Indian Heart Journal 72 (2020) 459–461

Contents lists available at ScienceDirect

Indian Heart Journal

journal homepage: www.elsevier.com/locate/ihj

Research Brief

Association between body mass index and hypertension subtypes in Indian and United States adults

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ARTICLE INFO

Article history:
Received 11 June 2020
Accepted 3 August 2020
Available online 11 August 2020

Keywords:
Hypertension
South Asian
Isolated diastolic hypertension
Epidemiology

ABSTRACT

The purpose of this cross-sectional, secondary analysis was to determine the association between BMI & lipids and hypertension subtype in U.S. and Indian adults. Obese BMI was significantly associated with isolated diastolic hypertension (IDH) compared to low/normal BMI (relative risk ratio [95% CI]; U.S.: 4.33 [2.88,6.52]; India: 2.51 [2.41,2.60]). Furthermore, BMI was more strongly associated with IDH than other hypertension subtypes in U.S. and non-obese Indian adults. In obese Indian adults, we observed higher odds of isolated systolic hypertension until the 6th decade, and systo-diastolic hypertension thereafter. Triglyceride levels were associated with IDH in U.S. adults (1.94 [1.43,2.63]).

1. Introduction

Hypertension is responsible for nearly half of all cardiovascular disease (CVD) deaths globally.[1,2] Recent literature has been increasingly differentiating between isolated systolic hypertension (ISH), isolated diastolic hypertension (IDH), and systo-diastolic hypertension (SDH) due to their differences in demographics and associations with end-outcomes.[3,4] There is a lack of knowledge on predictors of IDH, in part due to its low prevalence and inconsistent association with CVD.[5,6] In this study, we determine whether BMI and lipids are associated with IDH and other hypertension subtypes in two distinct study populations: United States and India.

2. Methods

A total of 790,641 non-pregnant adults (age ≥ 20) from the Clinical, Anthropometric, and Biochemical (CAB) portion of the 2014 Annual Health Survey (AHS) and 15,172 adults from the 2011–2016 U.S. National Health and Nutrition Examination Survey (NHANES) were included. The AHS is a representative survey administered annually in nine Indian states known as India's Empowered Action Group (EAG) States as well as Assam. NHANES is a nationally representative survey of the non-institutionalized, civilian United States population. Detailed information about the surveys can be found elsewhere.[7,8]

BP was determined as the average of two automatic Omron BP monitor readings in the Indian population and two mercury sphygmomanometer-based readings in the U.S. population. Further information about the BP procedure and quality control measures can be found in the Supplementary File.

BMI was categorized into low/normal BMI (India: <23 kg/m^2, U.S.: <25), overweight BMI (India: 23–27, U.S.: 25–30), and obese BMI (India: ≥27, U.S.:≥30).[9,10] Secondary predictors for U.S. participants included triglycerides (<150, ≥150 mg/dL), HDL (<40 for males, <50 mg/dL for females; ≥40 for males, ≥50 for females), and LDL (<100, ≥100 mg/dL).

The outcome was hypertension subtype. ISH was defined as SBP ≥ 140 mmHg and DBP < 90. IDH was defined as SBP < 140 and DBP ≥ 90. SDH was defined as SBP ≥ 140 mmHg and DBP ≥ 90.[11]

We estimated relative risk ratios (RRR) using multinomial logistic regression, adjusting for covariates (India: age, sex, rural/urban locality, fasting glucose; U.S.: age, sex, race/ethnicity, metabolic syndrome criteria, antihypertensives use, diabetes status, and daily caloric intake). All analyses accounted for the complex survey designs. Statistical analyses were done using SAS 9.4 (SAS Institute, Cary, North Carolina, USA).

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https://doi.org/10.1016/j.ihj.2020.08.009

3. Results

Among the 147,342 (19%) participants with hypertension in the Indian population, 28% had SDH, 26% had IDH, and 46% had ISH. Among the 2886 (16%) hypertensive participants in the U.S. population, 16% had SDH, 9% had IDH, and 75% had ISH. The age distribution of IDH was similar between Indian and U.S. adults, exhibiting an inverted U-shape pattern, with a peak in IDH in the 5th decade (Supplementary Fig. S1).

In U.S. and Indian adults, BMI was significantly associated with increased relative risk ratio (RRR) of IDH compared to normotension (Table 1). In U.S. adults, the adjusted risk of IDH in overweight individuals was nearly twice that of low/normal BMI individuals (RRR [95% CI]: 1.77 [1.11, 2.81]). Obese U.S. adults had more than four times the risk of IDH compared to low/normal BMI adults, resulting in a significant trend in risk of IDH with increasing BMI. Indian adults had similar RRR of IDH in overweight individuals, but lower RRR magnitude among obese individuals (Table 1).

The increased risk of IDH in overweight and obese U.S. adults was greater than either ISHor SDH, asseen by the non-overlapping RRRs (Obese group; RRR [95% CI]: IDH: 4.33 [2.88, 6.52], ISH: 1.12 [0.99, 1.27], SDH: 1.74 [1.37, 2.22]); this increased risk of IDH was seen in overweight but not obese Indian adults.

Obese Indian adults, compared to those with lower BMI, consistently have higher systolic, diastolic, and pulse pressures across all age groups (Supplementary Fig. S2). However, we observed that obese Indian adults have a higher and earlier peak prevalence of IDH (Supplementary Fig. S3) and that by age 60–64, IDH prevalence is similar to other BMI groups. This is reflected in the age-specific RRR of IDH: while in overweight Indian adults, the RRR of IDH is consistently higher than other hypertension subtypes until the 6th decade, the RRR of IDH in obese adults is generally lower than that of ISH and/or SDH (Supplementary Fig. S4).

In US adults, triglyceride levels, but not HDL or LDL levels, were positively associated with IDH and ISH, with a significantly stronger association seen with IDH (Table 2; RRR [95% CI]: IDH: 1.94 [1.43, 2.63], ISH: 1.14 [1.01, 1.29]).

Table 2
Association between lipids and hypertension subtype in U.S. Adults.

	Lipid Profile	
	Normal	Abnormal
		RRR (95% CI)
Isolated Diastolic Hypertension vs. Normotension		
Triglycerides	1 (ref)	1.94 (1.43, 2.63)
HDL	1 (ref)	0.89 (0.65, 1.22)
LDL	1 (ref)	1.37 (0.84, 2.23)
Isolated Systolic Hypertension vs. Normotension		
Triglycerides	1 (ref)	1.14 (1.01, 1.29)
HDL	1 (ref)	0.93 (0.81, 1.06)
LDL	1 (ref)	1.10 (0.90, 1.36)
Systo-Diastolic Hypertension vs. Normotension		
Triglycerides	1 (ref)	1.22 (0.99, 1.51)
HDL	1 (ref)	0.88 (0.70, 1.09)
LDL	1 (ref)	1.50 (0.98, 2.29)

Abbreviations: RRR: Relative Risk Ratio; CI: Confidence Interval.
Abnormal triglyceride cutoff set as ≥150 mg/dL.
Abnormal HDL cutoff set as <40 mg/dL in males and <50 mg/dL in females.
Abnormal LDL cutoff set as ≥100 mg/dL.
RRRs represent the relative risk of having a specific hypertension subtype vs. normotension in those with abnormal lipid levels compared to the relative risk in those with normal lipid levels. RRRs are adjusted for age, sex, race/ethnicity, lipids (other than predictor of interest), antihypertensives use, diabetes status, and daily caloric intake.

4. Discussion

In this cross-sectional study, we found that elevated BMI significantly increased the odds of IDH in both U.S. and Indian adults. We also found that the increase in odds of IDH was greater than that of ISH and SDH in obese U.S. adults, but not obese Indian adults. Abnormal triglyceride levels significantly increased odds of IDH in U.S. adults.

Our findings are consistent with recent literature suggesting that BMI is a significant risk factor for IDH. Mittal et al,[12] in a study on patients in rural South India, found 2.57 odds of IDH in overweight individuals compared to low BMI individuals. Furthermore, prospective studies of participants in China have also yielded positive associations between BMI and IDH (as well as with ISH and

Table 1
Association between BMI group and hypertension subtype in Indian and U.S. Adults.

		BMI Group			P for trend[c]
		Low/Normal	Overweight	Obese	
	RRR (95% CI)				
	Isolated Diastolic Hypertension vs. Normotension				
U.S.	Unadjusted	1 (ref)	2.03 (1.27, 3.25)	4.74 (3.13, 7.17)	<0.0001
	Fully Adjusted[a]	1 (ref)	1.77 (1.11, 2.81)	4.33 (2.88, 6.52)	<0.0001
India	Unadjusted	1 (ref)	1.81 (1.77, 1.85)	2.51 (2.41, 2.60)	<0.0001
	Fully Adjusted[b]	1 (ref)	1.79 (1.75, 1.83)	2.51 (2.40, 2.60)	<0.0001
	Isolated Systolic Hypertension vs. Normotension				
U.S.	Unadjusted	1 (ref)	1.12 (0.99, 1.27)	1.28 (1.14, 1.44)	0.0004
	Fully Adjusted	1 (ref)	0.87 (0.76, 1.00)	1.12 (0.99, 1.27)	0.002
India	Unadjusted	1 (ref)	1.48 (1.45, 1.51)	2.57 (2.49, 2.66)	<0.0001
	Fully Adjusted	1 (ref)	1.51 (1.48, 1.54)	2.53 (2.45, 2.62)	<0.0001
	Systo-Diastolic Hypertension vs. Normotension				
U.S.	Unadjusted	1 (ref)	1.50 (1.17, 1.94)	2.03 (1.60, 2.57)	<0.0001
	Fully Adjusted	1 (ref)	1.24 (0.96, 1.60)	1.74 (1.37, 2.22)	<0.0001
India	Unadjusted	1 (ref)	1.58 (1.54, 1.62)	2.71 (2.62, 2.81)	<0.0001
	Fully Adjusted	1 (ref)	1.55 (1.52, 1.59)	2.52 (2.43, 2.61)	<0.0001

Abbreviations: RRR: Relative Risk Ratio; CI: Confidence Interval.
[a] Fully adjusted model for U.S. participants adjusted for age, sex, race/ethnicity, HDL, LDL, triglycerides, antihypertensives use (yes/no), diabetes status (yes/no), and daily caloric intake.
[b] Fully adjusted model for Indian participants adjusted for age, sex, rural/urban locality, fasting glucose.
[c] P for trend determined using identical fully adjusted models, treating BMI group as an ordinal variable.

SDH).[13,14] Few studies, however, have reported differences among hypertension subtypes. The stronger association between BMI and IDH in our study may be due to IDH's younger demographic; long-term risk factors such as diet, stress, and atherosclerosis may not be clinically present, leading to a greater risk associated with BMI.

There was a lack of an increased IDH risk compared to ISH and SDH in the Indian obese group. We speculate that this may, in part, be the result of earlier onset of atherosclerosis and other cardiometabolic risk factors in obese South Asians.[15]

While triglyceride levels have generally been appreciated as a risk factor for systolic hypertension and downstream CVD,[16] we found that triglyceride levels increased risk of IDH more so than ISH or SDH. High triglyceride levels may be involved in early endothelial dysfunction, which may then lead to decreased vasodilation in peripheral vessels, increased myogenic tone, small-artery remodeling, and an increase in peripheral resistance and IDH.[17]

There are several limitations in this study. This is a cross-sectional analysis, so temporality cannot be inferred. BP readings may not accurately reflect hypertension status as they can fluctuate greatly throughout the day. There is possibility for residual confounding, especially among the Indian population due to lack of data on covariates. Furthermore, there was no medication use data among the Indian population and only self-reported medical history data among the U.S. population, which may have biased results.

Despite the low priority given to IDH compared to its systolic counterparts, those with IDH may be 8x more likely to progress to SDH or ISH than those with normal BP,[18] highlighting the need to address IDH and its potentially associated risk factors (BMI and triglycerides).

4.1. Key message

BMI is significantly associated with all hypertension subtypes, but significantly more associated with isolated diastolic hypertension than other hypertension subtypes in U.S. and non-obese Indian adults; the association is more complex in Indian adults with obesity, where we observe a higher risk of isolated systolic hypertension until the 6th decade, followed by systo-diastolic hypertension afterwards.

Ethics approval and consent to participate

This study was exempt from Institutional Review Board approval.

Funding

No funding provided for this study.

Consent for publication

Confirmed.

Availability of data and materials

Not applicable.

Conflicts of interest

The authors declare that they have no competing interests.

Acknowledgements

None.

Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ihj.2020.08.009.

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