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# Leisure Time Physical Activity As a Predictor of Poor Health in U.S. Adults

**Peter D. Hart***

Exercise Science, Glenville State University, Glenville, West Virginia, USA
Health Promotion Research, Havre, Montana, USA
Kinesmetrics Lab, Tallahassee, Florida, USA
*Corresponding author: pdhart@outlook.com

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**Abstract** **Background**: Perceived general health is a major dimension within the broader construct of health-related quality of life (HRQOL) and is associated with numerous outcomes such as chronic disease, disability, functional status, and mortality. Physical activity (PA) and muscular strengthening activity (MSA) are both known behaviors associated with improved HRQOL. However, post pandemic PA data are needed at the population level to examine the current relationships with HRQOL. The purpose of this study was to examine the extent to which PA and MSA relate to perceived general health in U.S. adults. **Methods:** Data for this study included 27,651 adult participants 18+ years of age from the 2022 National Health Interview Survey (NHIS). The main outcome variable was perceived general health, where participants responding as good or better were categorized as having good health and those responding fair or worse categorized as having poor health. The first predictor variable used was a 3 level PA measure of inactive, insufficiently active, and sufficiently active. The second predictor variable was a 4 level combined PA and MSA measure of meets neither, meets MSA only, meets PA only, and meets both PA and MSA guidelines. Covariates included age, sex, race/ethnicity, income, urban/rural status, and obese status. Poisson regression models with robust error variance were used to compute relative risk (RR) ratios and 95% confidence intervals (CIs). **Results:** Overall, 14.5% (95% CI: 14.0 – 15.1) of adults were categorized as having poor health, 24.3% (95% CI: 23.5 – 25.0) as meeting both PA and MSA and 46.5% (95% CI: 45.7 – 47.4) meeting neither PA or MSA guidelines. In the adjusted 3 level PA model, inactive and insufficiently active adults had RR = 2.58 (95% CI: 2.36 – 2.83) and RR = 1.70 (95% CI: 1.54 – 1.89) times greater risk of poor health, respectively, as compared to their sufficiently active counterparts. In the adjusted 4 level combined PA and MSA model, adults meeting neither PA or MSA, meeting MSA only and meeting PA only had RR = 3.27 (95% CI: 2.82 – 3.8813), RR = 2.70 (95% CI: 2.23 – 3.27), and 1.82 (95% CI: 1.54 – 2.15) times greater risk of poor health, respectively, as compared to those meeting both PA and MSA guidelines. Finally, slicing the last model by obese status, showed that non obese adults (RR = 4.05, 95% CI: 3.29 – 4.99) meeting neither PA or MSA had significantly greater RR of poor health than their obese counterparts (RR = 2.09, 95% CI: 1.70 – 2.57). **Conclusion:** These results indicate that meeting PA as well as combined PA and MSA guidelines protect adults against poor general health in the U.S. Health promotion planning efforts to increase PA should include perceived general health as a expectancy outcome.

***Keywords:*** *Physical activity (PA), Muscle strengthening activity (MSA), NHIS, General health*

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## 1. Introduction

Health-related quality of life (HRQOL) is a complex construct that can be defined generally as a self-assessment of health status as it relates to one's quality of life [1]. HRQOL can also be defined multidimensionally represented by specific components such as physical functioning, bodily pain, mental health, social function, and vitality [2]. General health is another dimension of HRQOL that is commonly assessed in population-based research [3]. Measures of HRQOL are used in public health and medical research as outcome variables because of their consistent ability to predict important health problems such as chronic disease, disability, functional status, and mortality [4]. The single perceived general health dimension of HRQOL is also predictive of morbidity and mortality but may additionally add valuable health information that is not captured in larger more complex participant-reported outcome measures [5].

The Physical Activity Guidelines for Americans (2nd Edition) includes recommendations for aerobic physical activity (PA) as well as muscle-strengthening activity (MSA) [6]. The current PA guidelines recommend accumulating 150+ minutes (150+ of moderate, 75+ of vigorous, or a combination) each week of aerobic-related moderate-to-vigorous PA (MVPA). The current guidelines

for MSA recommend doing muscle-strengthening activities of at least moderate intensity involving all major muscle groups on 2+ days each week. Thus, adults are recommended to meet both PA and MSA guidelines each week. Meeting PA and MSA guidelines is important because of their positive associations with personal health outcomes, including HRQOL [7,8]. However, less is known about these associations when both guidelines are concurrently considered. Additionally, post pandemic PA data are needed at the population level to examine current relationships with measures of HRQOL. Therefore, the aim of this study was to examine the extent to which PA and MSA relate to perceived general health in U.S. adults.

## 2. Materials & Methods

*Study Procedures*

Data from the 2022 National Health Interview Survey (NHIS) were used for this research. NHIS is conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) [9,10]. NHIS is used by CDC and NCHS as a primary source of data on the health of the civilian noninstitutionalized population of the U.S. NHIS collects data through personal household interviews with variables ranging from health behaviors (alcohol use, tobacco use, physical activity) to health status markers (chronic diseases, blood pressure, cholesterol, BMI, etc.). The current research used the *Sample Adult Interview* portion of NHIS including 27,651 adult participants 18+ years of age.

*Perceived General Health*

Perceived general health was assessed using a single item asking participants to rate their general health with the following response options: “excellent”, “very good”, “good”, “fair” or “poor”. Responses to this question were then numerically recoded from 1 to 5, with higher scores representing better general health. General health was then dichotomized, with those responding as good or better categorized as good and all others as poor.

*Three level Physical Activity (PA) variable*

PA was assessed from a series of questions asking participants about their physical activities such as exercise, sports, or physically active hobbies they may do in their leisure time. Both moderate-intensity and vigorous-intensity PA was assessed where moderate-intensity activities were described to cause moderate increases in breathing or heart rate and vigorous-intensity activities described to cause large increases in breathing or heart rate. Specific questions were asked regarding the frequency and duration of both types of physical activities and resulted in a combined aerobic-related leisure time MVPA variable with units of minutes per week (min/wk). A 3 level PA measure was constructed categorizing adults into one of the following groups: 1) inactive (no PA), 2) insufficiently active (some PA to 149 min/wk), and 3) sufficiently active (150+ min/wk).

*Four level combined PA and Muscle Strengthening Activity (MSA) variable*

To assess MSA behavior, respondents were asked how many times (per day, week, month, year) they participated in leisure-time physical activities specifically designed to strengthen their muscles (such as sit-ups, push-ups or lifting weights). Answers to this question were then used to categorize participants into one of two MSA groups: 1) those meeting MSA guidelines (participating in MSA 2+ days per week) or 2) those not meeting MSA guidelines (participating in MSA < 2 days per week). Using the 3 level PA and MSA variables, a 4 level combined PA and MSA variable was constructed categorizing adults into one of the following groups: 1) those meeting neither PA or MSA, 2) those meeting MSA only, 3) those meeting PA only, or 4) those meeting both PA and MSA guidelines.

*Demographic and BMI variables*

All covariate variables in this study were used as categorical variables and included age, sex, race/ethnicity, income quartile, residence type, and obese status. Age was categorized as three distinct groups: 1) 18 to 44 years, 2) 45 to 54 years, and 3) 65 to 85+ years. Sex was used as 1) male and 2) female. Race/ethnicity was categorized as four distinct groups: 1) White, 2) Black, 3) Hispanic, and 4) Other. Income was categorized into quartiles using the ratio of family income to poverty threshold variable. Income quartiles were not exactly evenly distributed and should be considered approximate, ranging from the lowest household incomes ($1^{st}$ quartile) to the highest household incomes ($4^{th}$ quartile). Residence type was categorized as two distinct groups: 1) rural and 2) urban residence. Finally, obese status was categorized as two distinct groups of 1) obese (BMI $\geq$ 30.0 kg/m$^2$) and 2) non obese (BMI < 30.0 kg/m$^2$).

*Statistical Analysis*

The data analysis included descriptive statistics such as weighted percentages with 95% confidence intervals (CI). The Rao-Scott chi-square statistic was used to test for difference between bivariate categorical variables. The relationship between the two different PA variables and perceived general health was examined using three different sets of regression models: a) bivariate unadjusted Poisson regression models, b) demographics adjusted Poisson regression models and c) all (demographics and obese status) adjusted Poisson regression models. Poisson regression models were used to estimate relative risk (RR) ratios (aka, prevalence ratios [PRs]) and 95% CIs. The RR was used to compare the *risk* estimates (or prevalences) of two different groups, where the most active groups served as the reference group in all models. Additionally, Poisson models were modified to include a robust error variance procedure to adjust for equidispersion [11,12]. Finally, to test the moderating effect of obese status on the PA and perceived general health relationship, a PA-by-obese interaction term was tested and subsequently resulted in two sets of models spliced by obese status. Significance was set to $p < .05$ and SAS version 9.4 with survey procedures used for all analyses [13,14].

## 3. Results

Table 1 contains the weighted percentages of general health status within different study-related subpopulations. Overall, 14.5% (95% CI: 14.0 – 15.1) of adults were categorized as having poor health in 2020. Subpopulations

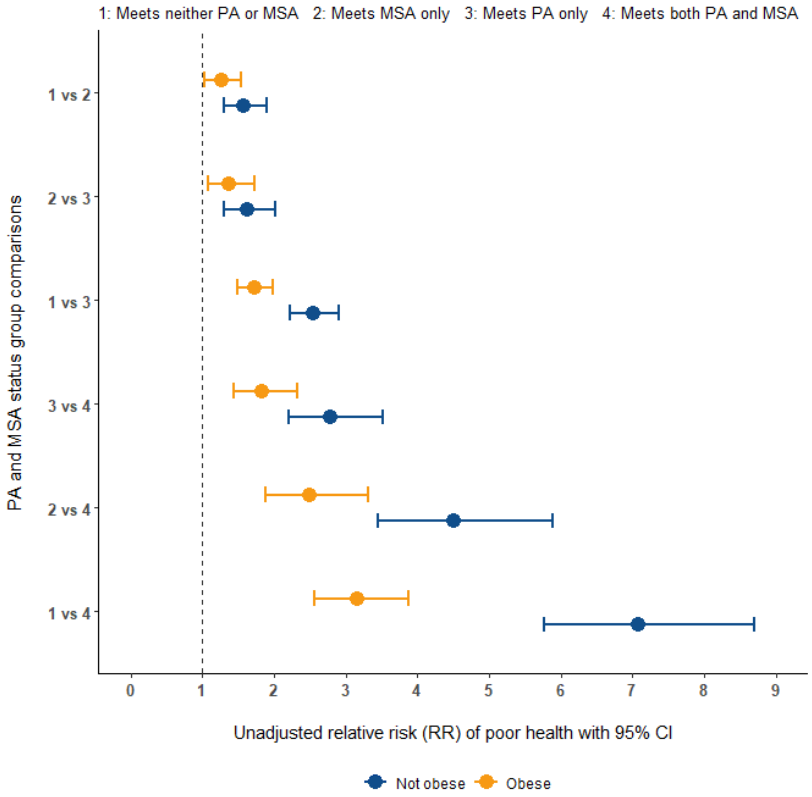
with greater ($p < .05$) rates of poor health were 65 to 85+ year old (23.5%, 95% CI: 22.3 – 24.6), Black (18.8%, 95% CI: 17.1 – 20.5), 1st income quartile (27.4%, 95% CI: 26.1 – 28.8), rural (19.6%, 95% CI: 18.0 – 21.2), and obese (20.5%, 95% CI: 19.5 – 21.5). Table 2 contains the weighted percentages of 4 level combined PA and MSA status groups within different study-related subpopulations. Overall, 24.3% (95% CI: 23.5 – 25.0) were considered meeting both PA and MSA and 46.5% (95% CI: 45.7 – 47.4) meeting neither PA or MSA guidelines. Subpopulations with greater ($p < .05$) rates of meeting neither PA or MSA guidelines were 65 to 85+ year old (55.6%, 95% CI: 54.3 – 57.0), Hispanic (53.2%, 95% CI: 51.3 – 55.1), 1st income quartile (58.6%, 95% CI: 57.0 – 60.2), rural (53.7%, 95% CI: 51.5 – 55.9), and obese (56.0%, 95% CI: 54.7 – 57.3).

Table 3 displays results from the regression models predicting poor health using the 3 level PA status variable. In the all adjusted 3 level PA model, inactive and insufficiently active adults had RR = 2.58 (95% CI: 2.36 – 2.83) and RR = 1.70 (95% CI: 1.54 – 1.89) times greater risk of poor health, respectively, as compared to their sufficiently active counterparts. Additionally, subpopulations with elevated risk of poor health remaining after adjustments included 65 to 85+ year old (RR = 2.52, 95% CI: 2.30 – 2.77), 1st income quartile (RR = 3.69, 95% CI: 3.29 – 4.13), and obese (RR = 1.52, 95% CI: 1.42 – 1.63).

Table 4 displays results from similar regression models predicting poor health but using the 4 level combined PA and MSA status variable. In the all adjusted 4 level combined PA and MSA model, adults meeting neither PA or MSA, meeting MSA only and meeting PA only had RR = 3.27 (95% CI: 2.82 – 3.8813), RR = 2.70 (95% CI: 2.23 – 3.27), and 1.82 (95% CI: 1.54 – 2.15) times greater risk of poor health, respectively, as compared to those meeting both PA and MSA guidelines. Similarly, subpopulations with elevated risk of poor health remaining after adjustments included 65 to 85+ year old (RR = 2.55, 95% CI: 2.32 – 2.81), 1st income quartile (RR = 3.80, 95% CI: 3.40 – 4.26), and obese (RR = 1.51, 95% CI: 1.41 – 1.62).

Table 5 contains results for the unadjusted regression model predicting poor health using 4 level combined PA and MSA status sliced by obese status. All RRs in this model were significantly different from 1.00. Most noteworthy is the significant difference between the RRs of the non obese and obese groups for greater risk of poor health in adults meeting neither PA or MSA guideline as compared to their counterparts meeting both PA and MSA guidelines. Specifically, non obese adults (RR = 7.08, 95% CI: 5.77 – 8.69) meeting neither PA or MSA had significantly greater RR of poor health than their obese counterparts (RR = 3.15, 95% CI: 2.56 – 3.88). Figure 1 displays these RR values with their respective 95% CIs.

Table 6 contains similar results but for the adjusted regression model predicting poor health using the 4 level combined PA and MSA status sliced by obese status. All RRs in this model were significantly different from 1.00 (less Obese: 1 vs 2.). Most notable again is the significant difference between the RRs of the non obese and obese groups for adults meeting neither PA or MSA guideline as compared to their counterparts meeting both PA and MSA guidelines. In detail, non obese adults (RR = 4.05, 95% CI: 3.29 – 4.99) meeting neither PA or MSA had significantly greater RR of poor health than their obese counterparts (RR = 2.09, 95% CI: 1.70 – 2.57). Figure 2 displays these RR values with their respective 95% CIs.



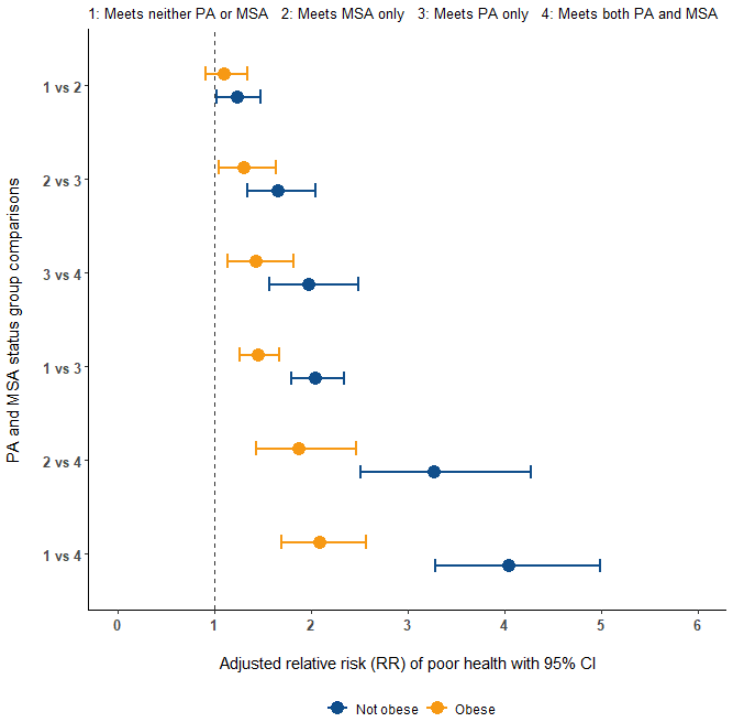

Note. All RRs are significantly different from 1.00.

**Figure 1.** Unadjusted relative risk (RR) statistics for poor health across 4 level combined PA and MSA status categories by obese status, NHIS 2022.

**Table 1. Characteristics of sample participants by general health status, NHIS 2022**

| Characteristic | Poor health | | | Good health | | | *p* |
|---|---|---|---|---|---|---|---|
| | *%* | *LL* | *UL* | *%* | *LL* | *UL* | |
| Overall (*N* = 27,645) | 14.5 | 14.0 | 15.1 | 85.5 | 84.9 | 86.0 | <.0001 |
| Sex | | | | | | | .0049 |
| Male | 13.8 | 13.1 | 14.5 | 86.2 | 85.5 | 86.9 | |
| Female | 15.2 | 14.4 | 15.9 | 84.8 | 84.1 | 85.6 | |
| Age (yr) | | | | | | | <.0001 |
| 18 to 44 | 8.1 | 7.5 | 8.8 | 91.9 | 91.2 | 92.5 | |
| 45 to 64 | 17.5 | 16.6 | 18.5 | 82.5 | 81.5 | 83.4 | |
| 65 to 85+ | 23.5 | 22.3 | 24.6 | 76.5 | 75.4 | 77.7 | |
| Race/Ethnicity | | | | | | | <.0001 |
| White | 13.5 | 12.9 | 14.2 | 86.5 | 85.8 | 87.1 | |
| Black | 18.8 | 17.1 | 20.5 | 81.2 | 79.5 | 82.9 | |
| Hispanic | 16.1 | 14.7 | 17.5 | 83.9 | 82.5 | 85.3 | |
| Other | 12.5 | 10.8 | 14.2 | 87.5 | 85.8 | 89.2 | |
| Income quartile[a] | | | | | | | <.0001 |
| 1st | 27.4 | 26.1 | 28.8 | 72.6 | 71.2 | 73.9 | |
| 2nd | 16.6 | 15.5 | 17.7 | 83.4 | 82.3 | 84.5 | |
| 3rd | 10.3 | 9.3 | 11.3 | 89.7 | 88.7 | 90.7 | |
| 4th | 6.0 | 5.4 | 6.5 | 94.0 | 93.5 | 94.6 | |
| Residence type | | | | | | | <.0001 |
| Rural | 19.6 | 18.0 | 21.2 | 80.4 | 78.8 | 82.0 | |
| Urban | 13.7 | 13.1 | 14.3 | 86.3 | 85.7 | 86.9 | |
| BMI status | | | | | | | <.0001 |
| Obese | 20.5 | 19.5 | 21.5 | 79.5 | 78.5 | 80.5 | |
| Non obese | 11.4 | 10.8 | 12.0 | 88.6 | 88.0 | 89.2 | |

Note. [a]Income quartile is approximate quartile categories for the ratio of family income to poverty threshold. p-value is for the Rao-Scott chi-square statistic. % is the weighted percentage estimate. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the %. Obese status was defined as a BMI ≥ 30.0 kg/m$^2$.




Note. All RRs are significantly different from 1.00, less Obese: 1 vs 2.

**Figure 2.** Adjusted relative risk (RR) statistics for poor health across 4 level combined PA and MSA status categories by obese status, NHIS 2022.

**Table 2. Characteristics of sample participants by 4 level combined PA and MSA status, NHIS 2022**

| | Meets neither PA or MSA | | | Meets MSA only | | | Meets PA only | | | Meets both PA and MSA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characteristic | *%* | *LL* | *UL* | *%* | *LL* | *UL* | *%* | *LL* | *UL* | *%* | *LL* | *UL* | *p* |
| Overall (*N* = 26,494) | 46.5 | 45.7 | 47.4 | 6.3 | 5.9 | 6.6 | 22.9 | 22.2 | 23.5 | 24.3 | 23.5 | 25.0 | <.0001 |
| Sex | | | | | | | | | | | | | <.0001 |
| Male | 41.2 | 40.1 | 42.4 | 6.4 | 5.9 | 6.9 | 23.9 | 23.0 | 24.9 | 28.4 | 27.4 | 29.5 | |
| Female | 51.6 | 50.5 | 52.6 | 6.2 | 5.7 | 6.7 | 21.9 | 21.1 | 22.7 | 20.4 | 19.5 | 21.2 | |
| Age (yr) | | | | | | | | | | | | | <.0001 |
| 18 to 44 | 40.1 | 38.8 | 41.3 | 6.5 | 5.9 | 7.1 | 21.6 | 20.6 | 22.7 | 31.8 | 30.7 | 33.0 | |
| 45 to 64 | 49.6 | 48.2 | 50.9 | 6.0 | 5.5 | 6.6 | 24.0 | 22.9 | 25.1 | 20.4 | 19.3 | 21.5 | |
| 65 to 85+ | 55.6 | 54.3 | 57.0 | 6.3 | 5.7 | 6.8 | 23.7 | 22.6 | 24.8 | 14.4 | 13.5 | 15.3 | |
| Race/Ethnicity | | | | | | | | | | | | | <.0001 |
| White | 44.1 | 43.0 | 45.2 | 6.1 | 5.7 | 6.5 | 24.8 | 23.9 | 25.6 | 25.0 | 24.1 | 26.0 | |
| Black | 49.8 | 47.5 | 52.2 | 8.0 | 6.7 | 9.3 | 18.3 | 16.5 | 20.1 | 23.9 | 21.8 | 25.9 | |
| Hispanic | 53.2 | 51.3 | 55.1 | 6.0 | 5.1 | 6.8 | 18.8 | 17.3 | 20.2 | 22.1 | 20.5 | 23.7 | |
| Other | 46.6 | 44.3 | 48.9 | 6.2 | 5.1 | 7.4 | 23.5 | 21.5 | 25.5 | 23.7 | 21.6 | 25.8 | |
| Income quartile[a] | | | | | | | | | | | | | <.0001 |
| 1st | 58.6 | 57.0 | 60.2 | 6.1 | 5.4 | 6.8 | 21.0 | 19.8 | 22.3 | 14.3 | 13.1 | 15.4 | |
| 2nd | 51.8 | 50.4 | 53.3 | 6.2 | 5.5 | 6.9 | 22.0 | 20.8 | 23.3 | 20.0 | 18.7 | 21.2 | |
| 3rd | 44.9 | 43.2 | 46.5 | 6.4 | 5.6 | 7.2 | 23.4 | 22.0 | 24.7 | 25.4 | 23.9 | 26.9 | |
| 4th | 34.7 | 33.4 | 35.9 | 6.5 | 5.9 | 7.0 | 24.6 | 23.5 | 25.7 | 34.3 | 33.0 | 35.6 | |
| Residence type | | | | | | | | | | | | | <.0001 |
| Rural | 53.7 | 51.5 | 55.9 | 5.5 | 4.7 | 6.4 | 24.6 | 22.7 | 26.5 | 16.2 | 14.6 | 17.9 | |
| Urban | 45.4 | 44.4 | 46.4 | 6.4 | 6.0 | 6.8 | 22.6 | 21.9 | 23.3 | 25.6 | 24.8 | 26.4 | |
| BMI status | | | | | | | | | | | | | <.0001 |
| Obese | 56.0 | 54.7 | 57.3 | 6.1 | 5.5 | 6.7 | 21.1 | 20.1 | 22.2 | 16.8 | 15.7 | 17.9 | |
| Non obese | 41.3 | 40.2 | 42.3 | 6.4 | 6.0 | 6.9 | 23.9 | 23.1 | 24.7 | 28.4 | 27.5 | 29.3 | |

Note. aIncome quartile is approximate quartile categories for the ratio of family income to poverty threshold. p-value is for the Rao-Scott chi-square statistic. % is the weighted percentage estimate. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the %. Obese status was defined as a BMI ≥ 30.0 kg/m2.

**Table 3. Regression models predicting poor health using 3 level PA status, NHIS 2022**

| | Unadjusted | | | Demographics adjusted | | | All adjusted | | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristic | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* |
| PA status | | | | | | | | | |
| Inactive | 4.06 | 3.73 | 4.43 | 2.72 | 2.48 | 2.98 | 2.58 | 2.36 | 2.83 |
| Insufficiently active | 2.03 | 1.84 | 2.25 | 1.76 | 1.59 | 1.95 | 1.70 | 1.54 | 1.89 |
| Sufficiently active | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Sex | | | | | | | | | |
| Male | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Female | 1.10 | 1.03 | 1.17 | 0.94 | 0.88 | 1.00 | 0.92 | 0.86 | 0.98 |
| Age (yr) | | | | | | | | | |
| 18 to 44 | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| 45 to 64 | 2.16 | 1.97 | 2.37 | 2.15 | 1.96 | 2.36 | 2.12 | 1.93 | 2.33 |
| 65 to 85+ | 2.89 | 2.64 | 3.17 | 2.44 | 2.22 | 2.68 | 2.52 | 2.30 | 2.77 |
| Race/Ethnicity | | | | | | | | | |
| White | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Black | 1.39 | 1.26 | 1.52 | 1.12 | 1.02 | 1.23 | 1.11 | 1.01 | 1.22 |
| Hispanic | 1.19 | 1.08 | 1.30 | 0.99 | 0.89 | 1.09 | 0.98 | 0.89 | 1.09 |
| Other | 0.92 | 0.81 | 1.06 | 0.95 | 0.83 | 1.09 | 1.03 | 0.90 | 1.18 |
| Income quartile | | | | | | | | | |
| 1st | 4.60 | 4.15 | 5.11 | 3.70 | 3.31 | 4.15 | 3.69 | 3.29 | 4.13 |
| 2nd | 2.79 | 2.50 | 3.11 | 2.34 | 2.09 | 2.63 | 2.29 | 2.04 | 2.58 |

| | Unadjusted | | | Demographics adjusted | | | All adjusted | | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristic | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* |
| 3rd | 1.72 | 1.51 | 1.97 | 1.56 | 1.36 | 1.78 | 1.53 | 1.34 | 1.75 |
| 4th | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Residence type | | | | | | | | | |
| Rural | 1.43 | 1.32 | 1.55 | 1.08 | 1.00 | 1.17 | 1.06 | 0.98 | 1.15 |
| Urban | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| BMI status | | | | | | | | | |
| Obese | 1.79 | 1.68 | 1.92 | | | | 1.52 | 1.42 | 1.63 |
| Non obese | 1.00 | ref | | | | | 1.00 | ref | |

Note. Poisson regression models estimate the relative risk (RR) and its 95% CI. Poisson models are modified to include a robust error variance procedure to adjust for equidispersion. Unadjusted models have a single predictor variable. Demographics adjusted model includes all predictor variables less BMI status. All adjusted model includes all predictor variables.

**Table 4. Regression models predicting poor health using 4 level combined PA and MSA status, NHIS 2022**

| | Unadjusted | | | Demographics adjusted | | | All adjusted | | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristic | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* |
| PA status | | | | | | | | | |
| Meets neither PA or MSA | 5.57 | 4.81 | 6.45 | 3.52 | 3.03 | 4.09 | 3.27 | 2.82 | 3.81 |
| Meets MSA only | 3.76 | 3.10 | 4.57 | 2.83 | 2.34 | 3.42 | 2.70 | 2.23 | 3.27 |
| Meets PA only | 2.52 | 2.14 | 2.98 | 1.90 | 1.61 | 2.25 | 1.82 | 1.54 | 2.15 |
| Meets both PA and MSA | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Sex | | | | | | | | | |
| Male | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Female | 1.10 | 1.03 | 1.17 | 0.92 | 0.86 | 0.98 | 0.90 | 0.84 | 0.96 |
| Age (yr) | | | | | | | | | |
| 18 to 44 | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| 45 to 64 | 2.16 | 1.97 | 2.37 | 2.14 | 1.95 | 2.35 | 2.12 | 1.93 | 2.33 |
| 65 to 85+ | 2.89 | 2.64 | 3.17 | 2.47 | 2.25 | 2.71 | 2.55 | 2.32 | 2.81 |
| Race/Ethnicity | | | | | | | | | |
| White | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Black | 1.39 | 1.26 | 1.52 | 1.14 | 1.04 | 1.26 | 1.13 | 1.03 | 1.25 |
| Hispanic | 1.19 | 1.08 | 1.30 | 1.01 | 0.91 | 1.11 | 1.01 | 0.91 | 1.11 |
| Other | 0.92 | 0.81 | 1.06 | 0.93 | 0.82 | 1.07 | 1.01 | 0.88 | 1.16 |
| Income quartile | | | | | | | | | |
| 1st | 4.60 | 4.15 | 5.11 | 3.81 | 3.41 | 4.27 | 3.80 | 3.40 | 4.26 |
| 2nd | 2.79 | 2.50 | 3.11 | 2.38 | 2.12 | 2.67 | 2.33 | 2.08 | 2.62 |
| 3rd | 1.72 | 1.51 | 1.97 | 1.57 | 1.37 | 1.79 | 1.54 | 1.35 | 1.76 |
| 4th | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| Residence type | | | | | | | | | |
| Rural | 1.43 | 1.32 | 1.55 | 1.09 | 1.00 | 1.17 | 1.06 | 0.98 | 1.15 |
| Urban | 1.00 | ref | | 1.00 | ref | | 1.00 | ref | |
| BMI status | | | | | | | | | |
| Obese | 1.79 | 1.68 | 1.92 | | | | 1.51 | 1.41 | 1.62 |
| Non obese | 1.00 | ref | | | | | 1.00 | ref | |

Note. Poisson regression models estimate the relative risk (RR) and its 95% CI. Poisson models are modified to include a robust error variance procedure to adjust for equidispersion. Unadjusted models have a single predictor variable. Demographics adjusted model includes all predictor variables less BMI status. All adjusted model includes all predictor variables.

**Table 5. Unadjusted regression model predicting poor health using 4 level combined PA and MSA status sliced by obese status, NHIS 2022**

| | | | Non obese | | | Obese | | |
|---|---|---|---|---|---|---|---|---|
| Comparison group | vs. | Reference group | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* |
| Meets neither PA or MSA | | Meets both PA and MSA | 7.08 | 5.77 | 8.69 | 3.15 | 2.56 | 3.88 |
| Meets MSA only | | Meets both PA and MSA | 4.50 | 3.44 | 5.88 | 2.50 | 1.89 | 3.31 |
| Meets PA only | | Meets both PA and MSA | 2.78 | 2.21 | 3.51 | 1.83 | 1.44 | 2.33 |
| Meets neither PA or MSA | | Meets PA only | 2.54 | 2.23 | 2.91 | 1.72 | 1.49 | 1.98 |
| Meets MSA only | | Meets PA only | 1.62 | 1.30 | 2.01 | 1.36 | 1.08 | 1.72 |
| Meets neither PA or MSA | | Meets MSA only | 1.57 | 1.30 | 1.90 | 1.26 | 1.03 | 1.55 |

Note. RR is crude relative risk of poor health. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the RR. Poisson models were used and modified to include a robust error variance procedure to adjust for equidispersion.

**Table 6. Adjusted regression model predicting poor health using 4 level combined PA and MSA status sliced by obese status, NHIS 2022**

| | | | Non obese | | | Obese | | |
|---|---|---|---|---|---|---|---|---|
| Comparison group | vs. | Reference group | *RR* | *LL* | *UL* | *RR* | *LL* | *UL* |
| Meets neither PA or MSA | | Meets both PA and MSA | 4.05 | 3.29 | 4.99 | 2.09 | 1.70 | 2.57 |
| Meets MSA only | | Meets both PA and MSA | 3.28 | 2.51 | 4.27 | 1.88 | 1.44 | 2.47 |
| Meets PA only | | Meets both PA and MSA | 2.05 | 1.79 | 2.34 | 1.46 | 1.27 | 1.67 |
| Meets neither PA or MSA | | Meets PA only | 1.98 | 1.57 | 2.50 | 1.44 | 1.13 | 1.82 |
| Meets MSA only | | Meets PA only | 1.66 | 1.34 | 2.05 | 1.31 | 1.05 | 1.64 |
| Meets neither PA or MSA | | Meets MSA only | 1.24 | 1.03 | 1.49 | 1.11 | 0.92 | 1.34 |

Note. RR is adjusted relative risk of poor health. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the RR. Poisson models were used and modified to include a robust error variance procedure to adjust for equidispersion.

# 4. Discussion

This study found that inactive as well as insufficiently active adults were at greater risk of reporting poor general health in the U.S. The protective effect gained by those meeting PA guidelines also remained after adjusting for commonly known confounding variables. Additionally, results found that adults meeting neither PA or MSA as well as those meeting only MSA or only PA guidelines, were at greater risk of reporting poor general health. Similarly, the protective effect gained by those meeting both PA and MSA guidelines remained after adjusting for the same confounding variables. These updated post-pandemic findings do in fact fall in line with previous research [15,16,17,18,19].

The unexpected and more noteworthy finding in this study was the relative risk of poor health in those meeting neither compared to those meeting both guidelines when compared across obese status groups. Specifically, the adjusted relative risk point estimate was almost doubled for the non obese population as compared to the obese. This finding highlights the separation in poor health that can be attributed to PA in non obese populations. Conversely, this also highlights the smaller gap in poor health risk across the extreme PA groups in obese. A review of the current literature resulted in no studies with similar findings. Future research is suggested to corroborate this study's substantial moderating effect of obese status on the PA and general health relationship.

This study has several strengths and limitations with many mentioned elsewhere [20]. Briefly, a few strengths of this study are: 1) the large sample size of over 26,000 adult participants, 2) the large collection of variables including health, PA, and demographic indicators, 3) the consistent use of PA assessments over survey periods including items for muscle strengthening exercise and the ability to assess combined PA and MSA guidelines, and 4) the ability to generalize to the entire civilian noninstitutionalized population of the U.S. Some limitations of the study are: 1) the inability to draw cause-and-effect relationships between PA and general health due to the nature of its cross-sectional survey design, 2) the inability to generalize to smaller regions such as states, counties or cities, 3) the use of surveys for data collection, 4) the use of self-reported assessment of PA and MSA for its main predictor variables, and 5) its use of self-reported general health as opposed to a more objective health status indicator. Therefore, the findings here should be considered as trends and used with caution.

# 5. Conclusions

This study found that meeting PA as well as combined PA and MSA guidelines protect adults against poor general health in the U.S. These associations remained after adjusting for demographic covariates. Health promotion planning efforts to increase PA should also include MSA as a combined PA recommendation. Additionally, perceived general health should be included as a expectancy outcome for adopting PA recommendations.

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