

Racial Differences in Maintaining Optimal Health Behaviors Into Middle Age



John N. Booth III, PhD,¹ Norrina B. Allen, PhD,² David Calhoun, MD,³ April P. Carson, PhD,¹ Luqin Deng, PhD,¹ David C. Goff Jr., MD, PhD,⁴ David T. Redden, PhD,⁵ Jared P. Reis, PhD,⁵ Daichi Shimbo, MD,⁶ James M. Shikany, DrPH,⁷ Stephen Sidney, MD,⁸ Bonnie Spring, PhD,² Cora E. Lewis, MD,¹ Paul Muntner, PhD¹

Introduction: Earlier development of cardiovascular disease risk factors in blacks versus whites may result from differences in maintaining health behaviors. Age-specific racial differences in maintaining health behaviors from ages 18 to 50 years were determined.

Methods: In 1985–1986, the population-based Coronary Artery Risk Development in Young Adults study enrolled 5,115 participants aged 18–30 years. In 2017, a total of 2,485 blacks and 2,407 whites with one or more optimal health behaviors at baseline who attended one or more of seven follow-up exams over 25 years (i.e., through 2010–2011) were analyzed. The primary outcome, maintaining four or more optimal health behaviors, included BMI <25; never smoking; ≥ 150 minutes/week of moderate to vigorous physical activity; no/moderate alcohol intake (women/men: zero to seven/zero to 14 drinks per week); and Dietary Approaches to Stop Hypertension diet adherence score ≥ 15 (i.e., baseline highest quartile). Hazard ratios comparing blacks with whites for maintaining optimal health behaviors were calculated among participants with each optimal behavior at baseline.

Results: From ages 18 to 50 years, 2.6% of blacks and 9.2% of whites maintained four or more optimal health behaviors (for optimal BMI: 16.0% and 30.1%, smoking status: 74.6% and 78.4%, physical activity: 17.7% and 21.4%, alcohol intake: 68.4% and 64.6%, diet adherence: 3.9% and 10.3%, respectively). The multivariable adjusted hazard ratio comparing blacks with whites was 0.63 [95% CI=0.56, 0.72] for maintaining four or more optimal health behaviors (for optimal BMI: 0.82 [95% CI=0.66, 1.01], smoking status: 0.57 [95% CI=0.52, 0.62], physical activity: 0.83 [95% CI=0.75, 0.91], alcohol intake: 1.19 [95% CI=1.03, 1.37], diet adherence: 0.71 [95% CI=0.61, 0.82]).

Conclusions: Fewer blacks than whites maintained four or more optimal health behaviors until age 50 years, but maintenance was low among both races.

Am J Prev Med 2019;56(3):368–375. © 2018 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

From the ¹Department of Epidemiology, University of Alabama at Birmingham, Birmingham, Alabama; ²Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, Illinois; ³Division of Cardiovascular Disease, University of Alabama at Birmingham, Birmingham, Alabama; ⁴Division of Cardiovascular Disease, National Heart Lung and Blood Institute, Bethesda, Maryland; ⁵Department of Biostatistics, University of Alabama at Birmingham, Birmingham, Alabama; ⁶Department of Medicine, Columbia University, New York, New York; ⁷Division of Preventive Medicine, University of

Alabama at Birmingham, Birmingham, Alabama; and ⁸Division of Research, Kaiser Permanente Northern California, Oakland, California

Address correspondence to: John N. Booth III, PhD, Department of Epidemiology, University of Alabama at Birmingham, 1665 University Boulevard, Ryals Building 220, Birmingham AL 35233.

E-mail: jnbooth@uab.edu.

0749-3797/\$36.00

<https://doi.org/10.1016/j.amepre.2018.10.020>

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death in the U.S.¹ The American Heart Association recommends lifelong engagement in modifiable health behaviors to prevent CVD risk factors from developing and to prevent or delay the incidence of CVD events.² The lifetime risk of dying from CVD is less than 9% for a nonsmoking adult aged 50 years with high high-density lipoprotein cholesterol and low total cholesterol, blood pressure, and glucose levels.³ These data highlight the importance of maintaining health-promoting behaviors (e.g., healthy body weight, nonsmoking, physical activity, healthy diet) to prevent CVD risk factors from developing before age 50 years.

Several CVD risk factors develop at younger ages in blacks than whites.¹ For example, black children have higher blood pressure levels and higher incidence of diabetes compared with their white counterparts.¹ Racial differences persist into young adulthood, with blacks having higher numbers of CVD risk factors than whites.^{1,4} Blacks also die from CVD at younger ages than whites.⁵ However, the lifetime risk for CVD mortality does not differ by race among adults with equal numbers of CVD risk factors in the fifth decade of life.⁶

Few studies of young adults with longitudinal follow-up have measured health behaviors, limiting reports on whether racial disparities exist in maintaining optimal levels of health behaviors into middle age. Using data from the Coronary Artery Risk Development in Young Adults (CARDIA) study, the baseline prevalence of optimal health behaviors in young adulthood and the maintenance of these behaviors from early adulthood into middle age are compared among blacks and whites. Optimal health behaviors are hypothesized to be less common among blacks compared with whites in early adulthood. Also, among young adults with optimal health behaviors, the maintenance of health behaviors into middle age are predicted to be lower among blacks than whites.

METHODS

Study Population

The CARDIA study has been described previously.⁷ Briefly, CARDIA is a National Heart, Lung, and Blood Institute–sponsored multicenter, longitudinal cohort study designed to examine the development and determinants of clinical and subclinical CVD and their risk factors. In 1985–1986, a total of 5,115 black and white adults, aged 18–30 years, were enrolled at four centers (Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California). The current analysis used data collected at in-person examinations conducted at Year 0 (baseline) and 2, 5, 7, 10, 15, 20, and 25 years

following the baseline exam (i.e., through 2010–2011). Between 72% and 90% of the surviving participants completed each follow-up exam. After excluding one participant who withdrew consent, data from 5,114 participants were analyzed to assess racial differences in optimal health behaviors at baseline. Racial differences in maintaining optimal health behaviors was determined among participants with at least one optimal health behavior at baseline and who attended at least one follow-up exam ($n=4,892$). The IRB at each site approved the CARDIA study protocol. Participants provided written informed consent at each examination.

Measures

Age, race, and gender were self-reported at exam Year 0 (baseline) and confirmed at exam Year 2. At exams conducted 5, 7, 10, 15, 20, and 25 years following baseline, annual household income was self-reported. At each exam, highest level of education achieved, and marital status were ascertained by self-report.

Five health behaviors shown to co-occur in U.S. adults were evaluated⁸: (1) BMI; (2) smoking status; (3) physical activity; (4) alcohol intake; and (5) a diet rich in fruits and vegetables and low in dairy, saturated, and total fat. At each exam, height and weight were measured by trained staff. Information on smoking status was collected using biomarker (i.e., serum cotinine)–validated self- and interviewer-administered questionnaires.⁹ Physical activity was self-reported using the validated CARDIA Physical Activity History questionnaire.^{10–12} As described previously, information on participation in five moderate and eight vigorous activities in four activity domains (i.e., recreational sports, exercise, leisure, occupation) over the past year was collected.^{10–12} Alcohol intake was assessed by asking participants: *Did you drink any alcoholic beverages in the past year?* Participants who responded *yes* were asked how many weekly servings of wine, beer, and liquor they consumed. At the baseline examination and 7 and 20 years following baseline, a detailed dietary history was collected using a validated interviewer-administered questionnaire with two components.^{13,14} Dietary practices were assessed with 18 questions on the use of fat and salt in cooking, table salt, and fast-food consumption. Also, comprehensive questions, lists of food items, and food models were used to quantify participants' usual consumption of foods within food groups and serving size; frequency of consumption (e.g., daily, weekly, or monthly); and preparation method. Dietary information was processed with a nutrient database developed by the University of Minnesota's Nutrition Coordinating Center. The Dietary Approaches to Stop Hypertension (DASH) diet was used to represent a diet rich in fruits and vegetables and with low dairy, saturated, and total fat.

BMI was calculated as body weight (in kilograms) divided by height (in meters) squared. An optimal BMI was <25. Optimal smoking status was defined by a self-report of never smoking tobacco products or smoking fewer than five cigarettes per week for <3 months throughout their life.¹⁵ Physical activity over the prior year was calculated in exercise units as the sum of the product of the annual frequency of participation in each moderate and vigorous activity assessed and weekly duration.^{10–12} Optimal physical activity was defined as ≥ 300 exercise units per week.¹² This is approximately equivalent to ≥ 150 minutes per week of moderate or vigorous physical activity.¹² Milliliters of alcohol intake per day was estimated and converted to drinks per week.¹⁶ Optimal alcohol intake was defined as no or moderate consumption

(i.e., women/men: zero to seven / zero to 14 drinks per week). A DASH diet adherence score was calculated for each participant using methods applied in CARDIA by Chang et al.¹⁷ Participants were grouped into quartiles using the distribution of DASH diet scores at baseline (range, 8 [least healthy] to 32 [healthiest]). Optimal diet was defined as having a DASH diet adherence score ≥ 15 (Quartile 4 at baseline). The primary outcome, maintenance of optimal health behavior overall, was defined as having an optimal level of four or five individual behaviors at all exams. The maintenance of individual optimal health behaviors were secondary outcomes.

Statistical Analysis

Missing data were imputed with ten data sets. Chained equations were used to impute data for the cross-sectional analyses. Joint modeling multiple imputation for multilevel data was used to impute data among participants analyzed for maintaining optimal health behaviors.¹⁸ This approach is useful for prospective study designs when observations are nested within higher order organizational units or clusters (e.g., repeated measurements [Level 1] nested within participants [Level 2]).¹⁸ Ignoring the probability of missingness in a multilevel structure by using single-level imputation can lead to point estimates and measures of uncertainty being biased.¹⁸ Although the joint model and chained equations methods provide similar imputed estimates for single-level data, using a multivariate linear mixed model (i.e., random-intercept model) to impute missing repeated measurements preserves the correlation of participant characteristics between (Level 1) and within (Level 2) clusters in multilevel data.¹⁸ Missing data for each characteristic and health behavior analyzed in the longitudinal analyses is reported by exam year in [Appendix Table 1](#) (available online).

The distribution of the number of optimal health behaviors and the percentage of participants with each optimal health behavior at baseline were calculated for blacks and whites, separately. The statistical significance of differences in the number of optimal health behaviors and each optimal health behavior comparing blacks with whites were calculated using chi-square tests. The analyses for optimal health behavior overall are described below and were repeated for each optimal health behavior, separately.

Using Poisson regression with robust SEs, prevalence ratios, and 95% CIs were calculated for having optimal health behavior overall at baseline comparing blacks with whites. The prevalence ratios were calculated with adjustment for age and sex (Model 1), and age, sex, education, and marital status (Model 2). Baseline characteristics were calculated among black and white participants with at least one optimal health behavior at baseline and who attended at least one follow-up exam (i.e., individuals analyzed for maintaining optimal health behaviors), for those with and without optimal health behavior overall. Next, the age-specific percentage and 95% CI of blacks and whites maintaining optimal health behavior overall from ages 18 through 50 years was calculated using a modified Kaplan–Meier method adjusted for the competing risk of death with the Practical Incidence Estimator.¹⁹ Chi-square tests were used to calculate the difference in the percentage of blacks and whites who maintained optimal health behavior overall at ages 20, 25, 30, 35, 40, 45, and 50 years. Hazard ratios and 95% CIs for maintaining optimal health behavior overall comparing blacks with whites was calculated among participants with optimal health behavior overall at baseline using pooled logistic regression with age as the timescale.²⁰ Censoring occurred at the age that the optimal health behavior was not maintained or the age at the end of follow-up. Two levels of adjustment were conducted as described above, with Model 2 also including income. The covariates were updated at each CARDIA exam. In a sensitivity analysis, the hazard ratios were recalculated using unimputed data wherein participants were followed through their last exam attended with status of maintaining the optimal level of each health behavior carried forward when all exams were not attended. Analyses were conducted in 2016–2017 using R version, 3.2.3; Stata/IC, version 12.1; and SAS, version 9.4. *P*-values < 0.05 were considered statistically significant.

RESULTS

Prevalence of Health Behaviors at Baseline Among All Participants

The percentage of participants who were enrolled in the CARDIA study with zero optimal health behaviors at baseline did not differ between blacks and whites, but blacks were less likely than whites to have four or more

Table 1. Participants' Baseline Characteristics by Race Status of Optimal Health Behavior Overall

Participant characteristic	Optimal health behavior overall ^a			
	Yes		No	
	Black (n=594)	White (n=956)	Black (n=1,891)	White (n=1,451)
Age, years	23.5±0.2	25.6±0.1	24.5±0.1	25.4±0.1
Men, %	55.8	44.8	39.9	49.0
Education less than high school, %	6.9	2.0	12.2	6.1
Annual household income <\$25,000, %	49.4	28.6	60.3	33.1
Married status, %	15.5	23.5	20.5	27.1

Note: Numbers in the table are mean \pm SE or percentages that were calculated among black and white participants who had at least one optimal health behavior at baseline and completed at least one follow-up exam. Joint modeling multiple imputation for multilevel data was used to impute missing information for analyses related to the maintenance of optimal health behaviors using data from year 0 (baseline) through year 25.

^aOptimal health behavior overall was calculated as the sum of having each individual optimal health behavior: BMI < 25 , never smoking status, ≥ 150 minutes per week of moderate or vigorous physical activity, no or moderate weekly alcohol intake, and diet adherence score ≥ 15 (quartile 4 [highest] at baseline, healthier). Participants with four or more individual optimal health behaviors were categorized as having optimal health behavior overall.

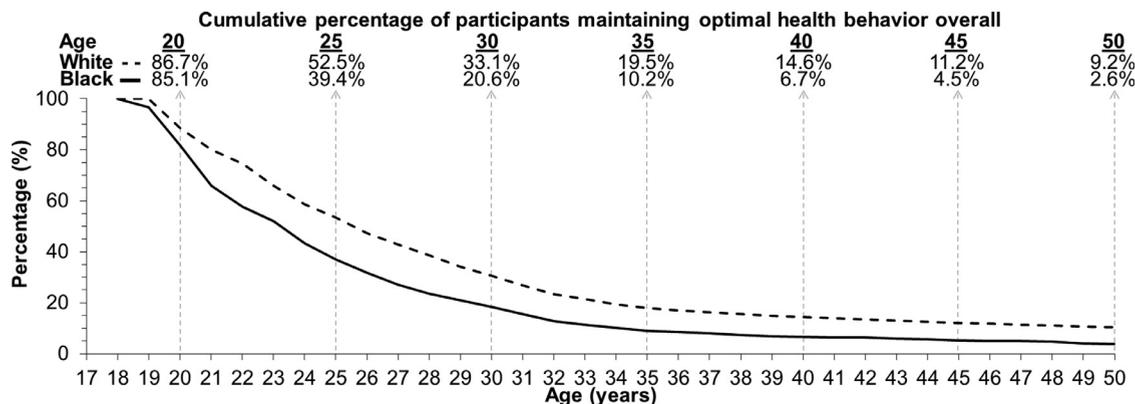


Figure 1. Age-specific percentage of black and white participants who maintained optimal health behavior overall.

Note: Joint modeling multiple imputation for multilevel data was used to impute missing information for analyses related to the maintenance of optimal health behaviors using data from year 0 (baseline) through year 25. There were 594 blacks and 956 whites with the optimal level at baseline. The age-specific percentage (95% CI) of black and white participants who maintained optimal health behavior overall and *p*-difference comparing the percentage of black with white participants who maintained optimal health behavior overall are reported in [Appendix Table 4](#) (available online). The percentages are adjusted for the competing risk of all-cause mortality. The age-specific percentage (95% CI) of black and white participants who maintained each individual optimal health behavior and *p*-difference comparing the percentage of black with white participants who maintained each individual optimal health behavior are reported in [Appendix Figures 2–6](#) and [Appendix Table 4](#) (available online).

optimal health behaviors at baseline ([Appendix Table 2](#) and [Appendix Figure 1](#), top panel, available online). Also, blacks were less likely than whites to have optimal BMI, physical activity, and diet adherence, and more likely than whites to have optimal alcohol intake ([Appendix Table 2](#) and [Appendix Figure 1](#), bottom panel, available online).

Blacks were less likely than whites to have optimal health behavior overall and optimal BMI, physical activity, and diet adherence at baseline after adjustment for age and sex ([Appendix Table 2](#), available online). In contrast, blacks were more likely than whites to have optimal alcohol intake. The full multivariable-adjusted prevalence ratio comparing blacks with whites for optimal health behavior overall was 0.61 (95% CI=0.55, 0.67); optimal BMI was 0.80 (95% CI=0.74, 0.85); optimal smoking status was 1.04 (95% CI=0.96, 1.12); optimal physical activity was 0.81 (95% CI=0.75, 0.87); optimal alcohol intake was 1.08 (95% CI=1.01, 1.14); and optimal diet adherence was 0.41 (95% CI=0.36, 0.46).

Maintenance of Optimal Health Behaviors Among Those With Optimal Levels at Baseline

Among participants with and without optimal health behavior overall at baseline and who attended at least one follow-up exam, blacks were younger, more likely to have less than a high school education and annual household income <\$25,000, and less likely to be married compared with whites ([Table 1](#)). Also, a higher percentage of blacks compared with whites with overall

optimal health behavior were men. In contrast, there was a low percentage of men among blacks compared with whites without optimal health behavior overall. Baseline characteristics among participants with and without each optimal health behavior and who attended at least one follow-up exam are reported in [Appendix Table 3](#) (available online).

A lower percentage of blacks than whites maintained optimal health behavior overall ([Figure 1](#) and [Appendix Table 4](#), available online) and optimal BMI and physical activity ([Appendix Figures 2 and 3](#) and [Appendix Table 4](#), available online) from ages 18 to 50 years. The likelihood of maintaining optimal smoking, alcohol intake, and diet adherence from ages 18 to 50 years was not statistically different between blacks and whites ([Appendix Figures 4–6](#) and [Appendix Table 4](#), available online).

After age and sex adjustment, blacks were less likely than whites to maintain optimal health behavior overall and optimal BMI, smoking status, physical activity, and diet adherence, but no difference was present for optimal alcohol intake ([Table 2](#)). The multivariable-adjusted hazard ratio comparing blacks with whites for maintaining optimal health behavior overall was 0.63 (95% CI=0.56, 0.72); optimal BMI was 0.57 (95% CI=0.52, 0.62); optimal smoking status was 0.82 (95% CI=0.66, 1.01); optimal physical activity was 0.83 (95% CI=0.75, 0.91); optimal alcohol intake was 1.19 (95% CI=1.03, 1.37); and optimal diet adherence was 0.71 (95% CI=0.61, 0.82). Results were consistent in an analysis using the un-imputed data (data not shown).

DISCUSSION

In this longitudinal population-based study, 23.5% of blacks and 39.2% of whites aged 18–30 years had four or five optimal health behaviors in young adulthood. In young adulthood, optimal BMI, physical activity, and diet adherence were less common among blacks compared with whites whereas optimal alcohol intake was more common. Only 2.6% of blacks and 9.2% of whites with optimal health behavior overall at baseline maintained it from age 18 years until 50 years. After multivariable adjustment, blacks were less likely than whites to maintain optimal health behavior overall and optimal BMI, physical activity, and diet adherence.

Although most middle-aged U.S. adults have few optimal health behaviors, RCTs provide strong evidence that modestly improving suboptimal health behaviors can lower CVD risk factors.^{21–23} As the effects of behavior modification accrue over time, achieving and maintaining small improvements in health behaviors can maximize the health benefits.^{22,24} However, reviews of published studies indicate the long-term maintenance of improved health behaviors is rare following interventions for primary prevention of CVD.^{25–30} Also, a few participants (blacks: 7.0%, whites: 8.8%) in the prospective Atherosclerosis Risk in Communities cohort study who did not consume five or more fruits and vegetables daily; did not participate in 2.5 hours per week of physical activity; were obese (BMI ≥ 30); and/or had a current smoker status at baseline adopted all of these health behaviors after 6 years of follow-up.²³ In the current

study, the low percentage of participants maintaining optimal health behavior overall demonstrates the need to encourage young adults, regardless of race, to maintain multiple individual optimal health behaviors across the life span. Studies are needed to characterize young blacks and whites who are more likely to maintain optimal health behaviors. This may provide a foundation for developing a screening tool that identifies individuals less likely to maintain each optimal health behavior who can receive personalized behavior counseling. Further, it can inform the development of novel interventions for maintaining optimal health behaviors in blacks and whites, separately.

It has been proposed that health behaviors explain racial differences in preventable and modifiable CVD risk factors including hypertension and diabetes.¹ Population-based studies of U.S. adults have consistently reported racial differences in the prevalence of optimal health behaviors.^{24,31–35} Blacks are less likely than whites to have higher numbers of optimal health behaviors.^{24,36} Also, the prevalence of optimal BMI, physical activity, and diet adherence is lower and optimal alcohol intake has been reported to be more common in blacks compared with whites.^{24,31–35,37} In the current study, most participants had at least one optimal health behavior at baseline and few had four or more. The baseline prevalence of optimal health behaviors reported herein among blacks and whites was similar to that in prior studies.^{24,31–37} The current study extends prior research by reporting the maintenance of optimal health behaviors from young adulthood into middle age. The

Table 2. Hazard Ratios for Maintaining Optimal Health Behaviors Comparing Blacks With Whites

Optimal health behavior maintained	<i>n</i> maintaining the optimal health behavior / <i>n</i> with the optimal health behavior at baseline (%)		Hazard ratio (95% CI) comparing blacks with whites	
	Black	White	Model 1	Model 2
Optimal health behavior overall ^a	15 / 594 (2.5%)	88 / 956 (9.2%)	0.64 (0.57, 0.72)	0.63 (0.56, 0.72)
BMI <25	238 / 1,485 (16.0%)	524 / 1,742 (30.1%)	0.62 (0.57, 0.67)	0.57 (0.52, 0.62)
Never smoker status	1,078 / 1,445 (74.6%)	1,053 / 1,343 (78.4%)	0.73 (0.59, 0.89)	0.82 (0.66, 1.01)
Physical activity ≥ 150 minutes per week	232 / 1,313 (17.7%)	339 / 1,585 (21.4%)	0.81 (0.74, 0.88)	0.83 (0.75, 0.91)
No or moderate alcohol intake	1,549 / 2,264 (68.4%)	1,309 / 2,026 (64.6%)	1.06 (0.92, 1.22)	1.19 (1.03, 1.37)
Diet adherence score ≥ 15 ^b	15 / 383 (3.9%)	100 / 975 (10.3%)	0.70 (0.61, 0.81)	0.71 (0.61, 0.82)

Note: Joint modeling multiple imputation for multilevel data was used to impute missing information for analyses related to the maintenance of optimal health behaviors using data from year 0 (baseline) through year 25. Boldface indicates statistical significance ($p < 0.05$). Model 1: Adjustment for age and sex updated at each time it was measured, as appropriate. Model 2: Adjustment for age, sex, less than a high school education, annual household income $< \$25,000$, and marital status updated at each time it was measured, as appropriate.

^aOptimal health behavior overall was calculated as the sum of having each individual optimal health behavior: BMI < 25 , never smoking status, ≥ 150 minutes per week of moderate or vigorous physical activity, no or moderate weekly alcohol intake, and diet adherence score ≥ 15 (quartile 4 [highest] at baseline, healthier). Participants with four or more individual optimal health behaviors were categorized as having optimal health behavior overall.

^bDiet adherence derived from Dietary Approaches to Stop Hypertension (DASH) scores at baseline using all participants. Quartile 1 (low, less healthy) to quartile 4 (healthier, optimal level): < 10 , 10 to < 12 , 12 to < 15 , and ≥ 15 .

maintenance of optimal health behavior overall decreased more quickly between ages 20 and 25 years in blacks compared with whites. Also, the percentage of blacks who maintained optimal health behavior overall remained lower than whites from age 25 years until 50 years. However, even among participants who entered adulthood with optimal health behaviors, a low percentage of participants maintained them until age 50 years, regardless of race. Blacks were less likely than whites to maintain optimal health behavior overall and optimal BMI, physical activity, and diet adherence into middle age.

Preventing the development of CVD risk factors may provide the most effective approach for lowering the incidence of CVD.^{2,3} Optimal health behaviors are central components of cardiovascular health, a concept introduced in 2010 by the American Heart Association to help highlight the importance of preventing CVD risk factors from developing and remaining CVD-free throughout the life course.² Although prior studies report that blacks have higher CVD mortality compared with whites,^{38–41} the lifetime risk for CVD does not differ in blacks compared with whites with the same number of risk factors.⁶ Interventions that improve the maintenance of optimal health behaviors throughout the life span may reduce the racial disparities in CVD risk.

Limitations

The current study has several strengths. The CARDIA study enrolled a large population-based cohort that comprises black and white adults aged 18–30 years who were followed for 25 years. The comprehensive data collection permitted adjustment for variables that were updated at each exam. Also, health behaviors were measured using a standardized protocol throughout follow-up. Despite these strengths, there are also limitations. Several health behaviors were self-reported, and objective measures of these factors were not available. Measurement error may have contributed to misclassification resulting in attenuated effect sizes. Also, diet history was assessed at only three exams. However, multilevel multiple imputation of repeated measurements within participants minimized bias in the point estimates attributable to racial differences in follow-up retention, and there was consistency when the results from analyses using the imputed and un-imputed data were compared.

CONCLUSIONS

There is a need to develop sustainable interventions that encourage the maintenance of optimal health behaviors into adulthood and from young adulthood into middle age. Racial differences in the individual optimal health

behaviors and optimal health behavior overall were present at baseline when participants were aged 18–30 years. Additionally, racial differences in the maintenance of optimal health behaviors were observed to be present between ages 20 and 25 years when the percentage of participants with optimal health behavior overall decreased more rapidly for blacks than whites. Although fewer blacks than whites maintained optimal health behavior overall, and optimal BMI and physical activity, maintaining optimal health behaviors until age 50 years was low among both blacks and whites.

ACKNOWLEDGMENTS

The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute (NHBLI); NIH; or HHS.

The Coronary Artery Risk Development in Young Adults Study (CARDIA) is conducted and supported by the National Heart, Lung, and Blood Institute (NHLBI) in collaboration with the University of Alabama at Birmingham (HHSN268201800005I and HHSN268201800007I); Northwestern University (HHSN268201800003I); University of Minnesota (HHSN268201800006I); and Kaiser Foundation Research Institute (HHSN268201800004I). This manuscript has been reviewed by CARDIA for scientific content.

John N. Booth III, Daichi Shimbo, and Paul Muntner contributed to study conception and design. John N. Booth III, Norrina B. Allen, David Calhoun, April P. Carson, Luqin Deng, David C. Goff, David T. Redden, Jared P. Reis, Daichi Shimbo, James M. Shikany, Stephen Sidney, Bonnie Spring, Cora E. Lewis, and Paul Muntner helped with acquisition or interpretation of data. John N. Booth III, Luqin Deng, Norrina B. Allen, and Paul Muntner performed the statistical analysis. John N. Booth III and Paul Muntner drafted the manuscript. John N. Booth III, Norrina B. Allen, David Calhoun, April P. Carson, Luqin Deng, David C. Goff, David T. Redden, Jared P. Reis, Daichi Shimbo, James M. Shikany, Stephen Sidney, Bonnie Spring, Cora E. Lewis, and Paul Muntner critically revised the manuscript.

NBA received research support from Novartis not related to the current project. APC receives research support from Amgen, Inc., not related to the current project. DS is a consultant for Abbott Vascular and Novartis Pharmaceuticals Corporation not related to the current project. BS receives support from Scientific Advisory Board Member for Actigraph and Arivale not related to the current project. PM receives research support from Amgen Inc. not related to the current project. No other financial disclosures were reported by the authors of this paper.

DC Goff was at the Colorado School of Public Health when this work was initiated.

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <https://doi.org/10.1016/j.amepre.2018.10.020>.

REFERENCES

- Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics—2017 update: a report from the American Heart Association. *Circulation*. 2017;135(10):e146–e603. <https://doi.org/10.1161/CIR.0000000000000485>.
- Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic impact goal through 2020 and beyond. *Circulation*. 2010;121(4):586–613. <https://doi.org/10.1161/CIRCULATIONAHA.109.192703>.
- Lloyd-Jones DM, Leip EP, Larson MG, et al. Prediction of lifetime risk for cardiovascular disease by risk factor burden at 50 years of age. *Circulation*. 2006;113(6):791–798. <https://doi.org/10.1161/CIRCULATIONAHA.105.548206>.
- Cockerham WC, Bauldry S, Hamby BW, Shikany JM, Bae S. A comparison of black and white racial differences in health lifestyles and cardiovascular disease. *Am J Prev Med*. 2017;52(1 suppl 1):S56–S62. <https://doi.org/10.1016/j.amepre.2016.09.019>.
- Jolly S, Vittinghoff E, Chattopadhyay A, Bibbins-Domingo K. Higher cardiovascular disease prevalence and mortality among younger blacks compared to whites. *Am J Med*. 2010;123(9):811–818. <https://doi.org/10.1016/j.amjmed.2010.04.020>.
- Berry JD, Dyer A, Cai X, et al. Lifetime risks of cardiovascular disease. *N Engl J Med*. 2012;366(4):321–329. <https://doi.org/10.1056/NEJMoa1012848>.
- Friedman GD, Cutter GR, Donahue RP, et al. CARDIA: study design, recruitment, and some characteristics of the examined subjects. *J Clin Epidemiol*. 1988;41(11):1105–1116. [https://doi.org/10.1016/0895-4356\(88\)90080-7](https://doi.org/10.1016/0895-4356(88)90080-7).
- Berrigan D, Dodd K, Troiano RP, Krebs-Smith SM, Barbash RB. Patterns of health behavior in U.S. adults. *Prev Med*. 2003;36(5):615–623. [https://doi.org/10.1016/S0091-7435\(02\)00067-1](https://doi.org/10.1016/S0091-7435(02)00067-1).
- Wagenknecht LE, Cutter GR, Haley NJ, et al. Racial differences in serum cotinine levels among smokers in the Coronary Artery Risk Development in (Young) Adults study. *Am J Public Health*. 1990;80(9):1053–1056. <https://doi.org/10.2105/AJPH.80.9.1053>.
- Sidney S, Jacobs DR Jr., Haskell WL, et al. Comparison of two methods of assessing physical activity in the Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Am J Epidemiol*. 1991;133(12):1231–1245. <https://doi.org/10.1093/oxfordjournals.aje.a115835>.
- Gordon-Larsen P, Boone-Heinonen J, Sidney S, Sternfeld B, Jacobs DR Jr., Lewis CE. Active commuting and cardiovascular disease risk: the CARDIA study. *Arch Intern Med*. 2009;169(13):1216–1223. <https://doi.org/10.1001/archinternmed.2009.163>.
- Gabriel KP, Sidney S, Jacobs DR Jr., et al. Convergent validity of a brief self-reported physical activity questionnaire. *Med Sci Sports Exerc*. 2014;46(8):1570–1577. <https://doi.org/10.1249/MSS.0000000000000278>.
- McDonald A, Van Horn L, Slattery M, et al. The CARDIA dietary history: development, implementation, and evaluation. *J Am Diet Assoc*. 1991;91(9):1104–1112.
- Liu K, Slattery M, Jacobs D Jr., et al. A study of the reliability and comparative validity of the cardia dietary history. *Ethn Dis*. 1994;4(1):15–27.
- Wagenknecht LE, Perkins LL, Cutter GR, et al. Cigarette smoking behavior is strongly related to educational status: the CARDIA study. *Prev Med*. 1990;19(2):158–169. [https://doi.org/10.1016/0091-7435\(90\)90017-E](https://doi.org/10.1016/0091-7435(90)90017-E).
- Gaffo AL, Roseman JM, Jacobs DR Jr., et al. Serum urate and its relationship with alcoholic beverage intake in men and women: findings from the Coronary Artery Risk Development in Young Adults (CARDIA) cohort. *Ann Rheum Dis*. 2010;69(11):1965–1970. <https://doi.org/10.1136/ard.2010.129429>.
- Chang A, Van Horn L, Jacobs DR Jr., et al. Lifestyle-related factors, obesity, and incident microalbuminuria: the CARDIA (Coronary Artery Risk Development in Young Adults) study. *Am J Kidney Dis*. 2013;62(2):267–275. <https://doi.org/10.1053/j.ajkd.2013.02.363>.
- Enders CK, Mistler SA, Keller BT. Multilevel multiple imputation: a review and evaluation of joint modeling and chained equations imputation. *Psychol Methods*. 2016;21(2):222–240. <https://doi.org/10.1037/met0000063>.
- Beiser A, D'Agostino RB Sr., Seshadri S, Sullivan LM, Wolf PA. Computing estimates of incidence, including lifetime risk: Alzheimer's disease in the Framingham Study. The Practical Incidence Estimators (PIE) macro. *Stat Med*. 2000;19(11–12):1495–1522. [https://doi.org/10.1002/\(SICI\)1097-0258\(20000615/30\)19:11/12<1495::AID-SIM441>3.0.CO;2-E](https://doi.org/10.1002/(SICI)1097-0258(20000615/30)19:11/12<1495::AID-SIM441>3.0.CO;2-E).
- D'Agostino RB, Lee ML, Belanger AJ, Cupples LA, Anderson K, Kannel WB. Relation of pooled logistic regression to time dependent Cox regression analysis: the Framingham Heart Study. *Stat Med*. 1990;9(12):1501–1515. <https://doi.org/10.1002/sim.4780091214>.
- Artinian NT, Fletcher GF, Mozaffarian D, et al. Interventions to promote physical activity and dietary lifestyle changes for cardiovascular risk factor reduction in adults: a scientific statement from the American Heart Association. *Circulation*. 2010;122(4):406–441. <https://doi.org/10.1161/CIR.0b013e3181e8edf1>.
- Whelton PK, He J, Appel LJ, et al. Primary prevention of hypertension: clinical and public health advisory from the National High Blood Pressure Education Program. *JAMA*. 2002;288(15):1882–1888. <https://doi.org/10.1001/jama.288.15.1882>.
- King DE, Mainous AG 3rd, Geesey ME. Turning back the clock: adopting a healthy lifestyle in middle age. *Am J Med*. 2007;120(7):598–603. <https://doi.org/10.1016/j.amjmed.2006.09.020>.
- Ford ES, Zhao G, Tsai J, Li C. Low-risk lifestyle behaviors and all-cause mortality: findings from the National Health and Nutrition Examination Survey III Mortality Study. *Am J Public Health*. 2011;101(10):1922–1929. <https://doi.org/10.2105/AJPH.2011.300167>.
- Prochaska JJ, Spring B, Nigg CR. Multiple health behavior change research: an introduction and overview. *Prev Med*. 2008;46(3):181–188. <https://doi.org/10.1016/j.yjmed.2008.02.001>.
- Ory MG, Lee Smith M, Mier N, Wernicke MM. The science of sustaining health behavior change: the health maintenance consortium. *Am J Health Behav*. 2010;34(6):647–659. <https://doi.org/10.5993/AJHB.34.6.2>.
- Fleming P, Godwin M. Lifestyle interventions in primary care: systematic review of randomized controlled trials. *Can Fam Physician*. 2008;54(12):1706–1713.
- Ebrahim S, Beswick A, Burke M, Davey Smith G. Multiple risk factor interventions for primary prevention of coronary heart disease. *Cochrane Database Syst Rev*. 2006(4):CD001561. <https://doi.org/10.1002/14651858.CD001561.pub2>.
- Prochaska JJ, Prochaska JO. A review of multiple health behavior change interventions for primary prevention. *Am J Lifestyle Med*. 2011;5(3):208–221. <https://doi.org/10.1177/1559827610391883>.
- Middleton KR, Anton SD, Perri MG. Long-term adherence to health behavior change. *Am J Lifestyle Med*. 2013;7(6):395–404. <https://doi.org/10.1177/1559827613488867>.
- National Center for Health Statistics. Hyattsville, MD: National Center for Health Statistics, 2014.
- Greenlund KJ, Daviglius ML, Croft JB. Differences in healthy lifestyle characteristics between adults with prehypertension and normal blood pressure. *J Hypertens*. 2009;27(5):955–962. <https://doi.org/10.1097/HJH.0b013e32832926fb>.
- Centers for Disease Control and Prevention (CDC). Usual sodium intakes compared with current dietary guidelines—United States, 2005–2008. *MMWR Morb Mortal Wkly Rep*. 2011;60(41):1413–1417.
- Reeves MJ, Rafferty AP. Healthy lifestyle characteristics among adults in the United States, 2000. *Arch Intern Med*. 2005;165(8):854–857. <https://doi.org/10.1001/archinte.165.8.854>.
- Franklin BA, Cushman M. Recent advances in preventive cardiology and lifestyle medicine: a themed series. *Circulation*. 2011;123(20):2274–2283. <https://doi.org/10.1161/CIRCULATIONAHA.110.981613>.

36. Spring B, Moller AC, Colangelo LA, et al. Healthy lifestyle change and subclinical atherosclerosis in young adults: Coronary Artery Risk Development in Young Adults (CARDIA) study. *Circulation*. 2014;130(1):10–17. <https://doi.org/10.1161/CIRCULATIONAHA.113.005445>.
37. Monsivais P, Rehm CD, Drewnowski A. The DASH diet and diet costs among ethnic and racial groups in the United States. *JAMA Intern Med*. 2013;173(20):1922–1924. <https://doi.org/10.1001/jamainternmed.2013.9479>.
38. Rosamond WD, Chambless LE, Heiss G, et al. Twenty-two-year trends in incidence of myocardial infarction, coronary heart disease mortality, and case fatality in 4 U.S. communities, 1987–2008. *Circulation*. 2012;125(15):1848–1857. <https://doi.org/10.1161/CIRCULATIONAHA.111.047480>.
39. Ford ES. Trends in the risk for coronary heart disease among adults with diagnosed diabetes in the U.S.: findings from the National Health and Nutrition Examination Survey, 1999–2008. *Diabetes Care*. 2011;34(6):1337–1343. <https://doi.org/10.2337/dc10-2251>.
40. Mozaffarian D, Benjamin EJ, Go AS, et al. Heart disease and stroke statistics—2016 update: a report from the American Heart Association. *Circulation*. 2016;133(4):e38–e360. <https://doi.org/10.1161/CIR.0000000000000350>.
41. Corti MC, Guralnik JM, Ferrucci L, et al. Evidence for a black-white crossover in all-cause and coronary heart disease mortality in an older population: the North Carolina EPESE. *Am J Public Health*. 1999;89(3):308–314. <https://doi.org/10.2105/AJPH.89.3.308>.