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Combining activity-related behaviors and attributes improves prediction of health status in NHANES

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Abstract

Background: This paper tested whether a physical activity index (PAI) that integrates PA-related behaviors (i.e., moderate-vigorous [MVPA] and TV viewing) and attributes (i.e., cardiorespiratory fitness and muscle strength) improves prediction of health status.

Methods: Participants were a nationally representative sample of US adults from 2011–2012 NHANES. Dependent variables (self-reported health status, multi-morbidity, functional limitations and metabolic syndrome) were dichotomized. Wald-F tests tested whether the model with all PAI components had statistically significantly higher area under the curve (AUC) values than the models with behavior or attribute scores alone, adjusting for covariates and complex survey design.

Results: The AUC (95% CI) values from the ROC analysis for the combined PAI and health status was 0.72 (0.68, 0.76), which was significantly higher than the behavior score (0.69 [0.66,

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Conflict of Interest

The authors declare no relevant conflicts of interest.

0.72]), or attribute score alone (0.68 0.63, 0.72]). The overall AUC for the PAI was 0.72 (0.69, 0.75) for multi-morbidity, 0.71 (0.67, 0.74) for functional limitations and 0.69 (0.66, 0.73) for metabolic syndrome, all higher than attribute scores alone.

Conclusions: These results provide empirical support that an integrated PAI may improve prediction of health and disease. Future research should examine the clinical utility of a PAI and verify these findings in prospective studies.

Keywords

cardiorespiratory fitness; physical activity; sedentary time; muscle strength

Introduction

There is considerable evidence that physical activity lowers risk for chronic diseases and improves longevity.¹ In 2008, the United States Department of Health and Human Services issued the Physical Activity Guidelines (PAG), recommending all adults engage in at least 150 minutes of moderate [3 METs] intensity aerobic physical activity and/or 75 minutes of vigorous [6 METs] activity.¹ In addition to moderate-to-vigorous physical activity [MVPA], other activity-related behaviors and physiologic attributes that have been linked to health. Specifically, the PAG recommends two strength training sessions per week,¹ and sedentary behaviors have been associated with chronic disease risk and mortality, even when considering time spent in MVPA². In addition, attributes such as cardiorespiratory fitness and muscle strength are robust predictors of morbidity and mortality (e.g.,^{3–6}). Researchers often test whether there are independent associations health-related outcomes and a specific behavior or attribute and, but, there may be additional health benefits derived from a combination of these predictors that are not apparent from understanding the individual associations.^{7,8}

A physical activity index (PAI) may improve our understanding of the type and amount of activity required for specific health benefits, while considering the complex relationships among physical activity behaviors and attributes.⁸ Integrating behaviors and performance metrics into a single index could be incorporated into a precision prevention framework and facilitate targeted behavior change. Exercise prescription is routinely individualized based on the interplay of behavior and functional performance for special populations, the general public, and athletes.^{9,10} Yet, there is a scarcity of data available on whether it is beneficial to integrate these behaviors and attributes in relation to health.

As an initial proof of concept, we propose to test whether a PAI that includes MVPA, sedentary time, aerobic fitness and grip strength improves prediction of health status compared to considering the components in isolation. Using nationally representative data from the National Health and Nutrition Examination Survey (NHANES), we first determined whether each of the PAI components were associated with broad self-reported and objective health-related outcomes. Second, we assessed whether a combination of these components score improves prediction of health status beyond the isolated individual components.

Methods

NHANES uses a four-stage stratified cluster probability sample design to sample the non-institutionalized, civilian US population and obtain results that are nationally representative of the US population.¹¹ The survey includes an in-person home interview during which demographic, socioeconomic, and health-related questions are assessed. Examination data, including medical, physiological, laboratory and anthropometrics, are collected during a separate visit to a Mobile Examination Center (MEC). NHANES data are collected in 2-year cycles. For our primary analysis we included data collected between 2011–2012, which had an overall response rate of 69.5% for the MEC sample. The National Center for Health Statistics Ethics Review Board approved the survey, and informed consent was obtained for all adult participants. Additional NHANES design and protocol details are available elsewhere.¹²

PAI components

Moderate-vigorous physical activity: The Global Physical Activity Questionnaire was used to assess the frequency and duration of leisure-time physical activity (vigorous and moderate intensity)¹³. To estimate MET-minutes of activity, minutes of moderate activity were 4 METs and vigorous activities were multiplied by 8 METs. Moderate and vigorous were added together and divided by 60 to convert to MET-hrs¹³. Weekly MET-hrs were then categorized as 1) 0 MET hr/wk; 2) 1–7.49 MET hr/wk; 3) 7.5–15 MET hr/wk; 4) 15–22.49 MET hr/wk and 5) 22.5 MET hr/wk. These categories were selected to be consistent with two recent pooled analyses showing differences in mortality risk across these categories.^{14,15}

Sedentary screen time: Participants self-reported how many hours per day they sat and watched TV or videos over the past 30 days. Response options were (none, <1hr, 1hr, 2hrs, 3hrs, 4hrs, 5 hours). These categories were consolidated into the following categories to be consistent with a recent paper examining television viewing and mortality.¹⁶ 1) Never or 0h/day; 2) 1–2 hr/day; 3) 2–3 hr/day; 4) 3–4 hr/day; 5) 5+hr/day.

Muscle strength: An objective measure of grip strength provides a simple, validated way to estimate overall muscle strength [38]. In NHANES, absolute grip strength was calculated as the sum of the largest reading from each hand and expressed in kilograms and has been used to generate national norm^{17,18}). To account for the correlation between body size and strength, we expressed grip strength divided by body weight. To generate quintiles of grip strength, we calculated gender and age (20–29y, 30–39 y, 40–49y, 50–59y, 60–69y 70y) specific percentiles (20th, 40th, 60th, 80th) that were weighted to the US population. Only participants who completed the grip strength assessment with both hands (per protocol) were included in the analysis to generate the nationally representative quintiles. However, there were 95 participants who only completed the grip strength assessment with one-hand. Since the correlation between two-handed and single-handed grip strength was 0.97, to maintain power, we multiplied their single-hand score*2 to generate an overall score and assigned them to the appropriate quintile for analysis.

Cardiorespiratory fitness: Aerobic capacity is the maximal of physiologic work an individual can do and is assessed by measuring cardiorespiratory fitness (CRF). Fitness can be directly measured or estimated with a non-exercise prediction equation. Because fitness was not assessed in the 2011–2012 NHANES, we used a prediction equation to estimate fitness that includes age, gender, BMI, resting pulse, and physical activity level (5-categories).¹⁹ This method has been developed and validated in general adults¹⁹ been associated with mortality,²⁰ and a similar equation was cross-validated among older adults.²¹ To generate quintiles of CRF, we calculated nationally representative weighted gender and age (20–29y, 30–39y, 40–49y, 50–59y, 60–69y 70 y) specific percentiles (20th, 40th, 60th 80th).

Behavior Score: an additive score was calculated for the combined behaviors of MVPA and TV viewing. Each behavior was scored (0 – 4) in categories as described above, thus the additive score ranged from 0 (0 MET-hr of MVPA per week and 5 hours per day of television) to 8 (22.5 MET-hr of MVPA per week and 5 hours per day of television). A score of 1 could indicate 0–7.49 MET-hrs of activity or 1 hr/day of television.

Performance score: an additive score was calculated for the combined performance scores of grip strength and estimated fitness. The score was derived by adding together the quintiles (0 being lowest quintile in both fitness and grip strength; 8 is highest quintile for both).

Health-related outcome variables

We tested four dependent variables that represent broad domains of health including self-reported health status, functional limitations, multi-morbidity and metabolic syndrome. Self-reported health status is a robust predictor of 5-year survival²². Responses were dichotomized into 1) Excellent or 2) Very Good, Good, Fair, or Poor. Functional status was assessed using self-reported difficulty performing six tasks - walking a quarter of a mile; walking up ten steps; stooping, crouching or kneeling; standing for long periods of time; standing up from an armless chair, and lifting or carrying heavy objects. A previous NHANES analysis reported a Cronbach's α of .893 for these items.²³ Each item was scored from 0–3, with participants reporting whether they had no, some, or much difficulty or were unable to perform the task. The sum of responses for each of these six items was then taken to create an overall measure of physical functioning, ranging from 0 to 18. Functional limitation status was dichotomized such that anyone reporting two or more limitations was considered functionally limited.²³ Multi-morbidity was scored based on self-reported, physician-diagnosed; arthritis, asthma, bronchitis, cancer, heart disease, diabetes, emphysema, liver disease, stroke, hypertension, high cholesterol. For obesity measured height and weight ($BMI = 30\text{kg/m}^2$) were used. Anyone reporting two or more chronic conditions was considered to have multi-morbidities.²⁴ Metabolic syndrome was defined using the National Cholesterol Education Program's Adult Treatment Panel III report (ATP III) criteria of meeting 3/5 of the following: waist circumference ≥ 102 cm (men) or ≥ 88 cm (women) blood glucose ≥ 100 mg/dL, triglycerides ≥ 150 mg/dL, systolic blood pressure ≥ 130 mm Hg and/or diastolic blood pressure ≥ 85 mm Hg, HDL cholesterol < 40 mg/dL (men) or < 50 mg/dL (women).²⁵

Covariates

Potential confounders were included as covariates including age (yrs), gender, race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican Americans, Other), education (less than high school, high school or general equivalency diploma, more than high school, missing), alcohol consumption (never, former, current drinker, missing), smoking status (never, former, current), and BMI (<25, 25–29.9, 30, kg/m²). BMI is included in the scoring for multi-morbidity and metabolic syndrome, therefore those models were not adjusted for BMI.

Statistical analyses

We first assessed whether each of the PAI components were individually associated with the health-related outcomes (health status, multi-morbidity, functional limitations and metabolic syndrome). For each of the categorical PAI components, we fit a separate logistic regression model for each of the four binary outcomes. We tested models adjusting for age, gender, and the covariates described above. Test for trend was determined using the median score for the categorical response of the PAI component as a continuous variable.

To determine whether the behaviors and performance metrics were associated with outcomes we first entered the additive scores as categorical variables in the logistic regression model for each outcome and then as continuous variables to assess trends. Lastly, to determine whether they were independently associated with the outcomes of interest the behavior and performance scores were entered simultaneously into the adjusted models as continuous variables.

We tested whether the PAI components were better than performance or behavior scores using a receiver operator characteristic (ROC) analysis. An ROC test examines how well the test separates the sample into those with and without the disease (or health status) in question. We examined the ability of the full PAI model to discriminate between the binary outcomes (health status, multi-morbidity, functional limitations and metabolic syndrome) by comparing area under the curve (AUC) values, which are an overall estimate of accuracy (that considers both sensitivity and specificity of disease classification). To test whether the model that included all PAI components had statistically significantly higher AUC values than the models with performance or behavior scores alone we used a Wald-F test that accounted sample weights and complex sample design of NHANES. Standard errors, which were used to compute 95% CIs for AUC values and Wald F-test, were estimated using the Fay replicate weight method based on balanced half-sample repeated replication to account for the complex survey design.²⁶ Lastly, we conducted sensitivity analyses to determine if the AUC values were consistent across sex (male/female), age groups (20–39, 40–59 and 60 y), BMI categories (<25, 25–24.9, 30 kg/m²) and race/ethnicity (Non-Hispanic White, Non-Hispanic Black and Hispanic)

CDC-recommended sample weights were included in the analyses to address differential sample selection, sample nonresponse and post-stratification adjustments.¹¹ All analyses were performed using SAS (version 9.3) (Cary, NC, USA) and the SAS-callable SUDAAN software for analysis of multistage-stratified complex survey data. SUDAAN program proc

logistic was used for the binary logistic regression. Two-sided *P*-values of <0.05 were used to indicate statistically significant associations.

Results

There were 5560 adults (18 y) who completed the NHANES interviews. Participants with missing data were excluded from the analyses, leaving a final analytic sample of 4590. There were 14 people missing MVPA, 7 missing television, 542 missing CRF and 406 missing grip strength and 1 missing health status. The primary reason for missing grip strength or CRF was related to incomplete examinations due to coming late/leaving early/lack of time. Participant characteristics are shown in Table 1. In total, 644/4590 (16.7%) reported excellent health, 2180 (44.9%) reported multiple chronic conditions, 853 (17.0%) reported functional limitations and 522 (12/3%) had metabolic syndrome.

Each of the PAI components (MVPA, TV viewing, fitness and grip strength) were independently associated with health status, multi-morbidity and metabolic syndrome and functional status (*P*-trend <0.05 for all) after adjustment for covariates, with the exception of estimated fitness, which was not significantly associated with functional limitations (*P*=0.16) (Table 2).

We next tested whether an additive score for the broad categories (behavior: TV + MVPA, performance: fitness + grip strength) was associated with the health-related outcomes. For odds of reporting excellent health, there was a significant linear association between both the behavioral and performance scores. Similar trends were observed for the other outcomes, with both behavior and performance scores significantly associated with odds of multi-morbidity, functional limitations and metabolic syndrome (Figure 1).

When included in the same model, behavior and performance scores were independently and positively associated with excellent health status. For every 1-unit increase in the behavior score the odds of reporting excellent health was increased by 21% (OR=1.21 (1.16, 1.27)), and for each increase in the performance score the odds were increased by 19% (OR=1.19 (1.07, 1.31)). For multi-morbidity, the performance score was significant (OR= 0.72 [0.68, 0.75]), but the behavior score was not (behavior: OR =0.95 [0.88, 1.02]). The odds of having functional limitations was significantly lower for both behavior score OR= 0.86 (0.81, 0.92) and performance score OR= 0.91 (0.86, 0.96) when included in the same model. Similarly, both behavior (OR=0.90 [0.85, 0.96]) and performance (0.81 [0.75, 0.87]) scores were significantly associated with greater odds of having metabolic syndrome.

The AUC values from the ROC analysis for the combined PAI (MVPA, TV viewing, fitness and strength combined) and health status was 0.72 (95% CI 0.68, 0.76), which was significantly higher than either MVPA alone (0.66 (0.63, 0.68), the combined behavior score (AUC=0.69 95% CI: 0.66, 0.72) alone, or the combined performance score alone (AUC=0.68 95% CI 0.63, 0.72) (Table 3). The overall AUC for the PAI was 0.72 (95% CI 0.69, 0.75) for multi-morbidity, 0.71 (95% CI 0.67, 0.74) for functional limitations and 0.69 (0.66, 0.73) for metabolic syndrome (Table 3). For all outcomes, the combined PAI model had higher AUCs compared to MVPA and performance scores alone (Table 3).

For functional limitations, the behavior score (AUC 0.70 (0.66, 0.73) was not significantly different than the combined PAI score (Table 3).

In stratified analyses, we examined whether AUC values were consistent across sex BMI categories and age groups. In general, the PAI AUC appeared robust and was similar across groups (Figure 2). The younger age categories had slightly higher AUCs for multi-morbidity, while AUC's were higher among normal weight individuals for metabolic syndrome (Figure 2).

Discussion

This study provides an initial proof-of-concept illustrating the potential utility of integrating multiple activity-related components, rather than separate evaluations of individual measures, to improve the prediction of health-related outcomes. Although these data are cross-sectional, they provide evidence that behavior and performance scores are differentially associated with the health-related outcomes in a nationally representative sample of US adults. To our knowledge, this is the first study to examine associations between a combination of behavior and performance scores compared to the metrics in isolation. These findings support recommendations to include both physical activity behavior and attributes as key components of assessment related to physical behavior.^{27,28}

Several of the PAI components have been considered in previous research and shown to be associated with disease and longevity.^{3,29–34} These studies include a recent review highlighting the potential public health impact of targeting sedentary behavior, physical activity and cardiorespiratory fitness⁸ and a corresponding analysis that demonstrated any combination of these behaviors was associated with decreased odds of obesity.³² The present finding extend this evidence to include grip strength, which was recently shown to be a stronger predictor of mortality than blood pressure, even when adjusting for physical activity.³⁰ We also used an innovative method, the ROC analysis, to estimate the discriminative ability of the combined metrics compared to different combinations, providing statistical support that the PAI in combination had significantly higher AUCs than performance or behavior scores alone.

Given the ongoing challenge of achievement and maintenance of physical activity recommendations for most Americans, the American Medical Association and American College of Sports Medicine have called for more research to develop evidence-based tools that would reduce clinical barriers to physical activity counseling.^{35,36} These efforts are also supported by the recently released National Physical Activity Plan,³⁷ which includes a recommendation for a more comprehensive clinical assessment of physical activity and inactivity. Since the PAI input data come from either single self-reported items, information pulled from a medical record or easily assessed measures the PAI may have utility in clinical practice for screening. While grip strength is not routinely assessed in office visits, it was integrated into NHANES due to its brevity, utility, and possibility for expansion into routine care and exercise prescription.^{17,38}

From a patient counseling perspective, the PAI may facilitate communication and have utility as a patient/participant motivation tool. Having a single, evidence based measure may help integrate distinct behavioral and performance constructs that are confusing to patients when the components are disaggregated (e.g., being sedentary and physically active).^{39,40} The PAI may provide an additional target to motivate behavior change by enabling specific, tailored goal setting could target increases in aerobic and muscular fitness rather than sole reliance on behavioral time goals. Providing discrete assessments of specific physical activity components may also allow clinicians to prioritize and tailor counseling recommendations, based on the age, physical function, health status and current lifestyle, consistent with the messaging “Be Active Your Way” from the 2008 Physical Activity Guidelines for Americans.¹ Future research will be needed to determine if the PAI approach has clinical utility or supports initiation or maintenance of an active lifestyle. Coordination with available patient resources, which may include mobile technologies, health services and other community assets, will also likely be required to support healthy behaviors outside of the clinical setting.

There are important limitations of our study that need to be considered. First, NHANES is a cross-sectional survey, thus there is the potential for reverse-causation (i.e., health limitations cause lower activity scores). Future research, with longitude data, is needed to replicate and confirm the finding that PAI score is associated with disease development in those without prevalent disease. There is also measurement error associated with self-reported physical activity and television viewing time that generally attenuates observed associations, and future research should examine whether objective measures of MVPA and/or sedentary enhance the predictive ability of the PAI.⁴¹ The estimated fitness equation has been well validated and been shown to be predictive of mortality,^{19,20} but it is not an objective physiologic measure, and there is still error associated with predicting rather than measuring cardiorespiratory fitness. We considered incorporating objective assessment of fitness from the 2003–04 cycle but found it was a highly selective sample of adults up to age 50 yrs (e.g., < 1% of those taking the test reported poor health, compared with 6% of the NHANES sample), thus the power for predicting health associations was great diminished and the results would not be generalizable. Muscle-strengthening behavior was not assessed in the NHANES 2011–2012. While increased strength is well known to accompany exercise training in adults of all ages, future research should assess the need to modify the PAI since adaptation to resistance exercise and absolute strength may vary.⁴²

Strengths of this study include the use to a nationally representative sample to generate quintiles of estimated fitness and grip strength. An additional strength is the range of health-related outcomes that were included in the analyses. We observed significant findings for a subjective health status variable that is strongly predictive of mortality as well as metabolic syndrome- a physiological variable reflecting risk status for type II diabetes and cardiovascular disease.²² The use of the ROC analyses allowed us to estimate the combination of PAI components compared to either behavior or performance scores alone, and the evidence indicated that the combination improved predictive value. However, future research should examine more complex scoring metrics that may be beneficial in developing an overall score that weights the components of the PAI to maximize the predictive value of an integrated PAI score, ideally in prospective studies.

Conclusions

These results provide empirical support that it may be beneficial to integrate performance and behavioral parameters of physical activity to improve disease prediction. The PAI may have utility in a clinical setting to monitor and provide personalized recommendations based on both behavior and current physiologic status. Future research should examine the potential clinical utility of this integrated approach and verify these findings using prospective designs.

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Figure 1 —.

Combined behavioral and performance scores in relation to health-related outcome metrics NHANES 2011–12.

Note: Behavioral score is additive score that includes moderate- to-vigorous physical activity (0–4) and television (0–4); performance is additive score that includes quintiles of estimated fitness and grip strength. Panel A and B: adjusted for age, gender, alcohol (never, former, current, missing), education (< high school [HS], HS, >HS), smoking (never, former, current, missing), BMI group (HS), smoking (never, former, current, missing), race (Mexican, other Hispanic, NH White NH Black, other).

Figure 2 —.
Stratified Analyses for area under the curve (AUC) from physical activity index (PAI) model for each of the health-related outcome metrics: NHANES 2011–12.

Table 1:

Descriptive characteristics of NHANES participants 2011–2012.

Demographic variables	Overall	Men	Women
Gender (N [%])	4590	2318 (49.0)	2272 (51.0)
Age (yrs) (mean[SE])	47.4 (0.8)	46.6 (0.9)	48.2 (0.8)
BMI (Kg/m ²) (mean[SE])	28.8 (0.2)	28.6 (0.3)	29.0 (0.3)
Obese (% [SE])	35.5 (1.4) %	34.3 (1.4) %	36.8 (1.8) %
Non-Hispanic White (% [SE])	67.7 (3.9) %	67.8 (4.0) %	67.6 (4.0) %
Non-Hispanic Black (% [SE])	11.4 (2.2) %	10.6 (2.2) %	12.2 (2.3) %
Current alcohol user (% [SE])	71.1 (1.5) %	73.1 (1.4) %	66.3 (2.2) %
Education (> HS) (% [SE])	64.1 (2.8) %	61.6 (3.0) %	66.5 (2.7) %
Current smoker (% [SE])	19.9 (1.1) %	23.9 (1.6) %	16.0 (1.3) %
Prevalence of health-related outcomes (N [%])			
Excellent Health	644 (16.7)	333 (16.4)	311 (17.0)
Multi-morbidity	2180 (44.9)	1044 (43.3)	1136 (46.5)
Functional Limitations	853 (17.0)	392 (15.2)	461 (18.8)
Metabolic Syndrome	522 (12.3)	250 (12.3)	272 (12.2)
Physical Activity Index Components (mean[SE])			
MVPA (min/week)	230.5 (16.9)	271.4 (20.3)	191.2 (18.0)
Television Viewing (h/day)	2.54 (0.06)	2.53 (0.06)	2.56 (0.06)
Grip Strength/body weight	0.90 (0.01)	1.04 (0.01)	0.77 (0.01)
Estimated fitness (METs)	9.33 (0.12)	11.0 (0.14)	7.76 (0.1)

Note: Values are weighted to address complex survey design. Fitness was estimated using equation developed by

MVPA is moderate-vigorous intensity activity, where reported minutes of vigorous activity were multiplied by 2 and added to moderate minutes. Fitness was estimated using a non-exercise prediction equation (20)

Table 2:

Associations between individual Physical Activity Index components and odds of very-good/excellent health status, multimorbidity and functional limitations

	0	0.1–7.49	7.5–14.9	15–22.49	22.5+	P-Trend
N	2293	467	515	366	949	
Excellent health *	1.0 (referent)	1.48 (0.93, 2.35)	1.67 (1.14, 2.45)	1.48 (1.05, 2.08)	2.98 (2.42, 3.67)	<0.01
Functional Limitations *	1.0 (referent)	0.65 (0.41, 1.03)	0.84 (0.53, 1.35)	0.68 (0.39, 1.18)	0.49 (0.34, 0.69)	<0.01
Multi-morbidity #	1.0 (referent)	1.02 (0.77, 1.34)	0.70 (0.55, 0.88)	0.71 (0.48, 1.07)	0.50 (0.39, 0.64)	<0.01
Metabolic syndrome #	1.0 (referent)	0.82 (0.55, 1.23)	0.80 (0.58, 1.12)	0.61 (0.33, 1.13)	0.64 (0.44, 0.92)	<0.01
	Never/0	1–2	2–3	3–4	5+	
N	635	700	1146	1343	766	
Excellent health *	1.0 (referent)	1.94 (1.03, 3.67)	2.08 (1.18, 3.67)	2.14 (1.18, 3.89)	3.43 (1.88, 6.26)	<0.01
Functional Limitations *	1.0 (referent)	0.86 (0.60, 1.24)	0.64 (0.48, 0.86)	0.39 (0.21, 0.71)	0.49 (0.31, 0.78)	<0.01
Multi-morbidity #	1.0 (referent)	0.64 (0.48, 0.86)	0.56 (0.40, 0.78)	0.46 (0.32, 0.65)	0.35 (0.26, 0.47)	<0.01
Metabolic syndrome #	1.0 (referent)	0.58 (0.37, 0.93)	0.75 (0.54, 1.04)	0.65 (0.42, 1.00)	0.32 (0.20, 0.52)	<0.01
	Q1	Q2	Q3	Q4	Q5	
N	924	924	978	891	900	
Excellent health *	1.0 (referent)	1.41 (0.83, 2.40)	1.48 (0.93, 2.35)	2.10 (1.02, 4.32)	3.37 (2.04, 5.56)	<0.01
Functional Limitations *	1.0 (referent)	0.94 (0.77, 1.15)	0.84 (0.55, 1.27)	0.63 (0.33, 1.20)	0.64 (0.31, 1.30)	0.16
Multi-morbidity #	1.0 (referent)	0.32 (0.23, 0.46)	0.19 (0.12, 0.29)	0.11 (0.07, 0.19)	0.11 (0.07, 0.16)	<0.01
Metabolic syndrome #	1.0 (referent)	0.68 (0.48, 0.98)	0.64 (0.41, 1.00)	0.70 (0.42, 1.15)	0.36 (0.13, 0.96)	<0.01
	Q1	Q2	Q3	Q4	Q5	
N	1135	966	805	839		
Excellent health *	1.0 (referent)	1.25 (0.84, 1.84)	1.56 (1.02, 2.39)	2.06 (1.32, 3.21)	2.88 (1.54, 5.38)	<0.01
Functional Limitations *	1.0 (referent)	0.72 (0.48, 1.09)	0.62 (0.44, 0.89)	0.42 (0.26, 0.67)	0.35 (0.19, 0.66)	<0.01

Multi-morbidity [#]	1.0 (referent)	0.39 (0.27, 0.56)	0.25 (0.17, 0.37)	0.17 (0.12, 0.23)	0.10 (0.08, 0.13)	<0.01
Metabolic syndrome [#]	1.0 (referent)	0.73 (0.45, 1.17)	0.72 (0.44, 1.16)	0.35 (0.20, 0.62)	0.23 (0.13, 0.43)	<0.01

Note: Grip strength is adjusted for Body Mass (Kg).

* adjusted for age, gender, alcohol (never, former, current, missing), education (<HS, HS, >HS), smoking (never, former, current, missing), BMI group (<25, 25–29.9, >30), race (Mexican, other Hispanic, NH White NH Black, other).

adjusted for age, gender, alcohol (never, former, current, missing), education (<HS, HS, >HS), smoking (never, former, current, missing), race (Mexican, other Hispanic, NH White NH Black, other).

Table 3:
Area Under the curve values for discrimination between health-related outcome metrics: NHANES 2011–12

	<u>Health Status</u>			<u>Multi-morbidity</u>			<u>Disability</u>			<u>Metabolic Syndrome</u>		
	AUC	95% CI	P-value	AUC	95% CI	P-value	AUC	95% CI	P-value	AUC	95% CI	P-value
Model	0.72	(0.68, 0.76)		0.72	(0.69, 0.75)		0.71	(0.67, 0.74)		0.69	(0.66, 0.73)	
MVPA alone	0.66	(0.63, 0.68)	0.00	0.61	(0.59, 0.64)	0.00	0.63	(0.60, 0.67)	0.00	0.59	(0.57, 0.61)	0.00
Behavior	0.69	(0.66, 0.72)	0.00	0.66	(0.63, 0.69)	0.00	0.70	(0.66, 0.73)	0.08	0.63	(0.61, 0.66)	0.00
Performance	0.68	(0.63, 0.72)	0.00	0.69	(0.66, 0.72)	0.00	0.60	(0.55, 0.64)	0.00	0.67	(0.63, 0.71)	0.03

Note: Model alone refers to combined MVPA and Television Viewing estimated fitness and grip strength value. Behavior score includes MVPA and Television Viewing, performance score includes estimates fitness and grip strength.