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Research Article

Using A New Accelerometry Method to Assess Lifestyle Movement Patterns of Americans: Influence of Demographic and Chronic Disease Characteristics

Paul D. Loprinzi

Bellarmine University, Department of Exercise Science, Donna & Allan Lansing School of Nursing & Health Sciences, Louisville, KY 40205, USA

Corresponding Author: Paul D. Loprinzi; email: ploprinzi@bellarmine.edu

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Abstract. The objective of this study was to examine factors (e.g., medical conditions) that influence the balance of lifestyle movement patterns of Americans. 6,093 U.S. adults from the 2003-2006 NHANES were evaluated. Four mutually exclusive lifestyle behavior groups included: 1) meeting physical activity (PA) guidelines and having a positive light-intensity PA-sedentary (LIPA-SED) balance (i.e., LIPA ≥ SED); 2) meeting PA guidelines, but having a negative LIPA-SED balance (i.e., LIPA < SED); 3) not meeting PA guidelines, but having a positive LIPA-SED balance; and 4) not meeting PA guidelines and having a negative LIPA-SED balance. The majority of individuals with chronic disease (e.g., stroke, coronary artery disease, peripheral arterial disease, diabetes, emphysema, and arthritis) and other impairments (e.g., vision and hearing impairment) were classified in the least desirable lifestyle group. Results showed that, for example, those with chronic kidney disease, compared to those without chronic kidney disease, were 2.6 times more likely to be in the least desirable movement group compared to the most desirable lifestyle movement group. Initially, efforts should focus on creating a positive LIPA-SED balance and doing so among those with chronic disease.

Keywords: Accelerometry, chronic disease epidemiology, health, physical activity

1. Introduction

It is well established that moderate-to-vigorous physical activity (MVPA) may help to prevent numerous chronic diseases, such as obesity, cardiovascular disease, stroke, hypertension, colon cancer, breast cancer, type 2 diabetes, osteoporosis, and premature all-cause mortality [1, 2]. Although cumulating evidence is starting to show independent (i.e., independent of moderate-to-vigorous physical activity) associations between light-intensity physical activity (LIPA) and sedentary behavior (SED) with health [3–7], this work has only started to emerge over the last decade. Additionally, this previous work has only examined the independent effects of different physical activity intensities. Presently, few studies have investigated the daily balance between SED, LIPA, and MVPA, and in particular, examined factors that influence daily movement patterns. Using accelerometer technology [8], four distinct lifestyle movement patterns were created in the present study, including: 1) meeting physical activity guidelines and having a positive LIPA-SED balance (LIPA ≥ SED); 2) meeting physical activity guidelines and having a negative LIPA-SED balance (LIPA < SED); 3) not meeting

physical activity guidelines and having a positive LIPA-SED balance; and 4) not meeting physical activity guidelines and having a negative LIPA-SED balance. The primary objective of this study was to examine the influence of demographic characteristics (e.g., age, gender, race-ethnicity, and poverty status) and medical conditions (e.g., arthritis, stroke, cardiovascular disease, vision impairment, hearing impairment, and chronic kidney disease) on the balance of lifestyle movement patterns of Americans. This information may help to identify vulnerable populations at risk of further complications associated with their disease or increased susceptibility to other chronic diseases due to an inactive lifestyle.

2. Materials and Methods

2.1. Design and participants. Data from the 2003–2006 National Health and Nutrition Examination Survey (NHANES) were used for the present study. These cycles were used because these are the only cycles that collected accelerometry data. NHANES uses a complex, multistage probability design among a representative sample of non-institutionalized U.S. civilians. Briefly, participants were interviewed in their homes and then subsequently examined in mobile examination centers (MEC). NHANES is conducted by the National Center for Health Statistics (NCHS), and all procedures for data collection were approved by the NCHS ethics review board. All participants provided written informed consent prior to data collection.

2.2. Measurement of physical activity. Participants were asked to wear the ActiGraph 7164 accelerometer during all activities, except water-based activities and while sleeping. Estimates for time spent in moderate-to-vigorous physical activity (MVPA) were summarized based on 1-minute bout intervals. Accelerometer activity counts/min between 0–99 were used to classify SED [9]; counts/min between 100 and 2019 were classified as LIPA; counts/min $\geq$ 2020 but less than 5999 were used to classify time spent at moderate intensity; counts/min $\geq$ 5999 were used to classify time spent at vigorous intensity [10]. Participants were classified as meeting physical activity guidelines if they engaged in 150-minutes of moderate-intensity or 75-minutes of vigorous-intensity physical activity per week or some combination of the two. To account for a combination of moderate and vigorous-intensity physical activity, minutes of vigorous-intensity per week were added to time spent at moderate intensity per week [11]. For the analyses described here, only those participants with at least 4 days with 10 or more hours per day of wear time were included in the analyses in order to make sure that data adequately captured habitual activity patterns [10]; at least 4 days of valid monitoring data (i.e., 10 hrs/day) has been shown to accurately predict habitual physical activity levels in adults [12, 13]. To determine the amount of time the monitor was worn, nonwear was defined by a period of a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1-2 minutes of activity counts between 0 and 100. [10] For further description of the accelerometry details, the reader is referred elsewhere [14].

2.3. Lifestyle behavior classification. Four mutually exclusive lifestyle behavior groups were created, which include: 1) those meeting physical activity guidelines and having a positive light-intensity physical activity-sedentary (LIPA-SED) balance (i.e., LIPA $\geq$ SED); 2) those meeting physical activity guidelines, but having a negative LIPA-SED balance (i.e., LIPA $<$ SED); 3) those not meeting physical activity guidelines, but having a positive LIPA-SED balance; and 4) those not meeting physical activity guidelines and having a negative LIPA-SED balance. Conceptually, the four groups represent a continuum with those in group 1 being considered the most active/desirable group and those in group 4 being considered the least active/desirable group.

2.4. Measurement of demographic characteristics. Demographic characteristics included age, gender, race-ethnicity, poverty-to-income ratio (PIR), cotinine, and body mass index (BMI). Participants completed questionnaires providing data on age, gender, and race-ethnicity. As a measure of socioeconomic status, a PIR value below 1 is considered below the poverty threshold. The PIR is calculated by dividing the family income by the poverty guidelines, which is specific to the family size, year assessed, and state of residence.

Serum cotinine was measured as a marker of active *smoking status* or environmental exposure to tobacco (i.e., passive smoking). Serum cotinine was measured by an isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry [15]. Height and weight were directly measured using standard protocols (e.g., shoes off), with BMI calculated from measured weight in kilograms divided by the square of height in meters.

2.5. Measurement of self-reported medical conditions. Self-reported medical conditions assessed included asthma, arthritis, congestive heart failure (CHF), coronary artery disease (CAD), stroke, emphysema, bronchitis, liver disease, thyroid disease, cancer, diabetes, depression, functional disability, sleep, and health status. Participants in the 2003–2004 and 2005–2006 cycles completed questionnaires to assess these medical conditions, with the exception of depression and sleep, with only participants in the 2005–2006 cycle completing these questionnaires.

Participants completed a questionnaire asking if they had ever been diagnosed by a doctor or health care professional with having: asthma, arthritis, CHF, CAD, stroke, emphysema, bronchitis, liver disease, thyroid disease, cancer. Participants were considered to have evidence of diabetes if they self-reported a previous diagnosis of the disease

(excluding gestational diabetes mellitus), were taking insulin or diabetic pills to lower blood sugar, had a HgbA1C of 6.5% or greater, [16] or had a fasting glucose level of 126 mg/dL or higher [17].

Participants completed the Patient Health Questionnaire-9 (PHQ-9) during the computer-assisted personal interview. The PHQ-9 depression scale consists of the actual 9 criteria upon which the diagnosis of DSM-IV depressive disorders is based. For each question, participants responded using a 4-point Likert scale, with responses including *not at all* (0), *several days* (1), *more than half the days* (2), and *nearly every day* (3). Items were summed, with higher scores indicating greater severity of depression. Participants with a score ≥ 5 were considered to have some depression symptoms [18]. The PHQ-9 has demonstrated evidence of validity and reliability, with Cronbach's alpha ranging from 0.86-0.89 and a 48-hour test-retest correlation coefficient of 0.84 [18]. In the present sample, internal consistency of this questionnaire, as measured by Cronbach's alpha, was 0.81.

Participants were considered to have a functional disability if they required special assistance for walking (e.g., cane), had limitations that prevented them from working, or reported having difficulty in any five functional disability categories, including *lower extremity mobility* (e.g., walking ¼ mile and walking up 10 steps), *general physical activity* (e.g., kneeling, standing for 2 hr, standing up from an armless chair, and lifting/carrying 10 lb), *activities of daily living* (e.g., dressing, getting out of bed, and walking between rooms on the same floor), *instrumental activities of daily living* (e.g., household chores), and *leisure and social activities* (e.g., doing leisure activities at home and going shopping). Further details of the individual items can be found elsewhere [19].

Participants completed the Functional Outcomes of Sleep Questionnaire [20] to assess sleep duration and sleep latency. Lastly, participants self-reported their health status as excellent, good, fair or poor.

2.6. Measurement of examination/laboratory-determined medical conditions. Examination/laboratory-determined medical conditions assessed included vision, hearing, peripheral arterial disease, peripheral neuropathy, chronic kidney disease, and cardiorespiratory fitness. Participants in the 2003–2004 and 2005–2006 cycles were assessed for each of these medical conditions, with the exception of peripheral arterial disease, peripheral neuropathy and cardiorespiratory fitness, with only participants in the 2003–2004 cycle completing assessments for these parameters.

Vision. Presenting visual acuity was assessed for each eye. In eyes with a presenting visual acuity of 20/30 or worse, corrected lenses were removed (if worn) and objective refraction was measured using an ARK-760 autorefractor in the MEC. Visual acuity of the better-seeing eye was used to classify participants given that sight in the better eye is most relevant to disability in numerous visual disorders [21, 22]. Participants with presenting better-eye visual acuity of 20/40 or better were considered to have normal sight. Participants with presenting visual acuity worse than 20/40, but postrefraction visual acuity in either eye were 20/40 or better, were considered to have uncorrected refractive error [23]. Participants with visual acuity worse than 20/40 after autorefraction, or who self-reported not being able to see light with both eyes open, were considered to have vision impairment [23]. Participants with missing data for presenting acuity in both eyes, or with visual acuity worse than 20/40 in both eyes with no autorefraction in either eye, were excluded from the analysis as they were considered to have incomplete visual acuity data.

Hearing. Using a modified Hughson Westlake procedure, hearing threshold testing was objectively conducted on both ears of participants at seven frequencies (500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz) across an intensity range of –10 to 120 dB. Low-frequency pure-tone average (LPTA) was obtained by calculating the average of air conduction pure-tone thresholds at 500, 1000, and 2000 Hz and high-frequency pure-tone average (HPTA) was obtained by the average of air conduction pure-tone thresholds at 3000, 4000, 6000, and 8000 Hz [24–27]. Measures of hearing loss were categorized according to the hearing sensitivity in the worse ear and defined as *hearing within normal limits* (LPTA & HPTA ≤ 25 dB), *mild hearing loss* (LPTA or HPTA 26–40 dB) and *moderate or greater hearing loss* (LPTA or HPTA > 40 dB) [28].

Peripheral Arterial Disease. Peripheral arterial disease was assessed by examination of the ankle brachial index (ABI). Participants 40 and older were initially eligible for the ABI examination. Participants were excluded if they had a bilateral amputation or weighed more than 400 pounds (due to equipment limitations). While participants rested in supine position, two systolic blood pressure measurements were made in the right arm (brachial artery) and both ankles (posterior tibial arteries). The right ABI was calculated by dividing the highest systolic blood pressure in the right ankle by the highest blood pressure in the arm; similarly, the left ABI was calculated by dividing the highest systolic blood pressure in the left ankle by the highest blood pressure in the arm. The lower of the ABI readings were used in the present analysis [29]. ABI as an indicator of peripheral arterial disease has been validated against gold-standard angiographically that has a sensitivity and specificity, respectively, of 95% and nearly 100% [30]. There appears to be a U-shaped relationship between ABI and cardiovascular disease morbidity and mortality [31]. An ABI < 1 results in an elevated risk for cardiovascular morbidity and mortality (i.e., greater arterial occlusion); between 1 and 1.4 is considered normal; and above 1.4 (suggesting poorly compressible vessels) is an independent risk factor for cardiovascular disease morbidity and mortality [31, 32]. As a result, participants were classified into two groups: normal ABI (1–1.4) and abnormal ABI (< 1 or > 1.4) [33].

Peripheral Neuropathy. Participants aged 40 years and older completed the peripheral neuropathy exam except when they refused testing or met one of the following exclusion criteria: (1) bilateral amputation, (2) weight over 400 pounds, (3) presence of conditions (e.g., casts) that interfered with testing, or (4) inability to understand the test instructions. Participants assumed supine position on an exam table while a trained health technician applied slight pressure (approximately 10-gram filament force) to the bottom of each foot while using a standard monofilament (5.07 Semmes-Weinstein nylon monofilament). In a non-sequential order, pressure was applied at three sites on each foot: the plantar-first metatarsal head, the plantar-fifth metatarsal head, and the plantar hallux. A site was considered insensate if the participant incorrectly determined when the monofilament was applied to the foot on at least two of three applications [34]. Participants were defined as having peripheral neuropathy if the examination determined at least 1 insensate area in either foot [34] based on prior work shown that this level of sensory loss is predictive of ulcers and amputations, and has demonstrated high sensitivity and specificity [35, 36].

Chronic Kidney Disease. Chronic kidney disease was defined as a glomerular filtration rate < 60 mL/min per $1.73m^2$, which was assessed from the Chronic Kidney Disease Epidemiology equation based on specified race, sex, and creatinine level [37].

Cardiorespiratory Fitness. Cardiorespiratory fitness (VO_{2max}) was assessed from a treadmill-based submaximal test. At the MEC, participants aged 12–49 years old were eligible for the treadmill-based cardiorespiratory fitness component. The protocol employed was a submaximal treadmill protocol, including a 2-minute warm-up period, two 3-minute exercise stages, and a 2-minute cool-down period. Participants were assigned to one of eight treadmill protocols. Differences between protocols included the initial intensity level and rise in the incline per stage. The participant's predicted VO_{2max} using the non-exercise prediction equation [38] was used to select the appropriate protocol. The objective of each protocol was to elicit a heart rate that was approximately 75–80% of the participant's age-predicted maximum heart rate (i.e., 220-age) by the conclusion of the test. Because the relationship between heart rate and oxygen consumption is assumed to be linear during exercise [39], VO_{2max} (mL/kg/min) was estimated by measuring the heart rate response to known levels of submaximal work. Classification of cardiorespiratory fitness was based on the reference cut-points used for adults 20–49 from the Aerobics Center Longitudinal Study (ACLS) [39, 40]. Low level of CV fitness was defined as an estimated VO_{2max} below the 20th percentile of the ACLS data of the same gender and age group; moderate fitness was defined as a value between the 20th and 59th percentile, and high fitness level was defined as at or above the 60th percentile.

2.7. Data analysis. All statistical analyses were performed using procedures from sample survey data using STATA (version 12.0, College Station, TX) to account for the complex survey design used in NHANES. To account for oversampling, non-response, non-coverage, and to provide nationally representative estimates, all analyses included the use of survey sample weights, clustering and primary sampling units. To examine the influence of demographic characteristics on lifestyle behavior, a multinomial logistic regression model was computed. In this singular model, the lifestyle behavior variable served as the outcome variable, and independent variables included age, gender, race-ethnicity, PIR, cotinine, and BMI (Table 1). The most favorable movement pattern group (i.e., meeting guidelines and having a positive LIPA-SED balance) served as the referent group.

To examine the association between the self-reported medical conditions and lifestyle behavior (outcome variable), multinomial logistic regression models were computed. Models were computed separately for each self-reported medical condition (Table 2), with each model controlling for age, gender, race-ethnicity, PIR, cotinine, and BMI. Similarly, separate models were computed to examine the association between examination-determined medical conditions and lifestyle behavior (outcome variable), with the same covariates included in these models (Table 3).

Statistical significance was established as $P < 0.05$. I acknowledge the use of multiple analytical tests, but I chose not to correct for multiple comparisons as the number of type I errors cannot decrease without increasing the risk of making a type II error when correcting for multiple comparison. Further, the theoretical assumption behind correction for multiple testing is that all null hypotheses are true simultaneously, which was not of interest in our study. Lastly, the observed associations in the present study have been supported by other work, providing further evidence that the observed associations are not likely a result of random chance.

3. Results

Participants in the present study included adults 20 yrs and older with sufficient accelerometry data (i.e., ≥ 4 days with 10+ hrs/day of monitoring), which included 6,093 participants. However, all available NHANES data were used; therefore, sample sizes are not the same for all analyses.

Demographic characteristics across the lifestyle behavior groups are shown in Table 1. Univariate findings showed that a higher SES was associated with a more favorable lifestyle behavior balance; and older age, female gender, non-Hispanic white race-ethnicity, and a higher BMI was associated with a less favorable lifestyle balance. Multivariable analyses showed that for every 1 year increase in age, participants were 6% (95% CI: 1.05–1.07) more likely to be in the least active/desirable group compared to the most

Table 1: Weighted demographic characteristics and associations across lifestyle groups, NHANES 2003–2006.

	Weighted Mean/Proportion/Odds Ratio (95% CI) Estimates Across the Lifestyle Behavior Groups			
Variable	**Meets PA Guidelines and Positive LIPA-SED Balance (Considered Most Active Group) (n = 850)**	**Meets PA Guidelines and Negative LIPA-SED Balance (n = 1,333)**	**Does Not Meet PA Guidelines but has Positive LIPA-SED Balance (n = 574)**	**Does Not Meet PA Guidelines and Negative LIPA-SED Balance (Considered Least Active Group) (n = 3,336)**
Age, yrs (n = 6093)	40.0 (38.8–41.3)	42.7 (41.5–43.9)	46.2 (44.7–47.8)	51.1 (52.9–55.4)
Odds Ratio: Age, 1 yr older † (n = 5580)	Referent	1.00 (0.99–1.01)	**1.03 (1.02–1.04)**	**1.06 (1.05–1.07)**
Gender, % (n = 6093)				
Men	19.7 (18.2-21.2)	34.4 (31.6–37.2)	6.0 (4.9–7.0)	39.8 (37.0–42.6)
Women	10.9 (9.2–12.5)	18.7 (16.3–21.2)	11.7 (10.2–13.2)	58.5 (56.2–60.8)
Odds Ratio: Female vs. Male † (n = 5580)	Referent	0.94 (0.72–1.22)	**3.75 (2.95–4.78)**	**3.03 (2.42–3.81)**
Race-Ethnicity, %				
Mexican American (n = 1267)	31.5 (27.8–35.1)	19.1 (16.4–21.8)	13.7 (11.4–16.1)	35.5 (31.9–39.0)
Non-Hispanic White (n = 3256)	13.2 (11.8–14.7)	28.0 (25.1–30.9)	8.0 (6.5–9.4)	50.6 (47.9–53.3)
Non-Hispanic Black (n = 1158)	13.4 (11.4–15.4)	23.9 (20.4–27.4)	10.4 (8.6–12.2)	52.1 (48.6–55.7)
Other (n = 412)	18.8 (14.6–23.0)	20.5 (14.5–26.4)	11.1 (7.4–14.9)	49.4 (43.5–55.3)
Odds Ratio: Other vs. Non-Hispanic White † (n = 5580)	Referent	0.58 (0.46–0.73)	0.87 (0.67–1.13)	**0.75 (0.57–0.98)**
Poverty-to-Income Ratio (n = 5816)	2.95 (2.79–3.11)	3.64 (3.53–3.75)	2.59 (2.41–2.77)	3.07 (2.94–3.21)
Odds Ratio: Poverty-to-Income Ratio, 1 unit higher † (n = 5580)	Referent	1.28 (1.19–1.37)	0.82 (0.74–0.91)	1.00 (0.92–1.08)
Cotinine, ng/mL (n = 5891)	69.1 (53.9–84.4)	45.7 (35.4–56.0)	63.9 (52.5–75.3)	59.6 (52.3–66.9)
Odds Ratio: Cotinine, 1 ng/mL higher † (n = 5580)	Referent	**0.99 (0.99–0.99)**	1.00 (0.99–1.00)	1.00 (0.99–1.00)
BMI, kg/m^2(n = 6044)	27.0 (26.4–27.5)	27.0 (26.5–27.4)	29.3 (28.5–30.2)	29.2 (28.8–29.6)
Odds Ratio: BMI, 1 kg/m^2 higher † (n = 5580)	Referent	0.99 (0.97–1.02)	**1.07 (1.04–1.10)**	**1.07 (1.05–1.09)**
Weight Status, %				
Normal Weight (18.5–24.9) (n = 1780)	19.1 (16.7–21.4)	30.6 (26.8–34.4)	6.7 (5.3–8.1)	43.4 (39.8–47.0)
Overweight (25–29.9) (n = 2194)	15.3 (13.6–17.1)	29.8 (26.3–33.3)	8.7 (7.1–10.3)	45.9 (42.9–49.0)
Obese (≥ 30) (n = 1989)	11.9 (9.3–14.4)	18.3 (15.5–21.2)	11.2 (9.4–13.0)	58.5 (54.6–62.3)

OR = Odds Ratio

BMI = Body mass index

† 1 multinomial logistic regression model was computed, with the lifestyle group variable serving as the outcome variable and the above demographic variables serving as independent variables.

Bold indicates statistical significance ($P < 0.05$)

Table 2: Weighted proportion of self-reported medical conditions and associations across lifestyle groups, NHANES 2003–2006.

	Weighted Mean/Proportion/Odds Ratio (95% CI) Estimates Across the Lifestyle Behavior Groups			
Variable	**Meets PA Guidelines and Positive LIPA-SED Balance (Considered Healthiest Group)**	**Meets PA Guidelines and Negative LIPA-SED Balance**	**Does Not Meet PA Guidelines but has Positive LIPA-SED Balance**	**Does Not Meet PA Guidelines and Negative LIPA-SED Balance (Considered Unhealthiest Group)**
% with Asthma (*n*=749)	12.2 (8.7–15.6)	27.6 (22.5–32.8)	9.5 (6.7–12.3)	50.5 (45.2–55.8)
% without Asthma (*n*=5335)	15.6 (14.2–17.0)	26.1 (23.5–28.7)	8.9 (7.6–10.1)	49.3 (46.8–51.7)
Odds Ratio: Asthma vs. No Asthma † (*n*=5571)	Referent	1.44 (0.91–2.28)	1.11 (0.67–1.85)	1.28 (0.81–2.02)
% with Arthritis (*n*=1724)	7.9 (6.3–9.5)	15.7 (12.6–18.8)	8.3 (6.5–10.1)	67.9 (64.9–70.9)
% without Arthritis (*n*=4354)	17.6 (16.2–19.0)	30.0 (27.4–32.6)	9.2 (8.1–10.3)	43.1 (40.5–45.7)
Odds Ratio: Arthritis vs. No Arthritis † (*n*=5567)	Referent	0.91 (0.65–1.28)	1.06 (0.74–1.54)	1.27 (0.98–1.66)
% with CHF (*n*=210)	4.5 (0.9–8.1)	6.4 (1.9–10.9)	5.2 (0.9–9.5)	83.7 (77.7–89.8)
% without CHF (*n*=5861)	15.4 (14.2–16.6)	26.9 (24.4–29.4)	9.1 (8.0–10.1)	48.5 (46.2–50.8)
Odds Ratio: CHF vs. No CHF † (*n*=5563)	Referent	0.80 (0.21–3.03)	1.23 (0.30–5.08)	2.23 (0.75–6.64)
% with CAD (*n*=282)	3.2 (0.1–6.3)	15.4 (10.2–20.6)	5.1 (2.2–8.0)	76.1 (71.0–81.3)
% without CAD (*n*=5785)	15.6 (14.4–16.8)	26.7 (24.2–29.3)	9.1 (8.0–10.3)	48.4 (46.0–50.7)
Odds Ratio: CAD vs. No CAD † (*n*=5560)	Referent	2.26 (0.76–6.69)	1.75 (0.53–5.78)	**3.08 (1.19–7.99)**
% with Stroke (*n*=215)	3.7 (0.0–7.9)	9.3 (4.1–14.5)	5.9 (2.2–9.7)	80.9 (74.0–87.8)
% without Stroke (*n*=5869)	15.4 (14.3–16.6)	26.7 (24.2–29.2)	9.0 (8.0–10.1)	48.6 (46.3–50.9)
Odds Ratio: Stroke vs. No Stroke † (*n*=5572)	Referent	1.54 (0.39–6.02)	1.60 (0.39–6.53)	2.73 (0.74–10.04)
% with Emphysema (*n*=134)	4.4 (0.0–8.8)	5.7 (2.2–9.1)	8.5 (1.6–15.3)	81.3 (73.6–88.9)
% without Emphysema (*n*=5948)	15.4 (14.2–16.5)	26.7 (24.2–29.2)	9.0 (7.9–10.0)	48.8 (46.5–51.1)
Odds Ratio: Emphysema vs. No Emphysema † (*n*=5574)	Referent	0.90 (0.30–2.66)	1.97 (0.52–7.40)	**3.10 (1.09–8.81)**
% with Bronchitis (*n*=377)	9.6 (5.5–13.6)	12.0 (7.2–16.8)	7.8 (4.4–11.1)	70.5 (64.5–76.4)
% without Bronchitis (*n*=5704)	15.5 (14.4–16.7)	27.3 (24.8–29.9)	9.0 (7.9–10.1)	47.9 (45.7–50.1)
Odds Ratio: Bronchitis vs. No Bronchitis † (*n*=5569)	Referent	0.81 (0.38–1.74)	1.05 (0.54–2.04)	1.71 (0.94–3.10)
% with Liver Problem (*n*=192)	8.9 (5.1–12.7)	29.5 (19.6–39.4)	5.3 (1.2–9.3)	56.1 (46.6–65.7)

Table 2: Continued.

	Weighted Mean/Proportion/Odds Ratio (95% CI) Estimates Across the Lifestyle Behavior Groups			
Variable	**Meets PA Guidelines and Positive LIPA-SED Balance (Considered Healthiest Group)**	**Meets PA Guidelines and Negative LIPA-SED Balance**	**Does Not Meet PA Guidelines but has Positive LIPA-SED Balance**	**Does Not Meet PA Guidelines and Negative LIPA-SED Balance (Considered Unhealthiest Group)**
% without Liver Problem (*n*=5886)	15.3 (14.1–16.5)	26.2 (23.7–28.8)	9.1 (8.0–10.2)	49.2 (46.8–51.5)
Odds Ratio: Liver Problem vs. No Liver Problem † (*n*=5568)	Referent	1.91 (0.99–3.66)	0.98 (0.34–2.83)	1.62 (0.91–2.89)
% with Thyroid Problem (*n*=618)	7.0 (4.6–9.4)	16.6 (12.6–20.6)	8.7 (5.9–11.6)	67.4 (62.8–72.1)
% without Thyroid Problem (*n*=5462)	16.1 (14.9–17.4)	27.5 (24.9–30.1)	9.0 (7.8–10.2)	47.2 (44.9–49.5)
Odds Ratio: Thyroid Problem vs. No Thyroid Problem † (*n*=5568)	Referent	1.20 (0.79–1.81)	1.01 (0.52–1.96)	1.28 (0.89–1.84)
% with Cancer (*n*=587)	7.4 (4.7–10.2)	17.3 (13.0–21.5)	5.1 (2.7–7.5)	70.0 (64.7–75.3)
% without Cancer (*n*=5497)	15.9 (14.7–17.1)	27.2 (24.5–29.9)	9.3 (8.1–10.5)	47.4 (45.0–49.8)
Odds Ratio: Cancer vs. No Cancer † (*n*=5572)	Referent	0.95 (0.57–1.58)	0.74 (0.34–1.61)	1.18 (0.76–1.82)
% with Diabetes (*n*=838)	7.5 (4.6–10.4)	10.2 (6.9–13.4)	7.9 (5.8–10.1)	74.2 (69.7–78.6)
% without Diabetes (*n*=5255)	16.0 (14.6–17.4)	28.1 (25.6–30.7)	9.1 (7.8–10.3)	46.6 (44.2–49.0)
Odds Ratio: Diabetes vs. No Diabetes † (*n*=5580)	Referent	0.70 (42.6–1.16)	1.04 (0.52–2.06)	**1.68 (1.03–2.75)**
PHQ-9 Depression Score (*n*=2802) ‡	1.78 (1.27–2.29)	1.78 (1.49–2.08)	2.18 (1.74–2.62)	2.90 (2.64–3.15)
% with Depression (*n*=514) ‡	9.9 (6.5–13.2)	19.1 (13.1–25.2)	7.7 (5.1–10.3)	63.1 (57.1–69.2)
% without Depression (*n*=2288) ‡	16.4 (14.1–18.7)	28.9 (24.6–33.2)	8.8 (7.4–10.3)	45.6 (42.2–49.1)
Odds Ratio: Depression vs. No Depression † ‡ (*n*=2607)	Referent	1.40 (0.85–2.31)	1.16 (0.59–2.29)	**2.49 (1.44–4.30)**
% with Functional Disability (*n*=2157)	5.5 (4.0–6.9)	13.3 (10.6–15.9)	6.4 (5.1–7.7)	74.7 (71.8–77.6)
% without Functional Disability (*n*=3936)	19.0 (17.6–20.4)	31.5 (28.7–34.2)	10.0 (8.6–11.3)	39.4 (36.9–41.8)
Odds Ratio: Disability vs. No Disability †	Referent	**1.50 (1.08–2.08)**	1.32 (0.89–1.96)	**3.17 (2.22–4.54)**
Sleep Duration, hrs (*n*=3008) ‡	6.7 (6.5–6.8)	6.9 (6.7–7.0)	6.9 (6.7–7.1)	6.9 (6.8–7.0)
Odds Ratio: 1 hr longer † ‡ (*n*=2760)	Referent	1.09 (0.98–1.22)	**1.23 (1.05–1.45)**	**1.14 (1.01–1.27)**
Sleep Latency, min (*n*=2995) ‡	18.9 (16.6–21.2)	17.1 (14.9–19.3)	20.3 (18.4–22.1)	21.0 (19.7–22.3)

Table 2: Continued.

	Weighted Mean/Proportion/Odds Ratio (95% CI) Estimates Across the Lifestyle Behavior Groups			
Variable	**Meets PA Guidelines and Positive LIPA-SED Balance (Considered Healthiest Group)**	**Meets PA Guidelines and Negative LIPA-SED Balance**	**Does Not Meet PA Guidelines but has Positive LIPA-SED Balance**	**Does Not Meet PA Guidelines and Negative LIPA-SED Balance (Considered Unhealthiest Group)**
Odds Ratio: 1 min longer † ‡ (*n*=2752)	Referent	1.00 (0.98–1.01)	1.00 (0.99–1.00)	1.01 (0.99–1.02)
Health Status, %				
Good or better (*n*=4515)	15.6 (14.2–17.0)	29.0 (26.2–31.8)	8.3 (7.1–9.6)	46.8 (44.2–49.5)
Fair or poor (*n*=1224)	12.1 (8.9–15.3)	12.2 (9.5–14.9)	11.1 (8.8–13.4)	64.4 (60.4–68.3)
Odds Ratio: Fair/Poor vs. Other † (*n*=5309)	Referent	0.78 (0.53–1.15)	1.14 (0.68–1.89)	1.37 (0.97–1.94)

CHF = Congestive Heart Failure

CAD = Coronary Artery Disease

† Separate models were examined for each medical condition. Each model controlled for age, gender, race-ethnicity, poverty status (poverty-to-income ratio), smoking (cotinine), and body mass index.

‡ Assessed only in the 2005–2006 NHANES cycle.

Bold indicates statistical significance ($P < 0.05$)

active/desirable group; females, compared to males, were 3 times (95% CI: 2.42–3.81) more likely to be in the least desirable group; non-whites were 25% (95% CI: 0.57–0.98) less likely to be in the least desirable group; and a 1 kg/m^2 increase in BMI was associated with a 7% (95% CI: 1.04–1.10) increased odds of being in the least desirable group.

The influences of self-reported medical conditions on lifestyle behavior are shown in Table 2. A high proportion of individuals with a self-reported medical condition were classified in the least desirable group. Specifically, 68% of arthritics, 84% of those with CHF, 76% of those with CAD, 81% of those with a history of stroke, 81% of those with emphysema, 71% of those with bronchitis, 67% of those with a thyroid problem, 70% of those with a history of cancer; 74% of those with diabetes, 63% of those with depression, 75% of those with a functional disability, and 64% of those with fair or poor health were classified in the least desirable lifestyle behavior group. Multivariable analyses showed that individuals with CAD, compared to those without CAD, were 3 times (95% CI: 1.19–7.99) more likely to be in the least desirable group compared to the most desirable lifestyle behavior group. Similarly, those with emphysema were 3 times more likely (95% CI: 1.09–8.81), those with diabetes were 68% more likely (95% CI: 1.03–2.75), depressed individuals were 2.5 times more likely (95% CI: 1.44–4.30), and disabled individuals were 3 times more likely (95% CI: 2.22–4.54) to be in the least desirable group compared to the most desirable lifestyle behavior. There was also evidence that longer sleep duration (OR = 1.14; 95% CI: 1.01–1.27) was unfavorably associated with lifestyle behavior.

The influences of examination/laboratory-determined chronic diseases on lifestyle behavior are shown in Table 3. A high proportion of individuals with examination/laboratory-determined medical conditions were classified in the least desirable group. Specifically, 81.2% of visually impaired individuals, 64% of those with moderate-to-severe hearing loss, 75% of those with peripheral arterial disease, 67% of those with peripheral neuropathy, and 82% of those with chronic kidney disease were classified in the least desirable lifestyle behavior group. Multivariable analyses showed that those with vision impairment, compared to those with normal vision, were 5 times more likely (95% CI: 1.70–15.1) to be in the least desirable group compared to the most desirable lifestyle behavior group. Similarly, those with peripheral arterial disease were 2.5 times more likely (95% CI: 1.25–5.15), those with chronic kidney disease were 2.6 times more likely (95% CI: 1.25–5.75), and those with low cardiorespiratory fitness were 2.8 times more likely (95% CI: 1.40–5.86) to be in the least desirable group compared to the most desirable lifestyle behavior group.

4. Discussion

It is well established that MVPA is favorably associated with numerous positive health outcomes [1, 2]. Cumulating evidence is also starting to show independent associations between LIPA and SED with health [3–7]; however, factors that influence lifestyle movement patterns among Americans are unknown. As a result, the aim of the present study was to examine factors that influence daily movement patterns.

In general, older age, female gender, and lower SES influence American's daily movement patterns, with these individuals likely to engage in the least desirable movement patterns. Also, and as expected, individuals with comorbid illness were unlikely to meet physical activity guidelines;

Table 3: Weighted proportion of objectively-determined medical conditions and associations across lifestyle groups, NHANES 2003-2006.

	Weighted Mean/Proportion/Odds Ratio (95% CI) Estimates Across the Lifestyle Behavior Groups			
Variable	**Meets PA Guidelines and Positive LIPA-SED Balance (Considered Healthiest Group)**	**Meets PA Guidelines and Negative LIPA-SED Balance**	**Does Not Meet PA Guidelines but has Positive LIPA-SED Balance**	**Does Not Meet PA Guidelines and Negative LIPA-SED Balance (Considered Unhealthiest Group)**
Vision, %				
Normal Vision (n = 5226)	15.1 (13.9–16.3)	27.2 (24.6–29.8)	8.9 (7.7–10.0)	48.7 (46.3–51.1)
URE (n = 351)	20.9 (15.6–26.2)	20.1 (14.7–25.5)	9.7 (5.5–13.9)	49.1 (42.4–55.9)
Vision Impairment (VI) (n = 141)	2.8 (0.0–5.8)	9.0 (0.9–17.0)	6.8 (1.6–11.9)	81.2 (73.0–89.5)
Odds Ratio: VI vs. Other † (n = 5283)	Referent	1.86 (0.60–5.72)	3.41 (0.79–14.7)	**5.07 (1.70–15.1)**
Hearing				
Mean High Frequency Pure Tone Average (n = 1529)	22.5 (20.0–24.9)	25.3 (22.5–28.0)	25.0 (21.6–28.4)	34.0 (31.6–36.4)
Mean Low Frequency Pure Tone Average (n = 1529)	12.1 (10.8–13.4)	13.6 (12.0–15.3)	16.3 (12.8–19.8)	18.8 (17.7–20.0)
% Hearing Within Normal Limits (n = 669)	19.8 (16.5–23.2)	30.8 (25.9–35.6)	9.7 (6.2–13.3)	39.5 (35.0–44.0)
% Mild Hearing Loss (n = 252)	11.7 (7.4–15.9)	28.7 (21.9–35.6)	10.1 (3.7–16.4)	49.3 (39.2–59.5)
% Moderate-Severe Hearing Loss (n = 608)	9.1 (6.4–11.8)	20.7 (16.3–25.1)	5.7 (3.2–8.1)	64.3 (59.1–69.5)
Odds Ratio: Moderate-Severe Hearing Loss vs. Other † (n = 1399)	Referent	1.26 (0.64–2.48)	1.00 (0.48–2.06)	1.42 (0.89–2.29)
Peripheral Arterial Disease ‡				
Mean ABI (n = 1,675)	1.11 (1.09–1.12)	1.12 (1.11–1.14)	1.07 (1.06–1.09)	1.07 (1.05–1.08)
% Normal ABI (n = 381)	12.5 (10.6–14.4)	26.0 (21.8–30.2)	9.0 (6.5–11.5)	52.4 (48.5–56.2)
% Abnormal ABI (n = 1294)	4.9 (2.2–7.6)	11.5 (5.1–17.8)	8.7 (4.6–12.9)	75.0 (68.2–81.2)
Odds Ratio: Abnormal ABI vs. Normal ABI † (n = 1546)	Referent	1.39 (0.53–3.60)	1.98 (0.61–6.41)	**2.56 (1.25–5.25)**
Peripheral Neuropathy, % ‡				
No Peripheral Neuropathy (n = 1,616)	10.7 (9.4–12.0)	22.3 (18.7–25.9)	8.4 (6.7–10.1)	58.4 (54.7
Peripheral Neuropathy (n = 347)	7.3 (3.1–11.5)	18.4 (10.2–26.5)	7.2 (2.1–12.2)	67.0 (61.4–72.5)
Odds Ratio: Peripheral Neuropathy vs. No Peripheral Neuropathy † (n = 1805)	Referent	1.04 (0.39–2.80)	0.87 (0.37–2.03)	0.95 (0.52–1.75)

Table 3: Continued.

	Weighted Mean/Proportion/Odds Ratio (95% CI) Estimates Across the Lifestyle Behavior Groups			
Variable	**Meets PA Guidelines and Positive LIPA-SED Balance (Considered Healthiest Group)**	**Meets PA Guidelines and Negative LIPA-SED Balance**	**Does Not Meet PA Guidelines but has Positive LIPA-SED Balance**	**Does Not Meet PA Guidelines and Negative LIPA-SED Balance (Considered Unhealthiest Group)**
Chronic Kidney Disease, %				
With Chronic Kidney Disease (n = 650)	2.6 (0.6–4.7)	10.0 (6.4–13.6)	5.2 (2.8–7.7)	82.0 (77.1–86.9)
Without Chronic Kidney Disease (n = 5,223)	16.4 (15.1–17.6)	27.8 (25.2–30.4)	9.3 (8.2–10.3)	46.4 (43.9–48.9)
Odds Ratio: Kidney Disease vs. No Kidney Disease † (n=5559)	Referent	1.51 (0.64–3.57)	1.60 (0.66–3.87)	**2.68 (1.25–5.75)**
Cardiorespiratory Fitness ‡				
VO2max (mL/kg/min) (n = 684)	41.2 (39.3–43.2)	40.8 (39.5–42.1)	37.0 (34.0–40.0)	35.0 (33.8–36.2)
Fitness Status, %				
Low Fitness (n = 126)	20.7 (12.8–28.7)	27.2 (18.2–36.2)	12.0 (4.5–19.5)	39.9 (31.5–48.3)
Moderate Fitness (n = 239)	24.8 (19.4–30.1)	36.6 (29.1–44.2)	8.8 (5.0–12.5)	29.6 (23.1–36.2)
High Fitness (n = 319)	29.8 (24.5–35.2)	42.9 (35.8–49.9)	7.2 (3.7–10.8)	19.9 (15.0–24.7)
Odds Ratio: Low Fitness vs. Other † (n = 643)	Referent	1.16 (0.51–2.62)	1.93 (0.58–6.44)	**2.87 (1.40–5.86)**

VI = Vision impairment

URE = Uncorrected refractive error

ABI = Ankle Brachial Index

† Separate models were examined for each condition. Controlling for age, gender, race-ethnicity, poverty status (poverty-to-income ratio), smoking (cotinine), and body mass index.

‡ Assessed only in 2003–2004 NHANES cycle.

Bold indicates statistical significance ($P < 0.05$)

however, the present findings highlight that very few individuals with comorbid illness had a positive LIPA-SED balance. Initially, promotion of a positive LIPA-SED balance among those with comorbid illness may be a sensible strategy given that individuals with certain conditions, such as peripheral arterial disease and functional disability, may have greater difficulty engaging in higher intensity levels (e.g., MVPA). Additionally, systematic inflammation is associated with certain conditions such as peripheral arterial disease [41], and engaging in higher intensity levels, may, initially, exacerbate these conditions as a result of the acute, pro-inflammatory response of MVPA [42].

In an effort to create a positive LIPA-SED balance, individuals, particularly those with comorbid illness, are encouraged to seek out opportunities to be active when the choice is available. For example, taking the stairs instead of the elevator, pacing on the phone instead of talking while seated, having a walking meeting instead of a sit-down meeting, and parking farther away in the parking lot. Encouragingly, recent research demonstrates that this 'lifestyle' activity, if accumulated in a sufficient dose, may be just as beneficial in improving health outcomes as compared to an equal dose of structured exercise [43]. Along these lines, a potential strategy to increase lifestyle activity and a positive LIPA-SED balance may be to have individuals set a timer on their watch/phone to beep every hour, which will prompt them to take a 2–5 minute sedentary break [44]. Assuming an individual is awake 18 hours a day, this approach alone would result in 32–90 minutes of physical activity per day. Of course, this approach should be tested for feasibility and

long-term compliance. However, there is some encouraging work showing that this lifestyle approach, compared to the structured exercise paradigm, is easier to initiate and maintain [45, 46]. Future research is encouraged to further examine the feasibility and efficacy of this lifestyle approach as well as other approaches aimed to increase a positive LIPA-SED balance. Given that Americans with coronary artery disease, emphysema, diabetes, depression, functional limitations, vision impairment, peripheral arterial disease, chronic kidney disease, and low cardiorespiratory fitness were much more likely to be in the least desirable behavioral pattern group, research examining the feasibility and efficacy of methods to induce a positive LIPA-SED balance may wish to focus on individuals with these conditions.

5. Conclusion

In conclusion, major findings from the present study are that various demographics, such as age, gender, race-ethnicity, SES, and BMI are related to an individual's daily movement patterns. Further, the presence of chronic disease also influenced daily movement patterns. The main limitation of the present study is the cross-sectional design, which precludes any ability to render cause-and-effect. Also, it was not possible to statistically control for all potential confounding variables. Despite these limitations, major strengths of this investigation include using a nationally representative sample of U.S. adults, employing an objective measure of physical activity, and examining factors that influence these movement patterns. Future work is needed to better understand how to create a positive LIPA-SED balance among adults with chronic disease.

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