Variations in Anthropometric Measures of Obesity with Age in the Jackson Heart Study

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Abstract

Background– Based on body mass index (BMI), the prevalence of obesity has been shown to vary by age and sex. However, age- or sex-related variations in obesity defined by anthropometric measures of central adiposity, which may be better proxies for obesity-related risk, is unclear.

Methods– Using data from 4063 African American (AA) participants in the Jackson Heart Study, linear and Poisson regression model analyses were conducted to estimate mean difference of standardized anthropometric measures and prevalence ratios of obesity based on body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR) by age cohort and sex.

Results– We found sex- and age-variations in the prevalence of obesity for all measures; however, these patterns varied. In cross-sectional analyses at Visit 2, older cohorts showed a lower prevalence of obesity based on BMI but a higher prevalence of obesity based on WHtR and WHR. In longitudinal analyses, for BMI, and WC, and WHtR, the mean and the prevalence of obesity from Visit 2 to Visit 3 increased only among younger cohorts; however, for WHR, the mean and the prevalence of obesity increased consistently from Visit 2 to 3 across all age cohorts for both sexes.

Conclusions–WHR appeared to be a more consistent anthropometric measure for monitoring the prevalence of obesity particularly among elderly AAs. Instead of BMI, WHR would be used to monitor the prevalence of obesity among elderly AAs in clinic.

Background

Ongoing monitoring of trends in obesity is a global health priority due to increased prevalence of obesity worldwide and its associated morbidity and mortality, trans-generational effects and disproportionate burden in disadvantaged populations¹⁻⁴. In such monitoring, the most commonly used measure of obesity is the body mass index (BMI), with obesity defined as a BMI of ≥ 30 kg/m². Based on this measure, the prevalence of obesity has been shown to vary by age, sex and race/ethnicity⁵⁻⁷. For instance, the prevalence of obesity in the US during 2017-2018 was reported to increase between the age groups of 20-39 and 40-59 years among men and women, and then declined in the age group of 60 years and older among men, but didn't decline among women. Furthermore, the age-adjusted prevalence of obesity was higher among African American (AA) women than among AA men, and higher among AA adults than all other races⁸.

Whether similar age- or sex-related variations in obesity defined by BMI are evident for anthropometric measures of central adiposity, which may be better proxies for obesity-related risk, is unclear. As African Americans (AAs) are known to have relatively less of their body mass in their trunks and relatively more in their extremities compared to non-Hispanic whites⁹, evaluations of age- and sex-related variations in measures of central adiposity could prove more useful in risk stratification studies. Also unclear is how these age and sex variations in anthropometric measures of obesity change with age within a cohort of middle-age to elderly AAs.

In this study, we used data from the Jackson Heart Study (JHS), a community-based longitudinal study of cardiovascular diseases among adult AAs in Jackson, MS, to examine the variations in average anthropometric measures of BMI, waist circumference (WC), waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR). We also assessed the prevalence of obesity according to BMI, WC, WHtR and WHR, by age and sex, cross-sectionally and longitudinally for different age-group cohorts.

Methods

Data Source

The JHS is the largest single-site, population-based cohort study of cardiovascular diseases in AAs. Participant recruitment for the JHS began in 2000, enrolling 5,306 AAs from the tri-county area of Jackson, MS metropolitan area. Participants were examined at baseline (Visit 1 2000-2004) and two additional examinations (Visit 2 2005-2008 and Visit 3 2009-2013). Additional details of the JHS study design, recruitment and data collection have been published previously¹⁰⁻¹². The JHS was approved by the IRBs of the University of Mississippi Medical Center, Jackson State University, and Tougaloo College. Informed consent was provided by all participants.

Analytic Sample

Because WHR data were only available at Visits 2 and 3, for comparison purposes, anthropometric measures from Visit 2 were used for the cross-sectional analysis of the average standardized anthropometric measures and the prevalence of obesity with cohort effect (age at Visit 2). Anthropometric measures from Visits 2 and 3 were used for the longitudinal analysis of changes in average standardized anthropometric measures and the prevalence of obesity due to the aging effect. All participants that returned for Visit 2 were included (N=4205). Participants who had missing values for any of the anthropometric measures of interest at Visit 2 were excluded (N=142), leaving 4063 participants in the analytic sample.

Anthropometric Measures

The anthropometric measures included body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR). BMI was calculated as (weight (kg)/height (m)²)¹³. WHtR was calculated as WC (cm)/height (cm) and WHR was calculated as WC (cm)/hip circumference (cm). Weight was measured to the nearest 0.1 kg and height to the nearest centimeter in light clothing and in stocking feet; WC was measured to the nearest centimeter at the umbilicus; hip circumference was measured to the nearest centimeter at the maximal protrusion. Obesity status (obese/non-obese) was classified based on cut-points recommended by guidelines or reported in the literature for each obesity measure as follows: BMI ≥ 30 kg/m²,¹⁴; WC > 88 cm for women or > 102 cm for men^{15, 16}; WHtR ≥ 0.5 ¹⁷; WHR ≥ 0.85 for women or ≥ 0.9 for men¹⁸.

Baseline Characteristics

Education was measured as years of schooling completed and included 4 categories: less than high school (<12 years), high school graduate or General Educational Development (GED), some college, and college graduate and above. Family income status was derived from family income and family size and adjusted by interview year of data collection to account for inflation, and was collapsed into four categories: poor (income less than poverty level), lower-middle (income 1 to 1.5 times the poverty level), higher-middle (income >1.5 but <3.5 times the poverty level), and affluent (income ≥ 3.5 times the poverty level)¹⁹.

Cardiovascular disease (CVD) history was defined at Visit 2 if the study participant had either: (i) history of coronary heart disease defined as either self-reported prior Myocardial infarction (MI) (diagnosed by a doctor or health professional, or hospitalization for MI), or ECG diagnosis of MI, or (ii) history of cardiac procedure defined as either prior coronary revascularization (coronary artery bypass grafting or percutaneous coronary intervention) or peripheral arterial revascularization, or (iii) prior carotid angioplasty or carotid endarterectomy, or (iv) self-reported stroke history (diagnosed by a doctor or health professional)²⁰.

Diabetes was defined as self-reported diabetes, hemoglobin A1c $\geq 6.5\%$, fasting glucose ≥ 126 mg/dl as per the 2010 American Diabetes Association guidelines, or use of glucose-lowering medications at Visit 2²¹. Hypertension (HTN) was defined as Visit 2 systolic blood pressure ≥ 140 mm Hg and diastolic blood pressure ≥ 90 mm Hg, taking antihypertensive medications, or answering “yes” to “Have you ever been told by a physician that you had high blood pressure?”²²

Abdominal adipose tissues (VAT) and subcutaneous adipose tissue (SAT) were measured at Visit 2 using a 16-channel multidetector CT with cardiac gating (Lightspeed 16 Pro; GE Healthcare, Milwaukee, WI). The detailed protocol of assessment of VAT has been reported previously²³. Briefly, the multidetector CT was used to scan the heart and lower abdomen, and the acquired CT imaging slices covering the lower abdomen from L3 to S1 were used for assessing VAT and SAT. The protocol used 24 contiguous slices, 2 mm thick, surrounding the center of the L4-L5 spine with 12 slices both above and below for quantification of VAT and SAT. Volume analysis software (Advantage Windows; GE Healthcare, Waukesha, WI) was used to segment and characterize each individual voxel as a tissue attenuation of fat with a threshold range of -190 to -30 Hounsfield units. The VAT and SAT volumes in cm³ were the sum of VAT and SAT voxels over 24 slices. A CT Reading Center (Wake Forest School of Medicine, Winston-Salem, NC) was responsible for quality control and image analysis.

Statistical Analysis

Cross-sectional analysis

Age at Visit 2 was grouped into 5 age cohorts (i.e., age groups at Visit 2): <45, 45-<55, 55-<65, 65-<75 and ≥ 75 years. Sex and age cohort effect on anthropometric measures was examined using linear regression models, and the adjusted means difference of standardized anthropometric measures were calculated.

The prevalence of obesity by age cohort and by sex were examined using Poisson regression models. Prevalence ratios were calculated to compare the prevalence of obesity by age cohort and sex.

To examine the effect of sex on the relationship between obesity and age cohort, stratified analyses by sex were performed. The significance of the effect of sex on the relationships between obesity and age cohort was tested by including a sex*age cohort interaction term in the statistical models.

Longitudinal Analysis

Longitudinal analyses of changes in average anthropometric measures with aging (from Visit 2 to Visit 3 with the average 3 follow-up years and range of 1.8 to 6.9 follow-up years) were examined using mixed effects models with random intercept (individuals) and random slope (aging

effect; follow-up time) for each sex and each age cohort used in the cross-sectional analysis.

Longitudinal analyses of the prevalence of obesity with aging (from Visit 2 to Visit 3) were examined using Poisson regression models with generalized estimating equations (GEE) for correlated data. Longitudinal changes in the prevalence of obesity were analyzed stratified by the 5 age cohorts used in the cross-sectional analysis. To test the effect of age and sex on the effect of aging (visit), an age*visit and sex*visit interaction term was included in the statistical models respectively.

Results

Table 1 shows the characteristics of the participants at Visit 2 that were included in the analytic sample. The mean age of the participants at Visit 2 was about 59.30 ± 12.20 years old (range 25-97) and about 64% were women. Over 85% of the participants had at least a high school education or GED. There were about 5% participants with CVD history, 69% with hypertension, 33% with diabetes at Visit 2. There were more women, more people with less than high school education, and more people with CVD, HTN, and diabetes in older age groups.

The participants had average of weight 90.92 (21.23) kg, height 168.62 (9.49) cm, BMI 31.98 (7.11) kg/m², WC 102.09 (15.84) cm, WHtR 0.61 (0.10), hip circumference 114.13 (14.59) cm, WHR 0.89 (0.08), VAT 830.53 (383.59) cm³, and SAT 2329.95 (1014.64) cm³. The prevalence of obesity defined by BMI, WC, WHtR and WHR were 56%, 68%, 91%, and 65% respectively. Older age groups generally had lower weight, height, BMI, hip circumference and SAT, but higher WHtR, WHR and VAT. The prevalence of obesity defined by BMI lower but those defined by WHtR and WHR higher among older groups than younger groups.

Table 2 show the mean difference of standardized anthropometric measures and prevalence ratios of obesity by sex and age cohort, using BMI, WC, WHtR and WHR definitions of obesity at Visit 2. Age-adjusted mean difference of standardized WHtR was significantly higher was in women than in men (mean difference -0.04; 95% CI -0.04,-0.03). Age-adjusted prevalence of obesity was higher in women than in men for all measures, except for WHR where the prevalence of obesity was higher in men than in women (prevalence ratio (PR) 1.27; 95% CI 1.22, 1.32). Sex-adjusted mean difference of standardized value and prevalence of obesity showed an increasing trend with age for WHtR and WHR, while showed a decreasing trend with age for BMI. For BMI, the mean difference of standardized value and PR (95% CI) comparing the oldest to the youngest age group were -0.68 (-0.80,-0.55) and 0.65 (0.57, 0.74) respectively. In addition, the increasing trend with age was most prominent with WHR. For WHR, the mean difference of standardized value and PR (95% CI) comparing the oldest to the youngest age group was 0.64 (0.52, 0.77) and 1.59 (1.44, 1.75) respectively. Statistically significant sex*age interactions were observed for BMI and WHR. However, the significant interactions were attributable to the changes in magnitude of the associations in different sexes (Supplemental Table 1).

Figure 1 shows the change in average anthropometric measures values vs. average age of the participants from Visit 2 to Visit 3 for each age cohort by sex. At each visit, women's mean BMI and WHtR were much higher than men's, while women's mean WC and WHR were lower than men's in all age cohorts. Younger cohorts had a significantly higher mean BMI, but a lower mean WHR than older cohorts for both men and women at Visit 2 (Supplemental Table 1).

Between Visit 2 and Visit 3, the average BMI tended to increase for men and women in age cohorts with <55 years of age, whereas it showed significantly decreasing trend for participants in age cohorts with ≥ 65 years of age. WC and WHtR had similar patterns of change between Visit 2 and Visit 3; however, a significant reverse trend was observed in the age cohort with ≥ 75 years of age). In contrast, WHR showed a consistent increasing trend between Visit 2 and Visit 3 (i.e., with aging) in all age cohorts, although the magnitude of the increasing trend generally decreased with increasing cohort's age.

In longitudinal analyses of change in the prevalence of obesity from Visit 2 to Visit 3, the prevalence of obesity increased in the younger cohorts (i.e., <45 and 45-<55 years) for all anthropometric measures (Table 3). In older cohorts (i.e., ≥ 55 years), the prevalence of obesity based on BMI, WC and WHtR appeared to be stable from Visit 2 to Visit 3. In contrast, the prevalence of obesity based on WHR in Visit 3 was higher than in Visit 2 in all age cohorts, although the increase slowed in older cohorts compared to younger ones. The PR (95% CI) of obesity using WHR comparing Visit 3 to Visit 2 was 1.29 (1.19, 1.39) and 1.06 (1.01, 1.11) in age cohort <45 and ≥ 75 years, respectively. Statistically significant sex*visit interactions were observed for WC in the oldest cohort (≥ 75 years) and WHR in the two youngest cohorts (<45 and 45-<55 years). The interactions were of a qualitative nature for WC; the prevalence of obesity in men using WC was significantly lower in Visit 3 than in Visit 2. The significant interactions were attributable to the changes in magnitude of the associations in different sexes (Supplemental Table 2).

Discussion

In this study of a large sample of adult AA men and women in Jackson, MS, we found sex- and age-variations in the prevalence of obesity based on not only BMI, but also WC, WHtR and WHR; however, the patterns of variation varied. In cross-sectional analyses, compared to younger cohorts, older cohorts had lower average BMI, but a higher average WHR; in contrast with a lower prevalence of obesity based on BMI in old cohorts, the prevalence of obesity based on measures of central obesity such as WHtR and WHR tended to be higher among older cohorts. These findings demonstrate that BMI is not likely to reflect as reliably as other anthropometric measures changes in central adiposity with aging as it does not

separate fat mass from lean muscle mass. In particular, despite older individuals showing a lower average BMI compared to younger individuals, older adults may have on average comparable WHRs.

In longitudinal analyses, the patterns variation in changes in obesity measures between Visit 2 and Visit 3 were similar for BMI, WC and WHtR, with the mean and prevalence of obesity increasing between visits only among younger cohorts. In contrast, the mean and prevalence of obesity based on WHR showed an increase from Visit 2 to Visit 3 across all age cohorts. These findings with WHR fit well with the postulated biological changes in old age, including redistribution of adiposity from limbs to visceral with concomitant loss of lean muscle mass, as approximated by waist circumference (central adiposity) and hip circumferences (gluteal muscle), respectively¹⁸.

Although the mean BMI, WC and WHtR decreased in older cohorts, the prevalence of obesity based on these measures remained stable between visits. A plausible explanation for this discrepancy is that the decrease in these measures among obese participants didn't reduce them to cutoff point values, and didn't affect the classification of obesity. In addition, the decrease in these measures among non-obese participants would not affect the classification of obesity. Therefore, the prevalence of obesity based on them remained unchanged.

The observation that the prevalence of obesity based on BMI, WC and WHtR were stable between visits while the prevalence of obesity based on WHR were increasing in old cohorts suggests that loss of lean muscle mass or change in the distribution of fat and lean mass with age may play an important role in disease risks associated with obesity in older adults. This may also partially explain why older adults considered to be overweight based on BMI have a lower mortality rate than those with lower BMI (the "obesity paradox")²⁴. In a prospective cohort study among male health professionals in the US, a significant positive monotonic association between predicted fat mass and all-cause mortality, and a U-shaped association between predicted lean body mass and all-cause mortality were found, suggesting that the "obesity paradox" may be largely caused by low lean body mass, instead of low fat mass, in the lower BMI range²⁵. In another prospective cohort study of older British men, it was found that sarcopenia and central adiposity were associated with higher all-cause mortality²⁶. In our own analyses in the JHS, we found the relationships between BMI, WC, WHtR and overall mortality to be J-shaped whereas there was a monotonic increasing relationship between WHR and overall mortality, suggesting once corrected for gluteal muscle mass, lower BMI or central adiposity does not afford greater mortality risks²⁷.

The strengths of this study include the large sample size and longitudinal follow-up of a well-characterized cohort of adult AAs, including a substantial proportion of elderly men and women, with standardized anthropometric measures of obesity across two visits, and a relatively high retention rate across visits. However, the study has several limitations. First, the longitudinal changes in the prevalence of obesity over the life-course were derived from participants from different age cohorts. While it is reasonable to assume that while the prevalence of obesity may differ by age cohort at one point in time and that the longitudinal trend observed in obesity measures may be consistent with the biology of aging, we cannot be certain that these trends will hold for all age groups without longer term follow-up of all age cohorts. Furthermore, the results may not be generalizable to all AAs across the US, as the sample was drawn solely from residents of Jackson, MS.

Conclusion

In conclusion, given the high burden of obesity-related health risks in AAs, it is important to identify practical and reliable anthropometric measures that may reflect central adiposity better than BMI across different age groups to monitor obesity trends and obesity-related risks in this population, and particularly among higher risk age cohorts. In particular, in our study, WHR appeared to be a more consistent anthropometric measure for monitoring the prevalence of obesity particularly among elderly AAs. These findings should be verified in other ethnically diverse populations.

List Of Abbreviations

BMI: Body mass index; AA: African American; WC: Waist circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; US: United States; JHS: Jackson Heart Study; MS: Mississippi; IRB: Institutional Review Boards; cm: Centimeters; kg: Kilograms; m²: squared meter; kg/ m²: Kilograms divided by meters squared; GED: high school graduate or General Educational Development; CVD: Cardiovascular disease; MI: Myocardial infarction; ECG: electrocardiogram; HTN: Hypertension; *mm Hg*: *millimeters of mercury*; VAT: Abdominal adipose tissues; SAT: subcutaneous adipose tissue; CT: computerized tomography; WI: *Wisconsin*; mm: *millimeters*; NC: *North Carolina*; GEE: generalized estimating equations; PR: prevalence ratio; CI: Confidence interval

Declarations

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Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute; the National Institute for Minority Health and Health Disparities; the National Institutes of Health; or the U.S. Department of Health and Human Services.

Authors' contributions

YG—analysis and interpretation of data, drafting and final approval of the manuscript; YM—statistical expertise, helped conduct the literature review, critical review and final approval of the manuscript; RAB—critical review and final approval of the manuscript; AGB—critical review and final approval of the manuscript; AC—conception and design of study, critical review and final approval of manuscript. All authors have read and approved the manuscript.

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Availability of data and materials

As a National Heart, Lung, and Blood Institute (NHLBI)-funded study, the JHS follows the NHLBI's Policy for Data Sharing, which includes depositing the data into the NHLBI's Biologic Specimen and Data Repository Information Coordinating Center (BioLINCC) to make it publically available to other investigators. The link to the JHS dataset: <https://biolincc.nhlbi.nih.gov/studies/jhs/>. Further download directions are provided on the website. NHLBI further requires the JHS to maintain the accuracy of this dataset, so the JHS Coordinating Center sends modifications to BioLINCC for incorporation as appropriate. Privacy and access settings are controlled by BioLINCC, and the investigators have no influence on these settings.

Ethics approval and consent to participate

The study was approved by the Institutional Review Boards of the four participating institutions (Jackson State University, Tougaloo College, the Mississippi State Department of Health and the University of Mississippi Medical Center) and participants provided written informed consent. All experiments were performed in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing Interests

None.

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Tables

Table 1. Characteristics at Visit 2 of Jackson Heart Study Participants included in the Analytic Sample.

Characteristics	Total	25-<45 yrs	45-<55 yrs	55-<65 yrs	65-<75 yrs	75+ yrs	p- value*
Sample Size	4063	481	996	1091	1041	454	
Age, mean (SD)	59.30 (12.20)	39.09 (5.04)	49.71 (2.87)	59.52 (2.99)	69.01 (2.75)	78.94 (3.45)	<0.001
Sex							
Women	2615 (64%)	288 (60%)	626 (63%)	700 (64%)	687 (66%)	314 (69%)	0.027
Men	1448 (36%)	193 (40%)	370 (37%)	391 (36%)	354 (34%)	140 (31%)	0.027
Education, n(%)*							<0.001
Less than high school	627 (15%)	11 (2%)	45 (5%)	107 (10%)	275 (26%)	189 (42%)	
High school graduate/GED	767 (19%)	81 (17%)	157 (16%)	191 (18%)	244 (24%)	94 (21%)	
Attended vocational school, trade school, or college	2660 (66%)	387 (81%)	792 (80%)	792 (73%)	519 (50%)	170 (38%)	
CVD History, n(%)							<0.001
No	3849 (95%)	473 (99%)	980 (98%)	1039 (95%)	957 (92%)	400 (88%)	
Yes	213 (5%)	7 (1%)	16 (2%)	52 (5%)	84 (8%)	54 (12%)	
HTN, n(%)							<0.001
No	1258 (31%)	310 (64%)	438 (44%)	286 (26%)	173 (17%)	51 (11%)	
Yes	2805 (69%)	171 (36%)	558 (56%)	805 (74%)	868 (83%)	403 (89%)	
Diabetes, n(%)*							<0.001
No	2183 (67%)	366 (87%)	662 (78%)	576 (62%)	411 (55%)	168 (54%)	
Yes	1072 (33%)	54 (13%)	186 (22%)	347 (38%)	341 (45%)	144 (46%)	
Weight (kg)	90.92 (21.23)	98.30 (26.86)	93.43 (22.04)	92.25 (19.77)	88.17 (18.56)	80.66 (16.77)	<0.001
Height (cm)	168.62 (9.49)	170.28 (9.75)	169.68 (9.29)	169.10 (9.54)	167.75 (9.06)	165.37 (9.59)	<0.001
Body Mass Index (kg/m2)	31.98 (7.11)	33.93 (9.17)	32.47 (7.35)	32.31 (6.75)	31.37 (6.38)	29.47 (5.54)	<0.001
Obesity by BMI(BMI>30 kg/m2)							<0.001
No	1806 (44%)	186 (39%)	426 (43%)	434 (40%)	491 (47%)	269 (59%)	
Yes	2257 (56%)	295 (61%)	570 (57%)	657 (60%)	550 (53%)	185 (41%)	
Waist Circumference (cm)	102.09 (15.84)	102.54 (19.20)	101.04 (16.12)	103.18 (15.24)	102.55 (15.34)	100.21 (13.44)	0.002
Obesity by waist (WC > 88 cm for women or > 102 cm for men)							<0.001
No	1301 (32%)	181 (38%)	350 (35%)	309 (28%)	313 (30%)	148 (33%)	
Yes	2762 (68%)	300 (62%)	646 (65%)	782 (72%)	728 (70%)	306 (67%)	
WHtR	0.61 (0.10)	0.60 (0.12)	0.60 (0.10)	0.61 (0.09)	0.61 (0.09)	0.61 (0.08)	0.001
Obesity by WHtR (WHtR ≥ 0.5)							<0.001
No	380 (9%)	73 (15%)	121 (12%)	90 (8%)	67 (6%)	29 (6%)	
Yes	3683 (91%)	408 (85%)	875 (88%)	1001 (92%)	974 (94%)	425 (94%)	
Hip Circumference (cm)	114.13 (14.59)	117.11 (16.85)	114.92 (15.09)	114.82 (14.03)	113.08 (13.84)	109.96 (12.69)	<0.001
WHR	0.89 (0.08)	0.87 (0.08)	0.88 (0.08)	0.90 (0.08)	0.91 (0.08)	0.91 (0.07)	<0.001
Obesity by WHR (WHR ≥ 0.85 for women or ≥ 0.9 for men)							<0.001

No	1435 (35%)	246 (51%)	448 (45%)	357 (33%)	289 (28%)	95 (21%)	
Yes	2628 (65%)	235 (49%)	548 (55%)	734 (67%)	752 (72%)	359 (79%)	
VAT (cm ³)	830.53 (383.59)	668.70 (301.92)	738.40 (338.95)	864.85 (387.79)	928.95 (414.13)	847.00 (359.33)	<0.001
SAT (cm ³)	2329.95 (1014.64)	2482.79 (1145.83)	2394.28 (1033.30)	2389.08 (1026.49)	2243.91 (949.41)	1991.09 (853.18)	<0.001

* One-way analysis of variance (ANOVA) Chi-square test was used for comparison of means of continuous variables; Chi-squared test was used for comparison of proportions of categorical variables.

SD=standard deviation; GED= General Educational Development; CVD= cardiovascular disease; HTN= hypertension; BMI=body mass index; WC=waist circumference; WHtR=waist-to-height ratio; WHR=waist-to-hip ratio; VAT= abdominal adipose tissues; SAT= subcutaneous adipose tissue; yrs=years.

Table 2. Mean Differences of Standardized Anthropometric Measures and Prevalence Ratio (PR) of Obesity Defined by BMI, WC, WHtR and WHR at Visit 2 by Sex (Women as Reference) and by Age Cohort (25<45 yrs Group as Reference).

	Mean difference (95% CI)				PR (95% CI)			
	Standardized BMI	Standardized WC	Standardized WHtR	Standardized WHR	BMI>30 kg/m ²	WC > 88 cm for women or > 102 cm for men	WHtR ≥ 0.5	WHR ≥ 0.85 for women or ≥ 0.9 for men
Sex*								
Women(reference)	1	1	1	1	1	1	1	1
Men	-0.01 (-0.08,0.05)	0.01 (-0.05,0.08)	-0.04 (-0.04,-0.03)	-0.02 (-0.08,0.04)	0.75 (0.70, 0.80)	0.59 (0.56, 0.63)	0.97 (0.95, 0.99)	1.27 (1.22, 1.32)
p-value	0.659	0.690	0.000	0.515	<.0001	<.0001	<.0001	<.0001
Age at Visit 2**								
25<45 yrs (reference)	1	1	1	1	1	1	1	1
45<55 yrs	-0.22 (-0.33,-0.12)	-0.09 (-0.20,0.02)	-0.01 (-0.02,0.00)	0.12 (0.01,0.23)	0.94 (0.86, 1.02)	1.04 (0.96, 1.12)	1.03 (1.00, 1.15)	1.14 (1.03, 1.27)
55<65 yrs	-0.26 (-0.36,-0.15)	0.05 (-0.06,0.15)	0.01 (-0.00,0.02)	0.41 (0.31,0.52)	0.98 (0.90, 1.07)	1.13 (1.06, 1.21)	1.08 (0.99, 1.08)	1.39 (1.26, 1.53)
65<75 yrs	-0.40 (-0.50,-0.29)	0.01 (-0.10,0.12)	0.01 (-0.00,0.02)	0.55 (0.44,0.65)	0.86 (0.79, 0.94)	1.10 (1.02, 1.18)	1.10 (1.06, 1.14)	1.49 (1.36, 1.65)
75+ yrs	-0.68 (-0.80,-0.55)	-0.13 (-0.26,-0.01)	0.00 (-0.01,0.01)	0.64 (0.52,0.77)	0.65 (0.57, 0.74)	1.05 (0.96, 1.14)	1.10 (1.05, 1.15)	1.59 (1.44, 1.75)
p-value for trend	<.0001	0.762	0.032	<.0001	0.007	0.612	<.0001	<.0001

*Mean difference and PR's for sex are age-adjusted. ** Mean difference and PR's for age are sex-adjusted.

PR=prevalence ratio; SE=Standard Error; BMI=body mass index; WC=waist circumference; WHtR=waist-to-height ratio; WHR=waist-to-hip ratio; yrs=years.

Table 3. Change in Prevalence of Obesity from Visit 2 to Visit 3 for Obesity Defined by BMI, WC, WHtR and WHR, by Age Cohort.

Prevalence of Obesity at Visit 3 vs. Visit 2 (reference)					
	N	BMI>30 kg/m2	WC > 88 cm for women or > 102 cm for men	WHtR ≥ 0.5 PR (95% CI)	WHR ≥ 0.85 for women or ≥ 0.9 for men PR (95% CI)
Age Cohort					
25-<45 yrs	481	1.06 (1.01, 1.11)	1.12 (1.06, 1.17)	1.06 (1.03, 1.10)	1.29 (1.19, 1.39)
45-<55 yrs	996	1.07 (1.03, 1.11)	1.085 (1.05, 1.12)	1.04 (1.02, 1.07)	1.20 (1.15, 1.26)
55-<65 yrs	1091	1.00 (0.96, 1.03)	1.02 (1.00, 1.05)	1.02 (1.00, 1.03)	1.12 (1.08, 1.16)
65-<75 yrs	1041	0.97 (0.93, 1.01)	1.006 (0.98, 1.04)	0.99 (0.97, 1.01)	1.09 (1.05, 1.13)
75+ yrs	454	0.99 (0.89, 1.11)	1.001 (0.95, 1.06)	0.974 (0.94, 1.01)	1.06 (1.01, 1.11)
p-value of age*visit interaction		0.0043	0.0002	<.0001	<.0001

PR=prevalence ratio; BMI=body mass index; WC=waist circumference; WHtR=waist-to-height ratio; WHR=waist-to-hip ratio; yrs=years.

Figures

Figure 1

The change in average anthropometric measures values vs. average age of the participants from Visit 2 to Visit 3 for each age cohort by sex.

Supplementary Files

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- [SuppTables.docx](#)