Original Article

RISK OF OBESITY FOR HYPERTENSION DIFFERS BETWEEN DIABETIC AND NON-DIABETIC SUBJECTS

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Abstract

In recent years, non-communicable diseases (NCD) like obesity, hypertension (HTN) and Type2 diabetes (T2DM) are on the increase, specially in the developing nations. Body mass index (BMI), waist-to-hip ratio (WHR) and Waist-to-height ratio (WHtR) are used as indices of obesity to relate T2DM, HTN and coronary artery disease (CAD). This study addresses whether the risk of obesity for HTN differs between T2DM and non-DM subjects. We investigated 693 diabetic patients from BIRDEM and 2384 from communities. We measured height, weight, waist-girth, hip-girth and blood pressure. All subjects underwent oral glucose tolerance test (OGTT). BMI, WHR and WHtR were calculated. Systolic and diastolic hypertension (sHTN and dHTN)) were defined as SBP $>=140$ and DBP $>=$ 90 mmHg, respectively. The prevalence of both sHTN and dHTN in T2DM was higher than the non-DM subjects (sHTN: 49.1 vs 14.3%, dHTN 19.6 vs. 9.5%). The comparison of characteristics between subjects with and without hypertension showed that the differences were significant for age, weight, waist-girth, BMI, WHR and WHtR for both T2DM and non-DM subjects (for all $p<0.001$). The increasing trend of hypertension with increasing obesity was observed more in the non-DM than in the T2DM subjects. The risk (OR) of obesity for hypertension increased with increasing WHR and WHtR in the non-DM than the T2DM subjects. Compared with the non-DM the T2DM participants had two to three folds higher prevalence of HTN. In either group, BMI, WHR and WHtR were significantly higher in the hypertensive than the non-hypertensive subjects. The prevalence of hypertension increased with the increasing BMI, WHR and WHtR but significant only in the non-DM. Further studies may confirm these findings and determine whether there was any altered association between blood pressure and obesity in diabetes possibily, with or without autonomic neuropathy.

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Keywords: obesity, hypertension, diabetes, odds ratio

Abbreviation: *BMI, body mass index (weight in kg / height in m.sq.); CAD, coronary artery disease; NCD, non-communicable disease; SBP, DBP, systolic & diastolic blood pressure; sHTN, dHTN, systolic and diastolic hypertension; OR, odds ratio; CI, confidence interval; SD, standard deviation; T2DM, Type 2 diabetes mellitus; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.*

Introduction

Recently, the developing communities are burdened increasingly with the metabolic and other non-communicable diseases[1]. It was reported that Bangladeshis are more susceptible to develop obesity, diabetes, hypertension, and coronary artery diseases compared with other South Asian migrants (Indian, Pakistani) settled in United Kingdom[2]. The risk factors related to these disorders were more prevalent in Bangladeshis than the native population[3,4]. Bangladeshis among the entire South Asian immigrants

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had highest risk of morbidity and mortality from HTN, T2DM and CAD[5,6] and these are emerging as major health problems in Bangladesh. Now, these diseases are given research priorities by the government[7].

It may be noted that small community surveys conducted at different time-points revealed an increasing trend of hypertension and diabetes in Bangladesh[8]. These studies showed that increasing central obesity (high WHR and WHtR) has been found significantly related to insulin resistance, which in turn may be related to hypertension and diabetes. This study addresses the association of obesity with hypertension and determines whether there was any difference of risk for developing hypertension in diabetic and non-diabetic subjects.

Subjects and Methods

This study was conducted on – a) diabetic patients registered in a referral center, BIRDEM in Dhaka City; b) a mixed community of rural and urban participants. All subjects of age 20 years or more were considered eligible for the study. Eight hundred diabetic patients were selected randomly from BIRDEM registry starting from January to April 1996, based on patients' reference number.

For community participants, we selected five villages from rural and two city corporation wards from urban (Dhaka City), purposively. We estimated sample size taking formula, $n = z^2 pq / e^2$; where, z = standard variate at a confidence level of 1.96, (approx, 2), p = prevalence of hypertension 11%[9,10], q = 100 – prevalence (11%) = 89, e = acceptable error (precision, 10% of the prevalence). According to the formula, sample size was estimated at 3236.

The investigations included age, sex, height, weight, blood pressure and blood glucose – both fasting and post-challenge. We informed each participant about the objectives and investigation procedures. Only after verbal consent, we enlisted them for investigation.

Measurements of height, weight, and waist- and hip-girth were taken with subjects wearing light clothes and no shoes. The weighing scales were calibrated daily by known standard weight. For recording the height, the subject stood in erect posture with his / her occiput, back, hip and heels touching the wall while gazing horizontally in front, keeping the tragus and lateral orbital margin in the same horizontal plane. The waist girth was measured by placing a plastic tape horizontally mid-way between the lower border of the12th rib and iliac crest along the mid-axillary line. Similarly, the hip was measured by taking a point at the extreme end on the buttock in stooping posture and the other point on the symphysis pubis. BMI, WHR and WHtR were calculated taking the anthropomtric measures.

Blood pressure was taken after 10 min rest with standard cuffs for adult fitted with mercury sphygmomanometer. All measurements were taken in sitting position placing the wrapped cuff at the heart level. Systolic and diastolic hypertension (sHTN and dHTN)) were defined as systolic and diastolic BP (SBP and DBP) $=>140$ and $=>$ 90 mmHg, respectively. For comparison, the diabetic subjects were excluded from the community participants.

Fasting and 2h post-load plasma glucose was estimated by the glucose oxidase (enzymatic oxidation) method (GOD/PAP Kit; Randox, Antrim, U.K.) using the auto-analyzer Screen Master-3000 (B.S. Biochemical Analyzer, Arezzo, Italy).

Statistical Analyses

The prevalence of hypertension was given in simple percentages. For comparison of continuous variables between groups (hypertensive vs non-hypertensive), we used Student's t-test. We divided all obesity variables (BMI, WHR, WHtR) into quartiles for estimation of odds ratio (OR) to assess risk of obesity for developing systolic and diastolic hypertension, separately in diabetic and non-diabetic individuals. We used SPSS version 12.0. We accepted 0.05 as level of significance.

Results

Of the selected 800 diabetic subjects, 693 (men 295, women 398) took part in the investigation from BIRDEM. The response rate was 86.6%.

For the community participants, 2384 (men 1491, women 893) participated. Overall, the response rate was 70%. The rural participants were 1332 (m / f = 808 / 524) and the urban participants were 1052 (m / f = 683 / 369). Thus, the response rates from the rural and urban communities were 74.8 and 59.1%, respectively.

The prevalence of both systolic and diastolic hypertension (sHTN, dHTN) in diabetic subjects was higher than the non-diabetic subjects (sHTN: 49.1 vs 14.3%, dHTN 19.6 vs. 9.5%). The prevalence of sHTN among the male and female diabetic subjects

were 45.0 and 52.6% and dHTN were 26.0 and 14.2%, respectively (table not shown). Much lower prevalence was observed in the non-diabetic subjects (sHTN: m / f =13.3 / 14.9%; dHTN: m / f = 10.1 / 9.2%).

The characteristics of the community participants were given in table-1 and that of diabetic participants in table-2. The comparison of characteristics between subjects with and without systolic hypertension were given in table-3. The differences were significant for age, weight, waist-girth, BMI, WHR and WHtR (for all $p < 0.001$). Only height did not differ.

Table 1. Characteristics of non-diabetic participants (n = 2384).

Characteristics	Range	Mean	SD
Age (y)	20 – 99	40.3	13.7
Height (cm)	107 – 183	157.6	8.9
Weight	25 – 89	50.2	10.5
BMI	11.9 – 45.3	20.5	3.6
Waist (cm)	30 – 99	71.4	9.9
Hip (cm)	32 – 115	81.8	8.0
Waist-to-hip ratio	0.52 – 1.38	0.87	.08
Waist-to-height ratio	0.21 – 0.78	0.45	0.06
Systolic blood pressure (mmHg)	70 – 230	116.4	20.5
Diastolic blood pressure (mmHg)	40 – 130	72.7	11.3
Blood glucose 2h post-load (mmol/L)	2.0 – 27.7	6.7	2.9

Table 2. Characteristics of diabetic patients (n = 693).

Characteristics	Range	Mean	SD
Age (y)	30 – 60	47.1	8.6
Height (cm)	135 – 186	157.8	8.8
Weight (kg)	35 – 97	61.3	10.2
BMI	13.9 – 39.3	24.6	3.57
Waist (cm)	67 – 120	88	7.9
Hip (cm)	63 – 116	89.8	7.0
Waist-to-hip ratio	0.81 – 1.52	0.98	.05
Waist-to-height ratio	0.43 – 0.79	0.56	.06
Systolic blood pressure (mmHg)	90 – 230	136.2	19.2
Diastolic blood pressure (mmHg)	55 – 120	83.4	8.8
Blood glucose 2h post-load (mmol / L)	7.0 – 40.0	18.4	6.2

Table 3. Comparison of characteristics between subjects with and without systolic hypertension among non-diabetic participants (n = 2381).

	SBP < 140mmHg		**SBP = > 140mmHg**		
	n = 2043		*n = 341*		*t-test*
Characteristics	Mean	SD	Mean	SD	*p*
Age (y)	38.5	12. 9	51.3	13.5	<0.001
Height (cm)	157.7	8.8	156.9	9.9	ns
Weight (kg)	49.9	10.3	52.1	11.7	<0.001
Body mass index	20.0	3.5	21.1	4.0	<0.001
Waist (cm)	70.8	9.7	74.8	10.4	<0.001
Hip (cm)	81.6	7.9	83.1	8.4	<0.01
Waist-to-hip ratio	0.87	0.08	0.90	0.08	<0.001
Waist-to-height ratio	0.45	0.06	0.48	0.07	<0.001
Systolic BP (mmHg)	110	13.1	154	17.4	<0.001
Diastolic BP (mmHg)	71	10	86	10.7	<0.001
Blood glucose (2h post-load, mmol/l)	6.5	2.6	7. 9	4.3	<0.001

SBP – systolic blood pressure

Table 4. Comparison of characteristics between subjects with and without systolic hypertension among diabetic participants (n = 693).

	SBP<140mmHg N = 331		SBP => 140mmHg N=362		t-test
Characteristics	Mean	SD	Mean	SD	p
Age (y)	45.7	8.6	48.4	8.4	<0.001
Height (cm)	158.7	8.6	156.9	8.9	<0.01
Weight (kg)	60.7	9.9	61.8	10.4	ns
Body mass index	24.0	3.1	25.1	3.7	<0.001
Waist (cm)	86.9	7.6	88.9	8.1	= 0.001
Hip (cm)	88.7	6.7	90.8	7.2	<0.001
Waist-to-hip ratio	0.98	.06	0.98	0.05	ns
Waist-to-height ratio	0.55	0.05	0.57	0.06	<0.001
Systolic BP (mmHg)	121	9	150	15	<0.001
Diastolic BP (mmHg)	79	5	87	9.5	<0.001
Blood glucose (2hh post-load, mmol/l)	18.7	6.6	18.2	5.9	ns

SBP – systolic blood pressure

For the diabetic participants, the differences were similar to that of non-diabetics with the exception that weight, WHR and 2h post-load glucose did not differ (table 4). It should be noted that the hypertensive diabetics were significantly shorter than their non-hypertensive counterparts ($p < 0.01$).

To determine the risk of obesity for developing hypertension, we estimated odds ratio for lower to higher quartiles in diabetic and non-diabetic population for a comparison. The comparisons were shown in figure 1 and 2. The increasing trend of developing systolic hypertension with increasing obesity quartile was profound in the non-diabetic than the diabetic subjects (figure 1: left vs. right).

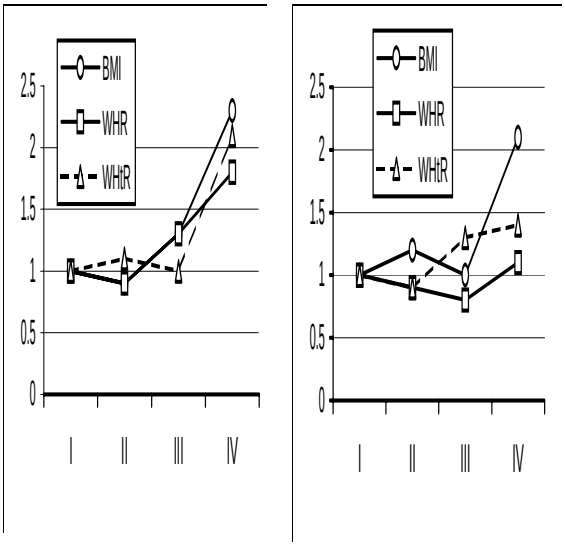

Figure 1. Odds ratio (OR) of systolic hypertension by quintiles of obesity indices of non-diabetic (left) and diabetic (right) subjects

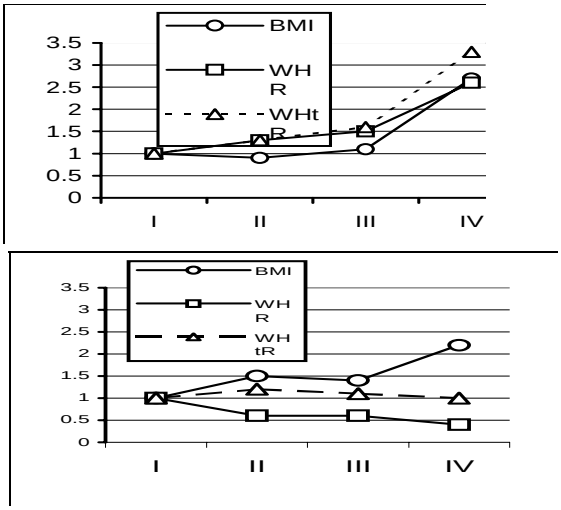

Figure 2. Odds ratio (OR) of diastolic hypertension by quintiles of obesity indices of non-diabetic (left) and diabetic (right) subjects

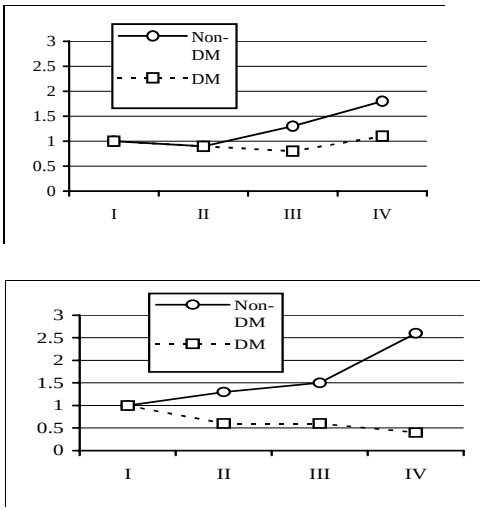

Figure 4. Odds ratio (OR) for developing sHTN (left) and dHTN (right) by WHR quintile: non-DM vs. DM

The differences of the increasing trend was more obvious for diastolic hypertension (figure 2: left vs. right). To make the comparison more sharp we compared the trend for each obesity index (figure 3 for BMI, figure 4 for WHR and figure 5 for WHtR). Marked differences were observed for quartiles of WHR and WHtR (Fig 4,5). Both the measures-WHR, WHtR indicate central obesity. The risk (OR) for hypertension increased with increasing quintiles of WHR and WHtR in the non-DM

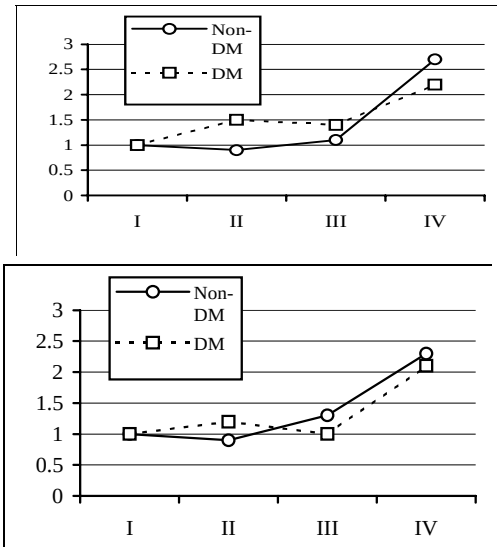

Figure 3. Odds ratio (OR) for developing sHTN (left) and dHTN (right) by BMI quintile: non-DM vs. DM

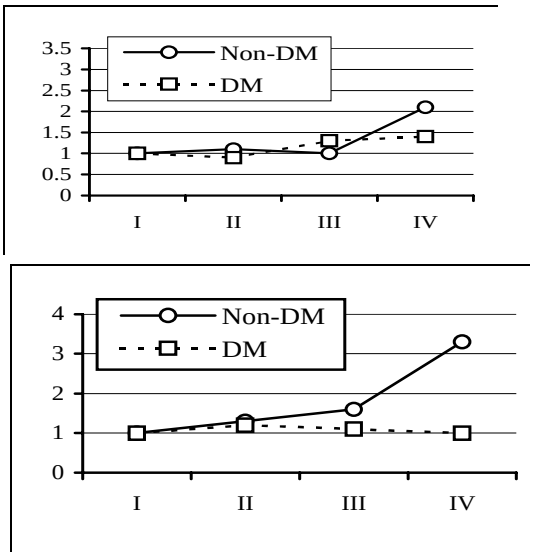

Figure 5. Odds ratio (OR) for developing sHTN (left) and dHTN (right) by WHtR quintile: non-DM vs. DM

but not in the T2DM, and marked difference was observed for diastolic hypertension.

Discussion

As regards the community participation the response rate, 59.1% from urban and 74.8% from rural limits the strength of the study results. It would have been more acceptable if we could ensure partipation over 80%. It may be noted that it was not a bias selection neither from the urban nor from the rural community.

The response rate could not be increased due to time taken for OGTT. About 15% refused to wait for two hours after glucose drink in urban and 10% in rural area. This refusal reduced the response rate. However, the response rate for estimated diabetic participants was satisfactory (86.6%). This study reasonably compared the prevalence of hypertension in diabetic and non-diabetic subjects keeping an approximate representation from rural and urban community. Possibly, this is the first study that corpared the differential effect of increasing obesity on hypertension between diabetic and non-diabetic subjects.

The comparison of characteristics showed that age, and all obesity variables ((BMI, WHR, WHtR) were significantly higher in the subjects with hypertension than without, irrespective of their glycemic status (T2DM and non-DM). This finding is not inconsistent to other studies[10-12]. The novel findings are that the trend of increasing prevalence of hypertension with the increasing general obesity (BMI) and central obesity (WHR and WHtR) differed between (T2DM) and non-diabetic (non-DM) subjects. The non-DM subjects showed higher prevalence of HTN with higher obesity, whereas, the T2DM showed very litte or no increase. A substantial if number studies reported that obesity is significantly related to hypertension[2,5, 10-12]. But it is not clear why there was no increase of hypertension with increasing obesity in the diabetic subjects. Possibly, autonomic neuropathy among T2DM changes the physiologic relationship between obesity and blood pressure. Jarmuzvwska et al.[13] found that the presence of sympathetic neuropathy and higher blood pressure remained independent predictors of SBP fall not only during the acute transition from supine to standing position but also during sustained orthostasis in type 2 diabetes. They concluded that lower baseline plasma adrenaline concentrations and plasma renin activity might be involved in the genesis of this hemodynamic response.

In Bangladesh, the diagnosis of diabetes appears to be late or mostly diagnosed in the advanced stage of the disease. Very few people diagnosed had early diagnosis before developing typical symptom like excessive thirst, excessive urination and weight loss. It is common for the developing communities that the diabetic patients present with these typical features in advanced stages of the metabolic disease when some form of complication like neuropathy has already developed. Ravisankar et al.[14] also observed that there were differences between BMI and BP indices, which might be due to differences in autonomic function and or energy metabolism. The diabetic participants might have developed some form of diastolic dysfunction, which is not infrequent as observed by some other studies[15,16].

Conclusion

The prevalence of hypertension among the diabetic subjects were 2 to 3 times higher than the non-diabetic population. Both general and central obesity were found to be significantly higher in the hypertensive than the non-hypertensive participants irrespective of their glycemic status. The increasing trend of hypertension with increasing obesity was significant only in the non-diabetic but not in the diabetic subjects, possibly, due to sympathetic neuropathy developed in the latter. Further study may be designed to confirm these findings and to determine whether there was any altered association between blood pressure and obesity in diabetes with or without autonomic neuropathy and / or ventricular dysfunction.

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