker	20	32	
Current smoker	16	16	
Other/unknown	14	4	
Employment status (%)			0.777
Full Time	38	32	
Not employed	22	18	
Other/unknown	40	50	
Any cardiac comorbidities (%)	86	62	0.675

Hyper inflammatory state (%)	7	3	0.678
Depression (%)	8	4	0.789
Psychiatric drugs (%)	15	8	0.892
Antidepressants/anxiolytics (%)	35	23	0.563
Anti-obesity drugs (%)	0.5	0.1	0.678
Beta blockers (%)	34	22	0.785
Antihyperlipidemia drugs (%)	36	24	0.376
Antihypertensives (%)	34	22	0.542
Any outpatient encounters (%)	96	90	0.651
Any inpatient encounters (%)	15	8	0.671
Any emergency department encounters (%)	15	7	0.693

Compared with control individuals, the case individuals had higher baseline BMI values (mean ± standard deviation: 32.8 ± 8.2 kg/m2 vs. 28.2 ± 6.4 kg/m2, $p < 0.01$). Cases were more likely to be younger, male, and to have higher healthcare resource use as measured by costs during the 12-month pre-index period than controls. Cases were also more likely to have experienced comorbidities related to diabetes and/or obesity and used medications related to diabetes or obesity during the 12-month preindex period than controls.

Table 2: Logistic Regression for Risk of T2D Diagnosis

	Odds Ratio 95%	**CI**
BMI category (%)		
18.5–24.9 kg/m2	1.14	1.30-1.44
25.0–29.9 kg/m2	1.60	1.49–1.78
30.0–34.9 kg/m2	3.16	2.92–3.48
35.0–39.9 kg/m2	5.75	5.32–6.46
40+ kg/m2	11.69	10.46–12.82
Male	0.97	0.92–1.02
Age group (%)		
18.5–24.9	1.25	1.15-1.36
25.0–29.9	1.19	1.11–1.28
30.0–34.9	0.74	0.67–0.81
35.0–39.9	0.79	0.70–0.88
40+	0.75	0.63–0.89
Smoking status (%)		
Former smoker	1.20	1.11–1.25
Current smoker	1.16	1.07–1.23
Other/unknown	0.42	0.35–0.45
Employment status (%)		
Not employed	1.15	1.06–1.23
Other/unknown	1.07	1.01–1.16
Any cardiac comorbidities (%)	1.70	1.58–1.83
Hyperinflammatory state (%)	2.08	1.83–2.37
Depression (%)	1.14	1.02–1.27
Psychiatric drugs (%)	1.31	1.21–1.43
Antidepressants/anxiolytics (%)	1.19	1.12–1.26

Anti-obesity drugs (%)	1.39	0.81–2.38
Beta blockers (%)	1.04	0.98–1.10
Antihyperlipidemia drugs (%)	1.38	1.30–1.47
Antihypertensives (%)	1.32	1.24–1.40
Any outpatient encounters (%)	0.66	0.57–0.76
Any inpatient encounters (%)	1.31	1.19–1.43
Any emergency department encounters (%)	1.03	0.95–1.12

The relative risks displayed a similar pattern: the relative risk was 1.5 (95%CI: 1.4–1.6) for overweight adults, 2.5 (2.3–2.6) for adults in Obesity Class I, 3.6 (3.4–3.8) for adults in Obesity Class II, and 5.1 (4.7–5.5) for adults in Obesity Class III. We found that the change in the magnitude of the ORs from one BMI category to the next was larger for individuals in higher BMI categories than individuals in lower BMI categories, as illustrated by the increasing slope of the lines connecting the ORs and, to a lesser degree, the lines connecting the relative risks. These patterns of ORs and relative risks imply that individuals in higher BMI categories were increasingly more likely to be diagnosed with T2D than individuals in lower BMI categories ($p < 0.05$). Other individual characteristics, aside from BMI, were also significantly associated with the risk of being diagnosed with T2D. Individuals who were 45–64 years old (compared with 18–44 years old), were black or other race (compared with white), or ever smoked (compared with never) were associated with an increased risk of T2D diagnosis. In addition, individuals who experienced comorbidities (any cardiac comorbidities, hyper inflammatory state, or depression) or who used medications (psychiatric drugs, antidepresion or anxiolytics, anti hyperlipidemia drugs, and antihypertensives) were more likely to have been diagnosed with T2D than those who did not, as were individuals with more medical costs in the pre-index period. However, the ORs of the individual characteristics (except for BMI) were not the focus of this study since they were included in the regression in order to adjust for the impact of BMI.

Discussion

Type 2 diabetes mellitus (DM) is a common disease whose prevalence is expected to double by the year 2030. [23] Among adults over age 60 the prevalence of excess weight was even higher, with 76.5% of men and 72.5% of women overweight or obese. [24] Adult obesity is forecasted to rise by 33% in the next two decades with severe obesity prevalence rising by 130%. [25] Combined with the aging of the baby-boom generation, these projections imply that there will be as many as 65 million more obese adults in 2030 than in 2010, of whom 24 million will be over age 60. [26]

Compared with control individuals, the case individuals had higher baseline BMI values (mean ± standard deviation: 32.8 ± 8.2 kg/m2 vs. 28.2 ± 6.4 kg/m2, $p < 0.01$). Cases were more likely to be younger, male, and to have higher healthcare resource use as measured by costs during the 12-month pre-index period than controls. Cases were also more likely to have experienced comorbidities related to diabetes and/or obesity and used medications related to diabetes or obesity during the 12-month pre index period than controls. The relative risks displayed a similar pattern: the relative risk was 1.5 (95%CI: 1.4–1.6) for overweight adults, 2.5 (2.3–2.6) for adults in Obesity Class I, 3.6 (3.4–3.8) for adults in Obesity Class II, and 5.1 (4.7–5.5) for adults in Obesity Class III. We found that the change in the magnitude of the ORs from one BMI category to the next was larger for individuals in higher BMI categories than individuals in lower BMI categories, as illustrated by the in- creasing slope of the lines connecting the ORs and, to a lesser degree, the lines connecting the relative risks. These patterns of ORs and relative risks imply that individuals in higher BMI categories were increasingly more likely to be diagnosed with T2D than individuals in lower BMI categories ($p < 0.05$). According to the Nurses' Health Study, the adjusted relative risk of T2D associated with each 5-unit increment in BMI ranged from 1.55 (95% CI: 1.36–1.77) to 2.36 (95% CI: 1.83–3.04) among women, depending on the participants' race/ethnicity, in the 1980–2000 prospective cohort [15]; and the overall relative risk of non-insulin-dependent T2D among women with BMI ≥ 29.9 kg/m2 relative to women with BMI ≤ 20.1 kg/m2 in the 1986–1994 cohort was 11.2 (95% CI: 7.9–15.9). [27]

Additionally, weight loss among subjects in the lifestyle-modification program was significantly and independently associated with reductions in blood glucose from pre-diabetic to normal levels. [28] Weight loss was also associated with long-term benefit in a follow-up study of the DPP program, which found that the 10-year cumulative incidence of T2D among participants in the lifestyle-modification program was lower compared with those treated with metformin or in the placebo group. [29] The risk of developing T2D for individuals who were overweight or obese was about 1.5–5 times higher than for individuals with normal BMI, as estimated in our study. This demonstrates the importance of continuous weight management, which not only can reduce the disease burden of obesity but also may prevent further progression to T2D. Weight management is particularly important for people with severe obesity, who were disproportionally at higher risk of developing T2D than individuals with less severe obesity. Physicians should regularly monitor the weight of their patients with obesity.

Conclusion

The present study concluded that that not only is BMI strongly and independently associated with the risk of being diagnosed with T2D, but also that the magnitude of this positive association is larger for higher BMI values. Further research on the association between BMI and the risk of developing T2D should include the time to the incident T2D diagnosis and, if data are available, account for individuals' pre-diabetic status and the timing and duration of obesity.

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