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Ideal Cardiovascular Health and Resting Heart Rate in the Multi-Ethnic Study of Atherosclerosis

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Abstract

Elevated resting heart rate (RHR) is associated with an increased cardiovascular disease (CVD) risk, but little is known about its association with cardiovascular health (CVH), assessed by the Life's Simple 7 (LS7) metrics. We explored whether ideal CVH was associated with RHR in a cohort free from clinical CVD. We conducted cross-sectional analysis of baseline data (2000–2002) of 6,457 Multi-Ethnic Study of Atherosclerosis participants in 2018. Each LS7 metric (smoking, physical activity, diet, body mass index, blood pressure, cholesterol and glucose) was scored 0–2. Total score ranged from 0–14. Scores of 0–8 indicate inadequate, 9–10 average, and 11–14 optimal CVH. RHR was categorized as <60, 60–69, 70–79 and ≥80bpm. We used

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Authors' contributions

OO (first author), OO (second author), and EM designed the study. OO and OO performed the statistical analyses and drafted the manuscript. OO, OO, ES, OF and EM provided critical revisions to the manuscript. OO (first author) and EM take full responsibility for the content. All authors have read and approved the final manuscript draft. The manuscript was approved by the MESA Publication Committee.

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Ethics approval and consent to participate

This study was conducted under the guiding principles of the Declaration of Helsinki for the protection of human subjects.

Institutional Review Boards of all participating MESA sites approved the study, and all participants signed informed consent. At the Johns Hopkins Field Center, the MESA Study was approved by the Johns Hopkins School of Medicine Office of Human Subjects Research Institutional Review Board; Principal Investigator: Dr. Wendy Post; approval number: NA_00030361/CR00015436; Title: Multi-Ethnic Study of Atherosclerosis (MESA).

Availability of data and materials

The MESA study participates in data sharing through the National Heart, Lung, Blood Institute (NHLBI) Biologic Specimen and Data Repository Coordinating Center (BioLINCC). Requests for access to the data can be made through their website: <https://biolincc.nhlbi.nih.gov/studies/mesa/>.

Competing interests

The authors declare that they have no conflicts of interest.

multinomial logistic regression to determine associations between CVH score and RHR, adjusting for age, sex, race/ethnicity, education, income, health insurance, and atrioventricular nodal blockers. Mean age of participants (standard deviation) was 62 (10) years; 53% were women; 47% had inadequate CVH, 33% average, and 20% optimal. Favorable CVH was associated with lower odds of having higher RHR. Compared to RHR <60bpm, participants with optimal CVH had adjusted odds ratio (95% CI) of 0.55 (0.46–0.64) for RHR of 60–69bpm, 0.34 (0.28–0.43) for 70–79bpm, and 0.14 (0.09–0.22) for 80bpm. A similar pattern was observed in stratified analysis by sex, race/ethnicity and age. Favorable CVH was less likely to be associated with elevated RHR irrespective of sex, race/ethnicity and age. More research is needed to explore the usefulness of promoting ideal CVH to reduce elevated RHR, a known risk factor for CVD.

Keywords

Resting heart rate; Ideal cardiovascular health metrics; Life's Simple 7; Prevention

Introduction

Resting heart rate (RHR) is an inexpensive, useful, and potentially modifiable clinical marker for cardiovascular disease (CVD) assessment [1, 2]. It is an independent risk factor for CVD, cancer, and all-cause mortality [3, 4]. Prior research shows that for every 10 beats per minute (bpm) increase in RHR, there is a 14% increased risk for a clinical CVD event [3]. However, less is known about the association of RHR with intermediate measures of cardiovascular wellness.

In their Strategic Impact Goal Statement, the American Heart Association (AHA) introduced the construct of ideal cardiovascular health (CVH), as a way of promoting “health” or “wellness” rather than focusing on disease [5, 6]. Ideal CVH is described as attaining the ideal criteria for seven health behaviors and factors called Life's Simple 7 (LS7) [5]. The link between CVH and subsequent CVD has been documented in the literature [6]. Epidemiological studies suggest that some components of the LS7 such as smoking, body mass index (BMI) and physical activity may be associated with RHR [7–9]. However, research between ideal CVH and RHR is sparse [10], particularly regarding whether differences exist in this relationship across sex, race/ethnicity, and age. Thus, there is a gap to fill in literature to better explain the role RHR plays in the association between CVH and CVD.

The aim of this study is to investigate the relationship between CVH (as measured by the overall score and its individual metrics) and RHR using data from the Multi-Ethnic Study of Atherosclerosis (MESA). We hypothesized that individuals with higher CVH scores or who meet the ideal criteria for the LS7 metrics will be less likely to have elevated RHR irrespective of sex, age, and race/ethnicity.

Methods

Study population

We conducted a cross-sectional analysis using baseline data from the MESA study. The MESA study methodology was described previously [11]. Between July 2000 and August 2002, the MESA study recruited 6,814 men and women aged 45–84 years with no prior history of clinical CVD at baseline from 6 United States (U.S.) centers (Baltimore, MD; St Paul, MN; Chicago, IL; Forsyth County, NC; New York, NY; and Los Angeles, CA). About 38% were White, 11% Chinese American, 28% Black and 23% Hispanic. The study protocol was approved by the institutional review boards of the recruitment centers, and informed consent was obtained from each participant. Study participants' information was obtained using standardized questionnaires, physical examination, and fasting laboratory blood draw. Of the 6,814 MESA study participants at baseline, we excluded 357 participants who did not have complete information on RHR and LS7 metrics leaving 6,457 participants.

Study measures

Dependent variable: Resting heart rate—The RHR for each study participant was obtained using a 12-lead electrocardiogram performed at rest during the baseline visit. Based on prior research [12, 13], RHR was categorized as <60, 60–69, 70–79 and ≥ 80 bpm and was also assessed as a continuous variable.

Independent variable: Life's Simple 7 metrics—An individual meets the AHA's definition of ideal CVH if he or she meets the ideal criteria for 4 health behaviors (non-smoking, physical activity at target levels, BMI <25kg/m² and recommended healthy diet) and 3 health factors (total cholesterol <200mg/dL, blood pressure <120/<80mmHg and fasting blood glucose <100mg/dL, without the use of medication) [5]. Data on smoking were collected with the use of self-report questionnaires. Smoking was classified as: non-smokers (participants who reported that they had never smoked or quit > 12months); former smokers (participants who quit in the last 12 months) and current smokers. A self-report survey instrument adapted from the Cross-Cultural Activity Participation Study [14] containing 28 questions on the time and frequency of activities during a week in the past month was used to assess physical activity. An estimation of the total minutes of moderate and vigorous exercise was used in this analyses [15]. Study participants' BMI in kg/m² was calculated from their measured weights and heights. A 120-item validated food frequency questionnaire adapted from the Insulin Resistance Atherosclerosis Study instrument [16, 17] was used to assess diet. Fish, fruits and vegetables, sodium intake of <1500mg/day, sugar-sweetened beverages <450 kcal (36 oz.)/week were the components of a healthy diet [5]. Participants were seated for 5 minutes before 3 blood pressure readings were taken. The mean of the last two readings were documented. A 12-hour fast preceded the collection of blood samples for the measurement of total cholesterol and blood glucose levels.

Covariates—The sociodemographic variables included in this study were: age, sex, race/ethnicity, education, income and health insurance. Sex was grouped into men and women while race/ethnicity was categorized as White, Chinese-American, Black or Hispanic. Education was categorized as <bachelor's degree or ≥ bachelor's degree; and income was

grouped into <\$40,000 or \$40,000. Additionally, a single variable was created for the use of atrioventricular (AV)-nodal blockers where participants gave “Yes” or “No” responses to the use of the following AV-nodal blockers: beta blockers, digitalis preparations, diltiazem, and verapamil.

Statistical analyses

We reported the characteristics of study participants by RHR categories. Continuous variables were presented as means with their corresponding standard deviation (SD) while categorical variables were presented as frequencies and percentages. Baseline characteristics were compared with ANOVA (continuous variables) and chi-square tests (categorical variables). Each LS7 metric was categorized into 3 groups: poor, intermediate and ideal [5], as illustrated in Supplemental Table S1. We assigned points to each of the 3 categories as follows: 0 points for poor, 1 point for intermediate and 2 points for ideal. The total CVH score ranged from 0 to 14 points [18]. As has been done in prior research, we categorized the CVH score as inadequate: 0–8 points, average: 9–10 points and optimal: 11–14 points [15, 19, 20].

We reported proportions of the CVH scores and LS7 metrics by categories of RHR. Using multinomial logistic regression, we examined the associations between the composite CVH score and RHR, as well as the associations between the LS7 metrics and RHR. For reference, we used RHR, <60bpm, inadequate CVH score and the poor category of the LS7 metrics. We fitted 3 regression models and estimates were reported as odds ratios (ORs) and 95% confidence intervals (CI). Model 1 was unadjusted. We adjusted for sociodemographic factors (age, sex, race/ethnicity, education, income, and health insurance status) in model 2. For model 3, we adjusted for model 2 covariates and AV-nodal blockers. Statistical interaction was tested with the likelihood ratio chi-square test by including the interaction terms for CVH*sex, CVH*race/ethnicity and CVH* age in a separate model similar to model 3. Because of our interest in subgroup analysis, we decided *a priori* to stratify our analysis by sex, race/ethnicity and age (<65 and ≥65 years) even if interaction testing was not significant.

We performed several supplemental analyses as follows: First, we examined the associations (in ORs and their corresponding 95% CIs) between the number of LS7 metrics in the “ideal” category and RHR. We compared participants with 3–5 and 6–7 ideal metrics to those with 0–2 metrics. We also stratified by sex, race/ethnicity, and age (<65 and ≥65 years) for this analysis. Second, we used linear regression analyses to evaluate the association between the CVH score and RHR, both as continuous variables. The covariates adjusted for in the three linear regression models were similar to those used for the logistic regression analyses.

Finally, to assess for non-linear relationship between CVH scores and differences in RHR, we also used a restricted cubic spline model with the CVH score of 6 as reference and knots at the CVH scores of 5, 8, 9, and 12, adjusted for model 3 covariates. All analyses were performed using STATA version 15.0 (StataCorp LP, College Station, Texas).

Results

The baseline characteristics of the study participants (n=6,457) varied across RHR categories as reported in Table 1. Fifty-three percent of participants were women, and the mean age with SD was 62 (10) years. Among study participants, 37.4% had RHR of <60bpm, 39.3% 60–69bpm, 17.6% 70–79bpm, and 5.6% ≥80bpm. A larger proportion of men had RHR of <60bpm. Participants with higher RHR were less likely to be physically active and were more likely to have higher systolic and diastolic blood pressure as well as higher BMI, total cholesterol and fasting blood glucose levels. Additional characteristics of study participants by RHR group are shown in Supplemental Table S2.

The CVH score and distribution of metrics by categories of RHR are shown in Table 2. For the total study population, 20.0%, 32.6%, and 47.4% had optimal, average, and inadequate scores, respectively. More than 50% of the study population met the ideal criteria for smoking, physical activity and fasting blood glucose (85.9%, 59.8%, and 74.1%, respectively). For BMI, diet, total cholesterol and blood pressure, 28.8%, 1.1%, 47.6%, and 34.5% met the criteria for the ideal category, respectively. Among participants with RHR <60bpm, with the exception of BMI and diet, the largest proportion met the criteria for the ideal category of the LS7 metrics. On the other hand, among participants with RHR ≥80bpm, much lower proportions of participants met ideal criteria.

The associations between overall CVH score and RHR in the study population are reported in Table 3. After adjusting for sociodemographic characteristics and AV-nodal blockers (model 3), participants with average and optimal CVH scores were less likely to have higher RHR compared to those with inadequate scores. For example, participants with optimal scores had 45%, 66%, and 86% lower odds of having RHR of 60–69, 70–79 and ≥80 bpm respectively. In the sensitivity analysis, where participants on AV nodal blockers were excluded (n=820), the adjusted ORs were similar to the main analyses (Supplemental Table S3).

The associations between the individual LS7 metrics and RHR are reported in Table 3 & 4. With the exception of smoking, a similarly graded association was observed in the association between the individual LS7 metrics and RHR. For example, participants in the ideal category of physical activity had 18%, 37% and 50% lower odds of having RHR of 60–69, 70–79 and ≥80 bpm respectively. For all the RHR categories, there was no significant interaction for CVH with sex and race/ethnicity. For the RHR categories 70–79 and ≥80, there was a significant interaction for CVH with age (p= .01 and .04 respectively).

The supplemental material shows additional analyses for the distribution of the individual LS7 metrics (Supplemental Table S1), the associations between CVH and RHR stratified by sex and race/ethnicity (Supplemental Table S4), and the associations between the number of ideal metrics and RHR for the overall cohort and stratified by sex, age and race/ethnicity (Supplemental Tables S5, S6 & S7). The results showed that irrespective of sex or race/ethnicity, participants with average and optimal CVH scores were less likely to have higher RHR. Additionally, having 3–5 and 6–7 ideal metrics (compared to having only 0–2 ideal metrics) were associated with lower odds of higher RHR. Supplemental Table S7 illustrates

average and optimal scores were associated with lower odds of higher RHR irrespective of age (<65 years and ≥ 65 years).

When using a restricted cubic spline model (Figure), we found the association of greater CVH score with RHR was inverse and actually quite linear. In the multivariable linear regression models, an increase in CVH score (per 1 unit increment) was associated with a decrease in RHR for the overall cohort and by sex, age, and race/ethnicity (Supplemental Table S8).

Discussion

Summary of findings

In this large multi-ethnic community-based cohort of adults free of CVD at baseline, we found that after adjusting for sociodemographic characteristics and AV-nodal blockers, study participants with average and optimal CVH scores were less likely to have higher RHR compared to those with an inadequate CVH score. A similar association was found in the stratified analysis by sex, race/ethnicity, and age. Additionally, participants in the ideal category of the LS7 metrics were less likely to have higher RHR compared to those in the poor category.

Comparison to previous research

The results of our study are comparable to those of a cross-sectional study that examined the impact of ideal CVH behaviors and factors on RHR among 83,824 employees in China, free of CVD who participated in a 2006–2007 health examination [10]. In that study, when compared to participants with no ideal CVH metrics, the risk of having an RHR ≥ 80 bpm decreased with an increase in the number of ideal metrics after adjusting for sex, age, triglyceride, high-density lipoprotein cholesterol, high-sensitive C-reactive protein, tea drinking, and alcohol drinking [10]. Participants with 1, 2, 3, 4, 5, and ≥ 6 ideal CVH metrics were 21%, 32%, 39%, 48%, 50% and 51% less likely to have RHR ≥ 80bpm respectively [10]. Our study now extends this finding by confirming a similar relationship among a more diverse, community-based sample in the U.S. including 4 race/ethnic groups and a broader age range. We found no significant interactions for the association of CVH and RHR with sex and race/ethnicity. While we did find a significant interaction of the association of CVH and RHR by age, this finding should be viewed cautiously in the absence of an *a priori* biological hypothesis for an age interaction. Furthermore, the associations of CVH and RHR were qualitatively similar for those aged <65 and ≥ 65 years.

Explanation of findings

Parasympathetic tone is known to dominate the heart rate in the resting state [21]. Our study supports that multiple intermediate metrics of cardiovascular wellness are individually associated with RHR. For example, we found ideal BMI was associated with lower odds of having higher RHR. Other studies have found a relationship between an increase in BMI and RHR which may be due to obesity-associated autonomic disturbances such as increases in insulin resistance and sympathetic activity, as well as a decrease in vagal tone [22–24]. We also found lower RHR among participants who met the ideal criteria for physical activity.

This also makes sense as research has shown that regular exercise lowers RHR by increasing vagal tone [25]. Smoking is another factor associated with higher heart rates likely by increases in the circulating levels of catecholamines and augmentation of sympathetic outflow, which causes long-term reduction in vagal drive [26–28]. While we only found a non-significant trend for lower odds of higher RHR with ideal smoking status, this is likely because the majority (86%) of our population fell into this category, limiting our ability to make comparisons.

Participants with ideal blood pressure levels were less likely to have higher RHR. An explanation for this finding may be similar to the previously described mechanisms for smoking, BMI and physical activity [29]. Although, reverse causation cannot be ruled out because elevated RHR is a risk factor for hypertension [30, 31]. The exact mechanism by which the ideal criteria for diet, cholesterol and blood glucose is associated with lower RHR is unclear. However, some studies suggest a decrease in sympathetic stimulation may also be responsible for the associations [32–34]. In addition, an indirect pathway could explain some of these findings. For example, poor dietary habits could predispose individuals to conditions such as endothelial dysfunction and chronic inflammation [35] that may cause elevated RHR.

Public health implications

Globally, approximately 17.9 million deaths were caused by CVD in 2015, an increase of 12.5% from 2005 [36] and by 2030 it is projected to increase to 23.6 million deaths. Between 2013 and 2014, the estimated direct and indirect cost of CVD in the U.S was \$330 billion with a projected increase to \$1.1 trillion by 2035 [37, 38]. In 2010, the AHA introduced the 2020 Strategic Impact Goals to improve the CVH of people living in the U.S by emphasizing the prevention of risk factors using the LS7 metrics as a measure of ideal CVH [5, 6]. Encouraging the attainment of ideal CVH may decrease the incidence of elevated RHR, a known risk factor, and contributor to the CVD burden.

In a secondary prevention population, a meta-regression conducted on 25 randomized clinical trials of 30,904 patients demonstrated a 30% decrease in the relative risk for cardiac death for every 10 bpm reduction in RHR with the use of pharmacologic intervention [39]. The authors concluded that regardless of the mechanism employed to decrease RHR, a similar benefit could be obtained in the reduction of CVD morbidity and mortality [39]. Although our study is cross-sectional and cannot determine a cause or effect, our research suggests that in a primary prevention population, optimizing cardiovascular wellness, through improvements in both health behavior and factor metrics, could also reduce RHR.

Strengths and Limitations

Our study has several strengths which include the large sample size and ethnic diversity that made it feasible to stratify results by sex, race/ethnicity and age. Additionally, data collection for the exposure and outcome variables was done using standardized methods and procedures. However, some limitations should be considered in the interpretation of the results. First, the cross-sectional analysis does not allow for causal inferences to be made between CVH and RHR. Second, only a single measurement of RHR was conducted at

baseline and may not reflect variations in circadian rhythm. Third, this study included only participants aged 45 to 84 years, therefore we cannot extrapolate the findings to people outside this age group. Fourth, in the stratified analyses presented in Supplemental material, under the RHR category ≥ 80 bpm, no result was reported for black participants in “6–7 vs. 0–2” ideal metric category because of the small sample size that met criteria for this category. Fifth, recall bias may have been introduced due to the use of self-administered questionnaires for the collection of data on smoking, physical activity, and diet. Lastly, we measured CVH status once at baseline and it may not be representative of prior or future CVH status of study participants.

Conclusions

We showed that achievement of favorable CVH was less likely to be associated with elevated RHR irrespective of sex, race/ethnicity and age even after accounting for other sociodemographic characteristics and AV-nodal blockers. Our findings imply that promoting ideal CVH may decrease the incidence of elevated RHR, a risk factor and contributor to the CVD burden, but this could not be determined from our cross-sectional study. Using well-designed studies, future research could explore the causal relationship between ideal CVH and RHR with the aim of understanding the underlying mechanisms by which favorable CVH reduces CVD events.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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List of Abbreviations

AHA	American Heart Association
ANOVA	Analysis of variance
AV-nodal blockers	Atrioventricular nodal blockers
BMI	Body mass index
bpm	beats per min

CI	confidence intervals
CVD	cardiovascular disease
CVH	cardiovascular health
LS7	Life's Simple 7
MESA	Multi-Ethnic Study of Atherosclerosis
OR	odds ratio
RHR	resting heart rate
SD	standard deviation
U.S	United States

References

1. Böhm M, Reil JC, Deedwania P, Kim JB, Borer JS: Resting heart rate: risk indicator and emerging risk factor in cardiovascular disease. *Am J Med* 2015, 128(3):219–228. [PubMed: 25447617]
2. Kim DI, Yang HI, Park JH, Lee MK, Kang DW, Chae JS, Lee JH, Jeon JY: The association between resting heart rate and type 2 diabetes and hypertension in Korean adults. *Heart* 2016, 102(21):1757–1762. [PubMed: 27312000]
3. Aune D, Sen A, Ó'Hartaigh B, Janszky I, Romundstad PR, Tonstad S, Vatten LJ: Resting heart rate and the risk of cardiovascular disease, total cancer, and all-cause mortality - A systematic review and dose-response meta-analysis of prospective studies. *Nutr Metab Cardiovasc Dis* 2017, 27(6):504–517. [PubMed: 28552551]
4. Aladin AI, Whelton SP, Al-Mallah MH, Blaha MJ, Keteyian SJ, Juraschek SP, Rubin J, Brawner CA, Michos ED: Relation of resting heart rate to risk for all-cause mortality by gender after considering exercise capacity (the Henry Ford exercise testing project). *Am J Cardiol* 2014, 114(11):1701–1706. [PubMed: 25439450]
5. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, Greenlund K, Daniels S, Nichol G, Tomaselli GF 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. [PubMed: 20089546]
6. Labarthe DR: From cardiovascular disease to cardiovascular health: a quiet revolution? *Circ Cardiovasc Qual Outcomes* 2012, 5(6):e86–92. [PubMed: 23170007]
7. Dinas PC, Koutedakis Y, Flouris AD: Effects of active and passive tobacco cigarette smoking on heart rate variability. *Int J Cardiol* 2013, 163(2):109–115. [PubMed: 22100604]
8. Kang SJ, Ha GC, Ko KJ: Association between resting heart rate, metabolic syndrome and cardiorespiratory fitness in Korean male adults. *J Exerc Sci Fit* 2017, 15(1):27–31. [PubMed: 29541128]
9. Martins D, Tareen N, Pan D, Norris K: The relationship between body mass index, blood pressure and pulse rate among normotensive and hypertensive participants in the third National Health and Nutrition Examination Survey (NHANES). *Cell Mol Biol* 2003, 49(8):1305–1309. [PubMed: 14984002]
10. Gao J, Liang X, Shi J, Huang Z, Wei X, Li H, Lin L, Xing A, Du X, Wu S: [Impact of ideal cardiovascular health behaviors and factors on resting heart rate in individuals without cardiovascular diseases]. *Zhonghua Xin Xue Guan Bing Za Zhi* 2014, 42(9):778–783. [PubMed: 25511100]
11. Bild DE, Bluemke DA, Burke GL, Detrano R, Diez Roux AV, Folsom AR, Greenland P, Jacob DR, Kronmal R, Liu K et al.: Multi-Ethnic Study of Atherosclerosis: objectives and design. *Am J Epidemiol* 2002, 156(9):871–881. [PubMed: 12397006]

12. Amoakwa K, Fashanu OE, Tibuakuu M, Zhao D, Guallar E, Whelton SP, O'Neal WT, Post WS, Budoff MJ, Michos ED: Resting heart rate and the incidence and progression of valvular calcium: The Multi-Ethnic Study of Atherosclerosis (MESA). *Atherosclerosis* 2018, 273:45–52. [PubMed: 29677630]
13. Rubin J, Blaha MJ, Budoff MJ, Rivera JJ, Shaw LJ, Blankstein R, Mallah MA, Carr JJ, Jones DL, Blumenthal RS et al.: The relationship between resting heart rate and incidence and progression of coronary artery calcification: the Multi-Ethnic Study of Atherosclerosis (MESA). *Atherosclerosis* 2012, 220(1):194–200. [PubMed: 21763655]
14. Ainsworth BE, Irwin ML, Addy CL, Whitt MC, Stolarczyk LM: Moderate physical activity patterns of minority women: the Cross-Cultural Activity Participation Study. *J Womens Health Gend Based Med* 1999, 8(6):805–813. [PubMed: 10495261]
15. Unger E, Diez-Roux AV, Lloyd-Jones DM, Mujahid MS, Nettleton JA, Bertoni A, Badon SE, Ning H, Allen NB: Association of neighborhood characteristics with cardiovascular health in the multi-ethnic study of atherosclerosis. *Circ Cardiovasc Qual Outcomes* 2014, 7(4):524–531. [PubMed: 25006187]
16. Block G, Woods M, Potosky A, Clifford C: Validation of a self-administered diet history questionnaire using multiple diet records. *J Clin Epidemiol* 1990, 43(12):1327–1335. [PubMed: 2254769]
17. Mayer-Davis EJ, Vitolins MZ, Carmichael SL, Hemphill S, Tsaroucha G, Rushing J, Levin S: Validity and reproducibility of a food frequency interview in a Multi-Cultural Epidemiology Study. *Ann Epidemiol* 1999, 9(5):314–324. [PubMed: 10976858]
18. Lloyd-Jones DM: Improving the cardiovascular health of the US population. *JAMA* 2012, 307(12):1314–1316. [PubMed: 22427616]
19. Ogunmoroti O, Oni E, Michos ED, Spatz ES, Allen NB, Rana JS, Virani SS, Blankstein R, Aronis KN, Blumenthal RS et al.: Life's Simple 7 and Incident Heart Failure: The Multi-Ethnic Study of Atherosclerosis. *J Am Heart Assoc* 2017, 6(6).
20. Ogunmoroti O, Michos ED, Aronis KN, Salami JA, Blankstein R, Virani SS, Spatz ES, Allen NB, Rana JS, Blumenthal RS et al.: Life's Simple 7 and the risk of atrial fibrillation: The Multi-Ethnic Study of Atherosclerosis. *Atherosclerosis* 2018, 275:174–181. [PubMed: 29920438]
21. Rosenwinkel ET, Bloomfield DM, Arwady MA, Goldsmith RL: Exercise and autonomic function in health and cardiovascular disease. *Cardiol Clin* 2001, 19(3):369–387. [PubMed: 11570111]
22. Hillebrand S, Swenne CA, Gast KB, Maan AC, le Cessie S, Jukema JW, Rosendaal FR, den Heijer M, de Mutsert R: The role of insulin resistance in the association between body fat and autonomic function. *Nutr Metab Cardiovasc Dis* 2015, 25(1):93–99. [PubMed: 25171899]
23. Scherrer U, Randin D, Tappy L, Vollenweider P, Jéquier E, Nicod P: Body fat and sympathetic nerve activity in healthy subjects. *Circulation* 1994, 89(6):2634–2640. [PubMed: 8205675]
24. Strandheim A, Halland H, Saeed S, Cramariuc D, Hetland T, Lønnebakken MT, Gerds E: Obesity-associated metabolic changes influence resting and peak heart rate in women and men. *Scand Cardiovasc J* 2015, 49(6):337–343. [PubMed: 26329857]
25. Kenney WL: Parasympathetic control of resting heart rate: relationship to aerobic power. *Med Sci Sports Exerc* 1985, 17(4):451–455. [PubMed: 4033400]
26. Hayano J, Yamada M, Sakakibara Y, Fujinami T, Yokoyama K, Watanabe Y, Takata K: Short- and long-term effects of cigarette smoking on heart rate variability. *Am J Cardiol* 1990, 65(1):84–88. [PubMed: 2294686]
27. Narkiewicz K, van de Borne PJ, Hausberg M, Cooley RL, Winniford MD, Davison DE, Somers VK: Cigarette smoking increases sympathetic outflow in humans. *Circulation* 1998, 98(6):528–534. [PubMed: 9714109]
28. Papatheanasiou G, Georgakopoulos D, Papageorgiou E, Zerva E, Michalis L, Kalfakakou V, Evangelou A: Effects of smoking on heart rate at rest and during exercise, and on heart rate recovery, in young adults. *Hellenic J Cardiol* 2013, 54(3):168–177. [PubMed: 23685653]
29. Fernandes RA, Freitas Júnior IF, Codogno JS, Christofaro DG, Monteiro HL, Roberto Lopes DM: Resting heart rate is associated with blood pressure in male children and adolescents. *J Pediatr* 2011, 158(4):634–637. [PubMed: 21095617]

30. Reule S, Drawz PE: Heart rate and blood pressure: any possible implications for management of hypertension? *Curr Hypertens Rep* 2012, 14(6):478–484. [PubMed: 22972532]
31. Aladin AI, Al Rifai M, Rasool SH, Keteyian SJ, Brawner CA, Michos ED, Blaha MJ, Al-Mallah MH, McEvoy JW: The Association of Resting Heart Rate and Incident Hypertension: The Henry Ford Hospital Exercise Testing (FIT) Project. *Am J Hypertens* 2016, 29(2):251–257. [PubMed: 26112864]
32. Børnaa KH, Arnesen E: Association between heart rate and atherogenic blood lipid fractions in a population. The Tromsø Study. *Circulation* 1992, 86(2):394–405. [PubMed: 1638708]
33. Carnethon MR, Yan L, Greenland P, Garside DB, Dyer AR, Metzger B, Daviglus ML: Resting heart rate in middle age and diabetes development in older age. *Diabetes Care* 2008, 31(2):335–339. [PubMed: 17959868]
34. Wang L, Cui L, Wang Y, Vaidya A, Chen S, Zhang C, Zhu Y, Li D, Hu FB, Wu S et al.: Resting heart rate and the risk of developing impaired fasting glucose and diabetes: the Kailuan prospective study. *Int J Epidemiol* 2015, 44(2):689–699. [PubMed: 26002923]
35. Whelton SP, Narla V, Blaha MJ, Nasir K, Blumenthal RS, Jenny NS, Al-Mallah MH, Michos ED: Association between resting heart rate and inflammatory biomarkers (high-sensitivity C-reactive protein, interleukin-6, and fibrinogen) (from the Multi-Ethnic Study of Atherosclerosis). *Am J Cardiol* 2014, 113(4):644–649. [PubMed: 24393259]
36. Global Burden of Disease Study Collaborators. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1459–1544. [PubMed: 27733281]
37. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, Chiuve SE, Cushman M, Dellings FN, Deo R et al.: Heart Disease and Stroke Statistics-2018 Update: A Report From the American Heart Association. *Circulation* 2018, 137(12):e67–e492. [PubMed: 29386200]
38. Projections of Cardiovascular Disease Prevalence and Costs: 2015–2035 Technical Report [report prepared for the American Heart Association]. Research Triangle Park, NC, Research Triangle Institute; 2016.
39. Cucherat M: Quantitative relationship between resting heart rate reduction and magnitude of clinical benefits in post-myocardial infarction: a meta-regression of randomized clinical trials. *Eur Heart J* 2007, 28(24):3012–3019. [PubMed: 17981830]

Highlights

- Little is known about the association between ideal cardiovascular health (CVH) and resting heart rate (RHR)
- We found that favorable CVH was associated with lower odds of having higher RHR regardless of sex, race/ethnicity and age
- More research should explore the usefulness of promoting ideal CVH to reduce elevated RHR, a risk factor for CV disease

Figure.

*Restricted cubic spline of the association between CVH score and resting heart rate

Note: RHR indicates resting heart rate; CVH, cardiovascular health; CVH score of 6 served as reference and knots were at CVH scores of 5, 8, 9 and 12.

*adjusted for sociodemographic factors and AV-nodal blockers (beta blockers, digitalis preparations, diltiazem, and verapamil)

Table 1-

Characteristics of Study Participants by Resting Heart Rate: MESA (N=6,457)

	Total (N= 6,457)	<60bpm (n=2,417)	60–69bpm (n=2,540)	70–79bpm (n=1,139)	80bpm (n=361)
<i>Age, mean (SD), y</i>	62.0 (10.2)	62.3 (10.2)	61.6 (10.1)	61.8 (10.3)	62.5 (10.1)
<i>Sex</i>					
Men n (%)	3055 (47.3)	1315 (54.4)	1107 (43.6)	486 (42.7)	147 (40.7)
Women n (%)	3402 (52.7)	1102 (45.6)	1433 (56.4)	653 (57.3)	214 (59.3)
<i>Race/Ethnicity</i>					
White n (%)	2507 (38.8)	965 (39.9)	984 (38.7)	430 (37.8)	128 (35.5)
Chinese American n (%)	795 (12.3)	272 (11.3)	353 (13.9)	135 (11.9)	35 (9.7)
Black n (%)	1704 (26.4)	669 (27.7)	625 (24.6)	294 (25.8)	116 (32.1)
Hispanic n (%)	1451 (22.5)	511 (21.1)	578 (22.8)	280 (24.6)	82 (22.7)
<i>Education</i>					
Bachelor's degree n (%)	2312 (35.8)	938 (38.8)	907 (35.7)	367 (32.2)	100 (27.7)
< Bachelor's degree n (%)	4145 (64.2)	1469 (61.2)	1633 (64.3)	772 (67.8)	261 (72.3)
<i>Income</i>					
\$40,000 n (%)	3180 (49.3)	1257 (52.0)	1245 (49.0)	522 (45.8)	156 (43.2)
<\$40,000 n (%)	3277 (50.8)	1160 (48.0)	1295 (51.0)	617 (54.2)	205 (56.8)
<i>Health insurance</i>					
Yes n (%)	5878 (91.0)	2211 (91.5)	2298 (90.5)	1036 (91.0)	333 (92.2)
No n (%)	579 (9.0)	206 (8.5)	242 (9.5)	103 (9.0)	28 (7.8)
<i>AV-nodal medications</i>					
Yes n (%)	820 (12.7)	414 (17.1)	287 (11.3)	87 (7.6)	32 (8.9)
No n (%)	5637 (87.3)	2003 (82.9)	2253 (88.7)	1052 (92.4)	329 (91.1)
<i>LS7 metrics</i>					
Current smoking n (%)	834 (12.9)	295 (12.2)	330 (13.0)	157 (13.8)	52 (14.4)
Body mass index (kg/m ²)	28.3 (5.5)	27.6 (5.0)	28.2 (5.5)	29.1 (5.8)	30.4 (6.6)
Physical activity (MET min/week)	400.5 (601.3)	462.1 (670.4)	383.9 (582.2)	349.3 (525.0)	266.1 (390.6)
Healthy diet score (0–5)	1.6 (0.9)	1.6 (0.9)	1.6 (0.9)	1.5 (0.9)	1.5 (0.9)
Total cholesterol (mg/dl)	194.2 (35.8)	192.1 (33.6)	194.5 (36.0)	196.7 (36.1)	199.0 (45.1)

	Total (N=9,457)	<60bpm (n=2,417)	60–69bpm (n=2,540)	70–79bpm (n=1,139)	80bpm (n=361)
Systolic blood pressure (mmHg)	126.3 (21.4)	125.3 (22.5)	126.0 (20.9)	127.5 (19.9)	130.5 (20.3)
Diastolic blood pressure (mmHg)	71.9 (10.2)	70.4 (10.0)	72.1 (10.2)	73.6 (10.0)	75.2 (10.8)
Fasting blood glucose (mg/dl)	97.3 (30.4)	92.2 (21.2)	96.7 (28.2)	103.4 (37.4)	116.4 (53.8)
<i>Number of ideal LS7 metrics</i>					
0 to 2	1698 (26.3)	479 (19.8)	633 (24.9)	411 (36.1)	175 (48.5)
3 to 5	4490 (69.5)	1809 (74.8)	1797 (70.8)	707 (62.1)	177 (49.0)
6 to 7	269 (4.2)	129 (5.3)	110 (4.3)	21 (1.8)	9 (2.5)

Abbreviations: MESA indicates Multi-Ethnic Study of Atherosclerosis; LS7, Life's Simple 7; SD, standard deviation; AV-nodal blockers include beta blockers, digitalis preparations, diltiazem, and verapamil. Percentages (%) rounded up to 1 decimal place.

Table 2-

Distribution of Life's Simple 7 Metrics by Resting Heart Rate

Resting heart rate	Total (N=6,457)	<60bpm (n=2,417)	60–69bpm (n=2,540)	70–79bpm (n=1,139)	80bpm (n=361)
<i>CVH score, n (%)</i>					
Inadequate (0–8)	3059 (47.4)	972 (40.2)	1187 (46.7)	641 (56.3)	259 (71.8)
Average (9–10)	2104 (32.6)	842 (34.8)	862 (33.9)	326 (28.6)	74 (20.5)
Optimal (11–14)	1294 (20.0)	603 (25.0)	491 (19.3)	172 (15.1)	28 (7.8)
<i>LS7 metrics, n (%)</i>					
Smoking					
Poor	834 (12.9)	295 (12.2)	330 (13.0)	157 (13.8)	52 (14.4)
Intermediate	79 (1.2)	32 (1.3)	27 (1.1)	16 (1.4)	4 (1.1)
Ideal	5544 (85.9)	2090 (86.5)	2183 (85.9)	966 (84.8)	305 (84.5)
Body mass index					
Poor	2053 (31.8)	640 (26.5)	801 (31.5)	437 (38.4)	175 (48.5)
Intermediate	2544 (39.4)	1015 (42.0)	1005 (39.6)	416 (36.5)	108 (29.9)
Ideal	1860 (28.8)	762 (31.5)	734 (28.9)	286 (25.1)	78 (21.6)
Physical activity					
Poor	1476 (22.9)	480 (19.9)	576 (22.7)	305 (26.8)	115 (31.9)
Intermediate	1121 (17.4)	366 (15.1)	464 (18.3)	222 (19.5)	69 (19.1)
Ideal	3860 (59.8)	1571 (65.0)	1500 (59.1)	612 (53.7)	177 (49.0)
Diet					
Poor	2919 (45.2)	1092 (45.2)	1123 (44.2)	526 (46.2)	178 (49.3)
Intermediate	3468 (53.7)	1293 (53.5)	1388 (54.7)	606 (53.2)	181 (50.1)
Ideal	70 (1.1)	32 (1.3)	29 (1.1)	7 (0.6)	2 (0.6)
Total Cholesterol					
Poor	867 (13.4)	277 (11.5)	350 (13.8)	171 (15.0)	69 (19.1)
Intermediate	2518 (39.0)	933 (38.6)	962 (37.9)	474 (41.6)	149 (41.3)
Ideal	3072 (47.6)	1207 (49.9)	1228 (48.4)	494 (43.4)	143 (39.6)
Blood pressure					
Poor	2422 (37.5)	882 (36.5)	917 (36.1)	448 (39.3)	175 (48.5)

Resting heart rate	Total (N=6,457)	<60bpm (n=2,417)	60–69bpm (n=2,540)	70–79bpm (n=1,139)	80bpm (n=361)
Intermediate	1807 (28.0)	644 (26.6)	688 (27.1)	352 (30.9)	123 (34.1)
Ideal	2228 (34.5)	891 (36.9)	935 (36.8)	339 (29.8)	63 (17.5)
Blood glucose					
Poor	696 (10.8)	156 (6.5)	261 (10.3)	187 (16.4)	92 (25.5)
Intermediate	977 (15.1)	298 (12.3)	384 (15.1)	211 (18.5)	84 (23.3)
Ideal	4784 (74.1)	1963 (81.2)	1895 (74.6)	741 (65.1)	185 (51.3)

Abbreviations: CVH indicates cardiovascular health; LS7, Life's Simple 7; SD, standard deviation; Percentages (%) rounded up to 1 decimal place.

Table 3 -
Multivariable Association Between Cardiovascular Health and Resting Heart Rate in the Overall Cohort

Overall CVH Score							
		60-69 vs <60	70-79 vs <60	80 vs <60	60-69 vs <60	70-79 vs <60	80 vs <60
		OR (95% CI)			OR (95% CI)		
Model 1: Unadjusted							
Inadequate	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Average	0.84 (0.74-0.95)	0.59 (0.50-0.69)	0.33 (0.25-0.43)	0.75 (0.44-1.29)	0.94 (0.50-1.77)	0.71 (0.24-2.09)	
Optimal	0.67 (0.58-0.77)	0.43 (0.36-0.53)	0.17 (0.12-0.26)	0.93 (0.79-1.10)	0.87 (0.71-1.07)	0.83 (0.60-1.14)	
*Model 2: Adjusted							
Inadequate	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Average	0.79 (0.69-0.90)	0.56 (0.48-0.67)	0.32 (0.24-0.43)	0.75 (0.44-1.29)	0.94 (0.50-1.78)	0.74 (0.25-2.20)	
Optimal	0.60 (0.51-0.70)	0.40 (0.33-0.50)	0.17 (0.11-0.26)	0.93 (0.78-1.10)	0.89 (0.71-1.10)	0.89 (0.64-1.23)	
†Model 3: Adjusted							
Inadequate	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Average	0.75 (0.66-0.86)	0.52 (0.44-0.61)	0.30 (0.22-0.39)	0.74 (0.43-1.27)	0.92 (0.49-1.73)	0.73 (0.24-2.15)	
Optimal	0.55 (0.46-0.64)	0.34 (0.28-0.43)	0.14 (0.09-0.22)	0.94 (0.79-1.12)	0.91 (0.73-1.12)	0.91 (0.65-1.26)	
Physical Activity							
		Body Mass Index					
		60-69 vs <60	70-79 vs <60	80 vs <60	60-69 vs <60	70-79 vs <60	80 vs <60
		OR (95% CI)			OR (95% CI)		
Model 1: Unadjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	0.79 (0.69-0.91)	0.60 (0.51-0.71)	0.39 (0.30-0.50)	1.06 (0.88-1.27)	0.95 (0.77-1.19)	0.79 (0.57-1.09)	
Ideal	0.77 (0.67-0.89)	0.55 (0.46-0.66)	0.37 (0.28-0.50)	0.80 (0.69-0.92)	0.61 (0.52-0.73)	0.47 (0.36-0.61)	
*Model 2: Adjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	0.81 (0.71-0.93)	0.62 (0.52-0.74)	0.42 (0.32-0.54)	1.04 (0.87-1.26)	0.96 (0.77-1.20)	0.81 (0.58-1.12)	
Ideal	0.71 (0.60-0.82)	0.52 (0.43-0.64)	0.38 (0.28-0.51)	0.84 (0.72-0.96)	0.66 (0.55-0.78)	0.51 (0.39-0.67)	
†Model 3: Adjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)

	Overall CVH Score			‡ Smoking		
	60–69 vs <60	70–79 vs <60	OR (95% CI)	60–69 vs <60	70–79 vs <60	OR (95% CI)
Intermediate	0.79 (0.69–0.91)	0.60 (0.50–0.71)	0.40 (0.31–0.52)	1.04 (0.86–1.25)	0.95 (0.76–1.19)	0.80 (0.57–1.11)
Ideal	0.67 (0.57–0.79)	0.48 (0.39–0.58)	0.35 (0.25–0.48)	0.82 (0.71–0.94)	0.63 (0.53–0.76)	0.50 (0.38–0.64)

Abbreviation: CVH indicates cardiovascular health measured by the CVH score and metrics; OR, odds ratio.

* Adjusted for socio-demographic factors (age, sex, race/ethnicity, education, income, and health insurance status);

† Adjusted for socio-demographic factors and AV-nodal blockers (beta-blockers, digitalis preparations, diltiazem, and verapamil). Interactions: 60–69: sex*cvh= .58; 70–79: sex*cvh= .97; 80: sex*cvh=.14; 60–69: race*cvh=.18; 70–79: race*cvh=.13; 80: race*cvh=.72; 60–69: age*cvh=.12; 70–79: age*cvh=.01; 80: age*cvh=.04;

‡, Categories for smoking are poor, intermediate and ideal.

Table 4 -
Multivariable Association Between Cardiovascular Health and Resting Heart Rate in the Overall Cohort

		Diet		Total Cholesterol			
		60–69 vs <60	70–79 vs <60	80 vs <60	60–69 vs <60	70–79 vs <60	80 vs <60
		OR (95% CI)			OR (95% CI)		
Model 1: Unadjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	1.04 (0.93–1.17)	0.97 (0.84–1.12)	0.86 (0.69–1.07)	0.82 (0.68–0.98)	0.82 (0.66–1.03)	0.64 (0.47–0.88)	
Ideal	0.88 (0.53–1.47)	0.45 (0.20–1.04)	0.38 (0.09–1.61)	0.81 (0.67–0.96)	0.66 (0.53–0.82)	0.48 (0.35–0.65)	
*Model 2: Adjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	0.97 (0.87–1.10)	0.92 (0.79–1.07)	0.81 (0.64–1.02)	0.85 (0.71–1.02)	0.87 (0.70–1.08)	0.67 (0.49–0.93)	
Ideal	0.75 (0.45–1.26)	0.39 (0.17–0.89)	0.32 (0.08–1.36)	0.86 (0.72–1.03)	0.72 (0.58–0.90)	0.52 (0.38–0.72)	
†Model 3: Adjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	0.97 (0.87–1.09)	0.92 (0.79–1.06)	0.81 (0.64–1.02)	0.86 (0.72–1.04)	0.89 (0.71–1.11)	0.69 (0.50–0.95)	
Ideal	0.75 (0.45–1.27)	0.39 (0.17–0.90)	0.32 (0.08–1.38)	0.86 (0.72–1.03)	0.72 (0.58–0.90)	0.52 (0.38–0.72)	
		Blood Pressure			Blood Glucose		
		60–69 vs <60	70–79 vs <60	80 vs <60	60–69 vs <60	70–79 vs <60	80 vs <60
		OR (95% CI)			OR (95% CI)		
Model 1: Unadjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	1.03 (0.89–1.18)	1.08 (0.91–1.28)	0.96 (0.75–1.24)	0.77 (0.60–0.99)	0.59 (0.45–0.78)	0.48 (0.34–0.68)	
Ideal	1.01 (0.89–1.15)	0.75 (0.63–0.89)	0.36 (0.26–0.48)	0.58 (0.47–0.71)	0.31 (0.25–0.40)	0.16 (0.12–0.22)	
*Model 2: Adjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Intermediate	1.02 (0.88–1.18)	1.08 (0.90–1.29)	0.99 (0.76–1.28)	0.77 (0.60–0.99)	0.60 (0.45–0.79)	0.49 (0.34–0.70)	
Ideal	0.92 (0.80–1.06)	0.69 (0.57–0.83)	0.33 (0.24–0.46)	0.53 (0.42–0.65)	0.29 (0.23–0.36)	0.14 (0.11–0.20)	
†Model 3: Adjusted							
Poor	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)

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	Diet				Total Cholesterol			
	60–69 vs <60	70–79 vs <60	80 vs <60	OR (95% CI)	60–69 vs <60	70–79 vs <60	80 vs <60	OR (95% CI)
Intermediate	0.93 (0.80–1.08)	0.92 (0.77–1.10)	0.83 (0.64–1.09)		0.76 (0.59–0.98)	0.59 (0.45–0.78)	0.48 (0.34–0.69)	
Ideal	0.80 (0.69–0.93)	0.54 (0.45–0.66)	0.26 (0.19–0.37)		0.50 (0.41–0.62)	0.26 (0.21–0.34)	0.13 (0.10–0.18)	

Abbreviation: CVH indicates cardiovascular health measured by the CVH score and metrics; OR, odds ratio.

* Adjusted for socio-demographic factors (age, sex, race/ethnicity, education, income, and health insurance status);

† Adjusted for socio-demographic factors and AV-nodal blockers (beta-blockers, digitalis preparations, diltiazem, and verapamil).