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Current employment status, occupational category, occupational hazard exposure, and job stress in relation to telomere length: The Multiethnic Study of Atherosclerosis (MESA)

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Abstract

Objective—Telomere length has been proposed as a biomarker of cell senescence, which is associated with a wide array of adverse health outcomes. While work is a major determinant of health, few studies have investigated the association of telomere length with various dimensions of occupation. Accelerated cellular aging could be a common pathway linking occupational exposure to several health outcomes.

Methods—Leukocyte telomere length was assessed using quantitative polymerase chain reaction (Q-PCR) in a community-based sample of 981 individuals (age: 45–84 years old). Questionnaires were used to collect information on current employment status, current or main occupation before retirement, and job strain. The O*NET (Occupational Resource Network) database was linked to the questionnaire data to create 5 exposure measures: physical activity on the job, physical hazard exposure, interpersonal stressors, job control, and job demands. Linear regression was used to estimate associations of occupational characteristics with telomere lengths after adjustment for age, sex, race, socioeconomic position, and several behavioral risk factors.

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Results—There were no mean differences in telomere lengths across current employment status, occupational category, job strain categories or levels of most O*NET exposure measures. There was also no evidence that being in lower status occupational categories or being exposed to higher levels of adverse physical or psychosocial exposures accelerated the association between age and telomere shortening.

Conclusions—Cellular aging as reflected by shorter telomeres does not appear to be an important pathway linking occupation to various health outcomes.

INTRODUCTION

Telomeres, the protective caps of the ends of chromosomes, become shorter during repeated DNA replication, and thus telomere length has been proposed as a biomarker of cell senescence.[1] Oxidative stress has also been shown to accelerate telomere shortening.[2] Thus shorter telomeres indicate cumulative history of oxidative stress, which accelerates cell senescence.[1] Shorter telomere length has been associated with a range of health outcomes including cardiovascular disease (CVD) and its risk factors,[3] incident cancer and cancer mortality,[4] chronic obstructive pulmonary disease (COPD),[5] decline in immune function,[6] and mortality. [7] Identifying environmental factors that shorten telomere length may shed light on etiologies of these adverse health conditions as well as on the causes of disparities in these conditions.

Many adverse health outcomes associated with shortening of telomere length are also linked to working conditions. For example, occupational exposure accounts for a substantial proportion (15%) of COPD cases, second only to cigarette smoking.[8] A sizable body of literature supports the link between CVD and job stress.[9] Some occupational exposures have been linked to specific types of cancer,[10] and different rates of mortality by occupation have been documented in many countries.[11–14] Occupational exposures, which are patterned by social class and race, may be important contributors to health disparities.[15] An effect of occupation on the general process of cellular aging, as reflected in telomere length, would provide evidence of a common pathway through which occupation could affect many different health outcomes.

While evidence has started to accumulate for a link between telomere length and life stress, such as caregiving [616] and childhood hardship or maltreatment,[1718] little is known about the association of telomere length with job stress and other occupational exposures. To date, very few studies have examined associations of occupational exposures with telomere length.[1920] Among 144 battery plant workers, Wu et al.[20] found that elevated lead levels in urine and blood were associated with shorter telomeres. Parks et al.[19] investigated various work schedule characteristics among 608 women and reported that working full-time was associated with shorter telomeres compared to working part-time. They found no associations between telomere length and irregular work hours or working at night. While lead and work schedule are important occupational exposures, a wider range of occupational characteristics and exposures need to be examined. Although several studies have examined telomere length and the more general construct of socioeconomic position, which is partly determined by occupation, results have been inconclusive.[21–23]

We used detailed data on multiple dimensions of occupation and occupational exposures available in the Multi-Ethnic Study of Atherosclerosis (MESA) to examine associations of telomere length with employment status, occupational category, and selected occupational exposures (i.e., physical activity on the job, physical hazard exposure, job strain, job control, and job demands). In addition to cross-sectional associations, we also examined whether occupational exposures modified the association between age and telomere length. Because telomere length is a marker of cellular senescence which could manifest in various forms of diseases,[1] investigating its relationship with various dimensions of occupation may help us understand the role of occupation in disease etiology and potentially the cause of health disparities across occupations.

METHODS

Study settings and participants

The data came from a subsample of the Multi-Ethnic Study of Atherosclerosis (MESA), an on-going cohort study designed to examine the prevalence and progression of subclinical CVD.[24] Between 2000 and 2002, MESA recruited 6814 adults, aged between 45 and 84, free of clinical CVD in six US communities. The original MESA sample consisted of 38% whites, 28% African Americans, 23% Hispanics, and 11% Asian (mainly Chinese) Americans. Of the 6814 MESA participants, about 1000 from the New York and Los Angeles study sites were randomly selected to participate in an ancillary study focusing on stress as a CVD risk factor. Telomere length was assessed for 981 participants in this ancillary study.

Telomere length

Leukocyte telomere length was measured from the blood sample taken during the first MESA exam (2000–2002) using quantitative polymerase chain reaction (Q-PCR).[25] Each sample was amplified for telomeric DNA and for 36B4, a single-copy control gene that provided an internal control to normalize the starting amount of DNA. A four-point standard curve (2-fold serial dilutions from 10 to 1.25 ng DNA) was used to transform cycle threshold into nanograms of DNA. Baseline background subtraction was performed by aligning amplification plots to a baseline height of 2% in the first 5 cycles. The cycle threshold was set at 20% of maximum product. All samples were run in triplicate and the median was used for calculations. The amount of telomeric DNA (T) was divided by the amount of single-copy control gene DNA (S), producing a relative measurement of the telomere length (T/S ratio). Two control samples were run in each experiment to allow for normalization between experiments, and periodical reproducibility experiments were performed to guarantee correct measurements. The intro- and inter-assay variability (coefficient of variation) for Q-PCR was 6% and 7%, respectively.

Occupation

During their visit to the field center, participants completed a questionnaire on their occupation and, job characteristics. The questionnaire was self-administered in their preferred language (English or Spanish).

Occupation was assessed with four open-ended questions modeled after the US Census (e.g., "What is/was your main job tasks?" "What is/was your job title"). Participants who were no longer working at the time of the MESA exam (approximately 55% of the sample) reported their main occupation before they stopped working. For those who were still working at the time of data collection, we asked about their current occupation. Experienced coders at the National Institute for Occupational Safety and Health (NIOSH) assigned the Census 2000 Occupation Codes to the responses, which were then converted to the Census 2002 Occupation Codes in order to facilitate the use of O*NET data (see below for details). The coded occupation was categorized in 5 groups: management, professional, service, sales/office, and blue-collar jobs. Current employment status was categorized in 5 groups: working full-time, working part-time, on-leave or unemployed, retired and not working (including homemakers), and retired but still working or volunteering.

Self-report measures of job control and job demands

For those who were current workers at the time of data collection (n=435), the Job Content Questionnaire (JCQ) [26] was used to obtain information about job control and job demands. These are two components of the demand-control model,[27] one of the most extensively studied job stress models. According to the demand-control model, high levels of job demands combined with low levels of job control (i.e., job strain) negatively impact health.[28–30] Job control was measured with JCQ's original nine items (e.g., "My job allows me to make a lot of decisions on my own"), and job demands with five items (e.g., "My job requires working very hard").[26] Each item had a four-point response scale ("never/almost never [=1]" to "often [=4]"), and the scale scores were calculated based on the original JCQ formula.[27] The score ranges from 12 to 48 for job demands, from 24 to 96 for job control. Chronbach's alpha was 0.82 for the job control scale, and 0.72 for the job demands scale. More detailed psychometric properties of the scales and comparisons across languages in the MESA sample are reported elsewhere.[31] Following the most commonly used formulation of job quadrant,[32] job strain categories were created by dichotomizing demands and control at their sex specific median (job control cutoff was 76 for men, 72 for women; job demands cutoff was 26 for men, 31 for women). Categories were low strain (low demands + high control), active jobs (high demands + high control), passive jobs (low demands + low control), and high strain (high demands + low control).

Occupational exposure measures from O*NET

We derived job characteristics measures from the Occupational Resource Network (O*NET), developed by the US Department of Labor.[33] O*NET provides detailed descriptive information for each of over 900 occupations in the US Standard Occupational Classification (SOC) system.[34] The original intent of the US Department of Labor was to help job seekers identify jobs that fit their skills and interests; however, O*NET's comprehensive descriptions of the wide array of occupations attracted researchers' interest in using it as an occupational exposure matrix.[3335] In their review, Cifuentes et al. (2010) observed that despite several methodological problems in earlier studies, O*NET is a promising source of job characteristics that may impact workers' health.

O*NET data describe characteristics of more than 900 SOC jobs through ratings obtained from randomly selected current job holders and occupational analysts. They assessed each job using a standardized rating system, which consisted of 277 items describing various aspects of the job (e.g., “In your current job, how much freedom do you have to make decisions without supervision? [for current job holders],” “To what extent does this occupation allow workers to make decisions on their own? [for occupational analysts]”). O*NET provides the raw mean value of each item as well as scaled mean values ranging from 0 to 100. The scaled mean values are useful because the 277 items have various response scales (e.g., a 7-point importance scale, a 5-point frequency scale). We linked each participant's reported occupation to the O*NET measures using the 2002 Census Occupation Codes.

For this study, five occupational exposure measures were derived from the O*NET16 database: physical activity on the job, physical hazard exposure, interpersonal stressors, job control, and job demands. For *physical activity on the job*, we used 3 items: time spent on sitting (reverse item), the importance of using arms and legs and moving the whole body in performing the job, and the level of general physical activities needed to perform the job. We calculated the mean of O*NET scaled means for the three variables. Crombach's alpha was 0.86.

For *physical hazard exposure*, we calculated the mean of 7 items that address common physical hazards traditionally studied in occupational safety and health. These 7 items asked the frequency of exposure to the following conditions: sounds and noise levels that are distracting and uncomfortable, very hot (above 90F) or very cold (under 32F) temperatures, extremely bright or inadequate lighting conditions, high places (e.g., working on poles, scaffolding, catwalks, or ladders), an environment that is not controlled (i.e., without air conditioning), outdoors under cover, and outdoors exposed to all weather conditions. Cronbach's alpha for the 7 item was 0.96.

For *interpersonal stressors*, we calculated the mean of 6 items: the importance of resolving conflicts and negotiating with others, frequency of conflict situations as part of the job, dealing with unpleasant, angry or discourteous people, dealing with physically aggressive people, the importance of maintaining composure and keeping emotions in check, and the importance of accepting criticisms and dealing calmly with high-stress situations. Cronbach's alpha was 0.88.

For *psychological job demands* and *job control*, we used the same items used by Cifuentes et al.[36] Namely, psychological job demands included four items addressing the ability to shift back and forth between tasks, the ability to concentrate on a task, the seriousness of error, and importance of being accurate. We calculated the mean of the four items. Cronbach's alpha was 0.68. As for *job control*, we used four O*NET items asking the extent to which the job makes use of workers' abilities and allows workers to try out their own ideas, to make decisions on their own, and to plan their work. Cronbach's alpha was 0.97.

Covariates

For all participants, the following information was collected in a questionnaire conducted during MESA Exam 1: age, self-identified race/ethnicity, educational attainment, household income, current smoking status, and pack-years for current and former smokers. Height and weight were measured at the study site and used to calculate the body mass index (BMI, kg/m^2). Because a significant association between current sleep quality and telomere length has been reported,[37] we included it in all analyses (i.e., "During the past week, my sleep was restless" with four response options: >1 day, 1–2 days, 31–4 days, and 51–7 days). For current workers, the number of years worked on the current job was asked in the questionnaire.

Statistical analyses

First, descriptive statistics of selected characteristics were calculated for all participants (n=981) and for the current worker subsample (n=435). Linear regression was used to estimate mean differences in telomere length associated with each of the following occupational characteristics: current employment status, occupational category, O*NET physical activity, O*NET physical hazard exposure, and O*NET interpersonal stressors.

We also investigated telomere length in relation to job control and job demands among current workers (n=435). For both the full sample and current worker subsample analyses, we tested the interaction term between age and each of the occupational characteristic variables in order to examine whether occupational characteristic modified the extent to which higher age was associated with shorter telomeres. Age, sex, and race variables were all grand-mean centered so that the effect of age would reflect the aging effect adjusted for the sex and race distribution of the sample. We compared regression coefficients as we added sets of covariates. Model 1 was adjusted for only age, sex, race/ethnicity, and the interaction between age and race/ethnicity as well as age and sex.[38] In Model 2 we added the interaction term between age and occupational characteristics. Then in Model 3, we assessed if the coefficients for occupational characteristics were affected by including current working status (still working vs. retired), job tenure (for the current worker subsample analyses only), indicators of socioeconomic position (i.e., household income, education, occupational categories), body mass index (BMI), current smoking status, pack-years, and sleep quality.

The study protocol was approved by the Institutional Review Board (IRB) at each study site as well as the National Heart, Lung, and Blood Institute. The analysis for this study was approved by the IRB at the National Institute for Occupational Safety and Health.

RESULTS

Characteristics of study participants are presented in Table 1. Mean age was 61.4 years for the full sample and 55.7 years for the current worker sample. The full sample was 47% male and 53% Hispanic; the current worker subsample was 51% males and 48% Hispanic. Compared to the full sample, the current workers had higher household income and more education, and a lower proportion of blue-collar workers. The average job tenure for the

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current workers was 14 years. Even though nearly half of the sample consisted of immigrants, the mean job tenure did not differ significantly between immigrants and non-immigrants (13.2 years and 15.1 years, respectively; χ^2=1.52, p=0.218).

The participants were nearly evenly distributed across occupational categories, except for a smaller proportion for management jobs. The sample included a wide range of occupations: 231 jobs were represented by the 981 participants in the full sample, and the 435 current workers held 155 jobs. Most common occupations included nurses' aide (n=47), room cleaner (n=35), administrative assistant (n=29), and janitor (n=23). The level of physical activity on the job, physical hazard exposure, and interpersonal stressors were similar for the full sample and the current worker subsample. The mean telomere length was longer for the current worker subsample than for the full sample.

Table 2 presents the mean differences in telomere length by current employment status and occupational category, as well as mean difference associated with 1 standard-deviation difference in three O*NET job characteristic measures for the full sample. The mean telomere length did not differ across current employment status or by occupational category, and the association of age with telomere length did not differ by current employment status or occupational category (all interaction p-values >0.05). There were also no statistically significant associations between telomere length and O*NET-derived physical activity on the job, physical hazard exposure, or interpersonal stressors, either as the main effect or in interaction with age.

Associations of telomere length with job strain, job control, and job demands (both self-report and O*NET) among current workers are shown in Table 3. The mean telomere length did not differ by job strain category, and the association of greater age and shorter telomere did not differ by job strain category (p for interaction = 0.096). O*NET job demands had a statistically significant interaction with age (p for interaction = 0.041) such that the association of greater age with shorter telomeres became weaker as job demands increased. This interaction was attenuated after all covariates were included in the model (p for interaction = 0.078).

DISCUSSION

This cross-sectional study of a multi-ethnic community sample explored associations of telomere length with several dimensions of occupation, including current employment status, occupational category, occupational exposure measures from O*NET, and self-reported job strain. We found no evidence that occupational category, employment status, or various features of occupation were associated with differences in telomere length. We examined the occupation-telomere relationship with socio-demographic characteristics and some behavioral risk factors accounted for, but these covariates did not influence the association (or lack thereof) between telomere length and various dimensions of occupation. There was also no consistent evidence that occupational factors modified the association of age with shorter telomeres.

Our results regarding no differences in telomere length by occupational category are consistent with other reports showing no associations of telomere length with socioeconomic position based on occupation.[21233940] Equivocal results were reported regarding the association between telomere length and other measures of socioeconomic position as well. Batty et al. [41] found no association between telomere length and educational attainment in a community-based sample of over 1500 men. Steptoe et al.,[23] on the other hand, reported that higher educational attainment was associated with longer telomeres among healthy men and women. Telomere length was not associated with either residential area deprivation [41] or individuals' own sense of their socioeconomic position among women.[42] While Cherkas et al. [22] did find shorter telomeres among women in manual jobs compared to those in non-manual jobs, all other studies as well as the current study suggest that telomere length may not reflect the increased disease risk associated with low socioeconomic position.

Our results are not consistent with some previous findings such as those reported by Parks et al.[19] They found that among women of ages between 35 and 74, full-time workers had shorter telomere compared to both part-time workers and those who were not in the workforce. Their sample was predominantly white (83%), with only 7% African Americans and 2% Hispanics. In our sample, whites represented only about a fifth of the sample, and immigrants accounted for nearly half. Even though our sample is larger than the Parks study, we did not find differences in telomere lengths by occupational characteristics. Other studies have found that associations between socioeconomic status (for which occupational measures are often proxies) and health outcomes are not always similar across ethnic groups or between immigrants and non-immigrants.[4344] This suggests that the heterogeneity in our sample may have made it difficult to identify differences in telomere length associated with occupational characteristics.

The O*NET job characteristics and job strain were not associated with telomere length in our sample, either as a main effect or as an interaction with age. One interaction with age was marginally significant, but the association was in the unexpected direction and was attenuated once covariates were adjusted for. While O*NET has been recognized as a potentially valuable source of job exposure data,[35] it has rarely been used in investigating objectively measured health outcomes, and no other studies have examined telomere length in relation to O*NET-derived job characteristics. Until more studies with objective health measures become available, it is difficult to evaluate the utility of O*NET as a job exposure matrix.

This study has a few limitations. The participants were of older age (mean age = 62), and about half of them were no longer working. The occupation data were either the person's current job or the main job before the person stopped working. O*NET information may not capture the job characteristics when the participants actually had the job, which could be many years ago as job exposure may have changed during that time. Also, job tenure was not available for former jobs reported by those who were no longer working. While this is a significant limitation, we are reasonably confident that these jobs were held for a substantial time period. In the 1980s and 1990s, when these participants were presumably working, median job tenure for middle-age workers was about 10 years.[45] A large proportion of retired workers in our sample, however, may have affected results because the association between occupational exposures and health outcomes appears to weaken after retirement (i.e., after occupational exposures end).[46] We conducted a sensitivity analysis by repeating the analyses in Table 2 (except for employment status) in the sub-sample of currently employed workers. Similar results were observed in this sub-sample as in the full sample.

Our sample included a wide range of occupations, which is a strength; but the large proportion of service and blue-collar workers in this older sample may mean that we had especially healthy people (i.e., healthy worker effect).[47] This could cause us to underestimate the association between occupation and telomere length. Also, nearly half of our participants were immigrants although the mean years spent in the US was 32 years, and over 95% of them had lived in the US more than 10 years prior to the data collection. If immigrant workers had a substantially shorter job tenure, estimates of job characteristics would be less accurate for immigrants than for non-immigrants, but job tenure did not differ by nativity among current workers. We have no reason to believe that job tenure among former workers differ considerably by nativity. The Current Population Survey from 1995 to 2008 showed that immigrants had on average 2.1years shorter job tenure than non-immigrants.[48] Another large-scale study of immigrants from Mexico reported a 1.1 year difference in 1992.[49] Given over 10 years of likely job tenure among former workers, we assume that a 1-to-2-year difference by nativity would not alter our conclusions. However, the large proportion of immigrants in the sample may have affected our results some other way because immigrants' jobs could be different even within the same job title. For example, being a restaurant owner as a Chinese immigrant and as a native-born American may be different experiences. The work environment of a given job title could also be very different for recent immigrants and the native born. O*NET measures describe typical characteristics of a given job, which may not apply to immigrants. O*NET exposure measures, as all job exposure matrices that apply average exposure by job title to individuals, produce non-differential misclassification that usually bias the results towards the null value. The psychological job demands items derived from O*NET are not typical measures of psychological job demands. Thus, it is not known how valid this scale is in predicting ill health. In addition, other occupational stressors, such as effort-reward imbalance, long work hours and shiftwork need to be assessed in relation to telomere length.

Blood processing methods may not be consistent across studies, and different methods may potentially select for different sub-populations of leukocytes, in which telomere length may vary. In order to minimize any potential differences, we used well-documented blood processing methods carried out by trained and certified personnel.[24,50] However, we are unable to rule out confounding of results by differences in leucocyte distributions associated with the occupational characteristics. We had a single measurement of telomere length and measurement error may have limited our ability to detect small effects. Nevertheless, as reported by Kim et al., a single measurement of leukocyte telomere length is a reliable indicator of an individual's telomere length within a several month time-span.[51] Although our sample was large compared to other telomere studies, it may not have been large enough to detect small effects of job characteristics on telomere length or interactions between age and various occupational characteristics.

Nevertheless, our study has several significant strengths: a diverse population sample, a wide range of occupations, and a sample that includes both current and former workers. Most importantly, this study examined various dimensions of occupation that have not been addressed in previous studies.

In conclusion, we did not find associations between telomere length and occupational characteristics. Even though occupation and telomere length are both associated with the same diseases (e.g., CVD, cancer), our results are not consistent with the notion that job characteristics examined in this study are antecedents of telomere shortening. Occupation is a complex phenomenon that can expose workers to various hazards, each of which may lead to adverse health conditions through unique pathways. Given the multi-ethnic nature of our sample and the older age of our participants, our findings must be confirmed in other studies. However, our preliminary conclusion is that the impact of occupation on multiple adverse health outcomes is not mediated by accelerated cellular aging.

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REFERENCES

1. von Zglinicki T, Martin-Ruiz CM. Telomeres as biomarkers for ageing and age-related diseases. Current Molecular Medicine. 2005; 5:197–203. [PubMed: 15974873]
2. von Zglinicki T. Oxidative stress shortens telomeres. Trends in Biochemical Sciences. 2002; 27:339–344. [PubMed: 12114022]
3. Fitzpatrick AL, Kronmal RA, Gardner JP, et al. Leukocyte telomere length and cardiovascular disease in the cardiovascular health study. American Journal of Epidemiology. 2007; 165:14–21. [PubMed: 17043079]
4. Willeit P, Willeit J, Mayr A, et al. Telomere length and risk of incident cancer and cancer mortality. JAMA. 2010; 304:69–75. [PubMed: 20606151]
5. Amsellem V, Gary-Bobo G, Marcos E, et al. Telomere dysfunction causes sustained inflammation in chronic obstructive pulmonary disease. American Journal of Respiratory and Critical Care Medicine. 2011; 184:1358–1366. [PubMed: 21885626]
6. Damjanovic AK, Yang Y, Glaser R, et al. Accelerated telomere erosion is associated with a declining immune function of caregivers of Alzheimer's disease patients. Journal of Immunology. 2007; 179:4249–4254.
7. Fitzpatrick AL, Kronmal RA, Kimura M, et al. Leukocyte telomere length and mortality in the Cardiovascular Health Study. The Journal of Gerontology Series A. 2010; 66A:421–429.
8. Boschetto P, Quintaballe S, Miotto D, et al. Chronic obstructive pulmonary disease (COPD) and occupational exposures. Journal of Occuaptional Medicine and Toxicology. 2006; 1:11.
9. Schnall PL, Belkić K, Landsbergis PA, et al. The workplace and cardiovascular disease. Occupational Medicine: State of the Art Reviews. 2000; 15:1–334.
10. IARC. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. World Health Organization; Lyon, France: 1999. Some organic solvents, resin monomers and related compounds, pigments and occupational exposures in paint manufacture and painting.
11. Steenland K, Burnett C, Lalich N, et al. Dying for work: The magnitude of US mortality from selected causes of death associated with occupation. American Journal of Industrial Medicine. 2003; 43:461–482. [PubMed: 12704620]

12. Mustard CA, Bielecky A, Etches J, et al. Avoidable mortality for causes amenable to medical care, by occuaption in Canada. Canadian Journal of Public Health. 2010; 101:500–506. [PubMed: 21370790]
13. Wada K, Kondo N, Gilmour S, et al. Trends in cause specific mortality across occupations in Japanese men of working age during period of economic stagnation, 1980–2005: Retrospective cohort study. British Medical Journal. 2012; 344:e1191. [PubMed: 22396155]
14. Holmes E, Davies A, Wright C, et al. Mortality rates according to occupation in New Zealand males: 2001–2005. The New Zealand Medical Journal. 2011; 124:16–28. [PubMed: 21475336]
15. Adler NE, Rehkopf DH. U.S. Disparities in health: Descriptions, causes, and mechanisms. Annual Review of Public Health. 2008; 29:235–252.
16. Epel ES, Blackburn EH, Lin J, et al. Accelerated telomere shortening in response to life stress. Proceedings of the National Academy of Sciences of the United States of America. 2004; 101:17312–17315. [PubMed: 15574496]
17. Surtees PG, Wainwright NWJ, Pooley KA, et al. Life Stress, Emotional Health, and Mean Telomere Length in the European Prospective Investigation into Cancer (EPIC)-Norfolk Population Study. Journals of Gerontology Series a-Biological Sciences and Medical Sciences. 2011; 66:1152–1162.
18. Tyrka AR, Price LH, Kao HT, et al. Childhood Maltreatment and Telomere Shortening: Preliminary Support for an Effect of Early Stress on Cellular Aging. Biological Psychiatry. 2010; 67:531–534. [PubMed: 19828140]
19. Parks CG, DeRoo LA, Miller DB, et al. Employment and work schedule are related to telomere length in women. Occupational and Environmental Medicine. 2011; 68:582–589. [PubMed: 21540175]
20. Wu Y, Liu Y, Ni N, et al. High lead exposure is associated with telomere length thortening in Chinese battery manufacturing plant workers. Occupational and Environmental Medicine. 2012; 69:557–563. [PubMed: 22539657]
21. Adams J, Martin-Ruiz CM, Pearce MS, et al. No association between socio-economic status and white blood cell telomere length. Aging Cell. 2007; 6:125–128. [PubMed: 17156082]
22. Cherkas LF, Aviv A, Valdes AM, et al. The effects of social status on biological ageing as measured by white-bloor-cell telomere length. Aging Cell. 2006; 5:361–365. [PubMed: 16856882]
23. Steptoe A, Mamer M, Butcher L, et al. Educational attainment but not measures of current socioeconomic circumstances are associated with leukocyte telomere length in healthy older men and women. Brain Behavior and Immunity. 2011; 25:1292–1298.
24. Bild DE, Bluemke DA, Burke GL, et al. Multi-Ethnic Study of Atherosclerosis: Objectives and design. American Journal of Epidemiology. 2002; 156:871–881. [PubMed: 12397006]
25. Cawthon RM. Telomere measurement by quantitative PCR. Nucleric Acids Research. 2002; 30:e47.
26. Karasek RA, Brisson C, Kawakami N, et al. The Job Content Questionnaire (JCQ): An instrument for internationally comparative assessments of psychosocial job characteristics. Journal of Occupational Health Psychology. 1998; 3:322–355. [PubMed: 9805280]
27. Karasek RA. Job demands, job decision latitude, and mental strain: Implications for job redesign. Administrative Science Quarterly. 1979; 24:285–308.
28. de Lange AH, Taris TW, Kompier MAJ, et al. “The very best of the Millennium”: Longitudinal research and the Demand-Control-(Support) model. Journal of Occupational Health Psychology. 2003; 8:282–305. [PubMed: 14570524]
29. Belkić KL, Landsbergis PA, Schnall P, et al. Is job strain a major source of cardiovascular disease risk? Scandinavian Journal of Work Environment & Health. 2004; 30:81–128.
30. Nieuwenhuijsen K, Bruinvels D, Frings-Dresen M. Psychosocial work environment and stress-related disorders, a systematic review. Occupational Medicine-Oxford. 2010; 60:277–286.
31. Fujishiro K, Landsbergis P, Diez Roux AV, et al. Factorial invariance, scale reliability, and validity of the decision latitude and psychological demands scales for immigrant workers: The Multi-Ethnic Study of Atherosclerosis (MESA). Journal of Immigrant and Minority Health. 2011; 13:533–540. [PubMed: 20582720]

32. Landsbergis PA, Schnall PL, Schwartz JE, et al. The association of ambulatory blood pressure with alternative forms of job strain. Scandinavian Journal of Work, Environment, and Health. 1994; 20:349–63.
33. Hadden WC, Kravets N, Muntaner C. Descriptive demensions of US occupations with data from the O*NET. Social Science Research. 2004; 33:64–78.
34. Mariani M. Replace with a database: O*NET replaces the discionary of occupational titles. Occupational Outlook Quarterly. 1999; Spring:3–9.
35. Cifuentes M, Boyer J, Lombardi DA, et al. Use of O*NET as a job exposure matrix: A literature review. American Journal of Industrial Medicine. 2010; 53:898–914. [PubMed: 20698022]
36. Cifuentes M, Boyer J, Gore R, et al. Inter-method agreement betwee O*NET and survey measures of psychosocial exposure among healthcare industry employees. American Journal of Industrial Medicine. 2007; 50:545–553. [PubMed: 17557294]
37. Prather AA, Puterman E, lin J, et al. Shorter leukocyte telomere length in midlife women with poor sleep quality. Journal of Aging Research. 2011; 2011 Article ID 721390.
38. Diez Roux AV, Ranjit N, Jenny NS, et al. Race/ethnicity and telomere length in the Multi-Ethnic Study of Atherosclerosis. Aging Cell. 2009; 8:241–257.
39. Ahola K, Sirén I, Kivimäki M, et al. Work-related exhaustion and telomere length: A population-base study. PLoS One. 2012; 7:e40186. [PubMed: 22808115]
40. Shiels PG, McGlynn LM, MacIntyre A, et al. Accelerated Telomere Attrition Is Associated with Relative Household Income, Diet and Inflammation in the pSoBid Cohort. PLoS One. 2011; 6
41. Batty GD, Wang Y, Brouilette SW, et al. Socioeconomic status and telomere length: The West of Scotland Coronary Prevention Study. Journal of Epidemiology and Community Health. 2009; 63:839–841. [PubMed: 19468018]
42. Woo J, Suen EWC, Leung JCS, et al. Older men with higher self-rated socioeconomic status have shorter telomeres. Age and Ageing. 2009; 38:553–558. [PubMed: 19556325]
43. Gallo LC, Espinosa de los Monteros K, Allison M, et al. Do socioeconomic gradients in subclinical atherosclerosis vary according to acculturation level? Analyses of Mexican-Americans in the Multi-Ethnic Study of Atherosclerosis. Psychosomatic Medicine. 2009; 71:756–762. [PubMed: 19661194]
44. Yost K, Perkins C, Cohen R, et al. Socioeconomic status and breast cancer incidence in California for different race/ethnic groups. Cancer Causes & Control. 2001; 12:703–711. [PubMed: 11562110]
45. Copeland C. Employee tenure trend lines, 1983–2010. Employee Benefit Research Institute Notes. 2010; 31:2–12.
46. Chandola T, Britton A, Brunner EJ, et al. Work stress and coronary heart disease: What are the mechanisms? European Heart Journal. 2008; 29:640–648. [PubMed: 18216031]
47. Arrighi HM, Hertz-Picciotto I. The evolving concept of the healthy worker survivor effect. Epidemiology. 1994; 5:189–196. [PubMed: 8172994]
48. Farber, HS. Job loss and the decline in job security in the United States. In: Abraham, KG.; Spletzer, JR.; Harper, M., editors. Labor in the New Economy. University of Chicago Press; Chicago, IL: 2010. p. 223-262.
49. Aguilera MB. The impact of the worker: How social capital and human capital influence the job tenure of formerly undocumented Mexican immigrants. Sociological Inquiry. 2003; 73:52–83.
50. Cushman M, Cornell E, Howard P, et al. Laboratory methods and quality assurance in the Cardiovascular Health Study. Clin Chem. 1995; 41:264–270. [PubMed: 7874780]
51. Kim S, Sandler D, Carswell G, et al. Reliability and short-term intra-individual variability of telomere length using monochrome multiplexing and quantitative PCR. PLoS ONE. 2011; 6:e25774. [PubMed: 21984947]

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What this paper adds

- Telomere length has been proposed as a biomarker of cellular aging, and shorter telomeres have been linked to various adverse health outcomes.
- Although many health outcomes have been also associated with occupational exposure, the association of telomere length with occupational exposure has been rarely studied.
- In a large, racially diverse sample, we found no mean differences in telomere lengths across current employment status, occupational category, job strain categories or levels of occupational exposure measures derived from O*NET.

Table 1

Characteristics of the full sample included in telomere analyses and the current worker subsample, the Multi-Ethnic Study of Atherosclerosis.

Characteristic	Full sample (n=981)	Current worker sub-sample for job strain analyses (n=435)
Mean age (SD) in years	61.4 (9.93)	55.4 (7.63)
Percent male	47.6	50.6
Race/ethnicity (% distribution)		
White	18.6	20.9
African American	28.3	34.9
Hispanic	53.1	44.1
Percent foreign-born	49.3	47.6
Income (% distribution)		
<$20,000	29.6	15.9
$20,000–$39,499	27.7	27.5
$35,000–$49,999	16.5	18.9
$50,000–$74,499	13.0	18.2
≥$75,000	13.1	19.4
Education (% distribution)		
Less than high school	27.1	18.4
Complete high school	20.3	16.6
Some college, vocational/associate degree	29.9	34.7
Bachelor's degree	11.1	14.3
Graduate or professional degree	11.6	16.1
Occupation (% distribution)		
Management	11.2	13.0
Professional	21.0	25.4
Service	23.6	25.6
Sales, Office, Admin. Support	20.2	20.2
Blue-collar	24.1	15.8
Current employment (% distribution)		
Working full-time	36.7	79.7
Working part-time	6.9	15.0
On-leave or unemployed	5.6	--
Retired, not working or volunteering	41.0	--
Retired, but working/volunteering	9.8	5.4
Current job tenure in years, mean (SD)	--	14.0 (11.4)
Mean O*NET physical activity (SD)	46.6 (21.2)	44.8 (21.2)
Mean O*NET physical hazard exposure (SD)	26.8 (15.7)	25.2 (14.9)
Mean O*NET interpersonal stressors (SD)	55.1 (11.3)	56.2 (11.3)
Mean O*NET job demands (SD)	--	52.2 (8.2)
Mean O*NET job control (SD)	--	51.9 (16.2)
Mean self-report job demands (SD)[1]	--	28.1 (8.3)

Characteristic	Full sample (n=981)	Current worker sub-sample for job strain analyses (n=435)
Mean self-report job control (SD)[2]	--	71.1 (15.8)
Job strain quadrant (% distribution)		
Low strain jobs	--	24.1
Active jobs	--	22.5
Passive jobs	--	25.6
High strain jobs	--	28.0
Body Mass Index (% distribution)		
<25 kg/m^2	23.5	25.3
25–29.9 kg/m^2	39.7	37.5
30–39.9 kg/m^2	32.3	31.3
>=40 kg/m^2	4.6	6.0
Smoking status (% distribution)		
Never smoker	52.4	51.7
Former smoker	36.1	34.5
Current smoker	11.5	13.8
Mean pack-years among ever smokers (SD)[3]	17.4 (19.0)	15.2 (16.0)
Percent restless sleep >1 day/week	41.6	41.6
Telomere length (T/S ratio)		
10th percentile	0.634	0.663
25th percentile	0.719	0.758
50th percentile	0.832	0.872
75th percentile	0.952	0.994
90th percentile	1.092	1.123
mean (SD)	0.845 (0.176)	0.885 (0.181)

[1] Range from 12 to 48.

[2] Range from 24 to 96.

[3] Mean pack years was calculated only for current and former smokers.

TABLE 2

Mean difference in telomere length (T/S ratio) associated with current employment status, occupational category, and a 1-standard-deviation difference in three O*NET characteristics after adjustments for sets of covariates (n=981).

	Model 1: Main effect			Model 2: Main effect + Age interaction			Model 3: Main effect + Age interaction + other covariates		
Occupational characteristics	**Mean difference**	**(95% Confidence Interval)**	**p-value**	**Mean difference**	**(95% Confidence Interval)**	**p-value**	**Mean difference**	**(95% Confidence Interval)**	**p-value**
Age	−0.0055	(−0.0070, −0.0040)	<0.001	−0.0050	(−0.0076, −0.0025)	<0.001	−0.0052	(−0.0077, −0.0026)	<0.001
Current employment status			0.934			0.985			0.928
Working full-time	Reference			Reference			Reference		
Working part-time	0.0107	(−0.0329, 0.0543)		−0.0048	(−0.0545, 0.0448)		−0.0115	(−0.0609, 0.0380)	
On-leave or unemployed	−0.0121	(−0.0597, 0.0355)		−0.0051	(−0.0743, 0.0641)		−0.0026	(−0.0673, 0.0725)	
Retired, not working/homemaker	−0.0004	(−0.0316, 0.0309)		−0.0051	(−0.0381, 0.0279)		−0.090	(−0.0429, 0.0249)	
Retired, working or volunteering	0.0099	(−0.0340, 0.0538)		0.0126	(−0.0498, 0.0750)		0.0157	(−0.0464, 0.0778)	
Age by employment interaction						0.689			0.430
Age*Working full time				Reference			Reference		
Age*Working part time				−0.0036	(−0.0089, 0.0016)		−0.0046	(−0.0098, 0.0006)	
Age*On-leave or unemployed				0.0009	(−0.0062, 0.0080)		0.0009	(−0.0062, 0.0080)	
Age*Retired, not working/homemaker				−0.0002	(−0.0035, 0.0032)		0.0002	(−0.0032, 0.0036)	
Age*Retired, working or volunteering				−0.0011	(−0.0071, 0.0048)		−0.0008	(−0.0067, 0.0051)	
Age	−0.0055	(−0.0066, −0.0044)	<0.001	−0.0059	(−0.0090, −0.0028)	<0.001	−0.0059	(−0.0090, −0.0026)	<0.001
Occupational Category			0.658			0.637			0.758
Management	Reference			Reference			Reference		
Professional	−0.0252	(−0.0652, 0.0147)		−0.0251	(−0.0654, 0.0152)		−0.0207	(−0.0613, 0.0199)	
Service	−0.0205	(−0.0610, 0.0200)		−0.0236	(−0.0645, 0.0174)		−0.0296	(−0.0739, 0.0147)	
Sales, Office, admin support	−0.0074	(−0.0480, 0.0333)		−0.0085	(−0.0496, 0.0325)		−0.0185	(−0.0610, 0.0240)	
Blue-collar	−0.0085	(−0.0485, 0.0315)		−0.0098	(−0.0505, 0.0308)		−0.0188	(−0.0637, 0.0262)	
Age by occupational category interaction						0.775			0.845
Age*Management				Reference			Reference		
Age*Professional				0.0012	(−0.0027, 0.0051)		0.0008	(−0.0031, 0.0047)	
Age*Service				−0.0009	(−0.0049, 0.0031)		−0.0009	(−0.0048, 0.0031)	
Age*Sales/Office				0.0008	(−0.0030, 0.0047)		0.0004	(−0.0034, 0.0042)	
Age*Blue-collar				0.0006	(−0.0033, 0.0045)		0.0010	(−0.0029, 0.0048)	

Occupational characteristics	Model 1: Main effect			Model 2: Main effect + Age interaction			Model 3: Main effect + Age interaction + other covariates		
	Mean difference	(95% Confidence Interval)	p-value	Mean difference	(95% Confidence Interval)	p-value	Mean difference	(95% Confidence Interval)	p-value
Age	−0.0053	(−0.0064, −0.0042)	<0.001	−0.0053	(−0.0064, −0.0042)	<0.001	−0.0055	(−0.0070, −0.0040)	<0.001
O*NET Physical activity on the job	−0.0019	(−0.0134, 0.0096)	0.751	−0.0020	(−0.0135, 0.0095)	0.816	−0.0007	(−0.0169, 0.0155)	0.933
Age* O*NET Physical activity on the job				0.0006	(−0.0005, 0.0018)	0.163	0.0006	(−0.0006, 0.0017)	0.315
Age	−0.0053	(−0.0064, −0.0042)	<0.001	−0.0053	(−0.0064, −0.0042)	<0.001	−0.0054	(−0.0070, −0.0039)	<0.001
O*NET Physical hazard exposure	0.0085	(−0.0034, 0.0205)	0.162	0.0080	(−0.0040, 0.0199)	0.192	0.0105	(−0.0053, 0.0262)	0.192
Age* O*NET physical hazard exposure				0.0010	(0.0003, 0.0022)	0.125	0.0009	(−0.0003, 0.0021)	0.163
Age	−0.0053	(−0.0064, −0.0042)	<0.001	−0.0053	(−0.0064, −0.0041)	<0.001	−0.0055	(−0.0071, −0.0040)	<0.001
O*NET Interpersonal stressor exposure	−0.0007	(−0.0121, 0.0107)	0.909	−0.0007	(−0.0121, 0.0107)	0.902	0.0029	(−0.0099, 0.0156)	0.659
Age * O*NET Interpersonal stressor exposure				−0.0001	(−0.0013, 0.0011)	0.881	−0.0003	(−0.0014, 0.0009)	0.665

Notes: Each occupational characteristic was examined separately. Models 1 and 2 were adjusted for age, sex, race, as well as age by sex and age by race interactions. Model 3 had additional covariates of household income, education, nativity, current smoking status, pack-years, BMI, and sleep quality. In addition, for current employment models, occupational category was adjusted, and for occupational category models, current employment was adjusted for. Both variables were included in the three O*NET characteristic models. Age was centered around the sample mean, and the O*NET variables were standardized to facilitate the interpretation of the regression coefficients. The mean differences for age and age interaction were estimated for one year of aging.

Table 3

Mean difference in telomere length (T/S ratio) associated with job strain quadrant and a 1-standard-deviation difference in job control and job demands among current workers (n=435).

	Model 1: Main effect			Model 2: Main effect + Age interaction			Model 3: Main effect + Age interaction + other covariates		
Occupational characteristics	**Mean difference**	**(95% CI)**	**p-value**	**Mean difference**	**(95% CI)**	**p-value**	**Mean difference**	**(95% CI)**	**p-value**
Age	−0.0044	(−0.0068, −0.0020)	0.003	−0.0076	(−0.0115, −0.0038)	0.001	−0.0101	(−0.0143, −0.0058)	<0.001
Job strain quadrant (self-report)			0.934			0.254			0.456
Low strain jobs	Reference			Reference			Reference		
High strain jobs	0.0034	(−0.0433, 0.0501)		0.0130	(−0.0508, 0.0767)		0.0142	(−0.0513, 0.0797)	
Active jobs	0.0099	(−0.0379, 0.0578)		0.0168	(−0.0445, 0.0781)		0.0330	(−0.0299, 0.0959)	
Passive jobs	0.0142	(−0.0322, 0.0606)		0.0557	(0.0008, 0.1106)		0.0442	(−0.0138, 0.1021)	
Age by job strain (self-report)						0.063			0.096
Age*Low strain jobs				Reference			Reference		
Age*High strain jobs				0.0027	(−0.0040, 0.0093)		0.0033	(−0.0034, 0.0099)	
Age*Active jobs				0.0026	(−0.0037, 0.0088)		0.0037	(−0.0027, 0.0101)	
Age*Passive jobs				0.0078	(0.0021, 0.0136)		0.0073	(0.0016, 0.0130)	
Age	−0.0047	(−0.0069, −0.0022)	0.001	−0.0047	(−0.0071, −0.0023)	0.001	−0.0065	(−0.0092, −0.0038)	<0.001
Job control (self-report)	−0.0029	(−0.0201, 0.0147)	0.741	−0.0137	(−0.0352, 0.0077)	0.210	−0.0043	(−0.0275, 0.0189)	0.715
Job demands (self-report)	−0.0089	(−0.0262, 0.0085)	0.315	−0.0083	(−0.0298, 0.0133)	0.452	0.0057	(−0.0172, 0.0285)	0.626
Age* Job control (self-report)				−0.0019	(−0.0041, 0.0003)	0.097	−0.0020	(−0.0042, 0.0002)	0.078
Age* Job demands (self-report)				−0.0001	(−0.0022, 0.0023)	0.966	0.0010	(−0.0013, 0.0034)	0.397
Age	−0.0043	(−0.0067, −0.0019)	0.005	−0.0040	(−0.0064, −0.0016)	0.001	−0.0063	(−0.0090, −0.0035)	<0.001
O*NET Job control	−0.0004	(−0.0197, 0.0189)	0.970	−0.0088	(−0.0319, 0.0143)	0.455	0.0199	(−0.0093, 0.0491)	0.182
O*NET Job demands	0.0051	(−0.0130, 0.0232)	0.583	0.0203	(−0.0030, 0.0446)	0.088	0.0217	(−0.0018, 0.0452)	0.071
Age*O*NET Job Control				−0.0016	(−0.0040, 0.0008)	0.188	−0.0013	(−0.0037, 0.0011)	0.281
Age* O*NET Job demands				0.0026	(0.0001, 0.0050)	0.041	0.0022	(−0.0002, 0.0047)	0.078

Notes: Self-reported job strain, job control and job demands, and O*NET job control and O/NET job control were examined separately. Models 1 and 2 were adjusted for age, sex, race, as well as age by sex and age by race interactions. Model 3 had additional covariates of household income, education, job tenure, nativity, occupational category, current smoking status, pack-years, BMI, and sleep quality. Age was centered around the sample mean, and the O*NET variables were standardized to facilitate the interpretation of the regression coefficients. The mean differences for age and age interaction were estimated for one year of aging.