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The Association Between Lipoproteins, Disability, and Physical Function Among Older Costa Rican Adults

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Abstract

Objective—To examine the relationship between total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) with disability and physical performance.

Method—Wave 1 data were from Costa Rican Longevity and Healthy Aging Study ($n = 2,827$). Lipoprotein profiles were measured using blood samples. Disability and physical functioning were measured with activities of daily living/instrumental activities of daily living (ADLs/IADLs) and objective assessment of physical performance.

Results—Lower HDL-C was associated with greater ADL disability, and lower TC with longer time to pick-a-pencil and Time-Up-Go (TUG) test. Age interacted between (a) TG and lung function, chair stands, and pick-a-pencil, and (b) HDL-C and TUG. Stratification showed lower TG and longer time picking up a pencil only for those above 84 years. Based on significant interactions with sex, lower TC was associated with slower chair stand time in women and higher HDL-C with slower chair stand time in men.

Discussion—Lower levels of lipoproteins may suggest worse physical function, but the association may differ by sex.

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Author Contributions

Marianne Chanti-Ketterl: concept and design, analysis and interpretation of data, and preparation of article; Alyssa Gamaldo: interpretation of data and preparation of article; Ross Anel: interpretation of data and preparation of article; Roland J. Thorpe: interpretation of data and preparation of article.

Authors' Note

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Declaration of Conflicting Interests

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Keywords

Hispanics; biomarkers; frailty; Latin America

Introduction

Physical function reflects the health status and the impact of chronic diseases, and is a crucial determinant of quality of life, affecting strength and mobility, as well as instrumental and basic activities of daily living (IADLs/ADLs) among older adults (den Ouden, Schuurmans, Arts, & van der Schouw, 2011; Idland, Pettersen, Avlund, & Bergland, 2013; Paterson & Warburton, 2010; Seals & Melov, 2014; Tak, Kuiper, Chorus, & Hopman-Rock, 2013). Cardiovascular disease (CVD) is an important contributor to disease burden and decreased quality of life, as it is often accompanied by limitation in functional abilities (Canavan et al., 2014; Giltay, Zitman, & Kromhout, 2008; Scott & Collings, 2012). Disruption in lipoproteins such as total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) are influential factors for atherosclerosis, subsequent complications such as CVD (Libby, 2012; Libby, Ridker, & Maseri, 2002; Perk et al., 2012) and, in turn, functional decline (van Peet et al., 2013; Welmer et al., 2014). The link between lipoprotein levels and physical function has been established in previous studies (Canavan et al., 2014; Cesari et al., 2010; Formiga et al., 2011; Giampaoli et al., 1999; Giltay et al., 2008; Guo, Matousek, Sundh, & Steen, 2002; Landi et al., 2007; Lawman et al., 2016; Lippi, Sanchis-Gomar, & Montagnana, 2014; Okamura et al., 2008; Reuben, Ix, Greendale, & Seeman, 1999; Sanders et al., 2014; Schalk, Visser, Deeg, & Bouter, 2004; Volpato et al., 2008; Welmer et al., 2014; Zuliani et al., 1999). However, only few have looked at these associations by sex (Guo et al., 2002; Schalk et al., 2004; Volpato et al., 2008), and no study has examined this association within a Hispanic subculture.

Although prior studies have observed a relationship between lipoproteins levels and physical functioning within older adults, the pattern of these relationships have been mixed. Studies examining disability (ADLs/IADLs) have generally observed associations between low levels of TC (Welmer et al., 2014; Zuliani et al., 1999), LDL-C (Zuliani et al., 1999), and HDL-C (Cesari et al., 2010; Formiga et al., 2011; Giampaoli et al., 1999; Landi et al., 2007; Zuliani et al., 1999), with worse ADLs/IADLs. A similar pattern has been observed in studies addressing physical performance. Lower levels of TC (Chio et al., 2009; Sanders et al., 2014; Schalk et al., 2004), LDL-C (Lawman et al., 2016), triglycerides (TG; Chio et al., 2009; Lawman et al., 2016), and HDL-C (Cesari et al., 2010; Chio et al., 2009; Landi et al., 2007; Lawman et al., 2016; Volpato et al., 2008) were significantly linked with worse physical performance (e.g., walking speed, chair stand test, grip, and lung function). However, high TC has also been found associated with disability (e.g., functional dependence ADL/ IADL performance; Welmer et al., 2014). Discrepancy in these outcomes may be associated with study design differences. Furthermore, the relationship between lipoproteins and physical function seem to vary by sex. As individuals get older, sex disparities in disability rates appear to widen (Gorman & Read, 2006). Women are known to experience more disability and physical function decline than men (Ferrucci et al., 2000;

Newman & Brach, 2001; Okoro et al., 2009; Schiller, Lucas, Ward, & Peregoy, 2012), a trend replicated in Hispanic samples (Palloni, Pinto-Aguirre, & Pelaez, 2002; Zunzunegui, Alvarado, Beland, & Vissandjee, 2009). Specifically, high TG and low levels of HDL-C have been associated with poor physical performance, especially among aging women (Guo et al., 2002).

Despite these important findings, no study has examined the association between serum lipoproteins and physical functioning within a Hispanic subculture. With Latin American countries aging faster than North American or European countries (Palloni et al., 2002), it is extremely important to understand the factors affecting physical function within the Latin American subcultures. Specifically, Costa Ricans have never been explored in this respect despite that 11.5% of the country's population is expected to surpass 65 years of age by the year 2025 (*I Informe estado de situación de la persona adulta mayor en Costa Rica*, 2008). Therefore, building on previous research, the purpose of this cross-sectional study was to examine whether measures of TC, TG, and HDL-C would be associated with physical function above and beyond demographics, cardiovascular risk factors (CVRFs) and important chronic health conditions in older Costa Ricans. Sex and age interactions with individual lipoproteins were also analyzed, and stratification was performed for significant interactions. We further explored nonlinear associations between each lipoprotein and outcome.

Method

The Costa Rican Longevity and Healthy Aging Study (CRELES) is an observational nationally representative sample of adults above the age of 60 residing in Costa Rica. All individuals consented, and completed in-person interviews in their residence. Participants self-reported medical history, psychosocial questionnaires, and most consented to biomarker, anthropometric measures, and physical functionality tests. A total of 2,827 were enrolled in Wave 1 between November 2004 and September 2006 (Rosero-Bixby, Fernandez, & Dow, 2010a). We excluded a total of 150 participants whose descriptive variables (e.g., age, education) were missing from the data set obtained. In this study, 2,677 older adults with physical function data were included in the analysis. The "Committee on Science and Ethics" of the University of Costa Rica approved the CRELES study in session reference VI-763-CEC-23-|-04.

Physical function is defined here according to the World Health Organization and the International Classification of Functioning (*How to Use the ICF: A Practical Manual for Using the International Classification of Functioning, Disability and Health [ICF]. Exposure Draft for Comment*, 2013) as a global term that encompasses disability and functioning. Disability was defined as activity limitations and/or restrictions measured with limitations in ADLs/IADLs. Self-reported disability was measured using ADLs (walking, bathing, eating, going to bed, using the toilet, and grooming; Abizanda et al., 2011) and IADLs (preparing food, managing money, shopping, and managing medications; Abizanda et al., 2011). Scores for each ADL/IADL were categorized as 0 = *does not need help*, 1 = *has difficulty but can do it without help*, 2 = *has difficulty and needs help*, and 3 = *cannot do the activity*. The scores for each ADL/IADL were summed to create a total ADL and total IADL score. The

ADL total scores could range from 0 to 20 and IADL total scores could range from 0 to 24, with higher scores reflecting more disability.

Physical performance was assessed through six functional tests (Buchman et al., 2008; de Souza Santos, Dantas, & Moreira, 2011; Rikli & Jones, 2013; Rosero-Bixby et al., 2010a; Sillanpaa et al., 2014; Wharton et al., 2009): (a) grip strength, a performance-based measure using a Creative Health Products dynamometer (model T-18; maximum strength in the dominant hand across two measures taken in kilograms), scores ranged from 4 to 54 kg, with higher scores reflecting better grip function and/or upper body strength. (b) Lung function was estimated by three consecutive peak breathing flow measurements recorded in liters per minute with a Mini-Wright type meter, the maximum peak flow measure was used; scores ranged from 40 to 730 L/min. If participants reported no difficulty completing a mobility and flexibility test (designed to measure lower body strength), measures were obtained. (c) Equilibrium/balance was assessed by asking the participant to remain standing with feet together for 10 s, variable ranged from 1 to 10 s. Less seconds standing reflected more limitation. (d) In chair stand test (a measure of lower body strength), the participant was asked to stand up five times from a sitting position with arms crossed on the chest as quickly as possible (range within the sample = 2–45 s). (e) If the participant did not have a cataract or other retinal procedure in the 6 weeks prior to test, agility was assessed by asking the participant to bend down and pick up a pencil from the floor and to assume the starting position. If they were unable to complete the task in less than 30 s, the test was discontinued; scores ranged between 1 and 21 s. Walking speed or the Time-Up-Go (TUG) test (Castanho et al., 2016) was measured by asking the participant to rise from a chair (from a sitting position) and walk a distance of 3 m at normal walking speed. The speed was recorded with a chronometer in seconds; scores ranged from 1 to 41 s.

Lipoproteins were collected after a 14-hr fasting period in participants' homes by venipuncture, normally the day after the main interview, and sent immediately to the participant laboratories for analysis. Specific protocol for laboratory can be found elsewhere (Rosero-Bixby et al., 2010a). This analysis does not include LDL-C as this variable in the data is derived from a calculation of the TC values, thus the findings would essentially be the same.

Covariates included (a) demographics (i.e., age, sex, highest year of education achieved, perceived economic situation, and body mass index [BMI] calculated as kg/m^2), (b) CVRFs (i.e., hypertension or taking antihypertensive and/or diuretic medication, antihyperlipidemics, glycosylated hemoglobin [HbA1c], smoking status, and self-report exercise), and (c) chronic health conditions, which were self-reported as part of the interview, included heart disease, stroke, arthritis, osteoporosis, pulmonary pathology (respiratory disease or chronic pulmonary disease), cancer, psychiatric conditions (e.g., depression), insomnia, and severe cognitive disability (if participant scored ≥ 11 items incorrectly of a short modified Spanish version of the Mini-Mental State Exam (MMSE) with a maximum of 15 points). Specific documentation of each covariate can be found elsewhere (Rosero-Bixby & Dow, 2009).

Statistical Analyses

Categorical variables were analyzed using Pearson chi-square test, and continuous variables were compared using the *t* test and reported as means with standard deviation (*SD*). Class-level variables stratified by sex were analyzed with ANOVA procedure. Weighted multivariate multiple regression models were used to examine the cross-sectional association between lipoproteins, disability, and physical function while adjusting for demographics, CVRFs, and comorbidity. Outcomes were analyzed separately for each lipoprotein. All lipoproteins were centered for the statistical analyses. Although regressions were adjusted for age, sex, area of residence, and education, sampling weights were applied to obtain representative estimates in the population (weights description can be found elsewhere; Rosero-Bixby et al., 2010b). To consider the possibility of effects differing by age or sex, interaction terms were included in the regressions as follows: (a) the first regression equation tested each separate lipoprotein, an interaction term for the lipoprotein with age and adjusted for demographics, CVRFs, and comorbidity; and (b) in the second equation, the interaction term was with sex. Age stratification was done using quartiles with the following age range: Q1 = 60–68, Q2 = 69–75, Q3 = 76–83, Q4 = 84–110.

Statistical significant findings from the regression models at the $p < .01$ level were stratified accordingly. Age stratification was performed based on age quartiles. We used the G*Power software (Faul, Erdfelder, Buchner, & Lang, 2009) to calculate power achieved in the regression analyses. We found that even in the stratified, fully adjusted regression models, there was sufficient power to observe even small effects as statistically significant. In addition, a quadratic term for each independent lipoprotein was included in each model to determine any nonlinear effects with each outcome measure. All reported statistics are double sided and with alpha = .01 overall to reduce Type-I error and all betas (β) are standardized. All statistical analyses were performed using SAS, version 9.4 (SAS Institute, Inc., Cary, NC).

Results

Sample characteristics are presented in Table 1. The mean age was 70.5 (range = 60–110 years), with 4th grade of elementary school being the average grade completed. When asked to rate their perceived economic situation, men rated their situation worse than women ($p < .001$). The mean BMI for the sample was 26.8, but there was a statistically significant difference with women having slightly higher BMI than men ($p < .001$). Women also had significantly higher TC and HDL-C than men ($ps < .001$), smoked and exercised significantly less ($ps < .001$). Women self-reported more hypertension and taking more hypertensive and diuretic medication than men ($ps < .001$). Men reported more hypercholesterolemia than women ($p < .001$), but women used more antilipidemic medication than men ($p < .001$). More women were diagnosed diabetic and/or had higher HbA1c levels than men ($p < .001$). With the exception of myocardial infarctions, women had overall more comorbidity than men ($ps < .001$). Table 2 displays the disability and functional measures for the sample by sex. Overall, women had more ADL disability, less grip strength, performed worse in lung function, and took longer to complete the chair stand test,

pick up a pencil, and the TUG test than men ($p < .001$). But there were no significant differences in IADLs ($p = .057$) or the time it took to stand up ($p = .840$).

Weighted Multivariate Multiple Regressions

The significant associations between lipoproteins and the outcomes of interest were as follows: (a) Lower HDL-C levels were associated with more ADL disability ($\beta = -.06$, $SE = 0.13$, $p = .008$), (b) lower TC was associated with longer times to pick up a pencil ($\beta = -.08$, $SE = 0.02$, $p = .002$), and (c) lower TC was associated with more difficulty in TUG ($\beta = -.09$, $SE = 0.04$, $p < .001$). No other lipoprotein was significantly associated with IADL disability, grip strength, lung function, standing up, or the chair stand test.

Age and Sex Interactions

Table 3 shows the age interactions for each outcome with the individual lipoproteins. Four age interactions were found with the following lipoproteins: (a) higher TG and better lung function ($p = .007$), (b) lower TG and longer times in the chair stand test ($p = .005$) and pick up a pencil ($p = .009$), and (c) higher HDL-C and longer time to complete TUG ($p = .001$). Table 4 presents the sex interactions. There were sex interactions between lower TC ($p < .001$) and lower HDL-C ($p = .008$) with longer time to complete the chair stand test. No other age or sex interaction was significant at the $p < .01$ level.

Stratified Analyses

Age and sex stratification are shown in Table 5. We only found a significant association between lower levels of TG and longer time to complete the pick-a-pencil task ($p = .007$) for those in the highest quartile, ages 84 to 110. Sex stratification for the chair stand test showed that the association with the lipoproteins differs by sex. Lower levels of TC were associated with longer chair stands only among women ($p < .001$) and higher levels of HDL-C were linked with longer chair stand time only among men ($p = .001$).

Quadratic Evaluation of Lipoproteins

We found a significant quadratic effect between higher TG and more IADL disability ($\beta = .07$, $SE = 0.01$, $p = .007$). There were no other statistically significant quadratic effects of other lipoproteins at the $p < .01$ level for (a) ADLs, (b) grip strength, (c) lung function, (d) standing, (e) chair stand test, (f) pick-a-pencil, and (g) TUG.

Discussion

Using a representative sample of adults 60+ years of age participating in the CRELES study, we examined TC, TG, and HDL-C in relation to physical function assessed as disability and performance measures while taking into account demographics, CVRFs, and comorbidity. This study represents the first look at this association in a Hispanic population. After adjusting for all covariates, we found lower HDL-C related to greater ADL disability and lower TC associated with longer times to pick up a pencil and the TUG measure. Our results confirm findings reported by several studies using populations ethnically different from ours (Canavan et al., 2014; Cesari et al., 2010; Landi et al., 2007; Okamura et al., 2008; Schalk et al., 2004; Zuliani et al., 1999).

Using a sample of older adults from Ireland, Canavan and colleagues (2014) observed that those older with lower levels of HDL-C had more functional loss even after full adjustment for demographics, CVRFs, and comorbidity (Canavan et al., 2014). Like Canavan and colleagues', our study adjusted for similar covariates and the associations also remained significant; however, we used a continuous scale for ADLs/IADLs whereas they used a dichotomous variable. Like other studies, we observed lower level of HDL-C associated with more disability. Among older Italian adults, significantly worse ADLs/IADLs were also observed with low HDL-C levels than with normal HDL-C levels (Cesari et al., 2010). Moreover, Landi and colleagues (2007) examined older adults from the Aging and Longevity in the Sirente geographic area (iLSIRENTE) study in central Italy, and found normal HDL-C levels at baseline associated with higher ADL/IADL scores in unadjusted models. In an earlier longitudinal study, Zuliani and colleagues (1999) studied 344 institutionalized older adults from northern Italy (not community dwelling), and found lower TC and HDL-C levels in the high disability group compared with those with low or mild disability. More recently, Formiga et al. (2011) found normal baseline HDL-C linked with better ADL performance among nonagenarians in Spain. However, inconsistent with these prior findings, Welmer and colleagues (2014) observed that older, community-dwelling Chinese with high TC had more functional dependence. But, their observed association was no longer significant after adjusting for demographics and CVRFs ($p = .087$).

Unlike other studies, we did not find significant associations between any other lipoprotein and disability. Longitudinal studies have observed associations between low TC and more disability. Reuben and colleagues investigated the effects of albumin and TC in community-living older adults and observed that low TC levels over a 3- and 7-year period increased the risk of functional decline measured with the Rosow-Breslau functional status score (Reuben et al., 1999). A 12-year cohort study among Japanese 60 to 74 years of age, also found that those with impaired ADLs had lower TC levels ($p = .030$; Okamura et al., 2008). However, it is important to note that our p value was set to less than .01 whereas most studies maintained it at less than .05.

In physical performance measures, our results show that particularly low levels of TC are indicative of decrease lower body function ability. Lower TC was associated with longer times to pick up a pencil from the floor and the TUG test. We were unable to find studies in the literature that also reported these lipoproteins in relation to the physical performance tests we used; most only focused on HDL-C. Studies have found higher HDL-C levels associated with faster walking speed (Cesari et al., 2010; Volpato et al., 2008) and better physical performance even after adjustments on the 4-m walk test (Landi et al., 2007). Unfortunately, when looking at physical performance measures, not all available studies in this area have used standardized tests for physical function in older adults (Rikli & Jones, 2013); therefore, a lack of adequate cross-study comparisons exist.

In this study, we further evaluated whether any of the statistical significant regressions were dependent on age or sex. We found that four associations were dependent on age: (a) higher TG and better lung function, (b) lower TG and longer times in the chair stands, (c) lower TG and longer time picking up a pencil, and (d) higher HDL-C and longer time to complete the TUG. Furthermore, age stratification showed that lower TG and longer times to pick up a

pencil were only significant among the oldest old in our sample (ages = 84–110). Although our study did not show significant associations between lipoproteins and lung function, we found age mediating the association between higher TG and better lung function. Although using a different population and not doing age interactions, an Italian study including 658 patients with amyotrophic lateral sclerosis (ALS), also observed significantly higher TG on those with better lung function (Chio et al., 2009). Considering the inconsistent observations, further studies are needed.

Our results also show a sex interaction in those with lower TC and lower HDL-C and longer times to complete the chair stands. However, we observed that the results were sex dependent presenting two very distinct patterns. In women, lower levels of TC appeared to be associated with more difficulty with lower body function (e.g., chair stands); whereas, in men it was higher HDL-C, the lipoprotein more indicative for lower body function (e.g., chair stand test). In the Longitudinal Aging Study Amsterdam (LASA), Schalk et al. (2004) also found lower TC associated with a decline in functional status in women even after adjustment for life style (OR = 2.38; 95% CI = [1.05, 5.42]) and disease-related factors (OR = 2.50; 95% CI = [1.07, 5.84]). However, unlike us, they found that men with lower TC were three times more likely to decline in functional performance compared with men with higher levels (OR = 3.00; 95% CI = [1.00, 8.97]; Schalk et al., 2004).

We did not observe any associations on age and/or sex interactions between lipoproteins and grip function. But results vary between reported studies (Giampaoli et al., 1999; Lawman et al., 2016; Sanders et al., 2014). Similar to our findings, a study among older nondisabled men from the Finland, Italy, Netherlands Elderly (FINE) study found TC not significantly associated with grip strength (Giampaoli et al., 1999). Sanders and colleagues (2014) found that only among men, a decrease in TC was associated with decreased grip strength. In a recent study using data from the National Health and Nutrition Examination Survey, higher levels of HDL-C and lower levels of TG were associated with increased handgrip strength among adults above the age of 20 in the United States (Lawman et al., 2016); however, when the study controlled for BMI, higher TC was associated with better grip strength only among men ($t = 3.96$, $p < .01$; Lawman et al., 2016).

No additional associations were observed between lipoproteins and physical function in this study. Despite multiple unique features of the CRELES study, this study is not without limitations. First, given the nature of the study, generalization of results outside Costa Rica may be limited. In addition, lipoprotein levels may be reflective of dietary patterns not accounted for in this analysis. Low levels of some of these lipoproteins have been related to nutritional deficiencies, poor health, and were found to be predictive of mortality in older adults (Akerblom et al., 2008; Cabrera, de Andrade, & Dip, 2012). Furthermore, many of the variables used in the analysis are self-reported, thus presenting the potential for recall bias. Moreover, 25% of the participants were represented by proxies, which may have affected results via inaccurate reporting. Finally, this study was cross-sectional and does not examine how potential age-related changes in lipoproteins may influence changes in physical function or risk of disability. Longitudinal research with the CRELES or other data is needed to explore these associations within Hispanic populations.

In conclusion, we primarily observed an association between lower levels of HDL-C and more disability and lower TC and worse lower body physical function among older Costa Rican adults. However, some of the specific types of disability and/or functional limitations were dependent on age and/or sex and some looked different among men compared with women. Among men, but not among women, high levels of TC were associated with worse lower functional limitations (e.g., chair stands); whereas among women, but not among men, low levels of HDL-C was associated with worse lower body performance. Future studies should explore these associations with length of follow-up and sensitivity of measurement in mind. Considering race/ethnicity in the investigation of the association between lipoproteins and physical function may also be important. Future studies should also strive to determine whether lower lipoproteins are indicative of poor physical function among older Hispanics of different countries and whether the association differs by sex. As the demographic shift toward longer life expectancy becomes more evident, discovering ways to prevent or postpone disability and/or functional decline becomes imperative. Lipoproteins may become accessible biomarkers indicative of functional health for aging cohorts and perhaps help decrease health care burden by slowing functional decline for future aging populations.

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Table 1

Weighted Characteristics of Participants by Sex

	Total Sample (N=2677) 100%	Men (n=1227) 46%	Women (n=1450) 54%	p- value
Mean Age	70.5	70.1	70.8	.021
Mean Education	4.0	4.1	4.0	.276
Current Economic Situation (%)				
Excellent	3.6	3.7	3.6	
Very Good	6.7	6.8	6.7	
Good	31.1	27.5	34.3	
Average/Normal	44.5	46.1	43.0	
Poor	14.1	15.9	12.4	<.001
Body Mass Index (kg/m ²)	26.8	26.0	27.6	<.001
Mean Lipoprotein Levels mmol/l				
Total Cholesterol	5.6	5.3	5.8	<.001
Triglycerides	1.9	1.8	1.9	.093
High-density lipoprotein cholesterol	1.1	1.1	1.2	<.001
Cardiovascular Risk Factors				
Mean Systolic Blood Pressure mmHg	144.3	143.5	145.0	.110
Mean Diastolic Blood Pressure mmHg	83.8	83.4	84.1	.105
Have Hypertension %	60.1	55.9	63.9	<.001
Taking Medications for Hypertension %	43.8	37.6	49.5	<.001
Taking Diuretics %	21.4	18.2	24.2	<.001
Hypercholesterolemia %	60.4	67.9	53.5	<.001
Taking Medication for Hypercholesterolemia %	21.4	18.3	24.2	<.001
Diabetics	25.6	20.9	30.0	<.001
Glycated Hemoglobin (HbA1c)	5.8	5.7	6.0	<.001
Exercise %	31.4	40.4	23.2	<.001
Smoking %				
Current Smoker	33.4	51.4	16.9	
Previous Smoker	10.1	16.8	4.0	
Never Smoked	56.5	31.7	79.1	<.001
Other Health Conditions %				
Stroke	3.8	3.5	4.1	<.001
Myocardial Infarction	4.6	5.7	3.7	<.001
Pulmonary Problems	13.8	11.2	16.3	<.001
Cancer	5.8	4.7	6.9	<.001
Arthritis	14.5	9.5	19.0	<.001
Osteoporosis	9.6	2.0	16.5	<.001
Psychiatric (nervous problems)	19.4	12.9	23.4	<.001
Insomnia	41.1	32.8	48.8	<.001
Cognitive Disability (n) %	11.0	9.5	12.4	<.001

Table 2**Disability and Physical Function Measures by Sex**

	Measurement Range	Total Sample (N=2677)	Men (n=1227)	Women (n=1450)	54.2%	p-value
ADL	0–20	1.7	1.4	1.9	<.001	
IADL	0–24	1.2	1.1	1.3	.057	
Grip Strength (Wharton et al.)	4–54	24.7	30.6	19.2	<.001	
Lung Function in L/m	40–730	302.8	366.7	242.6	<.001	
Stand-Up (seconds)	1–10	10.0	10.0	10.0	.840	
Stand-Up No Arms/Chair Stand test (seconds)	2–45	12.7	11.9	13.5	<.001	
Pick-a-pencil (seconds)	1–21	1.6	1.5	1.8	<.001	
TUG (seconds)	1–41	5.0	4.6	5.4	<.001	

Note: ADL=Activities of Daily Living, IADL=Instrumental Activity of Daily Living; TUG= time-up-go test. L/m=liters per minute

Table 3
Weighted Multivariate Multiple Regression Models for Outcomes and Lipoproteins with Age Interaction

	ADL Disability			IADL Disability			Grip Strength			Lung Function (L/m)		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
TC	-.06	0.38	.057	-.04	0.04		.158	0.01	.15	.799	0.05	2.48 .068
Age	0.14	0.05	<.001	0.17	0.005		<.001	-.025	0.02	<.001	-.023	0.32 <.001
TC*Age	-.01	0.005	.629	-.02	0.004		.431	-.01	0.01	.746	0.06	0.23 .027
TG	-.01	0.06	.813	-.04	0.05		.124	0.01	0.20	.661	0.05	3.26 .097
Age	0.14	0.005	<.001	0.18	0.005		<.001	-.025	0.02	<.001	-.023	0.32 <.001
TG*Age	-.02	0.005	.537	-.06	0.005		.036	0.03	0.02	.199	0.08	0.28 .007
HDL-C	-.03	0.17	.246	0.01	0.15		.574	-.01	0.57	.592	-.03	9.22 .253
Age	0.14	0.005	<.001	0.18	0.005		<.001	-.025	0.02	<.001	-.023	0.32 <.001
HDL-C*Age	0.04	0.02	.188	0.03	0.01		.221	-.01	0.05	.488	-.04	0.86 .107

	Stand-Up (sec)			Stand-Up No Arms/Chair Stand test (sec)			Pick-a-pencil (sec)			TUG (sec)		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
TC	-.03	0.01	.389	-.07	0.11		.054	-.012	0.03	.002	-.10	0.06 .003
Age	-.02	0.001	.493	0.28	0.01		<.001	0.24	0.004	<.001	0.28	0.01 <.001
TC*Age	-.001	0.001	.982	-.02	0.01		.593	-.05	0.003	.143	-.02	0.01 .543
TG	-.02	0.01	.601	-.07	0.13		.059	-.010	0.04	.010	-.01	0.08 0.830
Age	-.02	0.001	.511	0.28	0.01		<.001	0.25	0.004	<.001	0.28	0.01 <.001
TG*Age	0.002	0.001	.959	-.10	0.01		.005	-.10	0.003	.009	-.03	0.01 .392
HDL-C	-.04	0.02	.331	0.06	0.41		.074	0.08	0.11	.031	0.06	0.23 .06
Age	-.02	0.001	.532	0.28	0.01		<.001	0.24	0.004	<.001	0.28	0.01 <.001
HDL-C*Age	-.03	0.002	.406	0.02	0.04		.637	0.07	0.01	.047	0.11	0.02 .001

Note: β = Standardized beta coefficient. All lipoproteins and age are centered. ADL=Activities of Daily Living; IADL= Instrumental Activities of Daily Living; TUG= time-up-go test. Sec: seconds. TC=Total Cholesterol; TG=Triglycerides; HDL-C: High density lipoprotein cholesterol. Entries show: Standardized beta coefficient (β) with standard errors (SE) and (p) p-value. Model adjusting for age, sex, education, economic situation, Body Mass Index, Smoking, Exercise, Cholesterol Medications, Coronary Heart Disease, Stroke, Arthritis, Osteoporosis, Pulmonary disease, Cancer, Psychiatric problems, Insomnia and Cognitive Disability. Statistically Significant values at the <.01 level are bolded.

Table 4
Weighted Multivariate Multiple Regression Models for Outcomes and Lipoproteins with Sex Interaction

	ADL Disability			IADL Disability			Grip Strength			Lung Function (L/m)		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
TC	-0.06	0.11	.395	-0.09	0.10		0.11	0.35	.048	0.01	5.83	.798
Sex	0.02	0.10	.402	-0.04	0.09		-0.64	0.33	<.001	-0.51	5.41	<.001
TC*Sex	0.01	0.06	.846	0.07	0.06		-0.10	0.21	.064	-0.01	3.54	.881
TG	-0.04	0.12	.576	-0.02	0.11		-0.01	0.41	.823	-0.14	6.61	.019
Sex	0.01	0.10	.697	-0.05	0.09		-0.63	0.32	<.001	-0.51	5.29	<.001
TG*Sex	0.05	0.08	.478	0.02	0.07		-0.001	0.27	.975	0.13	4.20	.022
HDL-C	-0.13	0.42	.073	-0.14	0.38		0.03	1.39	.626	-0.01	22.85	.831
Sex	0.03	0.10	.270	-0.04	0.09		-0.63	0.33	<.001	-0.51	5.47	<.001
HDL-C*Sex	0.07	0.26	.303	0.14	0.23		-0.03	0.85	.856	0.01	13.90	.855

	Stand-Up (sec)			Stand-Up No Arms/Chair Stand test (sec)			Pick-a-pencil (sec)			TUG (sec)		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
TC	-0.12	0.01	.153	0.21	0.23		0.12	0.07	.134	0.07	0.14	.339
Sex	0.02	0.01	.455	0.18	0.21		0.14	0.06	<.001	0.14	0.13	<.001
TC*Sex	0.09	0.01	.267	-0.29	0.14		-0.21	0.04	.011	-0.17	0.08	.029
TG	-0.10	0.02	.206	0.07	0.84		0.04	0.07	.619	-0.07	0.16	.332
Sex	0.01	0.01	.657	0.17	0.26		0.12	0.06	<.001	0.12	0.12	<.001
TG*Sex	0.08	0.01	.298	-0.07	0.21		-0.06	0.05	.398	0.09	0.10	.209
HDL-C	0.01	0.06	.920	0.26	0.90		0.02	0.26	.786	-0.02	0.55	.809
Sex	0.02	0.01	.542	0.14	0.21		0.11	0.06	<.001	0.12	0.13	<.001
HDL-C*Sex	-0.02	0.04	.777	-0.21	0.55		0.005	0.16	.950	0.005	0.33	.944

Note: β = Standardized beta coefficient. All lipoproteins are centered. ADL=Activities of Daily Living; IADL= Instrumental Activities of Daily Living; TUG= time-up-go test. Sec: seconds. TC=Total Cholesterol; TG=Triglycerides; HDL-C: High density lipoprotein cholesterol. Entries show: Standardized beta coefficient (β) with standard errors (SE) and (p) p-value. Model adjusting for age, sex, education, economic situation, Body Mass Index, Smoking, Exercise, Cholesterol Medications, Coronary Heart Disease, Stroke, Arthritis, Osteoporosis, Pulmonary disease, Cancer, Psychiatric problems, Insomnia and Cognitive Disability. Statistically Significant values at the <.01 level are bolded.

Table 5

Weighted Multivariate Multiple Regression Models for Outcomes and Lipoproteins Stratified by Age and Sex for significant interactions

Age Stratification by Quartiles									
Lung Function (L/m)			Pick-a-pencil (sec)			Stand-Up No Arms/Chair Stand test (sec)			
	β	SE	p	β	SE	p	β	SE	p
TRIGLYCERIDES									
Q1: Age 60–68	–0.05	3.75	.172	–0.01	0.03	.841	0.04	0.12	.303
Q2: Age 69–75	0.02	4.58	.618	–0.003	0.06	.956	–0.01	0.17	.894
Q3: Age 76–83	0.08	4.92	.054	–0.06	0.07	.220	–0.05	0.23	.352
Q4: Age 84–110	0.09	4.22	.053	–0.19	0.12	.007	–0.16	0.34	.014
HDL-C									
TUG (sec)									
Q1: Age 60–68	–0.07	0.29	.108						
Q2: Age 69–75	0.05	0.23	.317						
Q3: Age 76–83	0.03	0.38	.520						
Q4: Age 84–110	0.09	0.74	.151						
Sex Stratification									
Stand-Up No Arms/Chair Stand test (sec)									
HDL-C									
Total Cholesterol									
Men	0.03	0.10	.338				0.12	0.40	.001
Women	–0.12	0.09	<.001				0.001	0.39	.982

Note: β = Standardized beta coefficient. TUG= time-up-go test. Sec= seconds. HDL-C: High density lipoprotein cholesterol. Entries show: Standardized beta coefficient (β) with standard errors (SE) and (p) p-value. Model adjusting for age, sex, education, economic situation, Body Mass Index, Smoking, Exercise, Cholesterol Medications, Coronary Heart Disease, Stroke, Arthritis, Osteoporosis, Pulmonary disease, Cancer, Psychiatric problems, Insomnia and Cognitive Disability. Statistically Significant values at the $<.01$ level are bolded.