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Short Communication

The association between demographic and lifestyle characteristics on patient cholesterol profile

Elizabeth Crush, Paul D. Loprinzi

Department of Health, Exercise Science and Recreation Management, The University of Mississippi, University, Mississippi, 38677, USA

Address for correspondence:
Paul D. Loprinzi, Department of Health, Exercise Science and Recreation Management, The University of Mississippi, University, Mississippi, 38677, USA.
E-mail: pdloprin@olemiss.edu

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ABSTRACT

Purpose: Examine the association between demographic parameters, weight status, and physical activity on patient cholesterol levels. **Methods:** Data from the 2003 to 2006 National Health and Nutrition Examination Survey were used. Blood samples were used to evaluate low-density lipoprotein (LDL)-cholesterol, high-density lipoprotein (HDL)-cholesterol, and triglycerides (TGs). Body mass index was evaluated from measured height and weight with physical activity evaluated via accelerometry. Multivariable logistic regression analysis was used to evaluate the association between the demographic and lifestyle characteristics with cholesterol profile. **Results:** 2129 U.S adults (≥20 years) provided data on the study variables and therefore constituted the analytic sample. Men, non-Hispanic whites (vs. non-Hispanic blacks), those with a lower income-to-poverty level (lower socioeconomic status), and obese (vs. normal weight) adults had a higher odds of having low HDL levels. Regarding LDL status, older adults, those not on cholesterol medication, and overweight and obese adults (vs. normal weight adults) had a higher odds of having high LDL levels. Regarding TG status, men, non-Hispanic whites (vs. non-Hispanic blacks), overweight and obese (vs. normal weight) adults, and those engaging in less light-intensity physical activity had a higher odd of having high TG levels. **Conclusions:** Demographic parameters and lifestyle characteristics play an important role on patient cholesterol profile.

KEY WORDS: Accelerometry, epidemiology, survival, weight status

INTRODUCTION

Research demonstrates that regular participation in physical activity is favorably associated with various cholesterol parameters [1,2]. For example, it has been shown that participating in physical activity is positively associated with high-density lipoprotein (HDL) levels [3]. A mechanism through which physical activity influences HDL levels may be via activation of lipoprotein lipase paired with inhibition of hepatic lipase [4,5]. Other lifestyle characteristics, namely obesity, are unfavorably also associated with cholesterol profiles [6]. Previous research has shown a positive relationship between obesity and low density lipoprotein (LDL) levels and an inverse relationship with HDL levels [7]. Mechanisms that could lead to this cholesterol profile in obese individuals may be via an increase in the activity of cholesteryl ester transfer protein and hepatic triglyceride (TG) lipase paired with a decrease in activity of postheparin lipoprotein lipase [8].

Various individual demographic parameters, including age [6], gender [9,10] and race-ethnicity [11], all influence cholesterol profile. The literature is somewhat mixed regarding the effects of age on cholesterol levels [12]. Research demonstrates that increased levels of physical activity may be required for women versus men to increase their HDL levels substantially [3]. Not as prevalent in the literature, however, is the comprehensive assessment of these parameters (physical activity, weight status, and demographics) on cholesterol profile. The literature is also divided on the extent to which these demographics have an influence on cholesterol profile. For example, one study found that there was an association between the TG to high-density lipoprotein cholesterol ratio among three of the major race/ethnicities in the United States [13]. However, minority populations such as non-Hispanic blacks and Mexican Americans have been seen to have more favorable cholesterol profiles [14]. Further, cholesterol levels as a function of objectively-measured physical activity (accelerometry) among a nationally representative sample of adults are relatively unknown. Such an investigation at a population level using robust measures may help to maximize generalizability. Thus, the purpose of this brief report was to, among a national sample of the US adults, examine the interrelationships between demographic parameters, objectively-measured physical activity, and patient cholesterol profile.

METHODS

Study Design

Data from the 2003 to 2006 National Health and Nutrition Examination Survey (NHANES) were used. NHANES is an ongoing survey conducted by the National Center for Health

Statistics. NHANES evaluates a representative sample of non-institutionalized US civilians, selected by a complex, multistage probability design. All procedures for data collection were approved by the NCHS Ethics Review Board, and all participants provided written informed consent before data collection.

Assessment of Cholesterol

HDL-cholesterol, fasting LDL-cholesterol, and fasting TGs were assessed from a blood sample taken during the mobile examination center. Participants were classified as having low (<40 mg/dL) or optimal HDL-cholesterol (40 mg/dL); optimal (<100 mg/dL) or high LDL-cholesterol (≥100 mg/dL); optimal (≤200 mg/dL) or high TG (>200 mg/dL) [15]. Details about the laboratory and examination procedures and quality control have been previously reported [16]. Briefly, using reagents from Roche/Boehringer-Mannheim Diagnostics, HDL-cholesterol was measured directly in the serum. TG was measured enzymatically in the serum using a series of coupled reactions in which TGs were hydrolyzed to produce glycerol. LDL-cholesterol was estimated according to the Friedewald calculation.

Assessment of Demographic and Health Variables

The following demographic and health-related variables evaluated included: Self-reported age, self-reported gender, self-reported race-ethnicity (Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, other/multi-race), poverty-to-income ratio (PIR), dietary consumption of fiber, total saturated fatty acids, cholesterol, self-reported use of cholesterol-lowering medications, and chronic disease index.

Participants completed a questionnaire to assess age, gender, race-ethnicity, and use of cholesterol-lowering medication. As a measure of socioeconomic status, PIR (ranging from 0 to 5; lower values indicating lower SES) was defined as the ratio of the family individual income to their poverty level. Dietary consumption of fiber, total saturated fatty acids and cholesterol were assessed from a dietary interview during the Mobile Examination Center. Finally, a chronic disease index variable was created summing the number of physician-diagnosed conditions including diabetes, cardiovascular disease, congestive heart failure, cancer, or stroke.

Assessment of Weight Status

Based on measured body mass index (BMI; kg/m^2), participants were classified as normal weight, overweight, or obese. Regarding BMI assessment, normal weight, overweight, and obese, respectively, was defined as a BMI of 18.5-24.9, 25-29.9, and ≥30 kg/m^2. Details on the assessment of these parameters have been published elsewhere: http://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_an.pdf.

Assessment of Physical Activity

Participants who were not wheelchair-bound were asked to wear an ActiGraph 7164 (Pensacola, FL) accelerometer on their right hip for 7 days. Accelerometers were affixed to an elastic belt that was worn around the participant's waist near the mid-axillary line at the level of the iliac crest. Participants were asked to wear the accelerometer during all activities, except water-based activities, and while sleeping. The accelerometer measured the frequency, intensity, and duration of physical activity by generating an activity count proportional to the measured acceleration. Accelerometry estimates were summarized in 1-min time intervals. Minutes with activity counts/min <100 were classified as sedentary behavior [17]; between 100 and 2020 counts/min were considered light-intensity physical activity; and >2020 but <5999 counts/min were classified as moderate-intensity physical activity; ≥5999 counts/min were classified as vigorous-intensity physical activity; and >2020 were classified as moderate-to-vigorous physical activity (MVPA) [18]. Participants engaging in ≥150 min/week of MVPA were considered to meet physical activity guidelines [19].

Only those participants with at least 4 days of 10 or more hours/day of accelerometer wear time were included in the analyses to ensure that data adequately captured habitual physical activity patterns [18]. To monitor the amount of time the device was worn, non-wear was defined by a period of a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1-2 min of activity counts between 0 and 100 [18]. The ActiGraph accelerometer has demonstrated evidence of reliability and validity [20].

Data Analysis

All statistical analyses were performed using procedures from sample survey data using Stata (version 12.0, College Station, TX, USA) to account for the complex survey design used in NHANES. To account for oversampling and nonresponse, and to provide nationally representative estimates, all analyses included the use of appropriate survey sample weights, clustering and primary sampling units. New sample weights were created for the combined NHANES cycles following analytical guidelines for the continuous NHANES [21]. Means and standard errors were calculated for continuous variables and proportions were calculated for categorical variables. Estimates were also adjusted for age, gender and race-ethnicity. Statistical differences between continuous variables and categorical variables were tested using an adjusted Wald test. Statistical differences between categorical variables were tested with design-based likelihood ratio tests.

Multivariable logistic regression analysis was used to examine the association of demographic, weight status, and physical activity levels in predicting the odds of having elevated low HDL-cholesterol, high LDL-cholesterol, and high TG. Three multivariable logistic regression analyses were computed (one for each cholesterol outcome). In each model, the demographic, weight status, and physical activity variables were included in the model. The additional secondary analyses were computed that examined the effects of the study variables on all-cause mortality; Cox proportional hazards were employed for these mortality analyses. A statistical significance was established as $P < 0.05$.

RESULTS

A total of 2129 US adults (≥20 years) provided data on the study variables and therefore constituted the analytic sample. Among these participants, the mean age was 46.3 years; 48.8% were male; and 73.1% were non-Hispanic white. Participants engaged in 476.9 min/day of sedentary behavior, 353.6 min/day of light-intensity physical activity, and 25.5 min/day of MVPA; 47.2% of the sample accumulated at least 150 min/week of MVPA (1-min bouts).

Table 1 shows the prevalence of low HDL, high LDL, and high TG among the 2129 U.S adults. 12.8%, 68.4%, and 15.8%, respectively, had low HDL, high LDL, and high TG (weighted estimates). Regarding the adjusted HDL prevalence estimates (adjusted for age, gender, and race-ethnicity), men, those with at least 1 chronic disease, overweight and obese adults, and those not meeting physical activity guidelines had a higher prevalence of having a low HDL level. Non-Hispanic blacks had a lower prevalence of low HDL than non-Hispanic whites.

Regarding the adjusted LDL prevalence estimates, other Hispanic (vs. non-Hispanic white), those not on cholesterol medication, those without the evaluated chronic diseases, and overweight and obese adults had a higher prevalence of having a high LDL level.

Regarding the adjusted TG prevalence estimates, men, those on cholesterol medication, those with at least 1 chronic disease, overweight and obese adults, and those not meeting physical activity guidelines had a higher prevalence of having a high TG level. Non-Hispanic blacks had a lower prevalence of high TG than non-Hispanic whites.

Table 2 reports the multivariate associations of demographic, weight status, and physical activity levels in predicting the odds of having low HDL, high LDL, and high TG. Men, non-Hispanic whites (vs. non-Hispanic blacks), those with a lower PIR, and obese (vs. normal weight) adults had a higher odds of having low HDL levels.

Regarding LDL status, older adults, those not on cholesterol medication, and overweight and obese adults (vs. normal weight adults) had a higher odds of having high LDL levels (Table 2).

Regarding TG status, men, non-Hispanic whites (vs. non-Hispanic blacks), overweight and obese (vs. normal weight) adults, and those engaging in less light-intensity physical activity had a higher odd of having high TG levels (Table 2).

Table 1: Prevalence (SE) of low HDL, high LDL, and high TG among US adults (≥20 years), NHANES 2003-2006

	Low HDL (<40 mg/dL)		High LDL (>100 mg/dL)		High TG (>200 mg/dL)	
Sample size, *n* (weighted %)	302 (12.8)		1448 (68.4)		354 (15.8)	
Demographic/health	**Unadjusted**	**Adjusted†**	**Unadjusted**	**Adjusted†**	**Unadjusted**	**Adjusted†**
Gender						
Men	19.2 (1.8)	19.2 (1.8)	70.3 (1.9)	70.5 (1.9)	19.0 (1.5)	19.0 (1.6)
Women	6.8 (1.1)	6.8 (1.1)[a]	66.6 (1.9)	66.4 (1.7)	12.9 (1.0)	12.9 (1.0)[a]
Race-ethnicity						
Mexican American	17.3 (1.5)	16.1 (1.7	70.1 (2.2)	73.2 (2.5)	19.3 (2.2)	20.3 (2.0)
Other Hispanic	9.3 (4.4)	8.9 (4.8)	78.8 (5.9)	81.4 (5.7)[b]	15.6 (4.8)	16.6 (4.7)
Non-Hispanic white	12.8 (1.4)	12.9 (1.3)	69.2 (1.6)	68.6 (1.6)	16.7 (1.1)	16.4 (1.1)
Non-Hispanic black	8.8 (1.5)	9.0 (1.5)[b]	63.3 (2.2)	64.2 (2.2)	8.0 (1.1)	8.5 (1.2)[b]
Other	15.4 (3.8)	16.2 (3.8)	57.8 (7.0)	58.4 (6.5)	14.9 (3.8)	15.4 (4.0)
On cholesterol-lowering medication						
Yes	14.8 (2.8)	15.1 (3.0)	56.6 (3.0)	49.2 (3.3)	26.5 (3.5)	25.1 (3.7)
No	12.5 (1.3)	12.5 (1.3)	70.2 (1.5)	71.3 (1.4)[c]	14.3 (1.1)	14.9 (1.2)[c]
Chronic disease index‡						
0 Chronic diseases	12.2 (1.2)	11.9 (1.9)	69.8 (1.5)	71.4 (1.5)	14.1 (1.1)	14.3 (1.1)
1+Chronic diseases	15.7 (1.6)	16.9 (2.0)[d]	61.2 (2.7)	54.3 (3.1)[d]	24.3 (2.7)	23.2 (3.0)[d]
Weight status						
BMI-determined						
Normal weight (18.5-24.9 kg/m^2)	5.5 (1.3)	6.0 (1.3)	60.7 (2.4)	62.0 (2.2)	7.1 (1.2)	7.5 (1.4)
Overweight (25.0-29.9 kg/m^2)	13.5 (1.4)	12.7 (1.4)[e]	72.7 (1.9)	71.7 (1.9)[e]	16.7 (1.3)	16.0 (1.3)[e]
Obese (30+kg/m^2)	19.1 (2.2)	19.4 (2.1)[e,f]	71.3 (1.5)	71.3 (1.7)[e]	23.4 (2.0)	23.8 (2.0)[e,f]
Accelerometer-determined physical activity						
Meeting physical activity guidelines (h150 min/week of MVPA)	11.4 (1.2)	9.0 (1.3)[g]	66.5 (2.1)	67.8 (2.3)	12.8 (1.6)	12.4 (1.7)[g]
Not meeting physical activity guidelines (<150 min/week of MVPA)	14.1 (1.6)	16.2 (1.8)	70.1 (1.1)	68.9 (1.1)	18.6 (1.1)	19.0 (1.2)

†Adjusted for age, gender, and race-ethnicity. Note, adjusted estimates for race-ethnicity were adjusted for age and gender. Similarly, adjusted estimates for gender are adjusted for age and race-ethnicity. [a]Significantly ($P<0.05$) different than men, [b]Significantly ($P<0.05$) different than non-Hispanic white, [c]Significantly ($P<0.05$) different than on cholesterol medication, [d]Significantly ($P<0.05$) different than 0 chronic diseases, [e]Significantly ($P<0.05$) different than normal weight, [f]Significantly ($P<0.05$) different than overweight, [g]Significantly ($P<0.05$) different than not meeting physical activity guidelines, ‡Chronic diseases included physician-diagnosed diabetes, cardiovascular disease, congestive heart failure, cancer, or stroke, MVPA: Moderate-to-vigorous physical activity, HDL: High-density lipoprotein cholesterol, LDL: Low-density lipoprotein cholesterol, TG: Triglycerides, NHANES: National Health and Nutrition Examination Survey

Table 2: Association of BMI-determined weight status and LDL, HDL and triglycerides among US adults (2003-2006 (n=2129))

Demographic	Odds ratio (95% CI)†					
	Low versus optimal HDL	P value	High versus optimal LDL	P value	High versus optimal TGs	P value
Age, 1 year older	0.98 (0.97-1.00)	0.08	1.04 (1.02-1.05)	<0.001	1.00 (0.98-1.01)	0.89
Female versus male	0.27 (0.16-0.45)	<0.001	0.81 (0.61-1.08)	0.14	0.64 (0.47-0.87)	0.006
Race-ethnicity (%)						
Mexican American versus white	1.16 (0.71-1.90)	0.53	1.27 (0.91-1.78)	0.14	1.29 (0.90-1.85)	0.14
Non-Hispanic black versus white	0.46 (0.29-0.75)	0.003	0.76 (0.56-1.04)	0.09	0.37 (0.26-0.54)	<0.001
Other versus white	0.99 (0.53-1.87)	0.99	1.07 (0.68-1.67)	0.74	1.00 (0.60-1.67)	0.98
PIR, 1 unit higher	0.85 (0.76-0.95)	0.009	1.03 (0.95-1.11)	0.41	0.96 (0.86-1.07)	0.50
Fiber, 1 g higher	0.98 (0.96-1.01)	0.16	0.98 (0.97-1.00)	0.09	1.00 (0.98-1.01)	0.76
Total saturated fatty acids, 1 g higher	0.99 (0.98-1.01)	0.78	1.00 (0.99-1.01)	0.07	1.00 (0.98-1.01)	0.94
Cholesterol, 1 g higher	1.00 (0.99-1.00)	0.56	0.99 (0.99-1.00)	0.17	1.00 (0.99-1.00)	0.81
Not on cholesterol-lowering medication versus on medication	0.99 (0.51-1.89)	0.97	2.85 (1.89-4.30)	<0.001	0.65 (0.39-1.09)	0.10
Chronic disease index, %¥						
1+ Chronic diseases versus 0	1.23 (0.81-1.84)	0.30	0.49 (0.34-0.72)	<0.001	1.37 (0.87-2.14)	0.15
Weight status						
BMI-determined‡						
Overweight versus normal weight	2.46 (1.22-4.98)	0.01	1.66 (1.31-2.11)	<0.001	2.41 (1.49-3.91)	0.001
Obese versus normal weight	3.75 (2.24-6.26)	<0.001	1.83 (1.37-2.44)	<0.001	3.54 (2.28-5.49)	<0.001
Accelerometer-determined physical activity						
Sedentary, 60 min/day increase	1.05 (0.94-1.17)	0.30	0.96 (0.89-1.04)	0.31	0.96 (0.87-1.07)	0.50
Light-intensity, 60 min/day increase	0.95 (0.81-1.10)	0.48	1.01 (0.92-1.11)	0.71	0.86 (0.76-0.96)	0.01
Meeting MVPA guidelines versus not meeting guidelines	0.70 (0.41-1.18)	0.18	0.90 (0.68-1.19)	0.47	0.79 (0.53-1.18)	0.25

†Three multivariable logistic regression models were computed: 1 for each cholesterol variable, ¥Chronic diseases included physician-diagnosed diabetes, cardiovascular disease, congestive heart failure, cancer, or stroke, ‡Normal weight: 18.5-24.9 kg/m^2; Overweight: 25-29.9 kg/m^2; Obese: ≥30 kg/m^2, MVPA: Moderate-to-vigorous physical activity, BMI: Body mass index, HDL: High-density lipoprotein

With regard to the latter, for every 60 min/day increase in light-intensity physical activity, adults had 14% lower odds of having high TG levels.

The noted beneficial effects of light-intensity physical activity on cholesterol prompted additional analyses to evaluate, in this sample, whether light-intensity physical activity had survival effects on all-cause mortality independent of LDL, HDL, and TG. When using linked mortality data from the National Death Index, 169 participants died during a mean follow-up period of 81.2 months (death censor occurring in 2011). After controlling for LDL, HDL and TG, those above the median (347 min/day) light-intensity physical activity had a 62% reduced risk of all-cause mortality (hazard ratio = 0.38; 95% confidence interval: 0.22-0.64; P = 0.001). The Kaplan–Meier survival curve is shown in Figure 1.

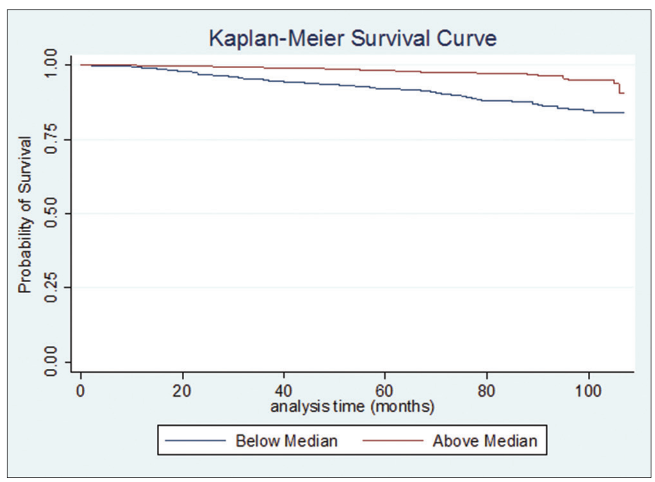

Figure 1: Kaplan–Meier survival curve among those above and below the median light-intensity physical activity level

DISCUSSION

The findings of this brief report are in alignment with the greater body of literature on this topic which demonstrates that demographic parameters and lifestyle characteristics play an important role on patient cholesterol profile. These findings, in particular, underscore the importance of serial monitoring of patient cholesterol profile among men, inactive adults, and obese individuals.

The prevalence of low HDL, high LDL, and high TGs are reported in Table 1. Most notably, men have a higher prevalence than women and Mexican Americans have a higher prevalence than the other race-ethnicities for having low HDL, high LDL, and high TGs. This is not in direct alignment with some work which has shown that minority populations, such as non-Hispanic blacks and Mexican Americans, have been seen to have more favorable cholesterol profiles [14].

The association of BMI-determined weight status and LDL, HDL, and TGs among US adults is reported in Table 2. Most notably, overweight versus normal weight individuals had a 146% increased odds of having low HDL levels, and obese versus normal weight individuals are even more likely to have low HDL levels, at 275% increased odds. This aligns with previous research that has shown a positive relationship between obesity and LDL levels and an inverse relationship with HDL levels [7].

Encouragingly, the present findings demonstrated favorable effects of light-intensity physical activity on TGs levels, which is an encouraging finding as chronically-diseased individuals may be disinclined to engage in higher intensity physical activity. Our results also demonstrate survival effects of light-intensity physical activity. As a result, light-intensity activities, such as low-intensity walking, dancing, and yoga should be considered as an important component of an active daily lifestyle. In alignment with other emerging work [22], sedentary behavior was not significant in any of the models after adjusting for physical activity. Although participating in moderate or high-intensity physical activity may not be possible for individuals with various chronic diseases, bouts of light-intensity physical activity could lead to improvements in individual cholesterol profiles. Increases in light-intensity activity have been shown to associate with lower LDL [23]. Thus, promotion of light-intensity physical activity to men, Mexican Americans, and overweight/obese populations, in particular, may be a useful strategy to help regulate their cholesterol profile.

CONCLUSION

Our findings demonstrated that various demographic and lifestyle characteristics are associated with cholesterol profile. The present findings of this brief report add to the literature by examining this topic using a national sample, employing objective measures of physical activity and weight status, and considering not only higher intensity physical activity, but also sedentary behavior and light-intensity physical activity, which is less common in the literature.

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