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Physical activity patterns and multimorbidity burden of older adults with different levels of functional status: NHANES 2003–2006

Jeremy A. Steeves, PhD, MPH[a,*], **Eric J. Shiroma, PhD**[b], **Scott A. Conger, PhD**[c], **Dane Van Domelen, PhD**[d], and **Tamara B. Harris, MD, MS**[b]

[a]Division of Education, Maryville College, Maryville, TN, 502 E. Lamar Alexander Parkway, 37804, USA

[b]Laboratory of Epidemiology and Population Sciences, National Institute on Aging, Bethesda, MD, USA

[c]Department of Kinesiology, Boise State University, Boise, ID, USA

[d]Department of Biostatistics, Johns Hopkins University, Baltimore, MD, USA

Abstract

Background: Physical function and physical activity decrease with age, but differences in physical activity patterns within different physical functioning groups are unknown.

Objectives: To describe physical activity patterns and multimorbidity burden by physical function group and age.

Methods: Actigraph accelerometer-derived physical activity patterns were compared by physical function (high functioning, activity limitations, activity of daily living disabled) determined by questionnaire and age among 2174 older adults (mean age = 70.9, sd = 0.2 years) from the cross-sectional 2003–2006 National Health and Nutrition Examination Survey. Associations between physical function, physical activity, and multimorbidity were examined.

Results: Reduced physical function and increased age were associated with lower physical activity, increased sedentary time and a compressed activity profile. During the most active hour of the day (11:00 a.m.), the oldest, lowest physical functioning group was 82% less active than the youngest, highest physical functioning group. High functioning had over 30% more total activity counts, over 56% more time in moderate-to-vigorous activity, about 8% less time sedentary and took approximately one more sedentary break/hour than lower physical functioning groups. Gender differences in physical activity variables were prevalent for high functioning, but limited within reduced physical functioning groups. Physical function, age, total activity counts/day, and breaks in sedentary time/day were independently associated with multimorbidity ($p < 0.005$).

Conclusions: Reduced physical function and increased age are associated with physical activity levels, and all three are associated with multimorbidity. Understanding physical activity

[*]Corresponding author. jeremy.steeves@maryvillecollege.edu.

differences by physical function is important for designing interventions for older individuals at increased risk for mobility disability.

Keywords

Old age; Impairment; Disabled; Accelerometer; Cross-sectional

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The Centers for Disease Control and Prevention reports that one out of every eight adults in the U.S. has a mobility limitation, such as serious difficulty walking or climbing stairs.[1] Mobility limitations are a major public health concern because they 1) restrict the ability of individuals to move about their natural environment, 2) limit an individual's independent participation in activities of daily living (ADL), 3) reduce their ability to engage socially, 4) and are associated with decreased physical activity (PA) and greater sedentary time.[2–5] Multimorbidity, defined as having two or more chronic diseases,[6] has been associated with greater mobility limitations and increased age.[7,8]

Despite the growing segment of the aging population, the large number of people with mobility limitations, and the importance of PA for a healthy lifestyle, research is limited on the PA behaviors of older adults with physical function limitations.[9,10] Recently, clinical and epidemiological aging research have proposed that measures of physical function be used as an alternative to disease status for assessing the health of older persons.[11] However, there is debate over what measures of PA or physical function are most appropriate. When accelerometer data are used to quantify PA, a standard set of intensity-based cut points are typically applied to identify time spent in different activity intensities (sedentary, light, lifestyle, moderate-to-vigorous physical activity (MVPA)).[12] Due to the reduced physical capacity of older adults with mobility limitations, the use of absolute cut points with this population may underestimate the relative intensity levels of PA.[10,12–14] As an alternative to cut points, some researchers have turned to other accelerometer-derived measures such as total activity counts/day, breaks in sedentary time, counts/minute, and using activity patterns to better understand how activity is accumulated over the course of the day.[10,15]

The purpose of this study was to describe the multimorbidity burden and accelerometer-assessed PA patterns (using both traditional accelerometer-derived PA variables and alternative activity pattern variables) of elderly adults within three physical function groups, within a national, population-based study.

Methods

Study population

The National Health and Nutrition Examination Survey (NHANES), a continuous cross-sectional survey conducted by the National Center for Health Statistics, is responsible for surveying the nations vital and health statistics[16]. Beginning in 1999, surveys, using a complex, multistage probability design, have been conducted annually. About 5000 civilians are surveyed per year; with those 60 and older, African American, and Hispanic over-sampled to produce reliable statistics. Each year a team of highly-trained, bilingual physicians, medical and health technicians, and dietary and health interviewers travel to 15

different counties across the country, to conduct health interviews at the respondents' homes and perform physical examinations in specially-designed mobile examination centers. All participants provided informed consent and the National Center for Health Statistics Research Ethics Review Board approved all protocols. Epidemiological studies and researchers interested in increasing knowledge about the nation's health profile, and developing health programs and policies frequently use this publicly available dataset which releases data in two year cycles.[16]

From 2003 to 2006, a PA monitor component was added to NHANES, providing an objective measure of PA for those 6 years of age and over[17]. Health technicians and phlebotomists at the mobile examination centers recruited eligible participants to wear the PA monitors. Those that used wheelchairs, or with impairments that prevented them from walking or wearing an accelerometer where ineligible for PA monitors. Participants were provided an elastic fabric belt to wear the device around the waist on the right hip during waking hours for 7 consecutive days. They were instructed to remove it during sleep and water activities, and were compensated $40 for returning the accelerometers through prepaid mail[17]. PA monitor data was processed and edited to remove outliers and unreasonable values based on published literature and expert judgment prior to data release.

From an initial sample of 20,470 participants who completed the 2003–2006 physical examination, this analysis focused on 2397 adult participants ≥60 yr (individuals older than 85 yr were top coded as 85) with at least four valid days (defined as ≥10 h of wear) of reliable accelerometer data, which has been a requirement for many previous analyses.[13] An additional 223 participants (9.3%) were excluded due to missing interview data (demographics, physical functioning, or chronic condition), leaving a sample of 2174.

Classification of physical function groups

Self-reported data on physical function limitations resulting from long-term physical, mental, and emotional problems or illness were obtained through the physical function interview questions. Responses were used to categorize individuals into three mutually exclusive physical function groups: ADL disabled (ADL-D), activity limitations (AL), and high physical functioning (HF). ADL-D was defined as needing special equipment to walk or having more than some difficulty with any of the following ADL items: walking between rooms on the same level, standing up from an armless straight chair, getting in and out of bed, eating (including holding a fork, cutting food or drinking from a glass), dressing (including tying shoes, working zippers, and doing buttons), reaching up over head, or using fingers to grasp or handle small objects. Participants were classified as AL if they were not already classified as ADL-D, and only had some difficulty with the above ADL items, or any difficulty walking up ten steps or walking for a quarter mile. Lastly, those who were not classified as ADL-D or AL were classified as HF. Previous NHANES analysis have employed similar definitions to determine physical functioning.[5,18]

Objectively measured PA

The uniaxial ActiGraph AM-7164, the most widely used and validated research-grade accelerometer available for measuring physical activity intensity[13], measured vertical

acceleration transformed to 'activity counts/minute', a proprietary unit of movement and its intensity in 1 min epochs. Accelerometer non-wear time, defined as a period of at least 60 consecutive minutes of zero activity counts/minute, allowing for one-to-two minutes of activity counts between 0 and 100, was determined using a previously established protocol.[13] Valid days of wear, defined as 10 or more hours/day of wear time were determined by subtracting non-wear time from 24 h.[13]

Estimates of activity intensity levels were classified for each minute of wear time with commonly used cut points, which were established for NHANES (0–99 counts/min = sedentary; 100–759 counts/min = light; 760–2019 counts/min lifestyle; ≥2020 counts/min = MVPA),[13,19] and estimates of the = proportion of wear time per day spent in each activity intensity level were determined. Accelerometer data was processed to derive average hourly values for each variable using customized software written in MATLAB R2006a. Total activity counts/day (an indicator of PA volume strongly correlated with cardiometabolic biomarkers),[15] mean activity counts/minute, MVPA min/week in modified 10-min bouts, and breaks in sedentary time/day and/hour (any time there was a transition to non-sedentary (a minute with ≥100 counts) from sedentary activity (a minute with <100 counts)) were calculated.

Determining multimorbidity

In a manner used in similar studies,[18,20] an ordinal multi-morbidity score (0–9) was constructed based on reporting a physician diagnosis of any of 9 chronic conditions questions in NHANES 2003–2006: arthritis, cancer, cardiovascular disease (congestive heart failure, coronary heart disease, or angina), chronic kidney disease, diabetes, hypertension, pulmonary disease (emphysema, chronic bronchitis, or asthma), osteoporosis, and stroke.[6,7]

Statistical analysis

Differences in characteristics (demographics and the prevalence of the 9 chronic conditions) by physical function groups were analyzed by analysis of variance (ANOVA) (continuous variables) and X^2 test (categorical variables). Adjusted means and standard error (SE) were calculated for accelerometer-derived PA variables. To determine the differences in PA variables between the three physical function groups and to compare men and women within each physical function group, Proc Surveyreg was used with Bonferroni correction (alpha = 0.05/10). To show daily PA pro files, hour-by-hour median activity counts/minute values were plotted by age category within physical function group. Additionally, hour-by-hour plots for the median proportion of time spent in different activity intensities were created by physical function group. Significant differences between groups were inferred by the presence of non-overlapping 95% CI of the outcome variable at each hour of the day. Regression models, adjusted for age, sex, BMI, and physical function group examined the associations between measures of PA (total activity counts, and breaks in sedentary time) and multi-morbidity score.

Analyses were conducted using SAS software V9.4 (Research Triangle Park, NC). To account for the complex sampling design of NHANES, the 4-year (2003–2006) sampling

weights were used for analysis. Two-year (2005–2006) sampling weights were used for analysis that included the 2005–2006 accelerometer step data.

Results

Of the 2174 older adults that were included in this study, 1049 (48%) were classified as HF, 650 (30%) were classified as AL, and 475 (22%) were classified as ADL-D (Table 1). The HF group was significantly younger, had lower BMI, and lower prevalence of hypertension, arthritis, diabetes, osteoporosis, stroke, and kidney disease, number of chronic conditions, and multimorbidity compared to AL and ADL-D groups ($p < 0.001$). The prevalence of cardiovascular disease and pulmonary disease was significantly different between all groups ($p < 0.001$).

Accelerometer wear time averaged 6.3 valid days, and 14.0 h/day overall. Table 2 presents a comparison of accelerometer-derived PA variables between HF, AL, and ADL-D, and men and women within physical function groups. The HF group had over 30% more total activity counts and activity counts/min, and over 75% more MVPA min/week in modified 10-min bouts than AL or ADL-D. HF also spent over 8% more time in light, over 36% more in lifestyle, over 56% more time in MVPA intensity levels, and about 8% less time in sedentary intensity than AL or ADL-D. Steps/day and peak 30-min cadence from 2005 to 2006 were not different between physical function groups.

Differences in accelerometer-derived variables between males and females occurred predominantly in the HF group, where men had 12% more total activity counts, 10% more activity counts/min, 33% more steps/day, 42% more MVPA, 16% more lifestyle, 4% more sedentary, 16% less light intensity activity, and had 8% less sedentary breaks than women.

Fig. 1 shows the hourly activity profiles of activity counts/minute by age categories within each of the three physical function groups. The HF group showed a steeper rise in morning activity counts/minute and had significantly higher activity counts/minute than the AL and ADL-D groups during the majority of the day (8:00 a.m. to 9:00 p.m.). Those in the 60–69-year category showed a more rapid increase in the morning compared to the 70–79 and 80 + categories. Percent differences in activity counts/minute between the oldest and the youngest-age category increased as physical function decreased. Within the HF group, the 80 + age category (n = 188) was 50% less active than the 60–69 age category (n = 590) during one of the most active hours of the day: 11:00 a.m. In the AL group, those aged 80+ (n = 180) were 62% less active than those aged 60–69 (n = 298), and in the ADL-D group, those aged 80+ (n = 87) were 69% less active than those aged 60–69 (n = 112) at 11:00 a.m. Those in the least active group (age 80 +, ADL-D [n = 87]) were 82% less active than the most active group (60–69, HF [n = 590]).

Within the HF grouping, the daily activity profiles of activity counts/minute were similar between the different age categories, creating the appearance of three right skewed non-symmetric distributions (Fig.1A). There were significant differences between all age categories hourly activity counts/minute (60–69 > 70–79 > 80+) for most of the day (11:00 a.m. – 5:00 p.m.).

Within the AL group, all age categories activity counts/minute were significantly different from 11:00 a.m. – 12:00 p.m., and from 1:00 p.m. to 9:00 p.m. (60–69 > 70–79 > 80+) (Fig. 1B). The age 60–69 daily activity profile appeared to be a right skewed non-symmetric distribution, while the daily activity profiles of the 70–79 and 80 + age categories appeared to be more symmetrical, nearly normal distributions.

The daily activity profiles of all the ADL-D age categories appeared to be symmetrical, nearly normal distributions. (Fig. 1C). For the ADL-D grouping, the age 60–69 category had significantly more activity counts/minute than the other age categories from 9:00 a.m. through 9:00 p.m.

Minutes/hour in MVPA, light, lifestyle, and sedentary activity intensity levels for each physical function group were plotted (Fig. 2). The HF group engaged in significantly more MVPA (11:00 a.m.–2:00 p.m., and 3:00 p.m.–4:00 p.m.), lifestyle (8:00 a.m.–10:00 p.m.), light (8:00 a.m.–1:00 p.m.), and less sedentary minutes (11:00 a.m.–3:00 p.m., and 6:00 p.m.–8:00 p.m.) than AL and ADL-D groups. There were no differences in sedentary breaks/hour.

In the simple linear regression (model 1), function was significantly inversely associated with multimorbidity score (Table 3). Beta-coefficients indicated that ADL-D and AL participants averaged 0.95 more chronic conditions relative to HF participants ($p < 0.001$). In the multiple regression (model 2), function, age BMI, female gender, total activity counts/day, and breaks in sedentary time/day were significantly related to multimorbidity score. Age, BMI, and total activity counts/day were significantly related to multimorbidity score in HF, while female gender, and total activity counts/day were significantly related to multimorbidity score in AL, and age, BMI, female gender, and breaks in sedentary time/day were significantly related to multimorbidity score in ADL-D.

Discussion

The older adults in this sample were highly sedentary (>60% of wear time in sedentary) and engaged in very little PA (<2% of wear time in MVPA, <50 min/week of MVPA in modified 10-min bouts, and <5400 steps/day). Based on total activity counts, the HF group was over 30% more active than the AL and ADL-D groups. The significant differences in activity levels between the groups indicate that the ability to walk without special equipment and to engage in ADLs (such as walking around the house from room to room, standing from a chair, and bathing) without difficulty is a major determinant to older adults' levels of PA and sedentary activity.

Previous studies have also found that the onset of daily activity is delayed with age.[21] We found that those with limited physical function (AL and ADL-D) and older age (70–79 and 80+) followed this slow start activity pattern, due to slower and less intense increases in activity in the morning, which essentially compresses activity into a smaller portion of the day. Those with greater mobility had higher peak activity and appeared to reach their peak activity level earlier in the day, which may be indicative of their ability to independently engage in daily self-care tasks such as bathing, dressing, running errands, and volitional

physical exercise; hypothetically performed in the morning hours.[10] This rapid rise in morning activity was evident in the HF and the 60–69 and 70–79 age categories and resulted in activity profiles that appeared to be right-skewed distributions. As physical function declined and age increased, the daily activity profiles of activity counts per minute resembled a normal distribution, reflective of a gradual ramping up of activity in the morning, peaking near midday, followed by a gradual ramping down of activity in the afternoon. After the morning peak, activity levels dropped off in the afternoon independent of physical function group, which may reflect an overall lower threshold for fatigue in the elderly which contributes to a sedentary lifestyle.[22]

Compared to the HF population, those with physical function limitations likely have significantly different physical movement patterns.[23] The use of special equipment to walk (47% of those in the ADL-D group) likely impacted the amount and intensity of activity that was performed throughout the day, and is likely related to the increased accumulation of sedentary time, and reduced number of sedentary breaks/day and less MVPA. Manns et al.,[5] recently showed that participants with lower extremity mobility disability were more sedentary, sedentary for longer periods of time, less active, and active for shorter periods of time compared to those without lower extremity mobility disability.

The differences in physical activity patterns we observed provide valuable insight into the amount and timing of activity, and could have implications for how to promote physical activity among older adults with disabilities. Some of the temporal differences in activity highlight specific times of the day where the efficacy of public health interventions to increase activity could be tested. For example, those with limited physical function may be encouraged to obtain short bouts of activity in the morning to counter their typical delayed onset of daily activity. Alternatively, promoting activity near midday, when the activity differences between HF and ADL-D were the greatest, could help reduce this discrepancy. Adding some activity in the afternoon or after the evening meal could also be beneficial to interrupt the general pattern of declining activity seen in the afternoon and evening. Incorporating a short walk after each of the three standard meal times may be an effective strategy that pairs a regularly scheduled behavioral cue (i.e. eating) with a health promoting behavior.

Regularly engaging in shorter bouts of activity could be more attainable than doing one large bout of activity for these less active, likely deconditioned individuals who may have barriers to MVPA. It would be important to tailor the intervention and the desired outcomes based on the individual physical function of the participant, however, to maintain independence, walking is likely the most important behavior older adults should be encouraged to incorporate into their daily activity. To explore the effect of the timing of physical activity as a strategy to increase total activity, interventions promoting increased physical activity earlier in the day could be compared to promoting increased activity at noon or in the evening. Considering recent evidence of the negative health consequences of prolonged sedentary behavior,[24] the large quantities of sedentary activity, with few breaks identified in our sample is particularly concerning. Therefore, promoting low-intensity, short bouts of lifestyle activity, in addition to reducing and breaking up prolonged bouts of sedentary behavior should also be an intervention target.

Physical functional limitations may reduce PA thereby increasing the risk for chronic diseases and further disability.[25] In our sample, greater functional limitations were associated with a significantly lower levels of PA and an increase in the prevalence of chronic conditions, and multimorbidity. Mobility disability can be caused by many different factors, with or without disease. With age, the etiological pathway typically progresses from chronic disease to mobility disability.[26] Longitudinal studies document that individuals with greater activity limitations are at increased risk for multimorbidity,[27] and 45% of those living with chronic conditions also suffer from some limitation in activity.[28] While physical function was strongly associated with multimorbidity, total activity counts/day and breaks in sedentary time/day provided additional insight into the risk for increased number of chronic conditions. Nearly 5.3 million deaths per year are related to poor PA habits.[3] Therefore, it is important to encourage those across the physical function spectrum to obtain as much PA as possible and to avoid spending excessive amounts of time engaged in sedentary behaviors.[29]

Martin et al.[21] and Schrack et al.[10] previously showed the impact of age on hourly PA profiles; with older age categories obtaining less activity throughout much of the day. Data from the Baltimore Longitudinal Study on Aging showed remarkable differences in activity levels between the youngest (<60 years) and oldest (75 + years) groups.[10] In our sample, PA levels were decreased significantly with each successive increase in 10 year age category. Some studies show older working adults are more active than their retired peers[30]; therefore, it is possible, that in the present study, the greater PA levels of the 60–69 age group may have been due to employment and work-related tasks.

It is intriguing that our data showed that men have a PA benefit over women predominantly in the HF group. One previous study in adults ≥50, found that women had lower levels of PA than men in both the disabled and non-disabled groups.[31] Our data support physical function impacting PA levels in such a way that the movement patterns of men and women with functional limitations become more uniform, and obscure the gender differences in activity levels commonly seen in individuals without mobility disabilities. Several studies have shown fewer gender differences in activity levels with advanced age.[32,33]

In our study, only the HF and AL men surpassed the 5000-step/day sedentary lifestyle index,[34] matching the number of steps from one previous older adult sample,[35] but falling short of pedometer-based estimates for healthy older adults (6000 to 8500 steps/day).[36] In general our samples daily step counts match with those of adults living with chronic illnesses and disabilities (3500–5500 steps/day).[36] Relative to healthy peers, both distance walked,[37] and walking pace[38] are typically reduced in individuals with chronic illness, frailty, and disability.

Peak 30-min cadence is considered an indicator of an individual's natural best effort in daily life.[39] Again, it was the HF and AL men who were close to previously reported values for adults 60–69 (65.2 steps/minute), while all others had slower walking speeds.[39] Slower walking speeds, while they may be related with a general pattern of activities, are consistently associated with reduced quality of life and well-being in old age, overall health status, and other unfavorable health outcomes, including risk of multimorbidity, increased

health care resource utilization, disability in activities of daily living, nursing home admission, and earlier mortality.[38,40]

The physical function groupings were created based on a variety of self-report physical function questions. As a result, it is possible that participants with only an upper body physical disability could have been classified as AL or ADL-D groups. Lower extremity physical disabilities may have a stronger association with the PA outcomes measured by waist worn accelerometer.[5] We were unable to distinguish between the types of special equipment (cane vs. walker)used by those in the ADL-D group (47% of those in the ADL-D group reported difficulty walking without using special equipment), which may impact PA differently. Additionally, the higher number of comorbidities in the AL and ADL-D groups conceivably could be associated with increased pain intensity, pain sites, higher level of fatigue, or perceived physical fatigability which is likely to impact levels of PA. It must be acknowledged that the r^2 values of our regression models were low, indicating that only some of the variation in multimorbidity was explained by variations in physical function group, gender, BMI, age, and physical activity outcomes.

Objective measures of PA are a major strength of this study. Waist-worn accelerometers are frequently used to capture the intensity of ambulatory movements,[13] nevertheless, it must be acknowledged that the waist-worn positioning of the device may not be the best for capturing some of the unique movement patterns of those with limited physical functioning[41]. Certain types of physical limitations may require different and/or multiple wear locations of accelerometers to optimally capture PA.

Conclusions

In summary, this study showed that the amount of objectively measured PA was impacted by physical function group and age. Our findings help provide insight into the expected values for several accelerometer-derived variables that describe the PA behaviors and profiles of special populations living with functional limitations. With more individuals entering old age, there will likely be an increase in the number of individuals living with physical function impairments, who will require medical services. Having a better understanding of the activity patterns in elderly patients with physical function limitations allows for opportunities to develop tailored interventions to help improve the activity patterns of this population. Increased PA levels could prevent chronic diseases and mobility disabilities and improve the quality and length of life in aging population groups.

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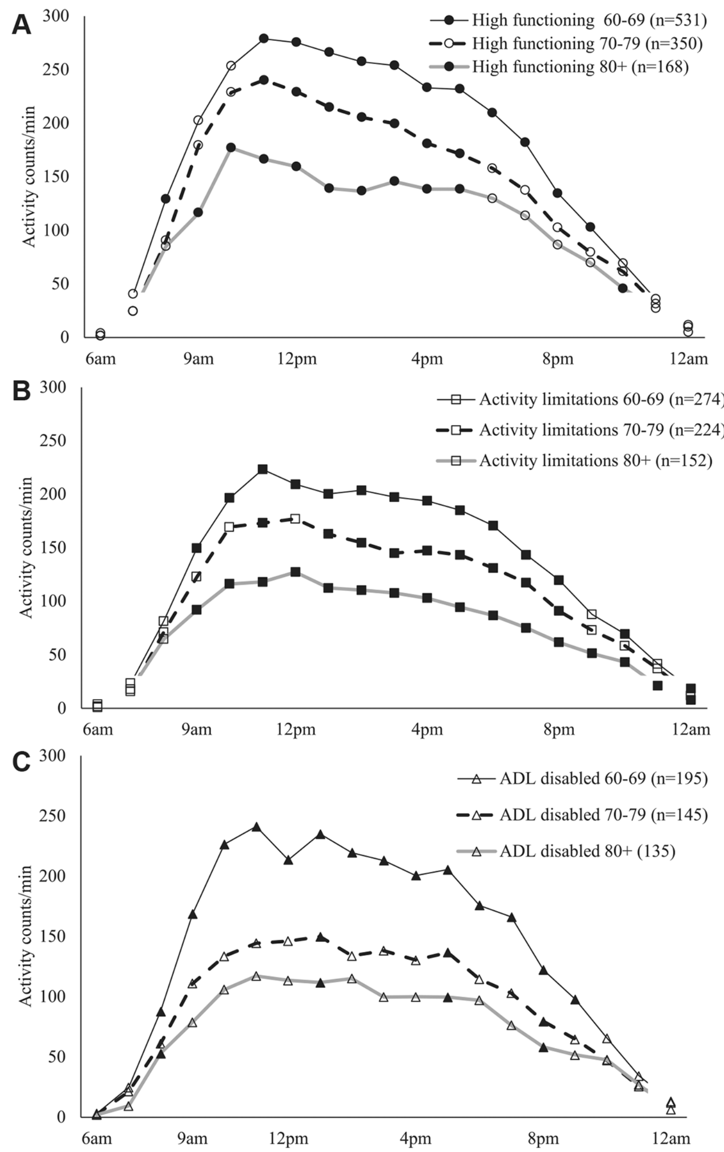

Fig. 1.

Hourly activity counts per minute by age category within the functional status grouping. A) High functioning (circles), B) Activity limitations (squares), C) Activities of daily living (ADL) disabled (triangles), 60–69 (solid thin black line), 70–79 (dashed thick black line), 80+ (solid thick grey line). Adjusted for gender, and wear time. Solid filled points indicate age categories that are significantly different from others at each hour based on non-overlapping 95% confidence intervals of the categories median values for the hour. One solid filled point/hour = specifies which one category is different from all others, two solid filled points/hour = specifies which two categories are different from each other, three solid filled points/hour = specifies all three categories are different from each other.

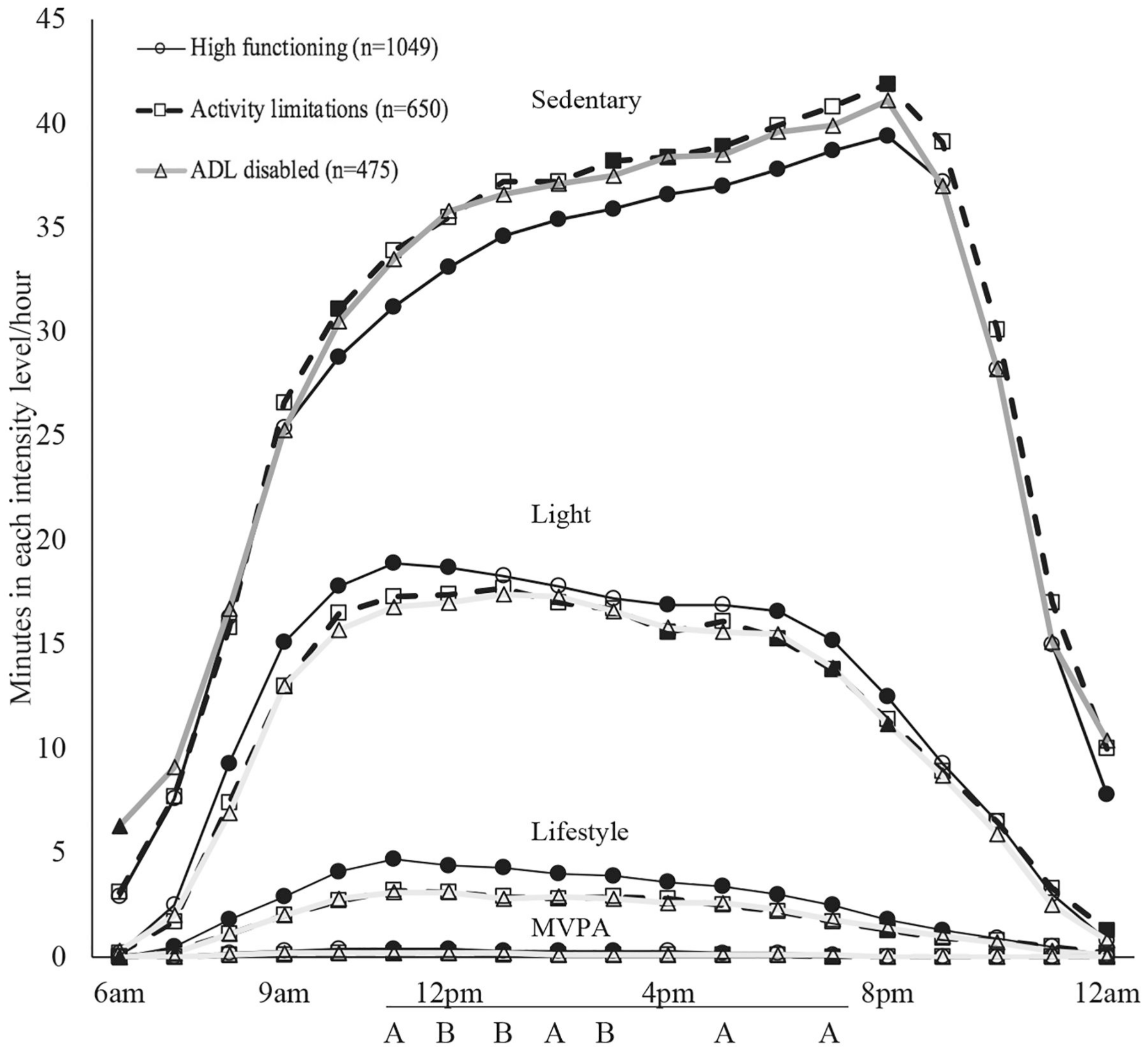

Fig. 2.

Minutes in each activity intensity level/hour by functional status grouping; High functioning (circles, solid thin black line), Activity limitations (squares, dashed thick black line), Activities of daily living (ADL) disabled (triangles, solid thick grey line). Solid filled points indicate functional status groups that are significantly different from others at each hour based on non-overlapping 95% confidence intervals of the groups median values for the hour. One solid filled point/hour = specifies which one group is different from all others, two solid filled points/hour = specifies which two groups are different from each other. A = High functioning has significantly greater moderate or vigorous physical activity (MVPA) than activity limitations during these hours, B=High functioning has significantly greater MVPA than all others during these hours. Sedentary, 0–99 counts; Light, 100–759 counts; Lifestyle, 760–2019 counts; MVPA ≥2020 counts.

Table 1

Characteristics of the study population by functional status groups (n = 2174).

Characteristic	HF (n = 1049)	AL (n = 650)	ADL-D (n = 475)	p-value
Age (years), M (SE)	69.7 (0.3)	72.0 (0.5)	73.4 (0.5)	<.001[a,b]
BMI, M (SE)	27.3 (0.2)	29.5 (0.3)	29.8 (0.6)	<.001[a,b]
Race/ethnicity, %. no.				0.74
Non-Hispanic white	83.9 (646)	81.9 (394)	81.4 (278)	
Non-Hispanic black	7.5 (163)	9.5 (114)	8.6 (69)	
Mexican American	3.3 (193)	3.3 (112)	4.2 (104)	
Other	5.4 (47)	5.3 (30)	5.7 (24)	
Sex, %. no.				
Men	48.2 (574)	40.4 (304)	38.5 (216)	0.003[a,b]
Women	51.8 (475)	59.6 (346)	61.5 (259)	
Education, %. no.				<.001[a,b]
<High school	20.4 (333)	27.5 (250)	32.5 (206)	
High school	28.8 (269)	28.9 (163)	28.1 (115)	
>High school	50.7 (444)	43.6 (237)	39.4 (153)	
Smoking, %. no.				0.61
Never	46.3 (482)	43.3 (272)	44.2 (216)	
Former	43.2 (440)	43.5 (281)	44.8 (216)	
Current	10.4 (127)	13.2 (97)	11.0 (43)	
Chronic Conditions, %. no.				
Hypertension	51.3 (536)	64.3 (416)	63.8 (304)	<.001[a,b]
Arthritis	38.3 (377)	66.2 (409)	66.0 (294)	<.001[a,b]
Cancer	20.5 (196)	25.6 (138)	23.6 (96)	0.16
Diabetes	10.9 (136)	20.0 (147)	22.9 (123)	<.001[a,b]
Cardiovascular disease	12.3 (122)	26.3 (158)	20.7 (100)	<.001[a,b,c]
Pulmonary disease	13.3 (128)	20.6 (122)	25.9 (113)	<.001[a,b,c]

Characteristic	HF (n = 1049)	AL (n = 650)	ADL-D (n = 475)	p-value
Osteoporosis	12.0 (107)	19.8 (115)	20.8 (85)	<.001[a,b]
Stroke	3.9 (42)	10.1 (65)	10.9 (55)	<.001[a,b]
Kidney disease	1.4 (20)	5.7 (34)	4.1 (23)	<.001[a,b]
Number of chronic conditions, M (SE)	1.6 (0.0)	2.6 (0.1)	2.6 (0.1)	<.001[a,b]
Multimorbidity (≥2), %. no.	50.7 (513)	75.9 (476)	73.8 (347)	<.001[a,b]
Wear time (hr/day), M (SE)	14.1 (0.1)	13.9 (0.1)	13.9 (0.1)	0.68

Note: HF: high functioning, AL: activity limitations, ADL-D: activity of daily living disabled, M: mean, SE: standard error, BMI: body mass index. p values for overall group comparisons. Pairwise comparisons.

[a] HF significantly different from AL.

[b] HF significantly different from ADL-D.

[c] AL significantly different from ADL-D.

Table 2

Comparison of accelerometer-derived physical activity variables[*] between HF, AL, and ADL-D, and men and women within functional status groups.

	n	Total Activity Counts	Activity counts/min	MVPA %	Light %	Lifestyle %	Sedentary %	MVPA min/ week in modified 10-min bouts	Breaks in sedentary time/day	Steps/day[!]	Peak 30-min cadence[!]
HF											
All	1049	210954 (5349)	242.5 (6.5)	1.6 (0.1)	28.7 (0.3)	7.7 (0.3)	62.0 (0.6)	42.9 (4.0)	86.6 (0.7)	4468 (219)	60.6 (1.6)
Men	574	224603 (7055)	255.7 (8.9)	2.0 (0.2)	26.5 (0.3)	8.3 (0.3)	63.3 (0.7)	49.8 (6.2)	83.0 (1.0)	5314 (218)	65.4 (1.6)
Women	475	198244 (6066)	230.2 (7.2)	1.3 (0.1)	30.8 (0.5)	7.1 (0.3)	60.7 (0.8)	36.5 (4.2)	89.9 (1.1)	3807 (222)	56.8 (1.6)
Gender p-value		**0.002**	**0.002**	**<0.001**	**<0.001**	**<0.001**	0.01	0.02	**<0.001**	**0.002**	0.029
AL											
All	650	152106 (5106)	174.6 (5.1)	0.8 (0.1)	26.6 (0.4)	5.2 (0.2)	67.4 (0.5)	14.1 (2.4)	84.8 (1.0)	4615 (248)	60.3 (1.6)
Men	304	155719 (6953)	175.7 (7.2)	0.9 (0.1)	24.4 (0.5)	5.5 (0.3)	69.2 (0.7)	13.5 (3.2)	82.0 (1.4)	5092 (291)	64.1 (2.2)
Women	346	149652 (5871)	173.8 (5.9)	0.7 (0.1)	28.0 (0.5)	5.0 (0.2)	66.2 (0.7)	14.6 (2.8)	86.7 (1.1)	4192 (336)	57.0 (1.8)
Gender p-value		0.85	0.87	0.15	**<0.001**	0.29	**0.004**	0.47	**<0.001**	0.02	**<0.001**
ADL-D											
All	475	154528 (5530)	178.8 (6.2)	0.9 (0.1)	26.2 (0.5)	5.3 (0.2)	67.5 (0.7)	19.4 (3.6)	83.4 (1.0)	4108 (202)	60.0 (1.8)
Men	216	164498 (9614)	187.0 (10.2)	1.1 (0.1)	24.2 (0.7)	5.8 (0.4)	68.9 (1.1)	21.8 (5.8)	80.9 (1.7)	4431 (276)	62.7 (1.2)
Women	259	148283 (5817)	173.7 (7.2)	0.7 (0.1)	27.5 (0.8)	5.0 (0.3)	66.7 (1.0)	17.9 (4.7)	85.0 (1.2)	3881 (354)	58.9 (3.0)
Gender p-value		0.56	0.69	0.08	**0.001**	0.41	0.04	0.90	**0.001**	0.13	0.11
Function p-value		**<.001**[a,b]	**<.001**[a,b]	**<.001**[a,b]	**<.001**[a,b]	**<.001**[a,b]	**<.001**[a,b]	**<.001**[a]	0.09	0.47	0.88

[*] Adjusted for age, gender, BMI, and wear time.

HF: high functioning, AL: activity limitations, ADL-D: activity of daily living disabled. Values are means and standard error of the mean. MVPA, Light, Lifestyle, Sedentary percentage, percentage of time spent in moderate-to-vigorous (≥2020 counts), light (100–759 counts), lifestyle (760–2019 counts), and sedentary (0–99 counts) intensity activity per daily minutes of wear time.

[!] Stepping variables from NHANES 2005–2006 only: HF (n = 476, 239 men and 237 women); AL (n = 314, 166 men and 148 women), and ADL-D (n = 247, 130 men and 117 women).

Note: Gender p-value for Men vs. Women comparison, p < 0.005 with Bonferroni adjustment. Function p-value for functional status group comparisons, p < 0.005 with Bonferroni adjustment.

[a] Pairwise comparisons: HF significantly different from AL,

[b] Pairwise comparisons: HF significantly different from ADL-D.

Table 3

Association between functional status, age, BMI, gender, total activity counts/day and breaks in sedentary time/day and multimorbidity (n: 2174): NHANES 2003–2006.[a]

Dependent variable	Model 1		Model 2		Model 2 within HF		Model 2 within AL		Model 2 within ADL-D	
Multimorbidity Score	**$R^2 = 0.11$**		**$R^2 = 0.19$**		**$R^2 = 0.08$**		**$R^2 = 0.08$**		**$R^2 = 0.18$**	
Independent variables	***B***	***p***	***B***	***p***	***B***	***p***	***B***	***p***	***B***	***p***
Intercept	1.639	<.0001	−0.076	0.874	0.091	0.902	2.26	0.02	−1.714	0.183
ADL-D	**0.95**	**<.0001**	**0.679**	**<.0001**						
AL	**0.95**	**<.0001**	**0.671**	**<.0001**						
AL vs. ADL-D	0.002	0.982	0.008	0.929						
Age			**0.021**	**<.001**	**0.017**	**0.0062**	0.001	0.949	**0.053**	**0.0003**
BMI			**0.036**	**<.0001**	**0.032**	**<.001**	0.027	0.06	**0.054**	**<.0001**
Female			**0.278**	**<.001**	0.148	0.112	**0.43**	**0.002**	**0.343**	**0.0325**
Total activity counts/day			**−0.000002**	**0.001**	**−0.000002**	**0.0014**	**−0.000003**	**0.0071**	−0.000001	0.6
Breaks in sedentary time/day			**−0.005**	**0.002**	−0.0025	0.337	−0.0037	0.386	**−0.014**	**0.024**

Model 1 shows the beta-coefficient and p-value from a simple linear regression model assessing the relationship between functional status (HF participants = reference category; HF: high functioning, AL: activity limitations, ADL-D: activity of daily living disabled) and multimorbidity score. Model 2 expands upon model 1 by adding age, BMI, sex (male = reference category), total activity counts/day, and breaks in sedentary time/day to the model.

[a]Four-year sampling weights (MEC4YR) were applied. Significant differences (p-value < 0.05) are bolded.