

Occupational Mobility and Carotid Artery Intima-Media Thickness: Findings From the Coronary Artery Risk Development in Young Adults Study

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Objective: To examine whether a 10-year change in occupational standing is related to carotid artery intima-media thickness (IMT) 5 years later. **Methods:** Data were obtained from 2350 participants in the Coronary Artery Risk Development in Young Adults (CARDIA) Study. Occupational standing was measured at the Year 5 and 15 CARDIA follow-up examinations when participants were 30.2 (standard deviation = 3.6) and 40.2 (standard deviation = 3.6) years of age, respectively. IMT (common carotid artery [CCA], internal carotid artery [ICA], and bulb) was measured at Year 20. Occupational mobility was defined as the change in occupational standing between Years 5 and 15 using two semicontinuous variables. Analyses controlled for demographics, CARDIA center, employment status, parents' medical history, own medical history, Year 5 Framingham Risk Score, physiological risk factors and health behaviors averaged across the follow-up, and sonography reader. **Results:** Occupational mobility was unrelated to IMT save for an unexpected association of downward mobility with less CCA-IMT ($\beta = -0.04, p = .04$). However, associations differed depending on initial standing (Year 5) and sex. For those with lower initial standings, upward mobility was associated with less CCA-IMT ($\beta = -0.07, p = .003$), and downward mobility was associated with greater CCA-IMT and bulb-ICA-IMT ($\beta = 0.14, p = .01$ and $\beta = 0.14, p = .03$, respectively); for those with higher standings, upward mobility was associated with greater CCA-IMT ($\beta = 0.15, p = .008$), but downward mobility was unrelated to either IMT measure (p values $> .20$). Sex-specific analyses revealed associations of upward mobility with less CCA-IMT and bulb-ICA-IMT among men only (p values $< .02$). **Conclusions:** Occupational mobility may have implications for future cardiovascular health. Effects may differ depending on initial occupational standing and sex. **Key words:** CARDIA, IMT, occupational mobility, occupational social class, socioeconomic status.

CARDIA = Coronary Artery Risk Development in Young Adults; CCA = common carotid artery; CI = confidence interval; CVD = cardiovascular disease; HDL-C = high-density lipoprotein cholesterol; FRS = Framingham Risk Score; ICA = internal carotid artery; IMT = intima-media thickness; OC/HRT = oral contraceptive/hormone replacement therapy; SBP = systolic blood pressure; SD = standard deviation; SE = standard error; SEI = Socioeconomic Index; SES = socioeconomic status; TC = total cholesterol.

INTRODUCTION

Risk for premature morbidity and mortality increases with decreasing socioeconomic status (SES) (1,2). Findings from cross-sectional and prospective research conducted both in the United States and in countries with universal health care access

have shown a continuous SES gradient in cardiovascular disease (CVD) risk such that CVD morbidity and mortality increase with decreasing SES (3–7). To what extent *change* in adult SES contributes to socioeconomic disparities in risk for disease and death has been examined in several large European cohorts. These studies investigated changes in occupational standing—the relative prestige associated with a given occupation based on the median education and income associated with that occupation—between two occasions during adulthood, typically young adulthood and middle age (8–13). A common finding across studies is that those with stable low standing evidenced the greatest risk, those with stable high standing evidenced the least risk, and those whose standing changed—either upwardly or downwardly between the two occasions—evidenced an intermediate level of risk. Slightly different findings emerged from a Swedish mortality study wherein occupational standing was measured three times (14). Consistent with the aforementioned findings, Swedish adults who maintained a high standing across all occasions showed the least mortality risk. However, two of the groups with changing occupational standing—those whose standing decreased between the first and second assessments and again between the second and third and those whose standing both decreased and increased—were at *greater* risk than those of stable low standing. Thus, the association between the direction of change in occupational standing and risk for disease and death may not be as straightforward as it seemed at first.

The previously mentioned research suggests that change in occupational standing—or *occupational mobility*—during the adult life course may influence individuals' future health trajectories. However, because they focus on clinical outcomes, particularly mortality and, in one case incident myocardial infarction (10), they say little about when, in the process of disease risk, occupational mobility may begin to have an effect. For example, experiencing a change in occupational standing may increase risk for CVD mortality by either increasing the

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likelihood of a clinical event among those with advanced subclinical disease or initiating atherogenic processes among those who are free from disease.

We address the question of whether change in occupational standing for 10 years during adulthood (30.2 [standard deviation {SD} = 3.6] to 40.2 [SD = 3.6] years) influences CVD at early stages of disease development by examining whether the extent of change is related to carotid artery intima-media thickness (IMT). Specifically, we expect that declining standing or *downward mobility* will be associated with greater IMT. Given the evidence to suggest that upward change in occupational standing as well may have implications for long-term health, we also examine the association of *upward mobility* with IMT. Although previous findings (14) suggest that upward mobility in some cases may place individuals at increased risk for premature mortality, it also seems reasonable to expect that increases in occupational standing may be beneficial, especially among those whose initial standings are low. Thus, we examine the role of initial standing (age, 30.2 [SD = 3.6] years) as a potential moderator of the associations of both upward and downward mobility with IMT.

Carotid IMT is frequently used as a surrogate marker of systemic vascular disease and has been found to be a strong predictor of future acute cardiovascular events. Whether carotid IMT indicates *atherosclerosis*, however, depends largely on the location of measurement. Whereas the internal carotid artery (ICA) and carotid bifurcation (*bulb*) constitute two regions where advanced atherosclerotic plaques are known to localize, the common carotid artery (CCA) generally is spared from advanced plaque formation (15,16). Thus, intimal thickening in the CCA may reflect the culmination of different disease processes than those reflected by thickening in the bulb and ICA. Because occupational mobility may differentially influence the specific disease processes affecting these different arterial regions, we examine CCA-IMT and bulb-ICA-IMT as separate outcomes. We also examine whether associations between occupational mobility and IMT in each of these regions are moderated by sex and race.

Our approach to these questions extends the literature on SES mobility and disease in three ways. First, wherein existing research is based on data from exclusively white samples, the present study reports findings from a sample composed of nearly equal proportions of blacks and whites. Second, all of the existing studies defined occupational mobility as movement between discrete social classes (e.g., “manual,” “skilled manual,” “nonmanual”). By comparison, the present study used a continuous marker of occupational standing, the Socioeconomic Index (SEI) by Stevens and Cho (17), from which we derived a continuous measure of occupational mobility. Use of this measure enabled the detection of more subtle changes in occupational standing that would otherwise be missed if mobility were defined as movement between broad occupational classes. Finally, although a few studies have reported associations between lower SES and greater IMT (18–21), this is the first study to examine whether change in SES is associated with this important indicator of CVD risk.

METHODS

Participants

In 1985 to 1986, 5115 adults aged 18 to 30 years were recruited into the Coronary Artery Risk Development in Young Adults (CARDIA) Study at four sites: Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California. The sampling strategy resulted in a population-based cohort that was balanced by race (52% black), sex (55% women), and education (40% with ≤ 12 years of education) both overall and within each clinical center (see Friedman et al. (22)). Follow-up examinations were conducted in 1987 to 1988 (Year 2), 1990 to 1991 (Year 5), 1992 to 1993 (Year 7), 1995 to 1996 (Year 10), 2000 to 2001 (Year 15), and 2005 to 2006 (Year 20). Retention rates for the surviving portion of the sample were 91%, 85%, 80%, 77%, 72%, and 69%, respectively. Institutional review committee approval was obtained at each site, and written informed consent was obtained at each examination. Data from Years 5 through 20 were used in the present report.

Exclusions

Of the 5115 individuals who initially enrolled in the CARDIA Study, 3284 attended the Year 20 examination, with 3257 having complete data on either CCA-IMT ($n = 3254$) or bulb-ICA-IMT ($n = 3025$). Participants without data on employment status or occupational standing at Year 5 or 15 ($n = 830$) were excluded from analysis. This number includes those with missing data and those who did not receive occupational standing scores because of being outside the workforce. Participants were also excluded if missing one or more of the measures used to approximate average, Year 5, or Year 20 health status ($n = 77$; see the next section). The resulting sample was thus composed of 2350 participants (2349 with complete CCA-IMT data and 2177 with complete bulb-ICA-IMT data). Relative to all participants enrolled in the CARDIA Study at baseline who were not included in these analyses, the present sample was comparable in sex distribution (women, 54.3% versus 54.6%) but was older (mean age at baseline, 25.2 versus 24.5 years), more educated (mean education at baseline, 14.2 versus 13.4 years), and less likely to be black (42.1% versus 59.6%).

Measures

Carotid Artery IMT

Images of the distal CCA-IMT, bulb-IMT, and proximal ICA-IMT were obtained at the Year 20 examination using high-resolution B-mode ultrasonography (Logiq 700; General Electric Co, United Kingdom). Details of the scanning protocol have been described previously (23). Carotid ultrasound images were recorded on videotape and transmitted to the Ultrasound Reading Center (Tufts University) for IMT scoring. Digitized images were examined by trained sonography readers, and IMT was measured as the distance between the lumen-intima and media-adventitia interfaces. Mean IMT for each segment was derived by taking the average of far and near wall measurements on both the left and right sides. Bulb-ICA-IMT was derived by taking the average of the bulb-IMT and ICA-IMT measurements. Means for CCA-IMT and bulb-ICA-IMT were subjected to \log_{10} transformation to eliminate skew. The correlation between the two segments was 0.43 ($p < .001$).

Occupational Standing

At Years 5 and 15, participants reported on employment status, current position, type of work, and most important duties. Subsequently, occupations were classified according to the 1990 US Census Bureau three-digit occupation codes and assigned an SEI score (17). Persons outside the workforce (homemakers, retirees, and disabled/unable to work) were not assigned scores. Briefly, SEI scores are “predicted prestige ratings” based on the median education and annual income typically associated with a given occupation. The SEI has a theoretical range of 0 to 100, with higher scores indicating higher standing. In the present sample, SEI scores ranged from 14.5 to 90.4, and average scores for Years 5 and 15 were 43.1 (SD = 20.4) and 46.7 (SD = 19.6), respectively. Employment data were also collected at Year 20 but were not available for analysis at the time of this writing.

Occupational Mobility

We represented change in occupational standing—or *occupational mobility*—with two semicontinuous variables that were derived from the

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simple difference in occupational standing scores between Years 5 and 15. The first indicated the extent to which participants' standings increased during the 10-year period (upward mobility), and the second indicated the extent to which participants' standings decreased (downward mobility). Each variable was scored as follows: if participants' standings increased between Years 5 and 15, they were assigned an upward mobility score equal to the magnitude of the change, and a downward mobility score of "0." If participants' standings *decreased* between Years 5 and 15, they were assigned a downward mobility score equal to the magnitude of the change, and an upward mobility score of "0." For ease of interpretation, the absolute value of the downward mobility score was used in analyses, so that higher values would indicate greater decreases in standing. Those whose occupational standing scores did not change during the follow-up were assigned a score of "0" for both mobility variables. We chose to represent occupational mobility as two unidirectional variables because doing so allowed us to distinguish the effects of differing magnitudes of positive relative to negative change. By comparison, were we to treat mobility as a single continuous variable, an increase in that variable could indicate either less of a negative change or the presence of a positive change, two experiential phenomena with very different psychological meanings.

Covariates

Standard covariates for the present analyses included known correlates of CVD risk or IMT specifically. Not all participants had complete data on these covariates. When less than 1% of participants were missing data on a given examination-specific covariate (e.g., Year 5 medical history), data from the preceding examination were substituted for the missing values. By comparison, when a substantial number of participants were missing data on a given risk factor, a set of two dummy variables was created comparing those with the risk factor and those with missing data on the risk factor, respectively, to those for whom the risk factor was absent (e.g., parents' medical history).

Demographics

Data on age, sex, and race (black or white) were collected at baseline. Education was determined based on participants' maximum years of schooling reported by the Year 20 examination (range, 0 to 20+ years) and was included as a covariate to control for possible correlations between maximum obtained education and occupational mobility. Marital status was represented by a dichotomous variable (married = 1, all others = 0). Statuses at both Years 5 and 20 were included as covariates to control for any status changes that may have occurred during the follow-up.

Parents' Medical History

At baseline, participants were asked whether their biological parents had ever received a diagnosis of hypertension, stroke, myocardial infarction, and/or diabetes mellitus. From these data, two parent history dummy variables were created that indicated whether *either* parent had ever been diagnosed with any of the aforementioned conditions (0 = no, 1 = yes; 0 = no, 1 = unknown). Parents' medical history was unknown for 380 participants (16%).

Physiological Risk Factors

Body mass index, systolic blood pressure (SBP), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglycerides were measured at Years 5, 7, 10, 15, and 20; plasma glucose was measured at Years 7, 10, 15, and 20. Procedures for collection and measurement of physiological risk factors previously have been reported (22). Because CVD pathogenesis is a lengthy process with an onset that often occurs decades in advance of manifest disease, we computed mean values of each measure by averaging across values obtained at each of the five (four for glucose) examinations. Eighty-seven percent of the sample had complete data on all variables, and more than 98% had complete data for at least four of the five examinations (or for at least three of the four examinations for glucose).

Medical History

Also at Years 5, 7, 10, 15, and 20, participants reported whether they *ever* had been diagnosed with hypertension and whether they were currently taking

any over-the-counter or prescription medications, including oral contraceptive/hormone replacement therapy (OC/HRT; women only). See CARDIA Web site (<http://www.cardia.dopm.uab.edu/>) for additional details. Two dichotomous variables were created to indicate whether participants reported a diagnosis of hypertension at Years 5 and 20, respectively. A third dichotomous variable was created to indicate whether participants were taking any medications at Year 20 with the potential to influence IMT (antihypertensives, antihyperlipidemics, and antidiabetics; 0 = no, 1 = yes). Year 15 hypertension status was substituted for 14 participants with missing Year 20 data, and Year 15 medication status was substituted for 12 participants with missing Year 20 data. OC/HRT use was represented by a continuous variable that indicated the number of examination years during which women reported taking OC/HRT (men coded as "0"). More than 90% of women had data on OC/HRT use for at least four of the five examinations.

Year 5 CVD Risk

Because IMT was not measured before Year 20, an additional control was added to approximate participants' Year 5 cardiovascular risk status. Framingham Risk Scores (FRSs) (24) were computed using Year 5 data on age, TC, HDL-C, SBP, smoker status, diabetes history, and left ventricular hypertrophy (LVH). LVH was determined based on participants' left ventricular (LV) mass index (ventricular mass [g] / height squared [m²]). Procedures for obtaining LV mass already have been described (25). A positive diagnosis of LVH was determined if LV mass index exceeded 50 g/m² for men and 47 g/m² for women (26). Participants with missing LV mass data ($n = 124$) were assumed to have negative diagnoses. In addition to being a reliable predictor of future clinical CVD (27), the FRS has been found to correlate cross-sectionally with carotid artery IMT both in men and women and in blacks and whites (28,29). In the present sample, Year 5 FRS was modestly correlated with both Year 20 IMT measures (CCA-IMT, $r = 0.14$; bulb-ICA-IMT, $r = 0.13$; p values < .001).

Health Behaviors

Data on smoking status (1 = current, 0 = former/never) and alcohol consumption (number of drinks per week; nondrinkers coded as "0") were collected at all CARDIA examinations (scales documented on CARDIA Web site, <http://www.cardia.dopm.uab.edu/>). From these data, we computed the following variables: mean alcohol consumption by averaging reported consumption levels across all examinations for which participants provided data and the total number of years of smoking by summing the number of years participants reported being smokers. More than 94% of participants had complete data on both of these variables at Years 5, 7, 10, 15, and 20.

Employment Status

Because employment status may influence both occupational mobility and general health, data from Years 5, 7, 10, and 15 were used to create the following three additional covariates. The first was the total number of years that participants reported working full-time, and the second was the total number of years participants reported being unemployed (see Janicki-Deverts et al. (30)). Indicators of full-time employment and unemployment history were each summed across the four examination years to create total scores. The third variable was the total number of years that participants reported being full-time students. Because only 6.5% of participants reported full-time school attendance during at least one of the four examinations, we created a dichotomous indicator of ever having attended school full-time during the 10 years of follow-up. For years during which participants were not employed, occupational standings were assigned based on participants' most recent job activity before exiting the workforce.

Statistical Analyses

All statistical analyses were performed using SAS v9.1.3 (SAS Institute Inc, Cary, NC). Separate multivariable linear regression models were used to examine associations of occupational mobility with CCA-IMT and bulb-ICA-IMT, respectively. The standard covariates (demographic characteristics [including Year 5 occupational standing], parents' medical history, physiological risk factors, Year 5 and 20 medical histories, Year 5 CVD risk, health behaviors, and employment status) were included in all of the main analyses

and entered simultaneously with the predictor. Because of the known J-shaped association between alcohol consumption and CVD risk (31), a quadratic term for average consumption was also included as a covariate. Finally, because carotid IMT images were analyzed by a pool of three readers and IMT measurements differed across readers, two dummy variables representing reader effects were included in the analyses. Main effects are expressed as unstandardized (B) and standardized β 's. Squared semipartial correlation coefficients (R^2) are reported as the measure of effect size. Adjusted R^2 values and confidence intervals (CIs) are reported to index model fit.

Moderation analyses were used to examine whether associations of occupational mobility with IMT differ according to individuals' initial standings. These models were identical to the main effect models described previously, save for the addition of the Year 5 occupational standing-by-predictor cross-product term. Similarly, in separate analyses, we explored sex and race differences in the association of occupational mobility with IMT by including the relevant sex (or race)-by-predictor cross-product term to each of the main-effects models. Values of p are presented for interaction terms. Post hoc examination and plotting of simple slopes were performed using the methods described by Aiken and West (32).

RESULTS

Sample Characteristics

The average age at Year 20 was 45.2 (SD = 3.6) years; 54% of participants were women, and 42% were black. Eight percent of participants reported a hypertension diagnosis at Year 5, and 22%, at Year 20. Fifty-eight percent reported having at least one parent with CVD or diabetes. At Year 20, 27% of participants were taking medication known to influence IMT, and 15% of women were taking OC/HRT. Table 1 displays additional sample characteristics and correlations of continuous covariates with Year 20 IMT. Table 2 displays mean differences in Year 20 IMT across levels of categorical covariates. Whereas Table 2 displays raw, unadjusted IMT scores, t tests were performed using \log_{10} -transformed IMT values as the dependent variable.

As previously reported (23), older age, male sex, and being hypertensive at Year 20, each was associated with greater CCA-IMT and bulb-ICA-IMT, whereas black race was associated with greater CCA-IMT only.

Multivariable Associations of Covariates With Year 20 IMT

When entered simultaneously into a model to predict CCA-IMT, nine covariates emerged as independent predictors of CCA-IMT (p values = .03 to <.001). Positive predictors included age; black race; average body mass index, TC, glucose, and SBP; and the total number of years as a smoker. Negative predictors were female sex and HDL-C. Save for a marginal inverse association between taking medications at Year 20 ($p = .06$) and CCA-IMT, no other associations were evident. By comparison, 11 covariates emerged as independent predictors of bulb-ICA-IMT when examined in multivariable analysis (p values = .04 to <.001). Positive predictors were largely the same as those for CCA-IMT save for the addition of an independent effect of Year 20 SBP and the lack of an effect of race. Negative predictors were female sex, HDL-C, triglycerides, and Year 20 education. Of the remaining covariates, years of full-time employment and having attended school during the follow-up both emerged as marginal correlates of greater bulb-ICA-IMT (p values < .08). No other associations were evident.

Occupational Mobility Between Years 5 and 15 and Year 20 IMT

Occupational Mobility

Forty-seven percent of participants experienced an increase in standing between Years 5 and 15, whereas 34% experienced a

TABLE 1. Sample Characteristics and Pearson Correlations With Year 20 Carotid Artery IMT

	M or Median	SD or IQR	Pearson r	
			CCA-IMT ^a	Bulb-ICA-IMT
Year 5 occupational standing	46.7	(19.6)	-0.07***	-0.05*
Year 20 education, y	15.8	(2.5)	-0.13***	-0.13***
No. examinations married	2	(0-5)	-0.05*	-0.01
No. examinations employed full-time	4	(2-4)	0.07**	0.10***
No. examinations unemployed	0	(0-1)	0.03	0.01
No. examinations current smoker	0	(0-1)	0.10***	0.09***
No. examinations taking oral contraceptives/hormone replacement (women only)	0	(0-1)	-0.10***	-0.06*
Average systolic blood pressure, mm Hg	110.7	(10.4)	0.34***	0.26***
Average body mass index, kg/m ²	27.5	(5.9)	0.26***	0.18***
Average total cholesterol, mg/dL	180.6	(29.2)	0.13***	0.16***
Average high-density lipoprotein cholesterol, mg/dL	52.0	(13.0)	-0.18***	-0.17***
Average triglycerides, mg/dL	92.7	(58.7)	0.14***	0.13***
Average glucose, mg/dL	94.0	(15.4)	0.24***	0.17***
Average alcohol consumption, ^b drinks/wk	4.2	(6.9)	0.05*	0.05*

IMT = intima-media thickness; M = mean; SD = standard deviation; IQR = interquartile range; CCA = common carotid artery; ICA = internal carotid artery.

* $p < .05$, ** $p < .01$, *** $p < .001$.

^a CCA-IMT, $n = 2349$; bulb-ICA-IMT, $n = 2177$.

^b Nondrinkers assigned a value of 0 drinks per week.

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TABLE 2. Mean Year 20 IMT (in Millimeters) by Level of Categorical Covariates^a

	CCA-IMT			Bulb-ICA-IMT		
	M	SD	t	M	SD	t
Sex			9.39***			11.18***
Men	0.70	0.12		0.77	0.18	
Women	0.66	0.11		0.69	0.15	
Race			10.88***			1.74
White	0.66	0.10		0.72	0.17	
Black	0.71	0.12		0.73	0.17	
Full-time school			0.94			0.42
No	0.68	0.11		0.73	0.17	
Yes	0.67	0.12		0.72	0.16	
OC/HRT ^b			2.28*			1.62
No	0.66	0.11		0.69	0.15	
Yes	0.64	0.09		0.67	0.14	
Year 5 hypertension			4.21***			3.10**
No	0.67	0.11		0.72	0.17	
Yes	0.71	0.12		0.77	0.20	
Year 20 hypertension			8.80***			6.12***
No	0.67	0.11		0.71	0.16	
Yes	0.72	0.12		0.78	0.21	
Medications			6.93***			5.68***
No	0.67	0.11		0.71	0.16	
Yes	0.70	0.12		0.76	0.20	
Parent medical history ^c			3.79***			2.88**
No	0.67	0.11		0.71	0.16	
Yes	0.69	0.11		0.73	0.18	

IMT = intima-media thickness; CCA = common carotid artery; ICA = internal carotid artery; OC/HRT = oral contraceptive/hormone replacement therapy.

* $p < .05$, ** $p < .01$, *** $p < .001$.

^a CCA-IMT, $n = 2349$; bulb-ICA-IMT, $n = 2177$.

^b Women with nonmissing OC/HRT data.

^c Participants with nonmissing parent medical history data.

decrease. The median change in standing among the upwardly mobile was 17.71 points (range, 0.03 to 68.53 points), and among the downwardly mobile, -14.03 points (range, -67.82 to -0.02 points).

Occupational Mobility and IMT

Using multivariable linear regression, we examined, in separate models, whether the extent of upward or downward change in occupational standing between Years 5 and 15 was associated with Year 20 IMT. Results indicated a paradoxical association of downward mobility with CCA-IMT such that greater decline in standing between Years 5 and 15 was associated with less Year 20 CCA-IMT ($B = -0.0003$, standard error [SE] = 0.0001, $\beta = -0.04$, $p = .04$, semipartial $R^2 = 0.001$, adjusted $R^2 = 0.31$, CI = 0.28–0.35). Greater upward mobility, by comparison, was unrelated to CCA-IMT ($B = -0.0002$, SE = 0.0001, $\beta = -0.03$, $p = .12$, semipartial $R^2 = 0.001$, adjusted $R^2 = 0.31$, CI = 0.28–0.34). Neither upward nor downward mobility was related to bulb-ICA-IMT (upward mobility: $B = -0.0001$, SE = 0.0002, $\beta = -0.01$, $p = .56$, semipartial $R^2 = 0.0001$, adjusted $R^2 = 0.24$, CI = 0.20–0.27; downward

mobility: $B = 0.0001$, SE = 0.0002, $\beta = 0.01$, $p = .51$, semipartial $R^2 = 0.0002$, adjusted $R^2 = 0.23$, CI = 0.20–0.27).

Moderation by Initial Standing

To address the question of whether the association of occupational mobility with IMT differs depending on initial standing, we incorporated the interaction of upward mobility or downward mobility with Year 5 occupational standing into the main-effects models. Results of these analyses suggested a moderating effect of Year 5 standing on both the association of upward mobility with CCA-IMT (interaction, $p = .001$) and downward mobility with both CCA-IMT (interaction, $p < .001$) and bulb-ICA-IMT (interaction, $p < .04$).

Figure 1 displays simple slopes of the association of upward mobility with CCA-IMT at high and low Year 5 standing. As illustrated by the figure, increasing standing between Years 5 and 15 was associated with less Year 20 CCA-IMT among those with low initial standings and greater CCA-IMT among those with high initial standings. Figure 2 displays analogous data for the associations of downward mobility with CCA-IMT and bulb-ICA-IMT. For both measures, greater downward mobility

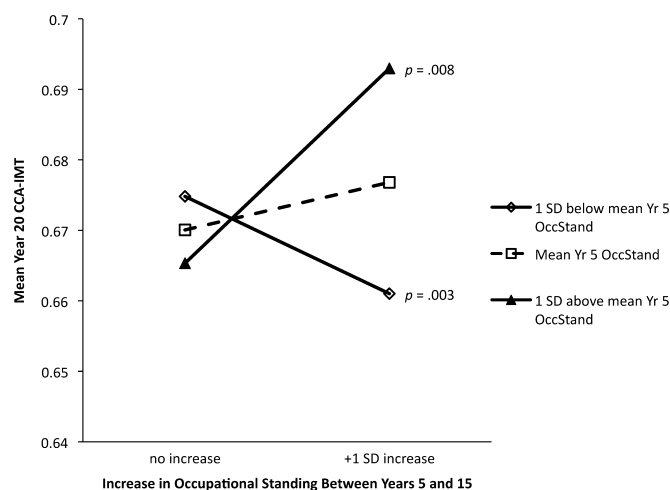


Figure 1. Simple effect associations of upward mobility between Years 5 and 15 with Year 20 common carotid artery intima-media thickness (CCA-IMT) by Year 5 occupational standing (OccStand). Models adjusted for CARDIA center; demographics; employment history; parents' medical history; physiological, medical, and behavioral risk factors; medications; oral contraceptive/hormone use; Year 5 Framingham score; Year 20 education; and sonography reader.

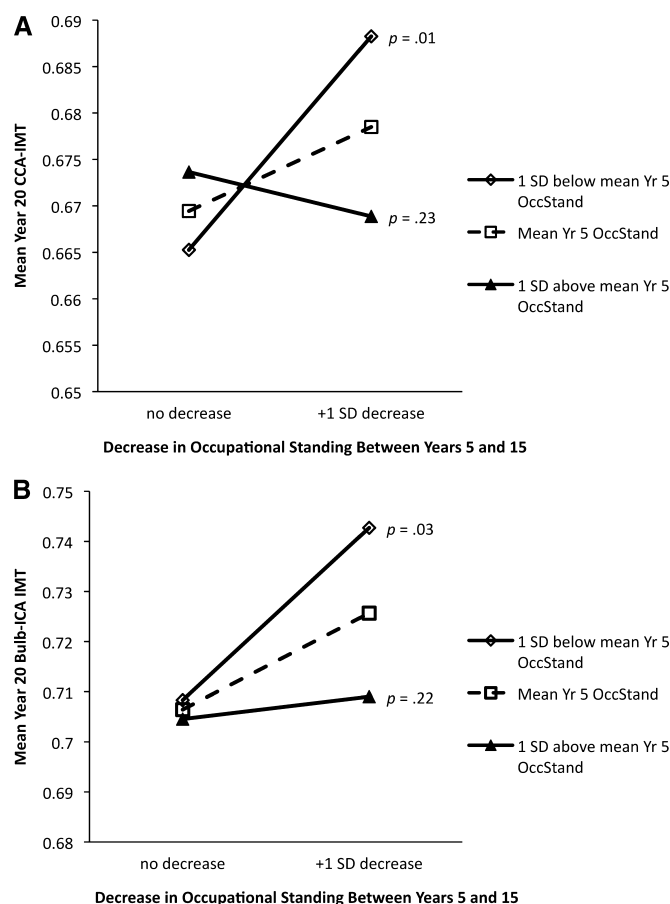


Figure 2. Simple effect associations of downward mobility between Years 5 and 15 with Year 20 common carotid artery intima-media thickness (CCA-IMT) (A) and Year 20 mean bulb-internal carotid artery-intima-media thickness (bulb-ICA-IMT) (B) by Year 5 occupational standing (OccStand). Models adjusted for CARDIA center; demographics; employment history; parents' medical history; physiological, medical, and behavioral risk factors; medications; oral contraceptive/hormone use; Year 5 Framingham score; Year 20 education; and sonography reader.

was associated with greater IMT among those with low initial standings but was unrelated to either CCA-IMT or bulb-ICA-IMT among those with high initial standings.

Moderation by Sex and Race

We conducted additional analyses to determine whether the associations of upward and downward mobility with Year 20 IMT differed depending on either sex or race. A protective effect of upward mobility was present for men but not for women (Fig. 3) for both CCA-IMT (interaction, $p = .05$) and bulb-ICA-IMT (interaction, $p = .002$), but associations of downward mobility with IMT did not differ by sex (interaction, p values $> .64$). Race did not moderate the association of upward or downward mobility with either IMT measure (interaction, p values $> .17$).

Ancillary Analyses

Because CCA-IMT and bulb-ICA IMT were moderately correlated ($r = 0.43$), we reexamined the main-effects analyses for those participants with data on both IMT measures ($n = 2176$) using multivariate statistics. Results of a multivariate multiple

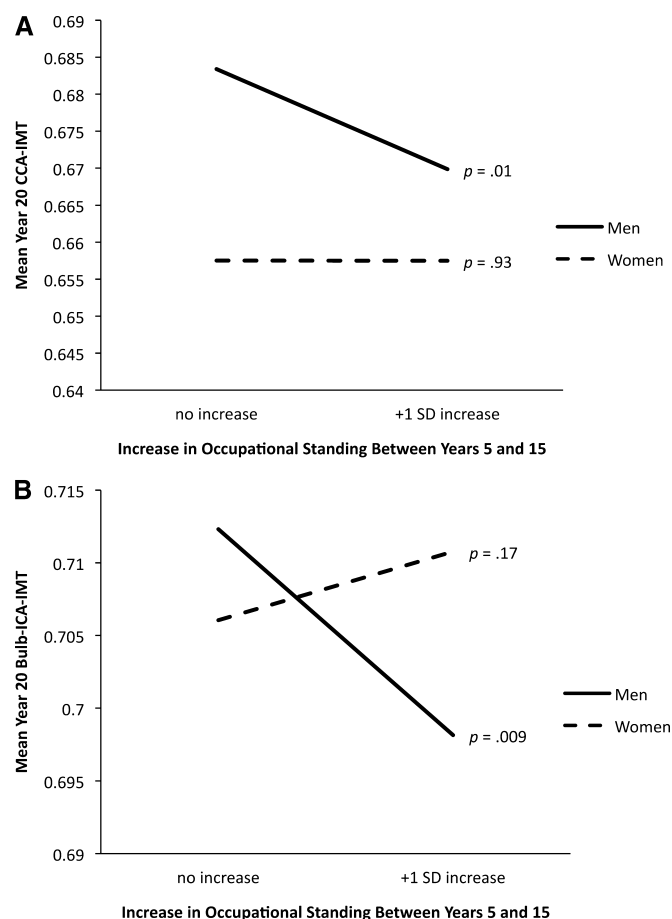


Figure 3. Simple effects associations of upward mobility between Years 5 and 15 with Year 20 common carotid artery intima-media thickness (CCA-IMT) (A) and Year 20 bulb-internal carotid artery-intima-media thickness (bulb-ICA-IMT) (B) by sex. Models adjusted for CARDIA center; demographics; employment history; parents' medical history; physiological, medical, and behavioral risk factors; medications; oral contraceptive/hormone use; Year 5 Framingham score; Year 20 education; and sonography reader.

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regression model that examined CCA-IMT and bulb-ICA-IMT as dependent variables revealed a significant effect of downward mobility ($F(2,2142) = 3.00$, Wilks $\Lambda p < .05$). Results of follow-up univariate analyses were similar to those reported previously in that downward mobility was associated with less CCA-IMT ($p = .50$) but was unrelated to bulb-ICA-IMT ($p = .50$). By comparison, there was no multivariate effect of upward mobility ($F(2,2142) = 1.16$, Wilks $\Lambda p = .31$), which again was consistent with the previously reported findings.

DISCUSSION

The present findings suggest that the association of 10-year change in occupational standing—or occupational mobility—with later carotid artery IMT differs with the direction of change, initial occupational standing, and sex. Associations were independent of demographic characteristics, employment status, parents' medical history, physiological and medical risk factors, health behaviors, FRS, initial occupational standing, education, and sonography reader.

When examined in the entire sample, occupational mobility was largely unrelated to IMT save for an unexpected association of downward change with less CCA-IMT. Collapsing across the entire sample, however, masked a more complicated association. Specifically, for those with lower initial occupational standings, upward mobility was associated with less CCA-IMT and downward mobility with greater CCA-IMT and bulb-ICA-IMT. In stark contrast, for those with higher initial standings, upward mobility was associated with greater CCA-IMT, whereas downward mobility was unrelated to either IMT measure. These findings are consistent with those of Nilsson and colleagues (14) who found both upward and downward changes in occupational standing to correlate with an elevated risk of premature mortality.

Loss of standing generally is thought to be associated with greater psychological stress (33). In turn, stress, via influences on the autonomic nervous system, hypothalamic-pituitary-adrenal axis, and poor health practices, may disrupt physiological homeostasis and initiate allostatic processes (34,35). This explanation is consistent with the findings for those with lower initial standings. Moreover, it is possible that this association is exacerbated in persons with low SES because they are more likely to experience other stressful life events (34) and are deficient in the resources necessary to cope successfully with the stress of downward mobility. It follows that upward mobility may decrease stress among these individuals, ultimately having a protective effect on future IMT via down-regulation of the processes described previously.

Why, then, would upward mobility correlate with greater CCA-IMT among those of high initial standing? Upward mobility may be accompanied by costs and benefits, and the cost-to-benefit ratio may be greater as one ascends the socioeconomic ladder. For example, for someone who is financially secure, the pay increase associated with movement to a higher job position may not offset the stress associated with greater responsibility or the need to spend more time at work. That such concomitants of upward mobility could have implications for CVD risk is

suggested by evidence that patients being treated for myocardial infarction are more likely to report increased work responsibilities before hospitalization relative to age-matched controls (36).

The relation of upward mobility with IMT also differed by sex, such that increasing standing was associated with less IMT among men only. The more reliable effect for men may be due to men receiving greater psychological benefits and, by extension, greater physiological benefits from upward occupational mobility. Alternatively, women may enjoy similar benefits but experience greater costs. Workplace advancement is more difficult for women than for men at all SES levels (37). Thus, among women, the rewards associated with actually having attained a comparatively higher standing may only partially compensate for the stress experienced during the process of pursuing that goal. Moreover, because women tend to assume more family responsibilities than men do, the increase in work-related obligations associated with upward mobility may contribute to greater role conflict and hence greater psychological stress. We tested this hypothesis empirically by examining the three-way interaction of sex by initial standing by upward mobility, but the complex interaction did not achieve statistical significance, conceivably because of low power (data not shown). Another factor that might contribute to these sex differences involves disparity between men and women in the extent of carotid artery disease at middle age. Carotid plaque area is greater for men than for women at all ages, but women's trajectories of age-related plaque increase begin to steepen at midlife (38). Although the age range of the present sample at Year 20 encompasses this period of accelerated plaque development among women, the variability in plaque area among women may not yet have been sufficient to detect an association with occupational mobility.

Unlike sex and initial occupational standing, race did not moderate the association of occupational mobility with either IMT measure, thus suggesting that the findings reported here are consistent across blacks and whites. Because no other study, to the best of our knowledge, has investigated potential race differences in the association of occupational mobility with health outcomes of any kind, additional research is necessary to confirm the present results.

A limitation of the present study is that IMT was not measured at Year 5. Thus, our findings cannot be interpreted as representing a truly prospective association. We controlled for initial health, however, by covarying participants' Year 5 hypertension histories, as well as their computed Year 5 FRSs (24). Although not as accurate as controlling for Year 5 IMT, we feel that the combination of these two variables provides an appropriate surrogate baseline control. Another limitation is that neither perceived stress nor job strain was measured at Year 15. Thus, we were unable to examine whether psychological stress might be driving the association of occupational mobility with IMT. Nevertheless, our findings were independent of health behaviors, thus suggesting that stress-related changes in life-style factors may not account for the association. Finally, the effect of occupational mobility was small, indicating that change in occupational standing is only one of several factors that influence

midlife IMT. However, given that occupational mobility is a common experience among most adults, even a small effect can have important implications for CVD risk in the larger population.

Despite these limitations, the present findings provide a unique perspective on the association of SES with physical disease. That occupational mobility should be associated with variation in a marker of early cardiovascular pathogenesis among generally healthy adults suggests that changes in SES may influence CVD risk at very early points in disease development.

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