The Influence of Race and Education on the Rate of Aging

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Abstract

The rate of functional and structural decline associated with the aging process is marked by significant heterogeneity within the population, manifesting as differences in disease susceptibility and longevity. Such health disparities are believed to be highly influenced by environmental differences, particularly between individuals of varying socioeconomic status and race. The current study uses data from NHANES III, a nationally representative sample to examine differences in aging rates by race and education for adults ages 30-75. Findings from this study suggest that black individuals or those with low education are more likely to experience an acceleration of the aging process. Furthermore, we found that low educated blacks may be at the highest risk and that having a college degree among blacks does not provide as great a health benefit as it does for white individuals with the same educational attainment.

Background

The rate of functional and structural decline associated with the aging process is marked by significant heterogeneity within the population[1], manifesting as differences in disease susceptibility and longevity[2]. Furthermore, given that genetics has been estimated to account for less than 30% of this variation[3], environment is believed to play a major role in the body's rate of degradation over time.

Disparities in health and mortality are multifactorial, potentially resulting from the confluence of factors associated with psychological stress, adverse health behaviors, and physical and social environments. The effects of race and socioeconomic status (SES) on disease and mortality have been well documented[4-7], providing evidence that the risk of many chronic conditions such as cardiovascular disease, hypertension, diabetes and stroke is significantly higher for blacks or low SES individuals[8]. Furthermore, it has been shown that low SES persons experience disease incidence and death an average of 5-10 years earlier than the rest of the population. The increased prevalence of morbidity and mortality within particular sub-groups may reflect a tendency towards "earlier aging" within disadvantaged segments of the population[9].

The focus of this study is to investigate the influence of education and race on Biological age relative to chronological age. We hypothesize that aging will be accelerated for black individuals or persons with low educational attainment, and that this will be increasingly true for individuals who are both. Furthermore, we expect that educational attainment will be less important for blacks relative to whites, and that highly educated blacks will still have a biological disadvantaged.

Data and Measures

Study Population

The study population included subjects from the third National Health and Nutrition Examination Survey (NHANES III), a nationally representative, cross-sectional study conducted by the National Center for Health Statistics (NCHS). Data for NHANES III were collected from at-home interviews, examinations taking place at a Mobile Examination Center (MEC). Further details of recruitment, procedures and study design are available through the Centers for Disease Control and Prevention[18]. Our study population was limited to adults aged 30-75, to insure subjects were old enough to be experiencing detectable age-related changes in biomarkers, yet not too old as to represent a select group with above average health and longevity. Our final analytic sample included 6,710 subjects. Excluded participants consisted of those with missing data on one or more of the biomarker measures, or individuals not identifying as either Non-Hispanic black or Non-Hispanic white.

Aging Rate Estimates

Biomarkers were selected based upon knowledge regarding their role or dependency on the aging process, independence, use in previous biomarkers of aging studies, their availability, and the statistical significance and strength of their relationship with age. Initially, 21 biomarkers were considered in our analysis. This was then reduced to 10 biomarkers that significantly correlated with chronological age at $r > 0.10$. Finally, principal component analysis (PCA) was

used to select only biomarkers loading on the first principal. These included: CRP, Serum Creatinine, Hba1c, Systolic Blood Pressure, Serum Albumin, Total Cholesterol, CMV, Serum Alkaline Phosphatase, FEV, and Serum Urea Nitrogen.

Biological age was calculated using a method proposed by Klemera and Doubal, which has been shown to predict mortality more accurately than chronological age or biological age calculated using alternative methods. The BA estimates using the Klemera and Doubal method (KDM) are based upon minimizing the distance between *m* regression lines and *m* biomarker points, within an *m* dimensional space of all biomarkers. In their paper, the authors defined BA as equal to CA, plus some random variable, R_{BA}, with a mean of zero and a variance s_{BA}^2. Biological age was calculated using equation 1.

$$BA_{EC} = \frac{\sum_{j=1}^{m}(x_j - q_j)\frac{k_j}{s_j^2} + \frac{CA}{s_{BA}^2}}{\sum_{j=1}^{m}\left(\frac{k_j}{s_j}\right)^2 + \frac{1}{s_{BA}^2}} \quad (1)$$

In order to produce an estimate for BA, using equation (1), s_j^2 and s_{BA}^2 had to be calculated. The value, s_j, represents the root mean squared error of a biomarker regressed on BA. However, given that BA is not measurable, root mean squared errors (MSE) from the regressions between each biomarker and CA, rather than BA, were used, as suggested by Haeng Cho et al. Finally, in order to calculate s_{BA}^2, equations 2-4 were used sequentially.

$$BA_E = \frac{\sum_{j=1}^{m}(x_j - q_j)\frac{k_j}{s_j^2}}{\sum_{j=1}^{m}\left(\frac{k_j}{s_j}\right)^2} \quad (2)$$

$$r_{char} = \frac{\sum_{j=1}^{m}\frac{r_j^2}{\sqrt{1-r_j^2}}}{\sum_{j=1}^{m}\frac{r_j}{\sqrt{1-r_j^2}}} \quad (3)$$

$$s_{BA}^2 = \left(\frac{\sum_{j=1}^{n}((BA_{Ei} - CA_i - \sum_{i=1}^{n}(BA_{Ei} - CA_i)/n)^2}{n}\right) - \left(\frac{1-r_{char}^2}{r_{char}^2}\right) \times \left(\frac{(CA_{max} - CA_{\min})^2}{12m}\right) \quad (4)$$

The value r_j^2, used to calculate the characteristic correlation coefficient from equation 3, refers to the variance explained by regression CA on *m* biomarkers. In accordance with the assumption made by Klemera and Doubal, s_{BA}^2 from equation 4 was transformed so that s_{BA} maintained the same mean, but was linearly increasing with age, with a difference of 5 between subjects at CA_{min} and CA_{max}. Finally, in order to estimate rates of aging, the difference between biological and chronological age was calculated so that values represented the degree to which an individual was older biologically compared to what is expected chronologically.

Sociodemographic Characteristics

Education was used to infer SES and was measured both continuously and using four categories—less than 12 years, 12 years, 13-15 years, and 16 or more years. Race was self-reported and included in analysis as a dummy variable, with black being set equal to 1 and white being set equal to 0. An interaction term was also created for race and of years of education measured continuously and centered on its mean.

Analytic Strategy

All analyses were run controlling for sex and chronological age. Adjusted mean aging rates were calculated and compared by educational groups, race, and education within race. Next education (continuous), race and an interaction term for race by education were regressed on aging rates and used to calculate expected aging rates for blacks and whites at each educational level from 0-17 years.

Preliminary Results

Sample characteristics, are shown in Table 1. Approximately half (51.85%) of the subjects were female, and ranged in age from 30-75, with a mean of 47.7 years. Approximately 10.8% of subjects self-reported as Non-Hispanic Black, while 89.2% self-reported as Non-Hispanic white. Education ranged from 0 to seventeen years, with a mean of 12.8 years. Additionally, 19.92% of subjects had less than 12 years of education, 35.13% had exactly 12 years of education, 20.38% had some college and 24.57% had a 4-year college degree or more. Finally, aging rate ranged from -15.3 to 41.85 years, with a mean of -0.23 years.

Adjusted mean aging rates by education, race and the combination of the two are shown in Table 2. Aging rates were found to decline as education level increased. Those with less than a high school degree were on average 3 years older biologically than chronologically, while high school graduates and individuals with some college were found to be about 1.5 years and 0.5 years older biologically than chronologically, respectively. Conversely, college graduates typically had decelerated aging rates, and were found to be just over a year younger biologically compared to chronologically. When examining age rates by race, whites were an average 0.5 years younger biologically, while blacks were over 4 years older biologically versus chronologically. Finally, when comparing mean aging rates by education for blacks and whites separately, dose responses were found in both groups, with higher educated individuals appearing younger biologically. However, while white college graduates were an average of 2.5 years younger biologically compared to chronologically, higher education did not off-set the accelerated aging of black college graduates, who were found to be almost 2.5 years older biologically than chronologically. Finally, as expected, black individuals with less than a high school education had the most accelerated aging and were almost 5 years older biologically compared to chronologically, while whites with similar educational attainment were only one year older biologically compared to chronologically.

Results from the OLS regression of education and race on the difference between biological and chronological age are shown in Table 3. Education was found to have a statistically significant negative association with aging rates (β=-0.388 $p<.0001$), while being black was significantly associated with accelerated aging (β=4.077 $p<.0001$). Additionally, the interaction between black and education was found to be statistically significant (β=0.120

p=.004). Finally, Figure 1 shows the predicted values of aging rates for blacks and whites by education, as calculated from the regression equation. While whites were found to be consistently lower than blacks, they also experienced a steeper slope in regards to the effect of education, which suggests that increasing education may not be as beneficial to blacks in contrast to whites.

Conclusion

This study contributes to the growing body of work that examines the effects of race and education on health. Preliminary findings from this study suggest that black individuals or those with low education are more likely to experience an acceleration of the aging process. Furthermore, we found that low educated blacks may be at the highest risk and that increasing education among blacks may still not be enough to offset the negative health status. In moving forward, we plan on including health behaviors in our analysis to determine their role as mediating factors in the association between race, education and aging.

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Table 1: Weighted Sample Characteristics

Characteristics	
Chronological Age, Mean (years)	47.7 (12.75)
Aging Rates, Mean (years)	-0.23 (5.23)
Sex—Female, (%)	51.85%
Race/Ethnicity, (%)	
Non-Hispanic White	89.2%
Non-Hispanic Black	10.8%
Education Category, (%)	
Less than 12 years	19.92%
12 years	35.13%
Some College	20.38%
College Degree	24.57%
Education, Mean(years)	12.80 (2.90)

Table 2: Adjusted Mean Aging Rates (Biological-Chronological Age)

Characteristics	Mean Aging Rates
Race	
Non-Hispanic White	-0.08
Non-Hispanic Black	4.07
Education Category	
Less than 12 years	2.49
12 years	1.43
Some College	0.68
College Degree	-0.67
Race and Education, Mean(years)	
Black, Less than 12 years	4.97
Black, 12 years	4.00
Black, Some College	2.72
Black, College Degree	2.67
White, Less than 12 years	0.96
White, 12 years	-0.21
White, Some College	-0.73
White, College Degree	-2.37

Table 3: Regression of Race, Education and Race by Education on Aging Rates (Biological-Chronological Age)

	β (S.E.)	p-value
Education (continuous)	-0.388 (0.028)	<.001
Black	4.077 (0.136)	<.001
Black*Education	0.120 (0.041)	.004
Chronological Age	-0.018 (0.005)	<.001
Female	-0.652 (0.127)	<.001
(Constant)	5.594 (0.484)	<.001
R-Squared 0.19		

Figure 1: Predicted aging rate values based on regression results