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Association Between Obesity and Insulin Resistance in Hypertension: A Case Control Study

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ABSTRACT

Non-communicable diseases (NCDs) cause 41 million deaths annually, accounting for 71% of global deaths. Cardiovascular diseases, cancers, respiratory diseases and diabetes are the leading NCDs. Detecting, screening and treating NCDs are vital in addressing the burden. This study aims to explore the association of BMI, abdominal obesity and insulin resistance with hypertension, as well as the coexistence of diabetes and hypertension. A case-control study was conducted at a Medical College in Central India involving individuals aged 30-70 years who visited the hospital between August 2022 and March 2023. The participants were divided into three study groups: Two cases and one control group. Comprehensive assessments, including medical history, physical examinations and laboratory tests, were conducted on all participants and the collected data were recorded in a standardized proforma. In patients with hypertension and those with both hypertension and diabetes mellitus, there was a gradual increase observed in body mass index (BMI), waist circumference, waist-hip ratio and waist-to-height ratio (WHtR). Notably, the highest levels of insulin resistance were observed in patients with both hypertension and diabetes mellitus. Obesity plays a significant role in the onset of Type 2 diabetes and hypertension. In assessing obesity, the waist-to-height ratio (WHtR) is considered a particularly valuable parameter. Insulin resistance is commonly observed in individuals with hypertension, as well as in those who have both diabetes and hypertension.

INTRODUCTION

Hypertension, or elevated blood pressure, is a major health concern associated with increased risks of various diseases. Globally, 1.28 billion adults aged 30-39 have hypertension, with a significant proportion in low- and middle-income countries. It is a leading cause of premature death and a considerable number of individuals with hypertension are unaware of their condition. High blood pressure accounts for approximately 7.5 million deaths each year and contributes to a significant burden of disability[1-3].

In India, the prevalence of elevated blood pressure, including those on medication, is 30.2% among men and 25.3% among women. Mildly elevated blood pressure is found in 15.7% of males and 12.4% of females, while moderate to severe elevation is seen in 5.7% of males and 5.2% of females. The Global Burden of Disease study reported that high blood pressure caused 1,638,049 deaths and 33,887,690 DALYs lost in India[4-5].

India, as a developing country, has witnessed rapid urbanization and industrialization, leading to notable health challenges. The prevalence of overweight/obesity, elevated blood pressure and elevated blood glucose levels has increased among individuals in India. This can be attributed to changes in lifestyles, dietary patterns and sedentary behaviors associated with the processes of urbanization and industrialization[6,7].

The escalating prevalence of overweight and obesity has emerged as a significant global public health concern[8]. Obesity is frequently regarded as a "gateway disease" due to its strong association with a diverse array of health complications, notably non-communicable diseases (NCDs)[9]. These NCDs encompass a range of chronic ailments, including cardiovascular diseases, diabetes, specific types of cancer and respiratory disorders, among others. Acknowledging obesity as a crucial risk factor for multiple health issues underscores the importance of addressing and preventing this condition through targeted public health interventions.

The World Health Organization (WHO) report of 2016 identified a concerning epidemic of overweight and obesity in India, characterized by a significant increase in prevalence. Between 2006 and 2016, the prevalence rose from 8.4-11.8%, indicating a 3.4% increase[8]. Another review study focusing on individuals aged 15-49 years revealed a general upward trend in the prevalence of overweight and obesity, with rates rising from 11-15% between 1998 and 2006[7]. This escalating trajectory of obesity is expected to lead to a substantial surge in the number of individuals affected by hypertension and type 2 diabetes mellitus (T2DM) in the future[10].

Body mass index, a widely used measure of adiposity, is considered an ideal indicator of body fatness due to its simplicity and strong association with obesity-related health risks. It provides a practical and effective approach to assess the potential health implications of excess weight by considering both height and weight[11-13].

Insulin resistance, characterized by decreased tissue sensitivity to insulin, is a key feature of various pathological conditions, referred to as the insulin resistance syndrome or metabolic syndrome[14]. This syndrome encompasses a cluster of symptoms including hypertension, hyperglycemia, dyslipidemia, increased waist circumference and insulin resistance, which collectively elevate the risk of cardiovascular and metabolic disorders[15].

Emerging evidence suggests that insulin resistance, traditionally associated with type 2 Diabetes, may also contribute to the development of hypertension[16]. While hypertension has been traditionally attributed to factors like salt sensitivity and hormonal imbalances, the complex interplay between insulin resistance and hypertension is now being recognized. Insulin resistance can disrupt vascular function, increase sympathetic activity, cause sodium retention and impair nitric oxide production, all of which contribute to elevated blood pressure. This understanding offers new opportunities for integrated approaches to managing and preventing both conditions.

Obesity plays a central role in the development of the insulin resistance syndrome, which encompasses metabolic abnormalities such as hyperinsulinemia, hypertension, hyperlipidemia, T2DM and increased cardiovascular disease risk[17,18]. Excess adipose tissue in obesity releases inflammatory molecules and disrupts insulin signaling, leading to insulin resistance and associated metabolic dysregulation. Addressing obesity and its underlying mechanisms is crucial in mitigating the risks and complications associated with the insulin resistance syndrome and its related conditions.

While insulin resistance and hyperinsulinemia are commonly observed in individuals with essential hypertension compared to normotensive individuals[19-24], there are conflicting results from population-based studies[25-27]. Factors such as genetic predisposition, lifestyle and study design contribute to this complexity. Further research is needed to understand the precise mechanisms and determinants of the insulin resistance-hyperinsulinemia-hypertension relationship.

This study aimed to investigate the association between obesity and insulin resistance in individuals with hypertension and determine the impact of coexisting Type 2 Diabetes Mellitus (T2DM) on insulin resistance. Understanding these relationships can improve management strategies for individuals with obesity, hypertension and T2DM.

MATERIALS AND METHODS

This case-control study was conducted at a Medical College located in Central India, targeting a population of individuals aged 30-70 years. The study duration spanned from August 2022 to March 2023 and it consisted of three distinct groups: Group 1 encompassed individuals diagnosed with systemic hypertension who were under antihypertensive medication, Group 2 comprised individuals with a dual diagnosis of type 2 Diabetes Mellitus (T2DM) and hypertension and Group 3 constituted healthy controls selected from the general population. Prior to implementation, the study protocol received the necessary scrutiny and approval from the Institutional Ethics Committee, ensuring compliance with ethical guidelines.

The study employed specific exclusion criteria, eliminating individuals with impaired glucose tolerance, pregnant and nursing women, individuals with physical disabilities that hindered anthropometric measurements, as well as those suffering from endocrine disorders such as Cushing's syndrome, thyroid diseases and renal impairment.

Each group, along with the control group, consisted of 77 subjects, with the control group comprising individuals selected from the hospital staff. Anthropometric measurements were conducted to assess various parameters, including height using a calibrated stadiometer and weight using a validated bathroom scale. The evaluation of abdominal obesity encompassed measurements of waist circumference (WC) and waist-to-hip ratio (WHR), while additional obesity parameters such as waist-to-height ratio (WHtR) and body mass index (BMI) were also assessed. Furthermore, the patients underwent thorough physical examinations and laboratory evaluations as part of the comprehensive study protocol.

RESULTS

The predominant age group in the study population was 46-60 years. The male-to-female ratios were 1.33:1, 1.08:1 and 0.97:1 in the 3 groups, respectively. Group 1 and 2 primarily consisted of manual laborers, while Group 3 had a higher proportion of professionals. However, there were no statistically significant differences observed in terms of age, gender and occupation among the groups, as indicated by the data presented in Table 1.

Table 2 demonstrates a progressive increase in anthropometric parameters, namely BMI, WC and WHR, among patients with hypertension and those with both hypertension and diabetes mellitus. Furthermore, patients with both hypertension and diabetes mellitus exhibited the highest levels of insulin resistance. The ANOVA test was employed to ascertain the differences between the groups, revealing a highly significant difference ($p<0.05$). Post Tukey test analysis indicated that each group significantly differed from the control group (Group 3). Additionally, a significant difference was observed between the various groups.

Table 3 presents the correlation between insulin resistance and specific anthropometric parameters, assessed using Pearson correlation. In group 1 (hypertensives), a positive relationship was observed between waist circumference (WC), hip circumference, waist-to-hip ratio (WHR) and insulin resistance. Similarly, in group 2 (diabetics and hypertensives), a positive relationship was found between WC, hip circumference, WHR and insulin resistance.

Table 1: Socio-demographic profile of the study participants

	Group 1 (n = 77)	Group 2 (n = 77)	Group 3 (n = 77)	p-value
Age (years)				
31-45	4	0	26	<0.05
46-60	44	46	43	
61-70	29	31	8	
Mean age	56.63±6.15	58.4±5.58	50.71±9.16	
Gender				
Male	44	40	38	0.61
Female	33	37	39	
Occupation				
Professional worker	20	18	25	0.87
Manual laborer	25	22	23	
Home maker	14	17	13	
Unemployed	18	20	16	

Table 2: Anthropometric profile of the study participants

	Group 1 (n = 77)		Group 2 (n = 77)		Group 3 (n = 77)		
	Mean	SD	Mean	SD	Mean	SD	p-value
BMI (kg m^{-2})	22.59	3.22	24.55	2.51	21.45	1.27	<0.05
WC (cm)	85.33	5.77	92.55	6.27	81.25	2.89	<0.05
WHR	0.92	0.02	0.91	0.02	0.81	0.02	<0.05
WHtR	0.61	0.03	0.59	0.04	0.54	0.03	<0.05
IR	3.11	1.25	3.73	0.97	1.37	0.19	<0.05

BMI: Body mass index, WC: Waist circumference, WHR: Waist hip ratio, WHtR: Waist height ratio, IR: Insulin resistance and SD: Standard deviation

Table 3: Correlation between anthropometric parameters and insulin resistance

	Statistic	Group 1 (n = 77)	Group 2 (n = 77)	Group 3 (n = 77)
BMI (kg m^{-2})	r-value	0.66	0.33	0.07
	p-value	<0.05	<0.05	0.56
WC (cm)	r-value	0.45	0.39	-0.05
	p-value	<0.05	<0.05	0.68
WHR	r-Value	0.43	0.29	0.06
	p-value	<0.05	<0.05	0.63
WHtR	r-value	0.03	0.36	-0.21
	p-value	0.81	<0.05	0.11
IR	r-value	0.51	0.17	0.11
	p-value	<0.05	0.18	0.42

BMI: Body mass index, WC: Waist circumference, WHR: Waist hip ratio, WHtR: Waist height ratio and IR: Insulin resistance

DISCUSSIONS

The primary objective of this study was to investigate the association between obesity, insulin resistance, hypertension and the coexistence of hypertension and diabetes. The study found that BMI was significantly higher in patients with both hypertension and diabetes compared to those with hypertension alone. Similar significant differences were observed for waist circumference (WC) and waist-to-hip ratio (WHR). Furthermore, the study revealed that patients with both diabetes and hypertension had the highest levels of insulin resistance, followed by patients with hypertension alone. These findings indicate a significant difference in insulin resistance compared to the control group, as well as differences among the different groups studied. Obesity is widely recognized as a significant risk factor for the development of various non-communicable diseases (NCDs), with type 2 diabetes having a particularly strong association with obesity. This close relationship between obesity and type 2 diabetes has given rise to the term “diabesity” which emphasizes the prevailing trend that a majority of individuals with diabetes are overweight or obese. This term serves as a reminder of the high prevalence of obesity among individuals with diabetes and underscores the importance of addressing obesity in the prevention and management of type 2 diabetes[28,29]. In the current study, consistent with previous research[30,31], it was observed that individuals with both diabetes and hypertension had higher mean obesity parameters compared to those with diabetes or hypertension alone. These findings align with the existing body of evidence, supporting the notion that the coexistence of diabetes and hypertension is associated with increased levels of obesity. The study's results provide further support for the association between obesity and the comorbidity of diabetes and hypertension, reinforcing the need for comprehensive management strategies that address obesity in individuals with these conditions. A meta-analysis conducted by Babu *et al*.[32] provided compelling evidence of a significant and plausible association between obesity and both hypertension and type 2 Diabetes Mellitus (T2DM) in studies conducted specifically in India[32]. This comprehensive analysis of existing research findings strengthens the understanding of the relationship between obesity and these two health conditions in the Indian context. Similarly, a separate study conducted by Kumar et al. also found a significant association between obesity and hypertension[33]. These independent studies support the notion that obesity plays a significant role in the development and progression of hypertension and further underscore the importance of addressing obesity as a modifiable risk factor in the prevention and management of hypertension and T2DM. Body mass index (BMI) is widely utilized as a primary tool for identifying and categorizing obesity. In a study conducted by Mitra *et al*.[34], it was observed that there is a positive correlation between BMI and the prevalence of hypertension. Specifically, the study found that individuals with a BMI below 18.5 did not exhibit hypertension, whereas 58.33% of individuals with a BMI above 30 were hypertensive[34]. However, it is important to note that BMI alone is considered an imperfect biomarker of obesity[35], as it does not distinguish between muscle mass and fat mass[36]. This limitation suggests that relying solely on BMI may not provide a comprehensive assessment of an individual's adiposity and highlights the need for additional measures or indicators to better evaluate the distribution and composition of body fat in relation to health outcomes. In addition, BMI does not provide precise information about body fat mass, nor does it account for gender differences in body fat distribution[37]. While waist circumference (WC) and waist-to-hip ratio (WHR) are affordable and easily accessible measures, they also have their limitations[38]. Another anthropometric parameter, waist-to-height ratio (WHtR), has emerged as a useful tool in assessing cardiovascular disease risk in the general population. An advantage of WHtR is that it utilizes a universal cutoff value of 0.5, applicable to both males and females[38,39]. Meta-analyses have demonstrated that WHtR is a more reliable indicator than WC and BMI in predicting cardiometabolic risks[39]. Asian Indians have been found to have a higher degree of insulin resistance compared to other ethnic groups and even apparently healthy young Asian Indians show signs of insulin resistance[40,41]. It has been observed that around 50% of individuals with hypertension also

exhibit insulin resistance, placing them at a significantly increased risk of cardiovascular disease[42]. This association between insulin resistance and hypertension has been further supported by the Insulin Resistance Atherosclerosis Study, which employed a different approach to validate the relationship[43-45].

CONCLUSION

BMI and abdominal obesity parameters play significant roles in the development of Type 2 Diabetes and Hypertension. Utilizing a combination of BMI and abdominal obesity parameters can aid in identifying individuals at risk. Among these parameters, Waist-to-Height Ratio (WHtR) is considered the most favorable as it adjusts for an individual's stature and provides a standardized value applicable to diverse ethnic groups and both genders. By implementing appropriate lifestyle modifications, it is possible to prevent or delay the onset and progression of type 2 Diabetes and hypertension. Furthermore, insulin resistance has been found to be associated with hypertension, particularly in individuals who have both hypertension and diabetes mellitus.

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