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Multivariate multiple regression analysis of fitness and sociodemographic variables in adults

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Abstract
Background: Little evidence exists regarding the multivariate relationship between a set of fitness variables and a set of sociodemographic predictor variables. The purpose of this study was to examine the independent relationship that sociodemographic predictors have on the linear combination of fitness variables in adults.
Methods: Data for this research came from adults 20+ years of age participating in the 2013-2014 National Health and Nutrition Examination Survey (NHANES). Grip strength (GS, kg), waist circumference (WC, cm), Moderate-to-vigorous physical activity (MVPA, min/wk), and sedentary time (ST, min/day) were the set of dependent variables. Sociodemographic predictor variables consisted of age, sex, race, income, education, and marital/partner status. Multivariate multiple linear regression analysis was employed to examine the independent relationship between predictors and the linear combination of fitness variables.
Results: The set of sociodemographic variables significantly (ps<.0001) predicted each of the fitness variables in separate univariate models. The multivariate multiple regression analysis indicated that each sociodemographic predictor significantly (ps<.001) predicts the linear combination of fitness variables.
Conclusion: Results from this study indicate that sociodemographic characteristics are related to a fitness construct consisting of muscular strength, body composition, physical activity, and sedentary behavior.

Keywords: Physical fitness, epidemiology, NHANES, population health

Introduction
Health-related physical fitness is a set of traits that relate to one's ability to perform physical tasks and that also relate to health status [1]. Health-related fitness components are cardiorespiratory endurance, muscular strength, muscular endurance, body composition, and flexibility [2]. Ample research exists relating sociodemographic characteristics to health behaviors like physical activity and sedentary behavior [3]. As well, evidence exists relating sociodemographic characteristics to certain fitness traits such as muscular strength and body composition [4]. However, little evidence exists regarding the multivariate relationship between a set of fitness and health variables and a set of sociodemographic predictor variables. Therefore, the purpose of this study was to examine the independent relationship that sociodemographic predictors have on the linear combination of fitness and health variables in adults.

Methods
Study design
Data for this research came from adults 20+ years of age participating in the 2013-2014 National Health and Nutrition Examination Survey (NHANES) [5]. NHANES collects data on health behavior, health status, and nutrition of non-institutionalized civilian residents of the U.S. The current study used data only from questionnaires and physical examinations. The sample in the current study consisted of adults with complete health, fitness and sociodemographic data.

Assessment of Fitness Variables
Grip strength (GS, kg) was measured in both hands using a handgrip dynamometer administered by a trained examiner. The largest dynamometer reading across all trials served

as the grip strength score in this study. A continuous PA variable was computed from constructed variables of minutes of moderate physical activity per week and minutes of vigorous physical activity per week. These two physical activity variables were then used to compute minutes of moderate-to-vigorous (MVPA) per week. Sedentary time (ST) was assessed from a question asking participants how much time they usually spend sitting in a typical day. Measurements for waist circumference (WC, cm) were collected by trained NHANES health professionals during a medical examination.

Sociodemographic variables

A total of six sociodemographic variables were used in this study: age, sex, race/ethnicity, income, education, and marital/partner living status. Age was simply used in units of years. Sex was converted to a male dummy coded variable with 1 for males and 0 for females. Race/ethnicity was converted to a White dummy coded variable with 1 for White race and 0 for all other races. Income was used in ordinal units of household income ranging from 1 (low) to 5 (high). Marital/partner living status was dummy coded with 1 for living with spouse/partner and 0 for not living with spouse/partner. Finally, education was converted to a college dummy coded variable with 1 for at least some college education and 0 for no college education.

Statistical analyses

Descriptive statistics were computed on all fitness and sociodemographic variables. Correlation coefficients were computed across all study variables to show inter-item associations. Multivariate multiple linear regression analysis of all fitness variables regressed on the set of sociodemographic predictors was conducted. All analyses were performed using SAS version 9.4 [6, 7]. All *p*-values were reported as 2-sided and statistical significance was defined as *p*-values < 0.05.

Results

Table 1 contains descriptive statistics for fitness and sociodemographic variables. Dummy variables were included in this table and the mean values can be interpreted as the percentage of participants that are male, White, living with spouse/partner, and had some college education. Table 2 contains the correlation matrix of all study variables. A significant percentage of the bivariate correlations were significant (*p*s<.05). Table 3 contains the multivariate multiple regression analysis of fitness variables regressed on sociodemographic predictors. The set of sociodemographic variables significantly (*p*s<.0001) predicted each of the fitness variables in separate univariate models. The multivariate multiple regression analysis indicated that each sociodemographic predictor significantly (*p*s<.001) predicts the linear combination of fitness variables.

Table 1. Descriptive statistics of study variables.

Variable	N	Mean	SD	Min	Max
GS	5211	36.98	11.57	6.10	82.80
WC	4986	99.24	16.61	55.50	177.90
MVPA	5390	201.65	391.04	0.00	4875.00
ST	5368	419.78	198.15	0.00	1200.00
Age	5392	48.62	17.51	20.00	80.00
Male	5392	0.48	0.50	0	1
White	5392	0.44	0.50	0	1
Income	4896	2.93	1.54	1	5
Living	5391	0.59	0.49	0	1
College	5386	0.57	0.50	0	1

Note. GS is maximal strength in kg. WC is waist circumference in centimeters. MVPA is minutes of moderate-to-vigorous physical activity per week. ST is sedentary time in minutes per day. Age is in years. Male is dummy coded 1 for males and 0 for females. White is dummy coded 1 for White race and 0 for all other races. Income is in ordinal units of household income. Living is dummy coded 1 for living with spouse/partner and 0 for not living with spouse/partner. College is dummy coded 1 for at least some college education and 0 for no college education.

Table 2. Correlation matrix of all study variables.

	GS	WC	MVPA	ST	Age	Male	White	Income	Living	College
GS	1	.125	.155	-.015	-.309	.714	-.003	.115	.107	.038
WC	.125	1	-.147	.087	.178	.087	.071	-.091	.034	-.049
MVPA	.155	-.147	1	-.085	-.147	.109	-.021	.081	-.036	.105
ST	-.015	.087	-.085	1	.022	.017	.045	.102	-.040	.135
Age	-.309	.178	-.147	.022	1	.009	.113	-.065	.062	-.071
Male	.714	.087	.109	.017	.009	1	.001	.055	.106	-.047
White	-.003	.071	-.021	.045	.113	.001	1	.056	.042	.114
Income	.115	-.091	.081	.102	-.065	.055	.056	1	.294	.341
Living	.107	.034	-.036	-.040	.062	.106	.042	.294	1	.057
College	.038	-.049	.105	.135	-.071	-.047	.114	.341	.057	1

Note. N=4,519. Values in bold are significant, *p*<.05. GS is maximal strength in kg. WC is waist circumference in centimeters. MVPA is minutes of moderate-to-vigorous physical activity per week. ST is sedentary time in minutes per day. Age is in years. Male is dummy coded 1 for males and 0 for females. White is dummy coded 1 for White race and 0 for all other races. Income is in ordinal units of household income. Living is dummy coded 1 for living with spouse/partner and 0 for not living with spouse/partner. College is dummy coded 1 for at least some college education and 0 for no college education.

Table 3. Multivariate multiple regression analysis of fitness variables regressed on sociodemographic predictors.

Parameter	GS			WC			MVPA			ST	
	Estimate	***SE***	***p***	***Estimate***	***SE***	***p***	***Estimate***	***SE***	***p***	***Estimate***	***SE***
Intercept	37.466	0.407	<.0001	91.992	0.932	<.0001	258.752	21.780	<.0001	348.152	11.136
Age	-0.209	0.006	<.0001	0.156	0.014	<.0001	-2.999	0.332	<.0001	0.429	0.170
Male	16.321	0.213	<.0001	2.879	0.489	<.0001	91.652	11.420	<.0001	10.131	5.839
White	0.556	0.215	.010	1.939	0.494	<.0001	-12.794	11.546	.268	10.589	5.903
Income	0.236	0.077	.002	-1.067	0.176	<.0001	13.872	4.119	.001	11.217	2.106
Living	0.901	0.227	<.0001	1.420	0.521	.007	-48.402	12.181	<.0001	-31.602	6.228
College	0.764	0.230	.001	-0.306	0.528	.562	69.332	12.348	<.0001	44.208	6.313
F			<.0001			<.0001			<.0001		

Note. *N*=4,519. GS is maximal strength in kg. WC is waist circumference in centimeters. MVPA is minutes of moderate-to-vigorous physical activity per week. ST is sedentary time in minutes per day. Multivariate tests include Wilks' Lambda (λ) with *F*-ratio and *p*=value. Age is in years. Male is dummy coded 1 for males and 0 for females. White is dummy coded 1 for White race and 0 for all other races. Income is in ordinal units of household income. Living is dummy coded 1 for living with spouse/partner and 0 for not living with spouse/partner. College is dummy coded 1 for at least some college education and 0 for no college education.

Discussion

The purpose of this study was to examine the independent relationship that sociodemographic predictors have on the linear combination of fitness and health variables in adults. The evidence supports the use of sociodemographic characteristics as predictors of a fitness and health construct in adults. One strength concerning this study was its novel use of a multivariate technique to model the relationship between a fitness and health construct and a set of sociodemographic predictor variables. Another strength of this study was its use of an objective measure of muscular strength. One limitation concerning this study was the cross-sectional nature of the NHANES design. Therefore, results from this study should not be considered cause-and-effect and should only be considered as correlational. Another limitation of this study was that it did not account for the complex sampling design used by NHANES. Therefore, inferences from this study should be considered correlational findings resulting from a sample of convenience and not representing all U.S. adults.

Conclusions

Results from this study indicate that a set of sociodemographic variables can predict a set of fitness and health variables in adults. Specifically, age, sex, income, education, race/ethnicity, and marital/partner living status are independent predictors of the linear combination of GS, WC, MVPA, and ST in adults 20+ years of age.

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