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Research Brief

Body mass index in young adulthood and mid-life cardiovascular risk factors in South Asian American adults: The MASALA study

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ABSTRACT

The association of self-reported BMI at age 20, at age 40, the highest BMI within the past 3 years, and current BMI with current mid-life cardiovascular risk factors and coronary artery calcium (CAC) was evaluated among 1148 South Asian American participants (mean age 57 years) in the MASALA study. A 1 kg/m^2 higher BMI at age 20 was associated with higher odds of hypertension (aOR 1.07, 95% CI 1.03−1.12), pre-diabetes/diabetes (aOR 1.05 [1.01−1.09]), and prevalent CAC (aOR 1.06 [1.02−1.11]) in mid-life. Associations were similar for all BMI measures. Weight across young adulthood is associated with mid-life cardiovascular health in South Asian American adults.

1. Introduction

Obesity is associated with higher risk for diabetes, hypertension, and atherosclerotic cardiovascular disease (ASCVD). The prevalence of obesity in young adults 18−25 years of age increased from 6.2% in 1976−1980 to 32.7% in 2017−18 in the US.[1] Weight patterns are often established prior to midlife,[2] and individuals' lifetime exposure to adiposity has a cumulative adverse effect on cardiovascular risk.[3] The impact of body weight and adiposity in young adulthood may be especially relevant for South Asian Americans, a population that experiences more diabetes and ASCVD at younger ages compared with other groups despite lower average body mass index (BMI).[4] To understand whether earlier-life adiposity measures are associated with mid-life cardiovascular risk factors, we evaluated the associations of BMI across young adulthood with mid-life ASCVD risk factors and coronary artery calcium (CAC) in participants of the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study.

2. Methods

Among 1164 MASALA participants, after excluding 16 participants with missing self-report of BMI earlier in life, the study sample included 1148 adults aged 40−84 years at enrollment. Study inclusion and exclusion criteria have been described.[5] Participants self-reported weight at age 20 years, age 40 years, and highest weight in the last 3 years. Current weight was objectively measured. BMI at all time points were calculated as weight (kg) divided by height-squared (m^2), using measured height from the baseline enrollment examination for all calculations, consistent with prior approaches.[6] Baseline characteristics were compared across BMI categories recommended for populations of Asian ancestry.[7,8]

Methods for measuring clinical characteristics (systolic and diastolic blood pressure; hemoglobin A1c; total, high-density lipoprotein [HDL], and low-density lipoprotein [LDL] cholesterol and triglycerides) and behaviors (physical activity, total daily calorie intake, smoking [current/former vs. never], alcohol intake [≥1 drink per week]), and CAC score have been reported.[5] Hypertension was defined as blood pressure ≥140/90 mmHg or use of an antihypertensive medication. Pre-diabetes mellitus (DM) or DM were defined by oral glucose tolerance test or fasting glucose. Dyslipidemia was defined as total cholesterol ≥200 mg/dL, triglycerides

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≥150 mg/dL, HDL ≤40 mg/dL, LDL ≥160 mg/dL, or taking a cholesterol medication. Prevalent CAC was defined as a score >0. Continuous CAC scores were skewed, so were log-transformed for analysis.

The association of BMI at age 20, BMI at age 40, highest BMI in the last 3 years, and current BMI with current cardiovascular risk factors and prevalent CAC was evaluated with multivariable logistic regression, adjusted for age, sex, smoking history, current alcohol intake, current total daily calorie intake, current physical activity. For the CAC outcome, a model additionally adjusting for current hypertension, current pre-DM/DM, and current dyslipidemia was evaluated. Since our objective was to identify whether BMI across the life-course was associated with mid-life cardiovascular health factors, models of earlier life BMI were not adjusted for current BMI, particularly since all measures of BMI were correlated (Pearson correlation coefficients = 0.37–0.95, $p < 0.01$). In secondary analysis, the association of BMI at age 20, BMI at age 40, highest BMI in the last 3 years, and current BMI with log-transformed continuous CAC score was evaluated with multivariable linear regression fully adjusted for all covariates. Analyses were conducted with SAS version 9.4. The MASALA study was approved by the Institutional Review Boards at Northwestern University and University of California, San Francisco. Participants provided informed consent.

3. Results

Among 1148 participants (mean age 57 [standard deviation, SD 9] years and 48% women, characteristics at enrollment stratified by Asian-specific BMI categories in Table 1), current BMI was <23 kg/m^2 in 261 participants (mean age 57 [SD 10] years), 23 to <27.5 kg/m^2 in 528 participants (mean age 57 [SD 9] years), and ≥27.5 kg/m^2 in 359 participants (mean age 56 [SD 9] years). The association of BMI across young adulthood with current cardiovascular risk factors and CAC is shown in Table 2. A 1 kg/m^2 higher BMI at age 20 was significantly associated with higher odds of current hypertension (aOR 1.07 [1.03–1.12]), current pre-diabetes or diabetes (aOR 1.05 [1.01–1.09]), and current prevalent CAC (aOR 1.06 [1.02–1.11], accounting for current ASCVD risk factors). Higher BMI at age 40, highest BMI in the last 3 years, and higher current BMI were also significantly associated with current hypertension, pre-diabetes or diabetes, dyslipidemia, and prevalent CAC in mid-life after adjustment. In secondary analyses, higher BMI at all ages was associated with a higher continuous log-transformed CAC score after adjustment (age 20: β 0.06, $p < 0.01$; age 40: β 0.05, $p < 0.01$; 3-year: β 0.05, $p < 0.01$; current: β 0.03, $p = 0.03$).

4. Discussion

In the MASALA study, self-reported BMI at multiple ages including in young adulthood, as well as current BMI, were associated with higher odds of mid-life ASCVD risk factors and CAC. These results indicate that BMI across young adulthood is associated with an individual's current ASCVD risk profile among South Asian Americans. These findings suggest that BMI as early as age 20 years may be related to the development of cardiovascular risk factors in this population, emphasizing the importance of promoting cardiovascular health early in the life course.

The association between BMI at age 20 with current ASCVD risk factors and CAC may reflect the adverse cumulative exposure to adiposity over the life-course.[3,9] Our observations are particularly important for South Asian Americans since they experience higher rates of ASCVD despite a lower average BMI compared with other ancestry groups,[4] suggesting that adiposity as measured by BMI remains important measure across adulthood to characterize ASCVD risk. These findings align with recent data from the Multi-

Table 1
MASALA participant current characteristics by life course body mass index change categories.

	BMI <23 kg/m^2	BMI 23 to <27.5 kg/m^2	BMI ≥27.5 kg/m^2
N	261	528	359
Women, N (%)	122 (46.7%)	239 (45.3%)	190 (52.9%)
Current age, mean (SD)	57.3 (9.9)	56.6 (9.4)	56.2 (9.0)
BMI at age 20 (kg/m^2), mean (SD)	19.3 (2.4)	20.3 (2.9)	22.0 (3.8)
BMI at age 40 (kg/m^2), mean (SD)	22.0 (2.0)	24.4 (2.3)	27.9 (3.8)
Highest BMI in last 3 years (kg/m^2), mean (SD)	22.7 (1.7)	26.4 (1.6)	31.8 (3.5)
Current BMI (kg/m^2), mean (SD)	21.5 (1.3)	25.2 (1.2)	30.7 (3.3)
Physical activity,[a] median (25th, 75th percentile)	1102 (510, 2100)	1102 (329, 2058)	787 (285, 1575)
Total daily calorie intake, mean (SD)	1651 (512)	1651 (533)	1675 (529)
Alcohol use, N (%)	91 (34.9%)	173 (32.8%)	102 (28.4%)
Systolic blood pressure, mean (SD)	123 (15)	125 (15)	129 (17)
Diastolic blood pressure, mean (SD)	72 (9)	74 (10)	75 (10)
Hypertension, N (%)	87 (33.3%)	213 (40.3%)	202 (56.3%)
Hemoglobin A1c, mean (SD)	5.9 (0.6)	6.0 (0.8)	6.2 (1.0)
Diabetes status			
Normal, N (%)	127 (48.7%)	216 (41.1%)	104 (29.0%)
Pre-diabetes, N (%)	80 (30.7%)	174 (33.1%)	135 (37.6%)
Diabetes, N (%)	54 (20.7%)	136 (25.9%)	120 (33.4%)
Total cholesterol, mean (SD)	186 (37)	187 (38)	187 (38)
HDL cholesterol, mean (SD)	55 (15)	50 (13)	48 (12)
LDL cholesterol, mean (SD)	109 (32)	111 (33)	113 (22)
Triglycerides, median (25th, 75th percentile)	98 (74, 135)	121 (91, 164)	125 (97, 164)
Cholesterol medication use,[b] N (%)	80 (30.7%)	156 (29.6%)	121 (33.7%)
Dyslipidemia, N (%)	178 (68.2%)	412 (78.0%)	282 (78.9%)
Current/former smoking, N (%)	39 (14.8%)	92 (17.4%)	59 (16.5%)
CAC score, median (25th, 75th percentile)	0 (0, 49)	0 (0, 75)	0 (0, 72)
Prevalent CAC (score >0), N (%)	108 (41.5%)	247 (47.0%)	179 (50.6%)
CAC score >100, N (%)	52 (19.9%)	118 (22.4%)	82 (22.8%)
CAC score >400, N (%)	27 (10.3%)	37 (7.0%)	31 (8.6%)

BMI: Body mass index, CAC: Coronary artery calcium, HDL: High density lipoprotein, LDL: low density lipoprotein.
[a] Physical activity reported in MET-min/week units.
[b] Cholesterol medications include statin, fibrate, niacin, ezetimibe, or colesevelam.

Table 2
Association of body mass index across the life course with current cardiovascular risk factors and coronary artery calcium.

	BMI at age 20	BMI at age 40	Highest BMI in last 3 years	Current BMI
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
Current Hypertension				
Unadjusted	1.05 (1.01–1.09)	1.05 (1.02–1.09)	1.11 (1.07–1.14)	1.10 (1.06–1.13)
Model 1[a]	1.07 (1.03–1.12)	1.12 (1.08–1.16)	1.14 (1.10–1.18)	1.13 (1.10–1.18)
Current Pre-DM/DM				
Unadjusted	1.05 (1.01–1.09)	1.06 (1.02–1.09)	1.09 (1.06–1.13)	1.10 (1.06–1.13)
Model 1[a]	1.05 (1.01–1.09)	1.08 (1.05–1.12)	1.10 (1.07–1.13)	1.11 (1.08–1.15)
Current Dyslipidemia				
Unadjusted	1.01 (0.97–1.05)	1.03 (0.99–1.07)	1.03 (0.99–1.06)	1.03 (1.00–1.07)
Model 1[a]	1.00 (0.95–1.04)	1.05 (1.01–1.10)	1.03 (1.00–1.07)	1.05 (1.01–1.09)
Current Prevalent CAC				
Unadjusted	1.06 (1.03–1.10)	1.01 (0.99–1.05)	1.05 (1.02–1.08)	1.03 (1.00–1.06)
Model 1[a]	1.07 (1.03–1.12)	1.10 (1.06–1.15)	1.10 (1.06–1.13)	1.09 (1.05–1.13)
Model 2[b]	1.06 (1.02–1.11)	1.08 (1.03–1.12)	1.08 (1.04–1.12)	1.06 (1.02–1.10)

BMI: Body mass index, CAC: coronary artery calcium, DM: diabetes mellitus. Bold indicates statistically significant. Odds ratios (95% confidence interval) per 1 kg/m^2 higher BMI.

[a] Model 1: Adjusted for current age, sex, smoking history, current alcohol intake, current total daily calorie intake, current physical activity.

[b] Model 2: Model 1 + additionally adjusted for current hypertension, current pre-DM/DM, current dyslipidemia.

Ethnic Study of Atherosclerosis, which indicate that self-reported lifetime weight patterns are associated with risk of heart failure.[6]

One strength of this study is the evaluation of factors across the life-course that may contribute to ASCVD risk and subclinical atherosclerosis in South Asian Americans, a population underrepresented in cardiovascular research. Limitations include that earlier life BMI was self-reported, which may be subject to recall and social desirability bias. However, self-reported weight history has demonstrated reasonable validity in epidemiologic analyses.[10,11] Ultimately, the results of this study support the potential clinical prognostic importance of BMI during young adulthood as a contributor to ASCVD risk over the life course in South Asian Americans, which may inform earlier-life strategies for mitigating ASCVD risk factors and atherosclerosis in this population.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Nilay Shah reports financial support was provided by National Heart Lung and Blood Institute. Alka Kanaya reports financial support was provided by National Heart Lung and Blood Institute. Alka Kanaya reports financial support was provided by National Center for Advancing Translational Sciences.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ihj.2023.02.005.

References

1. Ellison-Barnes A, Johnson S, Gudzune K. Trends in obesity prevalence among adults aged 18 through 25 Years, 1976-2018. *JAMA*. 2021;326(20):2073–2074.
2. Lewis TT, Everson-Rose SA, Sternfeld B, Karavolos K, Wesley D, Powell LH. Race, education, and weight change in a biracial sample of women at midlife. *Arch Intern Med*. 2005;165(5):545–551.
3. Charakida M, Khan T, Johnson W, et al. Lifelong patterns of BMI and cardiovascular phenotype in individuals aged 60-64 years in the 1946 British birth cohort study: an epidemiological study. *Lancet Diabetes Endocrinol*. 2014;2(8):648–654.
4. Volgman AS, Palaniappan LS, Aggarwal NT, et al. Atherosclerotic cardiovascular disease in South Asians in the United States: epidemiology, risk factors, and treatments: a scientific statement from the American Heart Association. *Circulation*. 2018;138(1):e1–e34.
5. Kanaya AM, Kandula N, Herrington D, et al. Mediators of Atherosclerosis in South Asians Living in America (MASALA) study: objectives, methods, and cohort description. *Clin Cardiol*. 2013;36(12):713–720.
6. Fliotsos M, Zhao D, Rao VN, et al. Body mass index from early-, mid-, and older-adulthood and risk of heart failure and atherosclerotic cardiovascular disease: mesa. *J Am Heart Assoc*. 2018;7(22), e009599.
7. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363(9403):157–163.
8. Shah NS, Luncheon C, Kandula NR, et al. Heterogeneity in obesity prevalence among asian American adults. *Ann Intern Med*. 2022;175(11):1493–1500.
9. Luo J, Hodge A, Hendryx M, Byles JE. Age of obesity onset, cumulative obesity exposure over early adulthood and risk of type 2 diabetes. *Diabetologia*. 2020;63(3):519–527.
10. Spencer EA, Appleby PN, Davey GK, Key TJ. Validity of self-reported height and weight in 4808 EPIC-Oxford participants. *Publ Health Nutr*. 2002;5(4):561–565.
11. Tamakoshi K, Yatsuya H, Kondo T, et al. The accuracy of long-term recall of past body weight in Japanese adult men. *Int J Obes Relat Metab Disord*. 2003;27(2):247–252.