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Associations of Work Hours with Carotid Intima Media Thickness and Ankle-Brachial Index: The Multi-Ethnic Study of Atherosclerosis (MESA)

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Abstract

Objectives—Long working hours may be associated with cardiovascular disease (CVD). The objective was to investigate cross-sectional associations of work hours with carotid intima media thickness (CIMT) and ankle brachial index (ABI).

Methods—Participants were 1,694 women and 1,868 men from the Multi-Ethnic Study of Atherosclerosis. CIMT and ABI were measured using standard protocols. Information on work hours was obtained from questionnaires. Mean values of CIMT and ABI were examined across five categories of hours worked per week (≤20, 21-39, 40, 41-50, >50) using ANOVA/ANCOVA. P-values for trend were obtained from linear regression models.

Results—Mean age of participants was 56.9±8.4 years; 52.4% were men. Distinct patterns of association between work hours and the subclinical CVD biomarkers were found for women and men, although this heterogeneity by gender was not statistically significant. Among women only, work hours were positively associated with common (but not internal) CIMT (p=0.073) after full risk factor adjustment. Compared to women working 40 hours, those working >50 hours were

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more likely to have an ABI <1 (vs. 1-1.4) (OR=1.85, 95% CI=1.01-3.38). In men, work hours and ABI were inversely associated (p=0.046). There was some evidence that the association between work hours and ABI was modified by occupational category (interaction p=0.061). Among persons classified as Management/Professionals, longer work hours was associated with lower ABI (p=0.015). No significant associations were observed among other occupational groups.

Conclusion—Working longer hours may be associated with subclinical CVD. These associations should be investigated using longitudinal studies.

Keywords

Atherosclerosis; carotid artery stenosis; ankle-brachial index; work

INTRODUCTION

American employees now work longer hours per year compared to their counterparts in several European countries such as France, Germany, the United Kingdom, and Sweden, and some Asian countries.[1] Moreover, the prevalence of long working hours (i.e., ≥ 50 hours per week) has continued to increase among Americans.[2,3] These trends represent potential public health problems because of the number and variety of adverse health conditions associated with long work hours. Abundant scientific evidence indicates that long work hours may lead to or are associated with psychological and physical disorders, including cardiovascular risk factors (e.g., obesity, abdominal adiposity) and cardiovascular disease (CVD).[4-6]

Limited evidence is available regarding the precise mechanism underlying the observed relationship between long work hours and CVD. Long work hours may be related to CVD through insufficient hours of sleep and the impact of sleep deprivation on cardiovascular risk factors.[7-10] Long work hours may also lead to poor lifestyle behaviors such as insufficient leisure-time physical activity and consumption of less healthy foods, which are also linked to systemic inflammation.[11-13]

Investigation of risk factors for subclinical CVD would allow preventive measures to be taken before clinical manifestation of clinical disease. Several non-invasive subclinical measures have demonstrated utility in predicting future CVD events, including the carotid intima media thickness (CIMT) and the ankle brachial index (ABI).[14,15] Lower socioeconomic status and job strain have been shown in some studies to be associated with greater CIMT.[16,17] Similarly, Fujishiro and colleagues recently reported that workers holding blue-collar jobs and those exposed to low levels of job control had larger CIMT.[18] Identifying additional occupational risk factors for atherosclerosis could be used to develop effective interventions for reducing the prevalence of CVD in workers.

The relationship between work hours and health status may vary by demographic and occupational group.[19] This could be a function of interactions with other exposures (such as sources of stress or environmental exposures) associated with gender or occupational category. In addition, the impact of long work hours on health may depend on the type of work being performed. There is some evidence of effect modification of the impact of work hours on health. For example, Artazcoz et al. reported that adverse health consequences of long working hours differed by gender.[20] Among men only, working 51-60 hours a week was associated with several adverse health outcomes including self-reported hypertension, smoking, sleep deprivation, and no leisure-time physical activity, whereas among women it was only related to smoking and shorter sleep duration.[20] Therefore, the main objectives of this study were to determine: a) whether long work hours are independently associated with subclinical CVD measured by carotid IMT and ankle-brachial index; and b) if any of these relationships are modified by gender or occupational group. We hypothesized that long work hours would be positively associated with CIMT and inversely associated with ABI and that these relationships would be significantly modified by gender and occupational group. .

METHODS

Study Design and Participants

The Multi-Ethnic Study of Atherosclerosis (MESA) was initiated in July 2000. Details of the study design and protocol have been previously published.[21] The original cohort of 6,814 men and women aged 45-84 consisted of persons from various racial and ethnic backgrounds (Whites, African-Americans, Hispanics, and Chinese Americans) who were recruited from six US field centers (Forsyth County, North Carolina; Northern Manhattan and the Bronx, New York; Baltimore City and Baltimore County, Maryland; St. Paul, Minnesota; Chicago, Illinois; and Los Angeles, California). The exclusion criteria for the study included any physician-diagnosed CVD or cerebrovascular disease, cancer or any serious medical condition, pregnancy, poor cognitive function, weight >300 lbs. (>136 kg), language barrier (unable to understand English, Spanish, Cantonese or Mandarin), living in a nursing home, or plans to leave the community within five years. Written informed consent was obtained from participants when they arrived at the study clinic. The institutional review boards of the six field centers and the National Heart, Lung, and Blood Institute approved the study protocol. Approval was also obtained by the institutional review board of the National Institute for Occupational Safety and Health for secondary analysis of the study data.

Most of the data for the current study were taken from the first examination (July 2000 to July 2002). Only persons who answered “yes” to the question “Do you work to earn money?” during the first data collection were included in this study (n=3,700). From this group, persons were excluded if they had missing values on ABI or CIMT (n=127) or on hours or days of work (n=11). The final sample size of 3, 562 persons consisted of 1,694 women and 1,868 men.

Hours of Work

Participants completed questions on occupational activities. Those who responded affirmatively to the question “Do you work to earn money?” were asked about the amount of time spent in all jobs. Number of days and hours worked per week were assessed from the question “How many days per week and hours per day do you work in all jobs?” The total number of hours of work per week was calculated by multiplying the two responses.

Carotid Intima Media Thickness

Trained technicians in each field center performed B-mode carotid ultrasonography. Images of the right and left sides of the near and far walls of the common carotid and internal carotid arteries were captured.[14,21] Carotid intima media thickness (CIMT) is a non-invasive measure which, when increased, has been shown to reliably predict subsequent CVD.[21] The Logiq 700 ultrasound device (General Electric Medical Systems, Waukesha, Wisconsin) was used to record images at all centers. An ultrasound reading center (Department of Radiology, Tufts-New England Medical Center, Boston, Massachusetts) measured maximal CIMT of the internal and common carotid sites as the mean of the maximum CIMT of the near and far walls of the right and left sides. The maximum common CIMT and the maximum internal CIMT reflect the mean of all variable maximum wall thicknesses across all scans, across both left and right sides, and across the near and far walls for the common and internal carotid variables, respectively. When one side indicated "bad image" or "can't tell" and the other side had a valid value, the valid measure was taken as the maximum. Intraclass correlation coefficients for inter-reader reproducibility of common CIMT and internal CIMT were 0.87 and 0.94, respectively; for intra-reader reproducibility, both exceeded 0.98.

Ankle Brachial Index

Ankle brachial index (ABI), a valid and commonly used measure of peripheral artery disease (PAD), is another non-invasive measure of increased CVD risk.[22-24] After a five-minute rest in a supine position, trained technicians measured participants' blood pressure in both arms and in the posterior tibial (PT) and dorsalis pedis (DP) arteries of both ankles, using appropriatesized cuffs and a continuous wave Doppler probe.[25] The ABI was computed separately for each leg. The highest of the PT or DP systolic pressures was used as the numerator, and the highest of the right vs. left brachial systolic pressures was used as the denominator. Ratios of the ankle blood pressure to brachial (arm) blood pressure were calculated separately for the left and right side. The selected ABI for the participant was the smaller of the right versus left ABI. All ABI measurements have intraclass correlation coefficients >0.9 and technical error of measurement <5%.

Covariates

Self-administered questionnaires provided information on demographic data and lifestyle. Participants selected one of 13 categories to indicate their total gross family income level which were then collapsed into four categories for analyses. They also reported the highest level of education completed. Height and weight were measured with participants wearing light clothing and no shoes. Body mass index was calculated as weight in kilograms divided by height in meters squared. Cigarette smoking was defined as current, former, or never. Pack-years of smoking were calculated. Resting blood pressure was measured three times in the seated position using a Dinamap model Pro 100 automated oscillometric sphygmomanometer (Critikon, Wipro GE Healthcare, Waukesha, Wisconsin). The average of the last two measurements was used in the analysis. Hypertension was defined as systolic pressure ≥140 mm Hg, diastolic pressure ≥90 mm Hg, or current use of antihypertensive medication.

Blood was drawn from participants after they had fasted for a minimum of 12 hours, and aliquots were prepared for central analysis and for storage at -70 degrees F at the University of Vermont and the University of Minnesota. Laboratory analysis was performed for lipid, lipoproteins, biological markers of inflammation, and many other components. Low-density lipoprotein (LDL) cholesterol was calculated by the Friedewald equation.[26] The total cholesterol/HDL cholesterol ratio was considered abnormal if it was >5.0 or if the participant used medication to reduce cholesterol. Diabetes was defined as fasting glucose ≥126 mg/dl or use of hypoglycemic medication. High-sensitivity plasma CRP was analyzed using fasting specimens.[27]

The MESA Typical Week Physical Activity Survey (TWPAS), adapted from the Cross-Cultural Activity Participation Study,[28] was used to obtain the time and frequency spent in various physical activities during a typical week in the previous month. The survey has 28 items in categories of activity: household chores, yard/lawn/garden work, care of others (children or adults), transportation, non-occupational walking, team sports and dancing, leisure activities (e.g., reading, watching TV), work (occupational or volunteer), and intentional exercise. Participants reported the average number of days per week and time per day engaged in the activities, as well as the intensity level (light, moderate, or heavy). Minutes of activity were summed for each discrete activity type and multiplied by metabolic equivalent (MET) level to derive composite physical activity levels.

Work-related Factors—Occupational information was collected by questionnaire.[18] Four open-ended questions modeled on the US Census occupation questions were used to determine the respondent's current occupation. For whom do/did you work? What type of business or industry is/was this? What kind of work do/did you do? What was your job title? Participants who were no longer working were asked to respond for their last main occupation. The responses were coded using the Census 2000 Occupational Codes and categorized as follows: (1) management/professional, (2) service, (3) sales/office, (4) farming, fishing and forestry, (5) construction, extraction and maintenance, and (6) production, transportation and material moving.[18] The last three categories included a small number of participants in this sample so they were combined into one category of ‘blue-collar jobs’.

Statistical Methods

Distributions of all variables were compared by gender using the chi-square and Students’ *t*-tests. We investigated the associations of several covariates with the independent (hours of work) and dependent variables (CIMT and ABI) using analysis of variance (ANOVA) and Pearson's correlation. Mean values for CIMT and ABI were obtained across five categories of total hours worked using ANOVA and analysis of covariance (ANCOVA). The five categories of work hours were selected by placing participants who worked 40 hours per week into one group and then dividing the remaining hours worked to obtain reasonable and fairly equal sample sizes in each group. P-values testing linear trends were obtained from multiple linear regression models where both independent and dependent variables were used in the continuous forms. Effect modification was assessed for gender and occupational group. Formal tests of effect modification were performed by including interaction terms in the fully adjusted models. Potential confounders and traditional CVD risk factors included in the models were age, gender, race/ethnicity, education, cigarette smoking status, pack-years of smoking, alcohol consumption, physical activity, HDL cholesterol, triglycerides, diabetes, hypertension, BMI, and annual household income. Because inclusion of CRP and occupational group in the multivariable models did not change the magnitude or direction of the associations, these two variables were omitted. ABI was divided into clinically meaningful categories (low < 1.0 (n=276); normal = 1.0-1.4 (n=3262); and high ≥ 1.4 (n=24)) for additional analyses. Although low ABI has been defined as <0.9 in several studies, we choose to define it as <1.0 in this study since this cut-point has been associated with CVD morbidity and mortality [15, 24] and the prevalence of low ABI defined as <0.9 was very low. Individuals with high ABI were excluded (n=24), then logistic regression was used to obtain the odds ratios (OR) and 95% confidence intervals (CI) for low ABI versus normal ABI among those working less or more than a full-time schedule compared to those working 40 hours per week. SAS version 9.2 was used to analyze these data.[29]

RESULTS

The mean age of all study participants was 56.9 ± 8.4 years (Table 1). The study included 52.4% men (n=1,868). The largest racial/ethnic group was Whites (41.5%), followed by African Americans (27.9%), Hispanics (20%), and Chinese Americans (10.6%). Nearly 50% of the participants were in occupations classified as Management/Professional; 20.7% were in Sales/Office, 15.9% in Service, and 15.0% in Blue-collar occupational categories. Twenty-one percent of participants worked more than 5 days per week and 14.2% worked more than 50 hours per week. Compared to women, men had significantly greater common CIMT (0.852 vs. 0.806 mm) and internal CIMT (1.035 vs. 0.907 mm), but higher ABI (1.153 vs. 1.104).

The age-adjusted associations of selected covariates with hours of work per week are presented in the Supplemental Table. Results showed that as hours of work increased, age and the proportions of women decreased. Those working more hours per week had higher household incomes, more education and were more likely to work in the managerial/ professional occupations. Hours of work per week were positively associated with composite physical activity, BMI, and diastolic blood pressure, and inversely associated with HDL cholesterol.

Race/ethnicity was significantly associated with CIMT and ABI (data not shown). African Americans had the highest mean common CIMT (0.867 ± 0.005 mm) while Chinese Americans had the lowest mean value (0.797 ± 0.008 mm). African Americans had the lowest mean ABI compared to the other racial groups. African Americans had the highest prevalence of low ABI (11.9%); Whites had a prevalence of 7.5%, Chinese Americans, 5.0%, and Hispanics, 3.8%. Workers in the highest educational category had the lowest mean common and internal CIMT values. Also, as educational level increased, ABI increased (p >0.0001). Smoking status was significantly associated with all subclinical CVD measures (p <0.0001) where current smokers had the highest mean CIMT values and the lowest ABI. Occupational category was not significantly associated with common CIMT but was significantly associated with internal CIMT (p = 0.002), where blue-collar workers had the highest mean value (1.044 ± 0.021 mm). Composite physical activity, pack-years of smoking, triglycerides, and BMI were all positively associated and HDL cholesterol was inversely associated with common and internal CIMT measures. Pack-years of smoking and HDL cholesterol were inversely related and BMI was positively related with ABI.

Table 2 presents the association of work hours with subclinical outcomes stratified by gender. Even though effect modification by gender was not statistically significant for the three outcomes, the associations for women and men were sufficiently different to justify them being presented separately. Significant positive associations were observed between work hours and common CIMT among women (linear trend $p = 0.008$), after adjustment for age, race/ethnicity, and education. After adjustment for CVD-related risk factors and annual household income, the positive association was still present though slightly attenuated (linear trend $p = 0.073$). There were no significant associations between common CIMT and work hours among men. Work hours were not significantly associated with internal CIMT for women or men. An inverse relationship was observed between work hours and ABI among men after full adjustment (linear trend $p = 0.046$).

Occupational group showed borderline significance as an effect modifier in the association between work hours and ABI (interaction $p = 0.061$) but did not modify the association between work hours and CIMT (Table 3). Among persons in the Management/Professional group, mean levels of ABI decreased as work hours increased after full risk factor adjustment (linear trend $p = 0.015$). This association was not statistically significant after adjustment for age only (linear trend $p = 0.941$), nor after adjustment for age plus gender, race/ethnicity, and education (linear trend $p = 0.175$). Further analyses identified physical activity as the variable responsible for this negative confounding. Work hours was not significantly associated with ABI among the occupational groups of Sales/office, Service, and Blue-collar.

Gender-stratified estimates for low ABI (<1.0) versus normal ABI (1.0-1.4), comparing work hour categories with 40 hours per week as a reference, are presented in Table 4. Among women, those working more than 50 hours per week were nearly twice as likely to have a low ABI after adjustment for all risk factors, OR=1.95, 95% CI (1.08, 3.54), compared to those working 40 hours per week. Women who worked less than 40 hours per week had slightly elevated risk compared to those working 40 hours per week, but the results were not statistically significant. Risk of low ABI was slightly elevated but not statistically significant among men who worked more than 40 hours per week compared to those who worked 40 hours per week. Effect modification by gender was not statistically significant.

DISCUSSION

In this community-based sample of employed individuals, we examined the association between work hours and measures of subclinical cardiovascular disease. Positive associations, which were borderline statistically significant, were observed between work hours and common CIMT among women only after full risk factor adjustment. In contrast, no associations between work hours and CIMT were observed among men. However, effect modification by gender was not statistically significant. Occupational group also did not significantly modify the association between work hours and CIMT.

The absence of associations between work hours and CIMT among men was unexpected. A prospective study conducted on Finnish middle-aged men reported positive associations between hours of work per week and change in intima media thickness over an 11-year period.[30] However this association was only significant in men with pre-existing CVD. No other published studies investigating associations between work hours and CIMT were identified. However, other studies provide evidence of increased CVD risk factors and CVD with increasing number of working hours.[4-6]

Although the mean differences in CIMT associated with work hours in women appear small (adjusted mean difference of 0.023 when comparing women working >50 hours to those working 40 hours per week), De Groot and colleagues (2008) note that these small differences in IMT are clinically significant.[31] For example, a reduction in IMT thickening of 0.012 mm per year is associated with a 50% reduction in the odds of cardiovascular events. IMT tends to progress with increasing age by 0.01 mm per year of age[32] making the differences we observed equivalent to about 2.3 years of aging.

In the present study, the relationship between work hours and common CIMT differed from the relationship between work hours and internal CIMT. No significant associations were observed between work hours and internal CIMT. That difference may be due to the fact that there are anatomical and physiological differences between the common and internal CIMT. The internal carotid is a muscular artery, whereas the common carotid is an elastic conducting artery, and these structural differences may result in varying effects of risk factors on these arterial segments.[33,34] Other studies report that age, prior history of hypertension, sex, diabetes, smoking status, and BMI are associated with bifurcation/internal carotid disease more than with common carotid disease .[34,35] Diabetes and smoking status have been shown to be associated with IMT of the common carotid but not with the internal carotid or bifurcation.[36] In the MESA cohort, a previous study reported that occupational category was associated with internal CIMT while job control was associated with common CIMT.[18] The current finding suggests that job characteristics, such as job control and long work hours, may affect mechanisms that influence common CIMT more than internal CIMT.

An inverse association was observed between work hours and ABI among men and among persons employed in Management/Professional jobs. In addition, women working > 50 hours per week were significantly more likely to have a low ABI vs. a normal ABI compared to those working 40 hours per week. No published studies investigating associations between work hours and ABI were identified.

Long work hours could contribute to the development of atherosclerosis through lifestyle behaviors such as physical inactivity.[11,12,38,39] Persons who work longer hours may not have the time to engage in regular physical activity or consume healthy meals on a regular basis. However, our results were generally similar after adjustment for physical activity. Work hours may also be associated with subclinical CVD through sleep deprivation. Sleep deprivation has adverse effects on almost all organs and systems in the human body.[9] Some of the deleterious effects of sleep deprivation are increased obesity, higher levels of cholesterol and triglycerides, and inflammation.[9-10] Work hours may also be associated with subclinical CVD through increased platelet activation and coagulation.[37]

Limitations and strengths

Due to the cross-sectional study design, we are not able to determine the temporal sequence of exposure to long work hours and subclinical CVD. We have only a single assessment at one point in time and work hours could have changed in either direction over time. If work hours status affects the development of atherosclerosis, it would most likely operate over a long time period. A longitudinal study design with multiple assessments of work hours would be ideal. Another possible limitation is the use of self-reported work hours as opposed to a more objective measure such as company work records. However, any information bias that may result is likely to be non-differential. It would have been beneficial to investigate the influence of sleep duration on the association of work hours and the subclinical CVD measures. However, no data were available on sleep duration at Exam 1. Another limitation is the relatively small sample sizes for some occupational groups which reduced the power to detect associations in stratified analyses.

In this study we had three outcomes and assessed three variables for effect modification. Multiple testing corrections are usually important when several unplanned tests, or tests suggested by initial exploration of the data, are conducted using the same dataset. In our study, most of the tests were pre-planned (*a priori* tests) and the number of multiple tests was not unreasonably large, hence the use of stringent adjustment methods may mask associations that would be important. However, given the large number of analyses that we conducted and the fact that the statistical significance was often marginal, chance remains a possible explanation for the associations that we report.

To our knowledge, this is one of few epidemiologic studies to investigate the associations between long work hours and CIMT or ABI. Internal and external quality control programs were utilized for all study measurements. Staff members were centrally trained and were required to demonstrate competency in relevant procedures before being certified to perform clinical examinations involving MESA study participants. The MESA dataset provided a rich resource in which to examine these associations, and included information on multiple factors that could potentially confound the associations of interest.

Conclusion

Among participants in the MESA cohort, working longer hours per week was weakly associated with greater common CIMT among women and with lower ABI among women and men. Although the heterogeneity by occupation was only marginally statistically significant, associations of longer work hours with lower ABI appeared to be restricted to persons in management and professional occupations.

These associations should be examined in longitudinal studies to determine if longer work hours lead to increases in CIMT and incidence of low ABI. It would also be of interest to examine whether the conditions under which the participants work longer hours (e.g., unrealistic job demands, threat of job loss, job satisfaction or intrinsic drive) modify the relation between longer work hours and atherosclerosis. If these results are confirmed, policies to reduce or limit work hours may have cardiovascular health implications.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

ABI	Ankle-brachial index
CIMT	Carotid intima media thickness
CVD	Cardiovascular disease
BMI	Body mass index
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
MESA	Multi-Ethnic Study of Atherosclerosis
MET-min	Metabolic-equivalent minutes
PAD	Peripheral arterial disease

REFERENCES

1. Rosnick D, Weisbrot M. Are shorter work hours good for the environment? A comparison of U.S. and European energy consumption. Int J Health Sci. 2007; 37:405–417.

2. Rones PL, Ilg RE, Gardner JM. Trends in hours of work since the mid-1970s. Monthly Labor Review. Apr.1997 :3–14. Stats.bls.gov/opub/mlr/1997/04/art1full.pdf. [PubMed: 10167906]
3. Jacobs, JA.; Gerson, K. The Time Divide. Harvard University Press; Cambridge, MA: 2004.
4. Yang H, Schnall PL, Jauregui M, et al. Work hours and self-reported hypertension among working people in California. Hypertension. 2006; 48:744–750. [PubMed: 16940208]
5. Park J, Kim Y, Cho Y, et al. Regular overtime and cardiovascular functions. Ind Health. 2001; 39:244–249. [PubMed: 11500000]
6. Kivimaki M, Batty GD, Hamer M, et al. Using additional information on working hours to predict coronary heart disease. Ann Intern Med. 2011; 154:457–463. [PubMed: 21464347]
7. Harma M. Workhours in relation to work stress, recovery and health. Scand J Work Environ Health. 2006; 32:502–514. [PubMed: 17173206]
8. Virtanen M, Ferrie JE, Gimenao D, et al. Long working hours and sleep disturbances: the Whitehall II Prospective Cohort Study. SLEEP. 2009; 32:737–745. [PubMed: 19544749]
9. AlDabal L, BaHammam AS. Metabolic, endocrine, and immune consequences of sleep deprivation. The Open Respiratory Med J. 2011; 5:31–43.
10. Van Bussel BC, Henry RM, Schalkwijk CG, et al. Low-grade inflammation, but not endothelial dysfunction, is associated with greater carotid stiffness in the elderly: the Hoorn Study. J Hypertens. Feb 15.2012 [Epub ahead of print].
11. Szostak J, Laurant P. The forgotten face of regular physical exercise: a 'natural' anti-atherogenic activity. Clin Sci (Lond. 2011; 121:91–106. [PubMed: 21729002]
12. Galland L. Diet and inflammation. Nutr Clin Pract. 2010; 25:634–640. [PubMed: 21139128]
13. Mullington JM, Haack M, Toth M, et al. Cardiovascular, inflammatory, and metabolic consequences of sleep deprivation. Prog Cardiovasc Dis. 2009; 51:294–302. [PubMed: 19110131]
14. Folsom AR, Kronmal RA, Detrano RC, et al. Coronary artery calcification compared with carotid intima-media thickness in the prediction of cardiovascular disease incidence. Arch Intern Med. 2008; 168:1333–1339. [PubMed: 18574091]
15. Fowkes FG, Murray GD, Butcher I, et al. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. JAMA. 2008; 300:197–208. [PubMed: 18612117]
16. Gallo LC, Troxel WM, Matthews KA, et al. Occupation and subclinical carotid artery disease in women: are clerical workers at greater risk? Health Psychol. 2003; 22:19–29. [PubMed: 12558198]
17. Rosvall M, Ostergren PO, Hedblad B, et al. Socioeconomic differences in the progression of carotid atherosclerosis in middle-aged men and women with subclinical atherosclerosis in Sweden. Soc Sci Med. 2006; 62:1785–1798. [PubMed: 16181715]
18. Fujishiro K, Diez Roux AV, Landsbergis P, et al. Associations of occupation, job control and job demands with intima-media thickness: The Multi-Ethnic Study of Atherosclerosis (MESA). Occup Environ Med. 2010; 68:319–326. [PubMed: 20935285]
19. Borrell C, Muntaner C, Benach J, et al. Social class and self-reported health status among men and women: what is the role of work organisation, household material standards and household labour? Soc Sci Med. 2004; 58:1869–87. [PubMed: 15020005]
20. Artazcoz L, Cortès I, Escribà-Agüir V, et al. Understanding the relationship of long working hours with health status and health-related behaviours. Journal of Epidemiology and Community Health. 2009; 63:521–527. [PubMed: 19254912]
21. Bild DE, Bluemke DA, Burke GL, et al. Multi-Ethnic Study of Atherosclerosis: Objectives and Design. Am J Epidemiol. 2002; 156:871–881. [PubMed: 12397006]
22. Li X, Luo Y, Xu Y, et al. Relationship of ankle-brachial index with all-cause mortality and cardiovascular mortality after a 3-year follow-up: the China ankle-brachial index cohort study. J Hum Hypertens. 2010; 24:111–116. [PubMed: 19516270]
23. Michos ED, Rice KM, Szklo M, et al. Factors associated with low levels of subclinical vascular disease in older adults: multi-ethnic study of atherosclerosis. Prev Cardiol. 2009; 12:72–79. [PubMed: 19476580]

24. Criqui MH, McClelland RL, McDermott MM, et al. The ankle-brachial index and incident cardiovascular events in the MESA (Multi-Ethnic Study of Atherosclerosis). J Am Coll Cardiol. 2010; 56:1506–1512. [PubMed: 20951328]
25. Aboyans V, Criqui MH, McClelland RL, et al. Intrinsic contribution of gender and ethnicity to normal ankle-brachial index values: The Multi-Ethnic Study of Atherosclerosis (MESA). J Vasc Surg. 2007; 45:319–327. [PubMed: 17264011]
26. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972; 18:499–502. [PubMed: 4337382]
27. Nettleton JA, Steffen LM, Schulze MB, et al. Associations between markers of subclinical atherosclerosis and dietary patterns derived by principal components analysis and reduced rank regression in the Multi-Ethnic Study of Atherosclerosis (MESA). Am J Clin Nutr. 2007; 85:1615–1625. [PubMed: 17556701]
28. Bertoni AG, Whitt-Glover MC, Chung H, et al. The association between physical activity and subclinical atherosclerosis: The Multi-Ethnic Study of Atherosclerosis. Am J Epidemiol. 2008; 169:444–454. [PubMed: 19075250]
29. SAS Institute Inc.. SAS/STAT® 9.2 User’s Guide. SAS Institute Inc.; Cary, NC: 2008.
30. Krause N, Brand RJ, Kauhanen J, et al. Work time and 11-year progression of carotid atherosclerosis in middle-aged Finnish men. Prev Chronic Dis. 2009; 6:A13. [PubMed: 19080019]
31. De Groot E, van Leuven SI, Duivenvoorden R, et al. Measurement of carotid intima-media thickness to assess progression and regression of atherosclerosis. Nat Clinical Pract Cardiov Med. 2008; 5:280–288.
32. Chambless LE, Folsom AR, Davis V, et al. Risk factors for progression of common carotid atherosclerosis: The Atherosclerosis Risk in Communities Study, 1987-1998. Am J Epidemiol. 2002; 155:38–47. [PubMed: 11772783]
33. Heath D, Smith P, Harris P, et al. The atherosclerotic human carotid sinus. J Path. 1973; 110:49–58. [PubMed: 4723537]
34. Espeland MA, Tang R, Terry JG, et al. Associations of risk factors with segment-specific intimal-medial thickness of the extracranial carotid artery. Stroke. 1999; 30:1047–1055. [PubMed: 10229743]
35. Tell GS, Howard G, McKinney WM. Risk factors for site specific extracranial carotid artery plaque distribution as measured by B-mode ultrasound. J Clin Epidemiol. 1989; 42:551–559. [PubMed: 2661730]
36. Bonithon-Kopp C, Touboul PJ, Berr C, et al. Relation of intima-media thickness to atherosclerotic plaques in carotid arteries: The Vascular Aging (EVA) Study. Arter Thromb Vasc Biol. 1996; 16:310–316.
37. Steptoe A, Marmot M. Atherogenesis, coagulation and stress mechanisms. Occupational Medicine: State of the Art Reviews. 2000; 15:136–138.
38. Thijssen DH, Cable NT, Green DJ. Impact of exercise training on arterial wall thickness in humans. Clin Sci (Lond). 2012; 122:311–322. [PubMed: 22150253]
39. Murie-Fernandez M, Irimia P, Toledo E, et al. Carotid intima-media thickness changes with Mediterranean diet: a randomized trial (PREDIMED-Navarra). Atherosclerosis. 2011; 219:158–162. [PubMed: 21802081]

What this paper adds

- There are few published studies investigating the relationship between work hours and carotid intima media thickness and ankle-brachial index.
- Greater common CIMT was observed with increasing hours of work per week among women.
- ABI values decreased with increasing hours of work per week among men and among persons employed in Manangement/Professional jobs.
- Women working > 50 hours per week were significantly more likely to have a low ABI vs. a normal ABI compared to those working 40 hours per week.

Table 1

Socio-demographic, lifestyle, cardiovascular and occupational characteristics of the study sample.

Characteristics	All (n=3562) %	Women (n=1694) %	Men (n=1868) %	P-value
Age (years)				
45-54	45.8	48.4	43.5	<0.0001
55-64	34.3	35.4	33.4	
65-74	16.0	13.5	18.2	
75-84	3.9	2.8	4.9	
Race/Ethnicity				
White	41.5	40.0	42.9	<0.001
Chinese American	10.6	9.6	11.6	
African-American	27.9	31.4	24.7	
Hispanic	20.0	19.1	20.8	
Educational status				
≤ High school grad/GED	26.2	28.8	23.9	<0.0001
Some College/Tech school	30.3	33.9	27.1	
Bachelor’s degree	19.8	18.0	21.5	
Graduate/professional	23.6	19.3	27.5	
Gross household income				
<US$20,000	12.1	14.2	10.2	<0.0001
US $20,000-50,000	36.0	41.8	30.7	
US $50,000-75,000	21.4	20.3	22.4	
>US$75,000	30.5	23.8	36.7	
Smoking status				
Never	50.0	57.8	43.0	<0.0001
Former	35.5	28.7	41.6	
Current	14.6	13.6	15.4	
Alcohol use (n=3548)				
Never	15.7	22.6	9.4	<0.0001
Former	22.3	19.9	24.5	
Current	62.0	57.4	66.2	
Diabetes (2003 ADA fasting criteria)				
Normal	78.3	82.6	74.4	<0.0001
Impaired Fasting Glucose	12.2	9.7	14.6	
Untreated diabetes	2.3	1.4	3.1	
Treated diabetes	7.2	6.3	8.0	
Hypertension (JNC VI 1997 criteria)				
No	65.1	65.1	65.2	0.925
Yes	34.9	34.9	34.8	
ABI				
< 1.0	7.8	10.6	5.1	<0.0001
1.0-1.4	91.6	89.2	93.7	

Characteristics	All (n=3562) %	Women (n=1694) %	Men (n=1868) %	P-value
≥ 1.4	0.7	0.2	1.1	
Occupational group				
Management/Professional	48.5	45.4	51.3	<0.0001
Sales/Office	20.7	27.5	14.4	
Services	15.9	20.2	11.9	
Blue-collar	15.0	6.8	22.4	
Hours of work per week				
≤ 20	15.7	17.4	14.2	<0.0001
21-39	22.4	26.5	18.7	
40	29.7	30.8	28.7	
41-50	18.0	15.1	20.6	
> 50	14.2	10.3	17.8	
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	56.9 ± 8.4	56.2 ± 7.9	57.5 ± 8.8	<0.0001
Physical activity (MET min/wk) †	14.4 ± 7.5	14.6 ± 6.8	14.2 ± 8.1	0.187
Pack-years of smoking*	10.7 ± 22.4	8.0 ± 16.2	13.1 ± 26.6	<0.0001
HDL cholesterol (mg/dL)	50.3 ±14.6	56.4 ± 15.3	44.6 ± 11.2	<0.0001
LDL cholesterol (mg/dL)	118.3 ± 31.5	117.7 ± 31.9	118.9 ± 31.2	0.282
Triglycerides (mg/dL)	130.4 ± 88.2	122.3 ± 82.2	137.8 ± 92.6	<0.0001
Systolic blood pressure (mmHg)	122.1 ± 19.5	121.0 ± 20.9	123.1 ± 18.1	0.001
Diastolic blood pressure (mmHg)	72.6 ± 10.3	69.3 ± 10.2	75.6 ± 9.4	<0.0001
Body Mass Index (Kg/m^2)	28.5 ± 5.4	28.9 ± 6.4	28.1 ± 4.3	<0.0001
Common Carotid IMT (mm)	0.831 ± 0.173	0.806 ± 0.168	0.852 ± 0.179	<0.0001
Internal Carotid IMT (mm)	0.972 ± 0.514	0.907 ± 0.474	1.035 ± 0.540	<0.0001
Ankle-Brachial Index	1.133 ± 0.112	1.104 ± 0.100	1.153 ± 0.112	<0.0001
Hours of work per week	38.6 ± 16.2	36.7 ± 15.7	40.4 ± 16.5	<0.0001

P-values are for differences between men and women and were obtained from the chi-square and Students' t- tests.

*Only ever-smokers included.

†MET min/wk in thousands

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Table 2

Adjusted mean values of subclinical CVD measures by hours of work per week, stratified by gender.

Subclinical CVD		Hours of work per week					p-value
		≤20	21-39	40	41-50	>50	
Common CIMT		*(n=288)*	*(n=434)*	*(n=510)*	*(n=250)*	*(n=168)*	
Women	Model 1	0.792 ± 0.009	0.803 ± 0.007	0.800 ± 0.007	0.802 ± 0.009	0.836 ± 0.011	0.002
	Model 2	0.791 ± 0.009	0.802 ± 0.007	0.801 ± 0.007	0.806 ± 0.009	0.831 ± 0.012	0.008
	Model 3	0.795 ± 0.009	0.805 ± 0.007	0.800 ± 0.006	0.804 ± 0.009	0.823 ± 0.012	0.073
		(n=259)	*(n=338)*	*(n=521)*	*(n=372)*	*(n=323)*	
Men	Model 1	0.845 ± 0.011	0.853 ± 0.009	0.848 ± 0.007	0.862 ± 0.009	0.853 ± 0.009	0.395
	Model 2	0.844 ± 0.011	0.855 ± 0.009	0.848 ± 0.007	0.862 ± 0.009	0.852 ± 0.009	0.414
	Model 3	0.849 ± 0.011	0.857 ± 0.009	0.852 ± 0.007	0.858 ± 0.008	0.850 ± 0.009	0.867
Internal CIMT							
Women	Model 1	0.932 ± 0.028	0.886 ± 0.021	0.879 ± 0.020	0.913 ± 0.028	0.961 ± 0.034	0.320
	Model 2	0.929 ± 0.028	0.884 ± 0.021	0.881 ± 0.020	0.920 ± 0.028	0.956 ± 0.034	0.361
	Model 3	0.932 ± 0.028	0.886 ± 0.021	0.871 ± 0.020	0.919 ± 0.028	0.952 ± 0.035	0.641
Men	Model 1	1.090 ± 0.034	1.043 ± 0.028	1.007 ± 0.022	1.011 ± 0.026	1.047 ± 0.028	0.660
	Model 2	1.090 ± 0.034	1.048 ± 0.028	0.998 ± 0.022	1.016 ± 0.026	1.051 ± 0.028	0.745
	Model 3	1.115 ± 0.034	1.049 ± 0.028	1.004 ± 0.022	1.011 ± 0.026	1.029 ± 0.029	0.140
Ankle-Brachial Index							
Women	Model 1	1.102 ± 0.006	1.104 ± 0.005	1.111 ± 0.004	1.108 ± 0.006	1.091 ± 0.007	0.954
	Model 2	1.103 ± 0.006	1.104 ± 0.005	1.112 ± 0.004	1.104 ± 0.006	1.092 ± 0.007	0.926
	Model 3	1.104 ± 0.006	1.103 ± 0.004	1.114 ± 0.004	1.102 ± 0.006	1.090 ±0.007	0.804
Men	Model 1	1.161 ± 0.007	1.156 ± 0.006	1.154 ± 0.005	1.150 ± 0.006	1.149 ± 0.006	0.122
	Model 2	1.162 ± 0.007	1.155 ± 0.006	1.155 ± 0.005	1.149 ± 0.006	1.149 ± 0.006	0.106
	Model 3	1.165 ± 0.007	1.158 ± 0.006	1.154 ± 0.005	1.149 ± 0.005	1.148 ±0.006	0.046

Results are mean ± SE. P-values test for trends and are obtained from multivariable linear regression. Model 1: Adjusted for age Model 2: Adjusted for age, race/ethnicity, education Model 3: Adjusted for 'Model 2' plus smoking status, pack-years of smoking, alcohol status, physical activity, HDL cholesterol, LDL cholesterol, triglycerides, diabetes, hypertension, systolic blood pressure, BMI and income. Effect modification by gender for common CIMT (p = 0.340), internal CIMT (p = 0.154), and ABI (p = 0.413).

Table 3

Adjusted mean values of ankle-brachial index by hours of work per week, stratified by occupational group.

	Hours of work per week					
	≤ 20	21-39	40	41-50	>50	p-value
Mgmt/Professional	*(n=253)*	*(n=350)*	*(n=423)*	*(n=371)*	*(n=260)*	
Model 1	1.140 ± 0.007	1.138 ± 0.006	1.138 ± 0.005	1.140 ± 0.006	1.140 ± 0.007	0.941
Model 2	1.144 ± 0.007	1.142 ± 0.005	1.140 ± 0.005	1.135 ± 0.005	1.134 ± 0.006	0.175
Model 3	1.147 ± 0.007	1.145 ± 0.005	1.141 ± 0.005	1.135 ± 0.005	1.129 ± 0.006	0.015
Sales/Office	*(n=124)*	*(n=168)*	*(n=239)*	*(n=98)*	*(n=73)*	
Model 1	1.109 ± 0.010	1.098 ± 0.008	1.130 ± 0.007	1.125 ± 0.011	1.123 ± 0.012	0.060
Model 2	1.112 ± 0.010	1.102 ± 0.008	1.131 ± 0.007	1.118 ± 0.011	1.115 ± 0.012	0.256
Model 3	1.110 ± 0.010	1.101 ± 0.008	1.132 ± 0.007	1.119 ± 0.011	1.115 ± 0.013	0.161
Service	*(n=96)*	*(n=157)*	*(n=147)*	*(n=60)*	*(n=77)*	
Model 1	1.099 ± 0.011	1.121 ± 0.008	1.137 ± 0.008	1.117 ± 0.012	1.107 ± 0.011	0.516
Model 2	1.106 ± 0.010	1.123 ± 0.007	1.132 ± 0.008	1.115 ± 0.012	1.103 ± 0.010	0.854
Model 3	1.107 ± 0.010	1.118 ± 0.007	1.131 ± 0.008	1.111 ± 0.012	1.108 ± 0.011	0.416
Blue-collar	*(n=60)*	*(n=85)*	*(n=209)*	*(n=82)*	*(n=73)*	
Model 1	1.160 ± 0.016	1.138 ± 0.013	1.130 ± 0.008	1.144 ± 0.013	1.135 ± 0.014	0.401
Model 2	1.171 ± 0.016	1.137 ± 0.013	1.130 ± 0.008	1.143 ± 0.012	1.129 ± 0.013	0.136
Model 3	1.164 ± 0.015	1.136 ± 0.012	1.130 ± 0.008	1.148 ± 0.012	1.134 ± 0.013	0.480

Results are mean ± SE. P-values test for trends and are obtained from multivariable linear regression. Model 1: Adjusted for age. Model 2: Adjusted for age, gender, race/ethnicity, education Model 3: Adjusted for 'model 2' plus smoking status, pack-years of smoking, alcohol status, physical activity, HDL cholesterol, LDL cholesterol, triglycerides, diabetes, hypertension, systolic blood pressure, BMI, and income. Effect modification by occupational group, p = 0.061.

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Table 4

Adjusted odds ratios and 95% confidence intervals for low ABI (<1.0) vs. normal ABI (1.0-1.4) by work hours per week, stratified by gender.

		Hours of work per week				
		≤ 20	**21-39**	**40**	**41-50**	**>50**
Women	Model 1	1.23 (0.75-2.03)	1 . 3 9 (0 . 90-2.13)	1.00	1.10 (0.64-1.89)	1.96 (1.14-3.35)
	Model 2	1.32 (0.77-2.27)	1.56 (0.99-2.48)	1.00	1.23 (0.69-2.20)	1.85 (1.01-3.38)
Men	Model 1	1.01 (0.49-2.06)	1.19 (0.61-2.32)	1.00	1.68 (0.86-3.28)	1.60 (0.81-3.18)
	Model 2	0.98 (0.46-2.10)	1.11 (0.54-2.29)	1.00	1.69 (0.82-3.45)	1.61 (0.76-3.43)

Model 1: Adjusted for age. Model 2: Adjusted for age, race/ethnicity, education, smoking status, pack-years of smoking, alcohol status, physical activity, HDL cholesterol, LDL cholesterol, triglycerides, diabetes (and/or on diabetic medication), hypertension (and/or on hypertensive medication), systolic blood pressure, BMI, and income.