THE ASSOCIATION OF STEP-BASED METRICS WITH ADIPOSITY AND BLOOD PRESSURE IN THE HISPANIC COMMUNITY HEALTH STUDY/STUDY OF LATINOS

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ABSTRACT

Samantha Rose Schilsky: The Association of Step-based metrics and Adiposity and Blood Pressure in the Hispanic Community Health Study/Study of Latinos
(Under the direction of Wayne D. Rosamond)

Measures of adiposity and elevated blood pressure (BP) are established and highly prevalent cardiovascular disease (CVD) risk factors. Physical activity is a recommended non-pharmacologic intervention for alleviating overweight and obesity as well as high BP. Steps are an interpretable measure of physical activity. Research examining associations between step volume and cadence in relation to BP and measures of adiposity is limited and has not been examined in an ethnically diverse Hispanic/Latino population.

This dissertation estimated associations of step volume (average daily total steps) and cadence (steps/min) with measures of adiposity and 6-year changes in measures of adiposity (weight, weight circumference (WC), body mass index (BMI) and weight maintenance) as well as measures of BP and 6-year changes in BP (systolic (SBP), diastolic (DBP)). The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) (2008-2017) was used for these analyses. We included 12,353 and 12141 adults for the cross-sectional analyses of measures of adiposity and BP respectively and 8,427 and 9,077 adults for the longitudinal analyses of measures of changes in adiposity and BP, respectively. Engaging in lower step volume and intensity was cross-sectionally associated with higher measures of adiposity and higher odds of obesity and hypertension. Compared to those in the highest quartile of daily steps those in the lowest quartile had 1.4 and 1.5 times the odds of obesity and hypertension, respectively.

Compared to those with the highest intensity levels, those in the lowest levels of average peak 30-minute cadence, brisk walking and faster ambulation and bouts of brisk walking and faster ambulation had a 1.6, 2.1 and 1.2 times the odds of obesity, respectively and a 1.4, 1.3 and 1.5 times the odds of hypertension, respectively. Engaging in less time spent sedentary (quartile 1) had a 0.74 times odds of hypertension compared to engaging in more time spent sedentary (quartile 4). Over a 6-year period, engaging in higher step intensity but not volume was associated with greater mean changes in weight and BMI.

These findings suggest that engaging in higher daily step volume and cadences may be associated with more favorable obesity and hypertension profiles in Hispanic/Latino populations.

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LIST OF ABBREVIATIONS

ACC	American College of Cardiology
AHA	American Heart Association
AHEI	Alternative healthy eating index
ATP	Adenosine triphosphate
BMI	Body mass index
BP	BP
BRFSS	Behavioral Risk Factor Surveillance System
CARMELA	Cardiovascular Risk Factor Multiple Evaluation in Latin America
CESD	Center for Epidemiological Studies Depression
CI	Confidence interval
CVD	Cardiovascular disease
DALYs	Disability adjusted life years
DBP	Diastolic BP
FFQ	Food frequency questionnaire
GED	General education development test
GPAQ	Global Physical Activity Questionnaire
HCHS/SOL	Hispanic Community Health Study/Study of Latinos
IPW	Inverse probability weighting
JNC	Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure
Kcal	Kilocalories
LDL	Low-density lipoprotein

METs	Metabolic equivalents
MVPA	Moderate-to-vigorous physical activity
NAVIGATOR	Nateglinide And Valsartan in Impaired Glucose Tolerance Outcomes Research Trial
NCI	National Cancer Institute
NEFA	Nonsterified fatty acid
NHANES	National Health and Nutrition Examination Survey
NHBPEP	National High Blood Pressure Education Program
NHLBI	National Heart Lung and Blood Institute
NHTS	National Household Travel Survey
NIH	National Institute of Health
OR	Odds ratio
O2	Oxygen
PAEE	Physical activity-related energy expenditure
SBP	Systolic BP
SES	Socioeconomic status
SF-12	Short Form-12 Version 2
WC	WC
WHO	World Health Organization
U.S.	United States
YRBSS	Youth Risk Behavior Surveillance System

CHAPTER 1: INTRODUCTION

Overweight and obesity and elevated BP are known risk factors for adverse cardiovascular events. Overweight and obesity are associated with an estimated 4 million deaths per year worldwide[1]. Nationally, between the years of 1999-2000 and 2017-2018, the prevalence of obesity and severe obesity has increased from 30.5% to 42.4% and 4.7% to 9.2% respectively[2]. It is estimated that the annual cost of obesity in the United States (U.S.) is approximately $147 billion U.S. dollars and medical costs for individuals who are obese are higher than those of normal weight[2, 3]. Elevated BP is one of the most important risk factors for cardiovascular disease (CVD)[4] and most common cause of CVD-related mortality and results in an estimated 9.7 million deaths per year worldwide[5]. It is estimated that individuals with hypertension will have approximately $2,000 greater annual healthcare expenditure costs compared to their non-hypertensive counterparts[6].

U.S. Hispanic populations have a high burden of obesity and elevated BP. In 2017-2018, Hispanic/Latinos had a higher prevalence of obesity (45%) than non-Hispanic whites (33%) and non-Hispanic Asians (17%) and a lower prevalence of obesity than non-Hispanic blacks (50%)[7]. Prior studies have found that Hispanics have a high 40-year risk for developing hypertension among adults 45 to 85 years of age (92%)[8] and have low rates of hypertension control (47.4%)[9]. Hispanics are the third fastest growing population in the U.S.[10] and comprise a large portion of the population with overweight and obesity[2, 11] and untreated or uncontrolled elevated BP[9]. Effective methods to alleviate these cardiovascular risk factors within this population is needed.

Physical activity is an individual modifiable risk factor important for maintaining a healthy weight or achieving weight loss as well as lowering BP[12]. Steps are a basic unit of locomotion[13]. Steps per day are an objective measure of physical activity that allows for incorporation of light intensity activities as well as moderate to vigorous physical activities[14]. Steps are easily understood metrics that can be leveraged as motivators for engaging in physical activity. The capability to capture a broad objective spectrum of physical activity measures and potential for development of easily conveyed step-based public health interventions support further research into understanding the relationship of step-based metrics with various health outcomes.

Exploration of the relationship between step-based metrics and measures of adiposity and BP has yielded mixed results. Further, previous research consists predominantly of cross-sectional analyses and short-term trials and intervention studies with limited generalizability to U.S. populations[15-30]. Additional research examining the relationship of step-based metrics with CVD risk factors is necessary in diverse populations to develop of appropriate step-based recommendations and interventions for the U.S. population.

This dissertation addressed gaps in current step-based metric research by examining the cross-sectional and longitudinal relationship between steps and measures of adiposity and BP in an ethnically diverse Hispanic/Latino cohort. Our findings suggest that step volume and intensity are cross-sectionally associated with measures of adiposity and hypertension status; longitudinally, step intensity is associated with changes in weight and BMI. Expanding our understanding of the relationship between step-metrics and CVD risk factors is needed for development of future physical activity recommendations and interventions for Hispanic/Latino populations.

CHAPTER 2: STATEMENT OF SPECIFIC AIMS

Aim 1a: Examine the cross-sectional association of daily steps (volume and cadence) with adiposity measures.

Hypothesis 1.1: There is an inverse relationship between mean daily step volume and cadence with waist circumference (WC) (cm), weight (kg), and body mass index (BMI).

Aim 1b: Examine the associations of daily steps (volume and cadence) with 6-year changes in adiposity measures.

Hypothesis 1.2: There is an inverse relationship between mean daily step volume and cadence assessed at baseline, with 6-year changes in WC (cm), weight (kg), and BMI (kg/m^2).

Aim 2a: Examine the cross-sectional association of daily steps (volume and cadence) with BP.

Hypothesis 2.1: There is an inverse relationship between mean daily step volume and cadence with BP.

Aim 2b: Examine the associations of daily steps (volume and cadence) with 6-year changes in BP

Hypothesis 2.2: There is an inverse relationship between mean daily step volume and cadence assessed at baseline, with 6-year changes in BP.

CHAPTER 3: BACKGROUND AND REVIEW OF THE LITERATURE

3.1. Background and review of overweight, obesity and high blood pressure

3.1.1 Public health burden of overweight and obesity and high blood pressure

Overweight and obesity and elevated BP are cardiovascular risk factors that continue to put a strain on our nation's overall health status and healthcare costs. Obesity and elevated BP are linked with multiple-organ system conditions such as CVD, stroke, type 2 diabetes and a multitude of additional comorbidities[31, 32]. Obesity, a risk factor for elevated BP, has nearly tripled since 1975, subsequently adding to the rise in global elevated BP[31]. Globally, the number of individuals with elevated BP and consequent deaths have increased significantly over the past two decades[33]. It is estimated that as of 2016, worldwide 1.9 billion adults were overweight and obese and as of 2019, 1.13 were hypertensive[31, 32]. Within the US, 42.4% are obese[34] and approximately 108 million U.S. adults have elevated BP[35].

Globally, high BMI contributed to 120 million disability-adjusted life years and approximately 4.0 million deaths, which is 7.1% of all-cause mortality. CVD contributed to the greatest frequency of high-BMI related mortality and disability adjusted life years (DALYs), accounting for 2.7 million deaths worldwide[1]. Mortality associated with an SBP of 140 mm Hg or higher accounted for 73.2% of all SBP-related deaths and 14% of global deaths. Most SBP related deaths can be attributed to ischemic heart disease, followed by hemorrhagic and ischemic stroke[33]. High BMI and hypertension remain a pressing issue for the future of the U.S. population.

Rates of obesity are continuing to rise in both adolescents and adults. It is estimated that over half of the children between the ages of 2 and 19 years in 2016 will be obese by 35 years of age[36]. Increases in weight are associated with increased in BP, thus as the population's obesity problem escalates, the risk of elevated BP continues to increase[37]. Treatment and control of hypertension have improved over the past decade, however, approximately 30-50% of U.S. adults remain hypertensive[12, 38] and this prevalence is projected to increase 9% by 2030[39]. Promotion of lifestyle interventions are needed to reduce the burden of hypertension and overweight and obesity among the U.S. population.

3.1.2 Overweight and obesity definition, history and epidemiology

Weight maintenance is the result of an energy intake equal to energy expended[40]. Weight gain is the result of a positive imbalance in energy intake[40]. Energy expenditure less than energy consumed results in a positive energy balance and consequently weight gain[40]. Energy balance is further influenced by genetic, epigenetic and environmental factors[40, 41]. Human bodies are capable of some regulation or adjustment of energy balance to promote weight stability, however, these changes are insufficient to prevent weight gain when exposed to persistent positive energy balance[40, 42-43]. Historically, it is hypothesized that metabolic mechanisms promoting fat storage were necessary in pre-agricultural society to provide energy reserves to individuals for survival[45]. Widespread obesity is considered a modern-day phenomenon and consequence of transition from an active lifestyle and predominantly plant-based diet to a highly sedentary lifestyle with increased dietary consumption of animal fat and sugar[45].

Evolution of the definition of overweight and obesity is rooted in our expansion of knowledge of the association between weight and health. Linkages between weight and health date back to 460 B.C. Hippocrates recognized that excess weight led to infertility and mortality, introducing the connection between health and weight[46, 47]. “Healthy weight” as a concept evolved with invention of the penny scale that allowed weight to be measured to the nearest pound[47, 48]. Insurance companies began to require “healthy weight” as a criteria for enrollment in policies[47, 49]. In 1942, ideal weight and height to weight tables were derived by the Metropolitan Life Insurance (MLIC) company using data from approximately four million MLIC policy holders[47, 50]. Weight categorization was dependent on longevity of life with no consideration of cause of mortality[47, 50]. The tables derived by the MLIC were the basis of current definitions for categories of weight. In 1959, the Society of Actuaries conducted “The Build and BP Study” which examined mortality of insured individuals based on variations in weight[47, 51]. Findings of an association between body weight and CVD mortality led to modification of the MLIC weight tables[47, 52]. “Ideal weight” was replaced with “desirable weight” in the updated tables[47, 49]. In 1973, the Fogarty International Center Conference on Obesity, from the 1959 MLIC tables recommended an “acceptable range” of weight for particular heights for men and women[47, 53-54]. In 1979, a second study of “The Build and BP Study” was conducted[47, 51]. Findings from this study resulted in raising “desirable weights” higher than the prior study, replacing the 1959 tables for height and weight with 1983 MLIC tables[47, 51].

The MLIC standard tables were the basis for development of BMI cut points. The National Institutes of Health Consensus Development Conference on the Health Implications of Obesity developed criteria to standardly define overweight, severe overweight obesity and severe obesity based on data from NHANES 1976-1980[47, 56]. Obesity and severe obesity were defined using the sum of triceps and subscapular skinfold thickness[47, 56]. Overweight was defined by a BMI > the 85th percentile and severe overweight as a BMI > the 95th percentile[47, 56]. Despite development of standard definitions, discrepancies in measurement protocols and definitions used by different institutions remained. In 1995, the World Health Organization (WHO) Expert Committee on Physical Status generated a report that acknowledged height and weight to be the basic anthropometric measurements of the human body[47, 57]. WHO recommendation in use of BMI with classification of BMI by cut-off points of 25, 30 and 40 was based on evidence from a meta-analysis of the association between BMI and mortality[47, 57]. In 1997, the NIH classified obesity based on approximately 394 randomized clinical trials[47, 58]. Obesity was defined identically by the NIH and WHO reaffirming choice of the cut points. In the U.S. Public Law 101-445, Title III, Section 301 requires Federal agencies to define overweight and obesity as a BMI consistent with the current edition of the Dietary Guidelines for Americans (Table 1)[47, 59-60].

Obesity unless specified can reflect multiple characteristics including body size, composition and appearance. Current accepted measures of obesity include BMI[45]. BMI is an estimate of body fat and gauge of risk for disease that may occur with increased body fat. Calculation of BMI uses the following formula[61]:

BMI=weight (kg) / [height (m)]2

BMI as an estimate of body fat has several limitations including overestimation of body fat in individuals with a muscular build and underestimation of body fat in individuals who have lost muscle[62].

WC is a measure of total and intra-abdominal body fat[63]. Measurement of WC as a complementary measure to BMI can help elucidate health risks associated with being overweight or obese. Health risk has a graded association with WC. WC as an additional measure to BMI can serve as a predictor of greater variance in health risk than BMI alone[64].

Table 1. Body mass index classification. [66]

Terminology	Definition by BMI	WC: Men 102 cm (40 in) or less, Women 88 cm (35 in) or less	WC: Men > 102 cm (40 in), Women > 88 cm (35 in)
Underweight	<18.5		
Normal	18.5 to <25		
Overweight	25.0 to <30	Increased	High
Obese	30+		
Obesity Class I	30 to <35	High	Very high
Obesity Class II	35 to <40	Very high	Very high
Obesity Class III	40+	Extremely high	Extremely high

BMI cut points define individuals with a BMI of 25+ overweight or obese. Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health[31]. Health risks associated with a BMI of 25+ include a multitude of chronic diseases such as CVD, diabetes mellitus, chronic kidney disease, hypertension, dyslipidemia, sleep disordered breathing, atrial fibrillation, dementia, venous thromboembolism, several cancers and musculoskeletal disorders[38, 67-68]. Mortality is also associated with BMI. Compared to those of normal weight, obese individuals have a higher risk of all-cause mortality[38, 69-71].

Nationally, obesity prevalence has significantly linearly increased over the past decade[7]. Obesity prevalence among adults has grown 7.2% between 1999-2000 (30.5%) and 2018 (42.4%)[7]. Mean body weight and WC significantly increased over the past decade for males and females. Males had a 4.1 kg mean increase in weight from 1999-2000 (mean weight=85.7 kg) to 2015-2016 (mean weight=89.8 kg). Females had a 3.1 kg mean increase in weight from 1999-2000 (mean weight=74.3 kg) to 2015-2016 (mean weight=77.4 kg)[72]. WC overall increased an average of 3 cm between 1999-2000 (mean WC=95.5 cm) and 2011-2012 (mean WC=98.5 cm). WC significantly increased between 2003 and 2012 despite a plateau in obesity prevalence[73].

Obesity prevalence varies by age. Adults 40-59 years of age have a higher prevalence (44.8%) than those who are 20-39 years (40.0%) and 60+ years (42.8%)[7]. Obesity prevalence does not significantly differ by sex. Age-adjusted prevalence of obesity was 39.7% and 40.3% for females and males respectively[7]. Age adjusted prevalence of severe obesity was lower in males (6.9%) than females (11.5%)[7].

Obesity prevalence varies by race. Non-Hispanic blacks have the highest prevalence (49.6%) followed by Hispanics (48.8%). Whites and non-Hispanic Asians had a lower prevalence (42.2% and 17.4% respectively)[7].

Trajectories for overweight and obesity in adulthood begins as early as childhood. Children who are overweight and obese in childhood are more likely to stay obese in adulthood. Obese children and adolescents are 5 times as likely to be obese as adults compared to non-obese children[74]. Approximately 55% of obese children will remain obese in adolescence, approximately 80% of those obese adolescents will remain obese in adulthood and approximately 70% of those obese adults will remain obese over the age of 30[51]. Despite childhood obesity trajectory risk, approximately 70% of obese adults were not obese in childhood or adolescence[74]. Adulthood risk factors should be considered in addition to childhood risk factors to address a large portion of the obese adult population.

A multitude of risk factors exist for overweight and obesity. Risk factors include genetics, race/ethnicity, maternal diet, famine exposure, parental obesity, parental smoking, gestational diabetes, prenatal exposure to endocrine-disrupting and other chemicals, diet, physical activity, sedentary behaviors, sleep, and stress [11]. Greater than 60 common genetic markers have been related to obesity susceptibility with the strongest susceptibility locus increasing obesity risk by 23%[11, 75-76]. Despite this elevated genetic risk, the most common genetic variants likely account for less than 1.5% of the overall inter-individual variation in BMI and the elevated risk of the most susceptible-locus may be modified by physical activity levels in adults[11, 75] suggesting population rises in overweight and obesity are unlikely being driven by genetics alone[40]. Race/ethnicity appears to play a role in obesity risk. Non-Hispanic blacks and Mexican Americans have a higher risk of obesity than whites[77].

Risk factors for obesity can be broken into individual and environmental factors. Individual modifiable risk factors include diet, physical activity, sedentary behaviors, sleep and stress. Caloric intake and diet quality are two components of the individual risk factor diet. Excess caloric intake and diets high in sugar and processed foods are associated with weight gain[11]. Excess weight gain can be prevented by energy balance and energy balance is controlled by following diet patterns outlined by the United States Dietary Guidelines for Americans. U.S. dietary guidelines emphasize consumption of whole grains, fruits, vegetables, lean protein, low fat and fat-free dairy products[78]. Stress is a modifiable risk factor linked with appetite and energy regulation. Greater stress can result in over or undereating and thereby weight gain and loss[79]. Physical activity is an individual risk factor important for maintaining a healthy weight or achieving weight loss. Energy expenditure from physical activity helps balance the energy consumed via caloric intake. Weight loss will be achieved when there is a caloric deficit[80]. Weight loss is primarily driven by caloric intake, however, engaging in regular physical activity helps maintain weight loss long term[81, 82]. Recommended guidelines for adults to maintain weight propose engaging in at least 150 minutes/week of moderate-intensity physical activity or 75 minutes/week of vigorous-intensity aerobic exercise or an equivalent combination of the two[83]. Sedentary behaviors independent of physical activity are a modifiable risk factor for obesity[84-86]. Television viewing, screen time, and other sitting time have a positive relationship with weight gain[84-87]. Sleep duration is a modifiable risk factor associated with weight gain. Associations between sleep and weight gain have been robust in pediatric populations and less consistent in adults[88].

Environmental risk factors include socioeconomic status (SES), education and the built environment. SES and education have inverse relationship with overweight and obesity[11, 89-90]. Stronger relationships between SES and overweight and obesity have been found in females than males. Low-paying jobs males hold may require more physically demanding work attenuating the relationship of SES and overweight and obesity for this population[11, 90]. The built environment encompasses neighborhood characteristics including the food environment, transportation, infrastructure, and walkability. Supermarket availability is inversely associated with obesity whereas fast-food availability is positively associated with obesity in adults[92]. Utilization of active transportation methods such as walking, and bicycling have been associated with lower obesity rates[92]. Walkability of a neighborhood may influence an individual's physical activity. Improvements in walkability may increase physical activity and thus reduce obesity in a population.

Individual and environmental risk factors each have important roles in overweight and obesity prevention. Individual factors can serve clinical purposes for identification of high-risk populations for overweight and obesity. Environmental risk factors for overweight and obesity provide opportunities for implementation of environmental targeted interventions to alleviate the burden of obesity in the population.

3.1.3 Obesity and U.S. residing Hispanic/Latinos

Overweight and obesity is a concern for Hispanic/Latino groups residing in the U.S. Hispanic adults have a high age-adjusted prevalence of overweight (36.2%)[93] and obesity

(48.8%)[7]. In 2016, Hispanics had > 30% of the obesity prevalence in 32 states compared to whites which had > 30% prevalence in 18 states[94]. Average changes in WC from 1999-2000 to 2011-2012 were second highest among Mexican-American women 70+ years of age (11.2 cm) and Mexican American men ages 20 to 29 years of age (8.7 cm) falling slightly behind non-Hispanic black women ages 30 to 39 years of age (11.6 cm)[73]. Obesity is prevalent in Hispanic youth populations ages 6-11 years of age (25.3%)[95]. Overweight and obesity prevalence lead to health risks for Hispanic populations. Cardiovascular related complications and biomarkers of risk have a positive association with obesity among Hispanic populations. Age-adjusted prevalence of hypertension, diabetes mellitus, high C-Reactive Protein levels and low High-Density Lipoprotein-Cholesterol levels among Hispanic males and females increase with rising increments of obesity[96]. Addressing disparities in the prevalence of overweight and obesity among Hispanic populations is necessary to reduce gaps in CVD risk within the U.S.

3.1.4 Blood Pressure definition, history and epidemiology

BP is a measure of circulatory function and reflects the balance of the blood volume ejected from the left ventricle of the heart with each cardiac cycle and arterial resistance to blood flow[45]. BP is measured in millimeters of mercury and is separated into systolic and diastolic determinants[45]. Systolic pressure is defined as the maximum pressure during contraction of the ventricles whereas diastolic is the minimum pressure recorded prior to the next contraction[45]. Physiologic mechanisms operate concurrently to maintain BP at a sufficient level to perfuse body tissues without damage[45].

High BP is considered both a cardiovascular condition by itself as well as a risk factor for atherosclerosis which precipitates conditions including coronary heart disease, stroke, heart failure and chronic kidney disease[45]. Atherogenesis due to sustained high BP is a result of elevated levels of angiotensin II as well as proinflammatory responses[97]. Angiotensin II catalyzes a biological pathway which ultimately stimulates the growth of smooth-muscle cells that infiltrate sub-endothelial atherosclerotic lesions[97, 98]. Angiotensin II binds to receptors which activate phospholipase C[97, 98]. Activation of phospholipase C increases intracellular calcium concentrations, smooth muscle contraction, protein synthesis, smooth muscle enlargement, smooth-muscle lipoxygenase activity, ensuing inflammation and oxidation of low-density lipoprotein (LDL)[97, 98]. Oxidation of LDL mediates the transformation of macrophages to foam cells which comprise the fatty streak observed in the genesis of atherosclerosis[99]. Sustained elevated BP further promotes an inflammatory response via formation of hydrogen peroxide and free radicals which reduce formation of nitric oxide and consequently increase leukocyte adhesion and peripheral resistance[97, 100-103].

Classification of BP serves clinical and public health purposes including surveillance and screening and treatment. Recognition of hypertension as a clinical entity dates back to 1896 with the invention of the cuff-based mercury sphygmomanometer[104]. Deeper understandings of BP pathophysiology, effects in diverse populations and interaction with comorbid conditions have shaped continuously evolving BP cut point definitions. Prior to the 1960’s, hypertension was diagnosed as a distinct disease termed “malignant hypertension” and patients were either “hypertensive” or “normal”[45]. Higher BP levels were thought to have greater risk of CVD complications with no division between normal persons and diseased[45]. Consideration of BP as a continuous measure or gradient rather than the dichotomy of “hypertensive” or “normal” arose in the 1960’s[45, 105].

National goals to reduce death and disability related to high BP led to establishment of the National High Blood Pressure Education Program (NHBPEP) by the then U.S. National

Heart and Lung Institute of the National Institute of Health (NIH) in 1972[106]. The NHBPEP aimed to reduce BP related morbidity and mortality through patient, public and professional education[106]. The NHBPEP evolved into a cooperative effort of agencies, state health departments, community groups[106]. The Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure (JNC) was created by NHBPEP as part of their education strategy[106]. The JNC was tasked with providing practical recommendations for identification of the total population with high BP, determining who will benefit from antihypertensive therapy and proposing therapeutic regimens to healthcare providers for translation into clinical practice. Between 1977 and 2003, the JNC issued 7 reports with progressively more rigorous criteria for the definition and treatment of hypertension[106-13].

In 2013, the National Heart Lung and Blood Institute (NHLBI) requested that the American Heart Association (AHA) and American College of Cardiology (ACC) take over management of guideline development for hypertension and cardiovascular risk[106, 114]. In 2017, the AHA and ACC in conjunction with additional stakeholders released the 2017 ACC/AHA/AAPA/ABC/ ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High BP in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines[12]. This report is the most recent guidelines to date and are considered the first comprehensive set released since 2003[12].

The newest recommendations updated clinical guidelines and categorization of BP. Updates to clinical guidelines include guidance for identification of white-coat hypertension and subsequent recommendation of home BP monitoring in addition to earlier aggressive treatment of high BP[12]. Medication use is now proposed for patients with a BP of at or above 130/80 mm

Hg who have had a prior CVD event, have diabetes mellitus, chronic kidney disease or are at atherosclerotic risk[12]. The guidelines acknowledge multiple medications may be needed to achieve BP control with the caveat that adherence to medication may be higher with use of a sole combination medication. Clinical care updates additionally recommend integration of risk factors such as socioeconomic status and psychosocial stress in patient's plan of care[12].

Updates to the categorization of BP include lowering the defined thresholds for high BP, elimination of the previously defined category of "prehypertension" and reclassification of a BP of 140/90 mm Hg from stage 1 to stage 2 hypertension (Table 2)[12]. Changes made in defining BP resulted in a disproportionate increase in the prevalence of high BP among younger populations, specifically those under 45 years of age[12]. Applying definitions from the 2017 guidelines rather than the JNC guidelines results in an additional 31.1 million U.S. adults classified as hypertensive between the years of 2011 to 2014[115].

Table 2. BP Categories as Defined by the ACC/AHA 2017 BP Guidelines [12]

Terminology	Definition
Normal	<120/80 mm Hg
Elevated	Systolic between 120-129 and diastolic <80 mm Hg
Stage 1	Systolic between 130-139 or diastolic between 80-89 mm Hg
Stage 2	Systolic at least 140 or diastolic at least 90 mm Hg
Hypertensive crisis	Systolic over 180 and or diastolic over 120 with patients needing prompt changes in medication if there are no other indications of problems, or immediate hospitalization if there are signs of organ damage.

Elevated BP and hypertension remain a concern among the U.S. population. Analysis of NHANES data has revealed prevalence increases in elevated BP from 12.2% to 14.4% between 1999 to 2016[116]. Modest declines in hypertension have been seen during this time period. Overall hypertension prevalence declined from 48.1% to 44.1% between 1999 to 2016; declines in hypertension were primarily driven by stage 1 hypertension. Stage 2 hypertension remained relatively stable with prevalence of 29.7% and 29.6% in 1999 and 2016 respectively[116].

Hypertension prevalence differs by sex and age. Males (51.0%) have a higher prevalence than females (39.7%) among adults 18 years or older[117]. Hypertension prevalence increases with age. Compared to adults ages $\geq$ 60 prevalence (males=75.2%, females=73.9%) is lower for all younger ages[117]. Awareness, treatment and control of hypertension increases with age. Compared to adults ages 20 to 39 (10.2%) years of age, control was higher among those 40 to 59 years (24.4%) and those 60 years or older (30%)[38].

Hypertension prevalence varies by race among adults 20 years and older. Non-Hispanic blacks have a higher prevalence of hypertension (males=57.2%, females=56.7%), compared to all other races[38]. Non-Hispanic whites had a similar prevalence of hypertension (males=50.2%, females=36.7%) compared to Hispanics (males=50.1%, females=36.8%)[117]. Potential factors that explain the differing racial prevalence of hypertension for Hispanics are unclear. Traditional risk factors for hypertension including education, socioeconomic status and levels of physical activity are lower among Hispanics than their non-Hispanic counterparts and thereby cannot explain the low prevalence rate observed[118]. The "Hispanic Paradox" describes this phenomenon where Hispanics have paradoxically lower rates of CVD despite having higher CVD risk factors[118].

Non-modifiable and modifiable risk factors exist for high BP. Non-modifiable risk factors include a family history of elevated BP, loss of blood vessel elasticity due to normal aging processes, chronic kidney disease and race/ethnicity[119]. Modifiable risk factors include: low levels of physical activity; overweight or obesity; a diet high in sodium, calories transfat and sugar; heavy alcohol use; obstructive sleep apnea; high cholesterol; stress; diabetes and tobacco use including second-hand smoke exposure[38, 119]. Modification of these risk factors can lead to reductions in BP. Achieving 90-150 minutes per week of aerobic exercise at 65%-75% heart rate reserve is estimated to result in a 5-8 mmHg reduction and 2-4 mmHg reduction in hypertensive and normotensive individuals respectively[120].

3.1.5 Hypertension and U.S. residing Hispanic/Latinos

Hypertension lifetime risk and control is of concern for Hispanic/Latinos residing in the U.S. The 40-year risk of developing hypertension is high among Hispanics (92%)[8]. Hypertension control is defined as achieving a satisfactory SBP/DBP during treatment of hypertension. Hispanics have a low control rate of hypertension (19.3%)[38]. Several national studies have found a higher prevalence of uncontrolled BP among Hispanics compared to their non-Hispanic counterparts. Examination of 2011-2016 NHANES data found 46.5% of treatment eligible Mexican Americans remained untreated[121]. Uncontrolled BP is the most common risk factor for CVD[122]. Uncontrolled hypertension is a major source of cardiovascular morbidity and mortality for Hispanics. Hispanic men and women have a mortality rate of 19.3 and 14.6 per 1000 persons respectively[38]. Hypertension awareness and treatment are factors that likely contribute to the higher lifetime incidence of hypertension in addition to hypothesized lifestyle, economic and cultural reasons. Hypertension awareness is defined as the self-report of hypertension diagnosis or use of BP lowering medications[123]. Hispanics Historically have been found to have poor hypertension awareness[124-128]. Poor hypertension awareness reduces the likelihood that an individual would modify their lifestyle or seek treatment for their underlying condition. Antihypertensive treatment is likely another contributor to the high lifetime risk and poor control rates of hypertension among Hispanics. Pharmacologic interventions in clinical trials have been found to be effective in reducing BP for Hispanic subjects[129]. Factors surrounding pharmacologic treatment such as prescription, utilization and adherence rates may each play a role in the suboptimal hypertension control observed among Hispanics[129-130]. Antihypertensive therapies are less likely to be utilized among Hispanics (60.7%) compared to white (73.9%) or black (70.8%) patients according to 2003-2012 NHANES data[130]. Combination therapies utilization rates are especially low for Hispanics (34.1%) compared to whites (45.8%) and blacks (48.3%)[130]. Adherence to antihypertensive medications is lower among Hispanics (49%) than white (58%) and Asian (52%) patients according to a study of Kaiser Permanente Northern California patients[131]. Poor adherence to hypertensive medication may be due to language barriers. Higher adherence was found among patients with a preference language of Spanish for those with a fluent Spanish speaking provider[131]. Lower prescription rates and poor adherence to antihypertensive medications may partially explain the high hypertension lifetime risk and low control among Hispanic populations. Addressing hypertension awareness and treatment among Hispanic populations is necessary to alleviate the burden of high BP within the U.S.

3.1.6 Summary

High BP, overweight, and obesity pose a large public health burden nationally and globally. High BP remains one of the most important risk factors for CVD and obesity continues to rise within the U.S. Risk factor modification is integral in reducing the downstream effects of high BP and overweight and obesity. Recognition of varying risks for different populations allows development of tailored interventions appropriate for respective populations. Modifiable risk factors should be explored among populations such as U.S. Hispanics that have higher a prevalence of uncontrolled BP and obesity. This proposal seeks to produce translational research that focuses on alleviation of the burden of BP and overweight and obesity in a U.S. Hispanic population. BP will be assessed continuously and categorically using current clinical cut points for research and clinical application. Limitations of measurements of BMI as a measure of body fat will be addressed by inclusion of measures of adiposity including WC and weight will provide a more accurate picture of weight related health risk. Findings from this work can contribute to the future U.S. public health physical activity guidelines.

3.2 Physical activity and sedentary behavior measurements and patterns in the U.S.

Physical activity is defined as any bodily movement produced by the skeletal muscles that promote energy expenditure[132]. Physical activity can be considered structured or incidental. Structured physical activity, also known as exercise, is planned or purposeful activity with the goal of health promotion and fitness[132-133]. Incidental activity, also known as lifestyle activity, is activity as a result of daily activities at work, home or during transport[133]. Ambulatory activities are a further classification of either incidental or structural physical activity that refers to activities specifically related to walking or running[134].

Physical activity can be described using four dimensions: mode, frequency, duration and intensity. Mode of physical activity is the specific activity performed such as walking or bicycling. Mode of physical activity can be further categorized by physiological and biomechanical demands such as aerobic or anaerobic, resistance or strength training and balance and stability training[133]. Frequency is defined by how often one engages in physical activity i.e. the number of sessions per day or week. Frequency is often qualified by the number of sessions (bouts) that are > 10 minutes in duration[133]. Duration is the amount of time spent engaging in an activity for a specified time frame[133]. Intensity is an indicator of metabolic demand of an activity and is defined as the rate of energy expenditure. Intensity measures can be captured by collection of physiological measures such as oxygen consumption and heartrate, subjective perceptual characteristics such as rating of perceived exertion and quantification of body movement such as stepping rate and 3-dimensional body accelerations[133].

Quantification of intensity is often achieved through computation of metabolic equivalents (METS), energy expenditure in kilocalories or simply summation of time spent in various physical activity intensity categories for a specified timeframe[133]. METs are a unit that reflects exercise intensity as measured by oxygen (O_2) •kg−1•min−1. O_2 increases with intensity of physical activity therefore, multiples of resting energy expenditure can be used to quantify intensity[133]. One MET is defined as 3.5 mL O_2•kg−1•min−1 which is resting energy expenditure during quiet sitting for a 70 kg person. Physical activity volume in a given timeframe can be calculated by the following formula[133]:

Physical activity volume= METs • duration • frequency

Kilocalories (kcal) are a measurement of energy expenditure. One liter of O_2 is approximately 5kcal of energy. Physical activity-related energy expenditure (PAEE) in kilocalories can be calculated using the following formula[133]:

PAEE= O_2 *consumed (L) • 5kcal/L.*

Daily PAEE is the sum of all the different physical activities engaged in per day. Energy expenditure increases with mass moved therefore, daily PAEE it is often expressed relative to body mass as kcal per kg of body mass per minute[133].

Intensity can be considered either relative or absolute. Relative intensity is determined relative to one's cardiorespiratory fitness. Absolute intensity refers to the amount of external work performed defined by METs[133]. MET threshold ranges classify absolute intensity as light, moderate and vigorous.

Capture of free-living physical activity among populations is challenging. Self-report, observational and device-based methods have been used to measure physical activity levels of the population. Each method has pros and cons and captures slightly different information. Self-report tools include questionnaires or diary's or logs and are generally cost-effective however, are subject to recall bias. Direct observation can collect contextual information however, is time consuming, subject to observer reactivity and is limited to a delineated space[135-139]. Physical activity measures can be captured by devices. Improvements in technology and wearables have increased popularity of capturing objective measurements of physical activity in research. Methods used to capture device-based measurements of physical activity and their varying strengths and limitations can be seen in Table 3.

Table 3: Device-based measurement methods for capture of physical activity

Device	Measures	Strengths	Limitations	Notes
Pedometers	Step count measured by a horizontal, spring-suspended lever arm that deflects when a subject's hip accelerates vertically with force beyond a threshold[136]	Correlate strongly with uniaxial accelerometers and direct observation of duration of activity[135, 136, 141, 142], inexpensive, captures shorter durations of physical activity frequently missed in self-report, useful for measurement of relative change in physical activity[133]	Inability to capture horizontal motion, intensity, frequency or duration of physical activity[143, 144], lack of standard thresholds across brands of pedometers resulting in different outputs for the same quantity of physical activity[145], reactivity to device[135, 137, 146], minimal data storage in the device[147]	
Accelerometers	Acceleration in G-forces (g)-reflects body acceleration and deceleration, some devices transform this into counts per second, minute or day which can further be translated into volume, rate or time spent at different intensities measured by METs or kcals (calculated using	Precise and can monitor activity down to multiple times per second, captures intensity levels, are accurate with static and dynamic behaviors[136, 148-151] , have larger memory capacities than pedometers[147]	Expensive, need of expertise for individual programming of devices[152], potential reactivity bias[135], inability to measure contextual information[136], limited capability to differentiate a wearer's body position dependent where they are worn[139], no standard protocol for managing or reducing data[133]	Worn on either an individuals hip, ankle, waist or thigh, detects movement in three orthogonal planes-anteroposterior, mediolateral and vertical[135, 153]

	prediction equations)[133]			
Heart rate monitors	Physiological indicators of physical activity and energy expenditure[154]	Capture energy expenditure from vertical trunk displacement that pedometers and accelerometers are unable to capture[155], useful in categorizing wearer's physical activity levels[136]	Tend to have discrepancies at very high and low intensity since heart rate and energy expenditure do not have a linear relationship with low intensities or rest[136, 156], measurements are impacted by individuals age, body composition, muscle mass, sex and fitness level[157]	Worn on chest or arms[136, 148, 158, 159]

Different brands of distinct devices have different measurement potential. Outputs from devices can be translated to physical activity metrics of interest. Steps are physical activity outputs captured by pedometers and some accelerometers. Step-based metrics of interest include step volume and intensity. Step count reflects volume of daily ambulatory activity. Cadence, or steps per minute is an indicator of intensity of ambulatory movement. Controlled studies using treadmills, tracks or hallways found cadence to have a correlation of 0.94 with absolute intensity measures defined by MET[160]. Walking speed is a function of cadence and step length. Increases in speed consequently increases cadence and therefore intensity[161-166]. Lower cadence bands when assessing free-living populations are likely reflective of incidental and sporadic step accumulation and higher cadences likely represent purposeful and greater speeds of locomotion[166]. Peak-30-minute cadence captures the average steps per minute recorded for the highest 30 minutes in a day[167]. Habitual step count, volume and intensity can be characterized with use of a single 7-day accelerometer administration. Reproducibility of accelerometer –

assessed physical activity and sedentary time was demonstrated in a subset of the Women's Health Study by examining the intra-class correlations of at least two 7-day accelerometer administrations within a 2 to 3-year period[168]. ICCs ranged from 0.67 (95% CI=0.60, 0.73) for bouted-MVPA to 0.82 (95% CI=0.77, 0.85) for total daily counts and were similar across all ages and BMI levels[168]. Reproducibility varied by metric, however, all ICCs were large enough to suggest 7-day accelerometer measurements capture habitual physical activity and sedentary time. Accelerometer measured step-metrics had improved capture of habitual physical activity compared to administered physical activity questionnaires[168]. Limitations of accelerometer measured step-metrics include the inability to estimate upper body movements and activities such as cycling and swimming as well as underestimation of steps for load-carrying activities such as weight training. Adjustment for non-ambulatory steps taken during underestimated activities in population estimates has been deemed unnecessary since these activities are infrequently performed and walking is the most prevalent form of physical activity and a functional part of life[169, 170]. Thresholds of steps per day define levels of activity among healthy adults (Table 4).

Table 4. Step-defined physical activity hierarchy [171]

Definition	Steps/day
Highly active	>12,500
Active	10,000-12,499
Somewhat active	7,500-9,999
Low active	5,000-7,499
Limited activity	2,500-4,999
Basal activity	<2,5000

Measurement and categorization of physical activity enables researchers to determine prevalence and trends in physical activity in relation to recommended physical activity. The Physical Activity Guidelines for Americans was issued first in 2008 and then updated in 2018 by the U.S. Department of Health and Human Services[83]. Recommendations for the public for remaining physically active and reducing risk of chronic disease are provided in these guidelines. Current physical activity guidelines for U.S. adults recommend engaging in at least 150 minutes of moderate-intensity aerobic activity (or at least 75 minutes of vigorous physical activity) in addition at least 2 days per week of muscle strengthening activities[83]. The 2018 Physical Activity Guidelines for Americans mostly aligns with the WHO's 2020 recommendations[172]. Levels of physical activity are defined in relation to meeting the physical activity recommendations (Table 5).

Table 5. Levels of physical activity according to the Physical Activity Guidelines for Americans [83]

Level of Activity	Definition
Inactive	Not getting any moderate- or vigorous intensity physical activity beyond basic movement from daily life activities.
Insufficiently active	Doing some moderate- or vigorous-intensity physical activity but less than 150 minutes of moderate-intensity physical activity a week or 75 minutes of vigorous-intensity physical activity or the equivalent combination. This level is less than the target range for meeting the key guidelines for adults.
Active	Doing the equivalent of 150 minutes to 300 minutes of moderate-intensity physical activity a week. This level meets the key guideline target range for adults.
Highly active	Doing the equivalent of more than 300 minutes of moderate-intensity physical activity a week. This level exceeds the key guideline target range for adults.

Sedentary behaviors are formally defined as any waking behavior characterized by an energy expenditure of < 1.5 METs while in a sitting, reclining or lying posture[173-175]. Sedentary time is considered the time spent for any duration in any context in sedentary behaviors. Sedentary bouts are considered periods of uninterrupted sedentary time and sedentary interruptions or breaks are considered non-sedentary bouts in between two sedentary bouts[174]. Reducing sedentary behavior is recommended by the current U.S. and WHO physical activity guidelines[83, 172].

Levels of physical activity among U.S. adults have been captured via multiple national surveys (Table 6)[176]. Prevalence estimates are dependent on the questionnaire utilized. Estimates may vary due to differing measurement capture of physical activity or variation between populations surveyed. Age-adjusted prevalence for reported physical activity are higher and inactivity lower for 2005 Behavioral Risk Factor Surveillance System (BRFSS) estimates compared to 2005 NHIS and NHANES estimates; estimates for NHIS 2005 and NHANES 2005 were similar[177]. Prevalence estimates of U.S. adults meeting recommended aerobic activity guidelines is higher for NHANES 2015-2016 data (65.2%) compared to NHIS 2015 data (49.7%)[178, 179]. Trends within population subgroups were similar independent of survey choice. Males were more likely to be active than females and non-Hispanic whites were more likely to be active than non-Hispanic black and other race/ethnicities[177].

Table 6. National surveys with measurement of physical activity[176]

National Survey	Survey Purpose	Collection Rate	Physical Activity Measure
Behavioral Risk Factor Surveillance System (BRFSS)	Assess behavioral risk factors with emphasis on state-level surveillance.	Year-round	Self-report questionnaire
National Health Interview Survey (NHIS)	Monitor health of the nation and progress toward national health objectives.	Year-round	Self-report questionnaire
National Health and Nutrition Examination Survey (NHANES)	Examine health of Americans through personal interview and direct physical examination of a cross-sectional representative sample.	Year-round	Self-report questionnaire, accelerometer
Youth Risk Behavior Surveillance System (YRBSS)	Monitor priority health risk behaviors that lead to causes of death, disability and social problems among adolescents.	Physical activity data collected bi-annually	Self-report questionnaire
National Household Travel Survey (NHTS)	Survey U.S. travel modes, commuting habits and long distance trips.	Every 5 years	Self-report questionnaire

Prevalence measures of physical activity also vary dependent how accumulation of physical activity is defined. Bout versus non-bout accumulation impacts the prevalence of levels of physical activity[180]. Requirement of at least 10-minutes or more bouts for moderate-to-vigorous physical activity (MVPA) resulted in a smaller proportion (9.7%) compared to non-bout proportions (44.8%) of the proportion of sufficiently active adults. Requirement of 10-minute bouts for lifestyle activity resulted in a smaller proportion (57.9%) compared to non-bout proportions (95.6%) of sufficiently active adults[134]. Bouts are commonly used for assessment of physical activity accumulation since it represents sustained periods of physical activity; however, mortality risk reduction associated with MVPA may be independent of how physical activity is accumulated[181].

Physical activity participation has increased over the past decade, however, the majority of the nation remains sub-optimally active. As of 2018, only 27.6% of males and 20.8% of females reported meeting both aerobic and muscle strengthening activity guidelines[176]. Muscle strengthening activity recommendations were met by 3.6% of adults and aerobic activity recommendations were met by 54.2% of adults [176]. Populations meeting aerobic physical activity guidelines differ by age and race/ethnicity. Older adults were less likely to adhere to the guidelines compared to younger adults. Non-Hispanic whites were more adherent to the aerobic guidelines than non-Hispanic blacks, Hispanics and others[182]. Populations meeting muscle strengthening recommendations differ by aerobic activity, income, education, self-rated health, sex and BMI[182]. Meeting muscle strengthening guidelines was inversely associated with insufficient aerobic activity, low income, low education, poor self-rate health, female gender and being overweight or obese[182-186].

Time spent in sedentary behavior has significantly increased from 2007 through 2016. Joint physical inactivity and time spent sitting is highly prevalent in U.S. adults[179]. Approximately 1 in 4 individuals report sitting more than 8 hours per day and 4 in 10 individuals are physically inactive; 1 in 10 individuals report joint physical inactive and sitting for greater than 8 hours per day[187]. Time trends for hours spent sedentary are similar for race/ethnicity. Hispanics consistently have the lowest mean hours per day of sedentary time compared to Non-Hispanic white, Non-Hispanic black and other races[179].

Distribution of physical inactivity is not geographically uniform across the U.S. Physical inactivity while nationwide, clusters in the Southern regions of the U.S. Higher prevalence of adults achieving physical activity recommendations cluster on the West Coast[188].

Leisure time physical activity has significantly increased from 2004 to 2014 primarily among white-collar versus blue-collar workers. Largest increases in leisure time physical activity were among workers in public administration[189]. Occupation related physical activity may offset low leisure time physical activity. Strong associations exist between occupational category and daily activity levels. High activity occupational categories have higher total activity counts, MVPA and steps as well as lower time spent in sedentary activity compared to occupations classified as low occupational activities[190]. Despite strong associations between occupation type and daily physical activity levels, a "physical activity paradox" has been cited in several studies. Men engaging in high occupational physical activities were found to have an increased risk of all-cause mortality in a systematic review[191]. Limitations including restricted geographical representation and variations in socioeconomic gradients across studies may have confounded this relationship and more research exploring this paradox is needed[192].

Active transport related physical activity is an additional daily activity that may offset low leisure time physical activity. Transportation surveys found increases in walking trips with a trip defined as "from one address to another" and a negligible increase in cycling between 2001 and 2017[193]. Active travel to reach public transportation was found to be the most important form of walking. Walking at both ends of the trip was found for 90% of all public transport trips completed. Increases in prevalence of active travel was driven by increased time walking per walker rather than increases in the proportion of individuals walking. Rates of active travel are consistently higher among neighborhoods with high population densities[193]. Active travel prevalence varied by demographic background. Non-Hispanic whites had the lowest prevalence of walking 30 minutes per day compared to Hispanics, African Americans and Asians in 2001[194].

Between 2001 and 2017, walking increased the most for non-Hispanic whites. Compared to non-Hispanic whites, other ethnic backgrounds were less likely to walk at any level by 2017[193].

Free-living U.S. adults ≥ 20 years of age average a cadence of 60 or more steps per minute for approximately 30 minutes per day[166]. Daily, U.S. adults accumulate approximately 4.8 hours of zero cadence wear time (indicating sedentary behavior), 8.7 hours between 1 and 59 steps per minute, approximately 16 minutes per day of 60-79 steps per minute, approximately 8 minutes at 80-99 steps per minute, approximately 5 minutes at 100-119 steps per minute and approximately 2 minutes at 120 or more steps per minute[166]. Males average a slightly higher peak 30-minute cadence (73.7) than females (69.6). Peak indicators decline with age and increasing levels of obesity[167].

3.2.1 Physical activity among Hispanic/Latinos residing in the U.S.

Hispanic/Latinos residing in the U.S. have a low prevalence of physical activity (31.7%)[195]. Individual examination of structured and incidental physical activity highlight how Hispanic/Latinos accumulate physical activity. Hispanics appear to obtain more daily activity incidentally. Prevalence estimates of regular participation in leisure time physical activity (and meeting physical activity guidelines) is low for Hispanic/Latinos (21.6%)[93]. Self-reported leisure time may not be an accurate representation of daily physical activity, particularly not for Hispanic populations. Incidental physical activity accumulation occurs for Hispanics with more physically demanding jobs. Barriers to physical activity commonly cited among Hispanics include environmental access, perceived access to facilities which enable physical activity to occur, neighborhood safety and time constraints due to multiple role responsibilities[196-198]. Hispanics have lower access to parks and recreational facilities compared to their non-Hispanic white counterparts in an ecologic study of 7139 census tracts in California, Illinois, Maryland, Minnesota, North Carolina and New York[199].

3.2.2 Summary

Physical activity can be captured and expressed using a variety of methods and measurements. Despite increases in physical activity, a large percentage of the U.S. adult population are not meeting recommended aerobic or muscle strengthening guidelines and there have been increases in sedentary behaviors over the past decade. Potential health risks associated with low levels of physical activity and high levels of sedentary behavior are becoming increasingly important to study given the current state of participation in these activities. Incidental and structured physical activity participation varies by race. Hispanics have higher levels of incidental than structured physical activity, thus self-reported leisure time may not accurately capture Hispanics total daily activity. Objective measures obtained using accelerometers, such as step-based metrics, can better estimate engagement in light physical activity and sedentary time. Decreasing costs of and increasing acceptability of wearable physical activity tracking devices enables researchers to easily capture objective measurements and thus expand our understanding of how total daily physical activity impacts health outcomes and risks.

Elucidation of the relationship between total daily physical activity as measured by step-based metrics and health risk factors among Hispanic populations may inform future step-based physical activity guidelines and easily understood public health interventions. This dissertation examined step-based metrics in relation to cardiovascular risk factors in a U.S. Hispanic population. Limitations of these metrics including an inability to measure arm movement are outweighed by the potential for objective measurement of daily ambulatory movement and intensity. Continuous and categorical examination of step-based metrics addresses concerns regarding current lack of consensus for cut-points.

3.3 Physical activity and sedentary behavior

3.3.1 Physical activity as a protective factor for overweight and obesity

Mechanisms for weight control and loss via physical activity are multifactorial. Cell size alteration, increasing metabolic processes and appetite regulation are proposed systems through which physical activity impacts weight control and loss. Excess adipose tissue leads to development of obesity. Adipose tissue is responsible for the release of glycerol and free fatty acids via lipolysis in addition to the generation and storage of neutral lipids via lipogenesis and esterification[200]. Adipose tissue can be delineated as white or brown adipose tissue. White adipose tissue is unilocular and predominantly stores energy whereas brown adipose tissue are multilocular and expend stored energy via thermogenesis[201]. A hallmark of obesity is dysfunctional adipose tissue leading to hypertrophy of visceral white adipose tissue and subsequent recruitment of additional adipocytes[202-204]. Exercise training can result in adaptation of white adipose tissue morphology and biochemical properties including reducing lipid content and adipocyte size consequently reduced adiposity[205-207].

Expansion of adipose tissue compromises core metabolic processes. Lowering of mitochondrial content is one mechanism through which metabolic processes are compromised. Physical activity may improve mitochondrial capacity by increasing mitochondrial content and expression of proteins related to mitochondrial biogenesis and metabolism[200, 208-210]. Endurance training remodels fatty acid mobilization and oxidation during and post-exercise which in turn modulates adipokine secretion and regulates mitochondrial metabolism[200, 211].

Physical activity plays a role in appetite regulation and thereby influence appetite's downstream effects of weight control and loss. Regulation of appropriate caloric intake can be induced by a cascade of signals catalyzed by increases in physical activity among sedentary individuals. Increased aerobic activity promotes increases in post prandial satiety signaling and subsequent suppression of orexigenic drive[212, 213]. Decreases in appetite promote appropriate caloric consumption for weight maintenance. Resistance training was not found to activate this signal cascade which may be a result of differences in insulin sensitivity[213, 214].

Multiple biological pathways explain the relationship between physical activity and weight maintenance and loss. Increased physical activity promotes weight loss through alteration of cellular size, metabolic metabolism and regulation of caloric intake drives.

3.3.2 Sedentary behavior as a risk factor for overweight and obesity

Overweight and obesity are consequences of a multitude of sedentary behavior driven pathways. Sedentary behaviors trigger insulin resistance, hyperlipidemia, decreased clearance of dietary lipids, reduced fasting and post-prandial lipid oxidation in favor of more use of carbohydrates as fuel and ectopic storage fat[215-221]. Collectively, these abnormalities define "metabolic inflexibility" which is a cause of weight gain[221, 222].

Bedrest trials simulate prolonged sedentary behavior and are used to examine physiological changes as a consequence of high sedentary time. Changes in insulin resistance and oxidation of fat in response to sedentary time have been identified in multiple bedrest trials. Dolkas et al. examined forced 14-day bed rest in seven healthy young men[223]. Participants developed significant insulin resistance during bedrest. Hyperinsulinemia returned to control values as exercise was restored[223]. Blanc et al.[215] examined acute effects of sedentary behavior 16 males and females. Participants underwent head down bed rest mimicking weightlessness for a 7-day period. Post-bed rest participants had increased insulin to glucose ratios, lower normetanephrine, decrease in basal levels of lipid oxidation and lower nonsterified fatty acids. Solely males exhibited a lower production of endogenous glucose and an increase in exogenous glucose. Reductions in sympathetic activity and insulin resistance from 7-day bedrest were demonstrated in this trial[215]. Bergouignan et al conducted a randomized trial that followed 18 males for 3 months of bed rest[218]. Independent of changes in energy balance, sedentary periods decreased the oxidation of saturated but not monosaturated fats among participants[218]. Bergouignan et al. conducted an additional study examining 8 females with 2-months of bedrest[219]. Stable isotope labeling was used to examine the plasma metabolic fate of dietary fat. Bedrest increased spillover of nonsterified fatty acid (NEFA) released after hydrolysis of lipoprotein triglycerides by lipoprotein lipase. Higher NEFA spillover suggests peripheral tissues are less likely to take up NEFA[219]. Muscle atrophy was hypothesized to contribute to lower plasma fat clearance and indirectly hyperlipidemia[217]. Dirks et al. examined 10 healthy young males for 10 days of forced bed rest[220]. Bed rest resulted in 1.4 + 0.2 kg lean tissue loss, a 3.2 + 0.9% decline in quadriceps CSA, VO2 peak decline of 6.4 + 2.3, a 29 + 5% decrease in whole-body insulin sensitivity and a decline in muscle oxidative capacity[220].

Sedentary behavior results in metabolic abnormalities and subsequently weight gain. Bed-rest trials allow for examination of physiological responses to prolonged sedentary behavior. Trials reaffirm proposed sedentary behavior driven weight gain mechanisms of changes in insulin resistance and lipid oxidation.

3.3.3 Mechanisms linking physical activity, sedentary behaviors and BP

Voluntary, dynamic, whole body exercises provoke changes in cells, tissues and organs as a response to increased metabolic activity of contracting skeletal muscle. Volitional effort derived in the motor cortex of the brain catalyzes recruitment of motor units by the spinal cord resulting in a specified movement pattern[224]. As an acute response to this movement, neural feedback from contracting skeletal muscles signal the cardiovascular, respiratory and metabolic systems to meet demands of the limited disruption of homeostasis[224].

Acute respiratory responses to physical activity include oxygen transport. Muscle mass engaged in exercise determines the O_2 flux and total fuel requirement. Maximal oxygen uptake (VO_2max) is determined by the ability of the following: the central nervous systems recruitment of motor units, the pulmonary and CVD systems delivery of O_2 to contracting muscles and the muscles consumption of O_2 in the oxidative metabolic pathways[224]. When exercise intensity increases, regional and global brain blood flow increases approximately 20 to 30% while transitioning from rest to moderate exercise to evoke maximal O_2 uptake VO_2max[225-232].

Acute cardiovascular responses to exercise are dependent on the autonomic nervous system. The feedforward "central command" activates areas in the brainstem to increase heartrate, BP and ventilation. Feedback to the central nervous system from myelinated and unmyelinated type III and IV afferents in contracting muscles increase sympathetic activation and feedback to the brainstem on BP is provided from baroreceptors in the carotid sinus and aortic arch. Central command-mediated vagal withdrawal and activation of sympathetic outflow during exercise augment cardiac stroke volume and ensures that venous returns from the active muscle vasculature maintains diastolic filling and stroke volume to regulate the heart rate[224].

Acute skeletal muscle responses to exercise involve vasodilation of the active skeletal muscles, primarily small arterioles, resulting in increases in blood flow. Dilator substances and mechanisms include inward rectifying K+ channels, adenosine, adenosine triphosphate (ATP), products of skeletal muscle metabolism and reactive O_2 species[224]. During exercise, blood flow is redistributed from visceral organs and inactive muscle via vasoconstriction of these vascular beds allowing a greater fraction of cardiac output to reach active skeletal muscle and partially counteract a decrease in total peripheral resistance. Redistribution of blood flow to skin during physical activity promotes sweating to regulate temperature during exercise[224].

Acute cardiovascular alteration to dynamic and isometric exercise drives long-term remodeling and chronic adaptations. Autonomic and sensory feedback systems reset so that lower BP is permitted allowing greater increases in skeletal muscle blood flow[224]. Cellular modification in the brainstem are often pro-vagal and sympathoinhibitory and thus explain in part why lower heart rates and BP are found during exercise after training[224]. Dynamic exercise results in remodeling of the vascular system via signaling pathways involving nitric oxide, prostaglandins and vascular endothelial growth factors[224]. Remodeling includes increases in the diameter of large conducting vessels, number of arterioles and capillary density. Endurance training promotes increases in cardiac chamber size due to induced increases in blood volume and catecholamine concentrations[224].

Acute and chronic responses to physical activity are regulated by neural feedback systems. Neural feedback systems act on the respiratory, cardiovascular and skeletal muscle systems and each in turn regulate blood flow as a homeostatic response.

3.3.4 Physical activity as a protective factor for elevated BP

Positive dose-response relationships have been found for physical activity and prevention of hypertension in epidemiological studies. Biological links for the positive dose-response relationship is less understood. Hypertension etiology is multifactorial thus complicating the understanding of the mechanistic interplay between physical activity and hypertension. Proposed mechanisms through which physical activity decreases the risk of hypertension can be seen in Table 7[233].

Table 7. Proposed physical activity induced biological mechanisms and pathways for hypertension reduction [233]

Lowering of:	Increases in:
• vascular resistance	• endothelial function
• arterial stiffness	• renal function
• oxidative stress	• sodium handling
• inflammation	• baroreflex sensitivity
• body weight	• parasympathetic activity
• renin-angiotensin system activity	• angiogenesis
• sympathetic activity	• arteriogenesis
• vascular responses to adrenergic and endothelin receptor stimulation	• arterial compliance
• intima-media thickness	• arterial lumen diameter
• psychosocial stress	

Animal and cell studies have identified additional potential mechanisms. Rat models demonstrated alteration of insulin sensitivity and autonomic nervous system function by aerobic exercises as well as alteration of vasoconstriction regulation by resistance training[233, 234]. Proposed mechanisms may vary by race/ethnicity. Differential effects to exercise stimuli across different races have been demonstrated in cell studies[233, 235, 236]. Multiple physical activity induced biological mechanisms and pathways likely act in parallel to protect the body from increases in BP.

3.3.5 Sedentary behavior as a risk factor for elevated BP

Positive relationships between time spent in sedentary behavior and risk of hypertension have been identified in epidemiological research. Precise biological mechanisms for the relationship between sedentary behavior and hypertension risk is less understood. Potential biological mechanisms must ultimately alter cardiac output or peripheral resistance. Mechanisms likely include metabolic, autonomic and direct vascular pathways that result in oxidative stress, low grade inflammation, and metabolic signaling that ultimately lead to hypertension[237, 238].

Metabolic demand must be considered to understand the biological underpinnings of alteration of cardiac output in relation to sedentary behaviors. Metabolic demand for common sedentary behaviors are approximately 1.0 MET[239]. Low metabolic demand yields low vasodilatory metabolites and consequently constriction of precapillary arterioles and closure of precapillary sphincters[238]. Constriction and closure of arterioles and sphincters results in blood being shunted through metarterioles. Capillary closure simultaneously reduces pressure differential with upstream feed arteries reducing blood flow and endothelial shear stress ultimately promoting vasoconstriction via reduced nitric oxide and increased endothelin-1[238].

Autonomic responses to prolonged sitting include increases in the sympathetic nervous system (SNS) which in turn results in vasoconstriction, decreased glomerular filtration rate and increased renin release. Low grade inflammation from these responses result in increased BP[238]. Vascular responses to prolonged sitting include decreases in blood flow which result in endothelial dysfunction and nitric oxide synthase (NOS) uncoupling. NOS uncoupling is the reduction of O2 to superoxide which aggravates oxidative stress and ultimately results in increased BP[238].

Sedentary postures may independently increase BP. Seated postures create bends and constrictions in lower limb blood vessels which result in mechanical increases in peripheral resistance and promote turbulent blood flow patterns that impact blood flow and regulation[238, 240, 241]. Horizontal positions shift fluids accumulated from increased hydrostatic reducing venous returns rostral overnight exacerbating sleep apnea[238, 242-244]. Sleep apnea is associated with nocturnal hypertension and non-dipping BP patterns[243]. Fluid accumulation may also result in carotid baroreceptor unloading and reduced baroreceptor afferent activity and subsequently increases in efferent sympathetic activity[238]. Weight gain, muscle atrophy, vascular rarefaction, endothelial damage and stiffening of the arteries are all associated with prolonged sitting and are additional proposed mechanisms for sustained elevation and peripheral resistance in hypertension[238].

Concurrent behaviors linked with prolonged sitting such as television watching and eating, may result in increases in BP. Food intake exaggerates elevations in glucose and insulin levels. Food intake in conjunction with prolonged is expected to cause sympathoexcitation and noradrenaline release from arterial nerve terminals thereby increasing BP[238]. Metabolic and anatomical based reactions are plausible sedentary time induced mechanisms for increases in BP.

3.3.6 Summary

Effects of physical activity and sedentary behavior on obesity and BP are multifactorial in nature. Precise biological pathways for these relationships are not fully understood. Physical activity and sedentary behavior related mechanisms that drive weight gain include alterations in the metabolic and autonomic nervous system. Physical activity and sedentary behavior related mechanisms that drive increases in BP include changes in the vascular, metabolic and autonomic nervous systems. Overweight and obesity and BP related physiological responses to physical activity and sedentary behavior support further exploration of physical activity as a tool to alleviate overweight and obesity and hypertension. Physiological studies support biological plausibility of relationships, however, these studies are conducted in laboratory settings and do not account for additional external environmental factors; therefore, physiological studies do not provide us with a full picture of real world relationships. The proposed study seeks to establish real-world associations for the biological relationships described between physical activity overweight and obesity and BP. Leveraging observational data allows for elucidating relationships step-based metrics with measures of adiposity and BP in autonomous individuals in a real-world setting.

3.4 Physical activity and sedentary behavior literature and overview of step-based metrics

3.4.1 Meta-analyses, reviews of the relationship between physical activity and overweight and obesity

Inverse relationships between physical activity and weight have been found in prospective and cross-sectional studies. Systematic reviews serve as a summary of the current body of evidence surrounding a research topic. Longitudinal associations between objective and subjective physical activity and weight change in adults and children was examined in a systematic review of papers published since 2,000. Self-reported measures of physical activity were used in 12 studies; 9 of which found a negative association between physical activity and weight[245]. Objective measures of physical activity were assessed in 2 studies; one study found significant modification of the association between PAEE and weight gain over a 5-year period by age whereas the other study found that neither physical activity or PAEE were related to change in body weight over a 4-year period[245]. Relationships between objective accelerometer measures of light physical activity and changes in measure of adiposity were reviewed in a systematic review of 37 cross-sectional studies that leveraged the NHANES dataset. Associations with WC was assessed in 9 studies; 8 of the studies found significant positive relationships[246]. Associations with BMI was assessed in 5 studies; 4 of the studies found significant positive relationships[246].

Relationships between sedentary time and measures of adiposity differ by body composition measure. Cross-sectional relationships between objectively measured sedentary time and cardiovascular outcomes were examined in a systematic review and meta-analysis of 46 papers published prior to February 2017[247]. Outcomes of body composition measures were examined in 15 papers. Body mass was assessed in 4 of the papers; one paper found a significant positive association with sedentary time. Adjustment for MVPA attenuations the significant association found for body mass. No association was found for fat mass or lean mass in all studies. BMI was assessed in 24 papers; 10 papers found positive significant associations. Adjustment for MVPA attenuated significant associations found for BMI in 3 of the studies. WC was assessed in 30 papers; 15 found positive significant association[247]. Adjustment for MVPA and cardiorespiratory fitness attenuated significant associations found for WC in 4 of the studies. Body fat was assessed in 7 papers; 3 papers had a positive significant association. Adjustment for MVPA attenuated significant associations found for body mass in one study. WC was the only body composition measure found to have significant mean increases with increases in sedentary time in the meta-analysis[247]. Meta-analyses can be used to systematically assess conclusions for multiple studies. Meta-analyses have revealed inverse relationships between physical activity and measures of adiposity whereas less consistent findings have been found for sedentary time dependent on the adiposity measure assessed and choice of adjustment covariates.

3.4.2 Meta-analyses and reviews of the relationship between physical activity, sedentary time and BP

Meta-analyses of prospective cohort studies have documented inverse relationships for moderate and vigorous levels of physical activity and incident hypertension. Higher pooled relative risks of incident hypertension were found for low levels of recreational physical activity in a meta-analysis of 14 prospective cohort studies including 136,846 individuals hypertension-free at baseline[248]. High versus low physical activity had a pooled relative risk of 0.81 (95% CI 0.76-0.85) and pooled relative risk of 0.89 (95% CI 0.85-0.94) for moderate versus low physical activity. Non-significant inverse relationships for high and moderate occupational physical activity compared to low was found[248].

Meta-analyses of prospective cohort studies have documented linear dose response relationships for leisure time and total physical activity and incident hypertension. Reductions in risk of hypertension with increasing levels of leisure physical activity was found in a meta-analysis of 22 articles assessing 29 different prospective cohort studies including 330,222 individuals hypertension-free at baseline[249]. Increments of 10 MET-hr and 50 MET-hour per week of leisure time physical activity had a 6% and 7% reduction in risk of hypertension, respectively. Risk of hypertension was additionally reduced by 6% for participants who met the recommended physical activity minimum guidelines, compared to inactive participants[249]. Increasingly greater levels of physical activity enlarged the magnitude of the protective effect for hypertension. Risk of incident hypertension decreased with increasing total physical activity with adjustment for BMI; without adjustment, a more modest reduction was seen[249].

Systematic reviews have reported on the current research examining light intensity physical activity and various measures of BP. A systematic review of objectively measured light-intensity physical activity and cardiometabolic risk factors identified 24 cross-sectional studies and 6 longitudinal studies published prior to February 2017[250]. Significant inverse relationships with SBP was found in one study; all studies examining associations with DBP were non-significant. Associations with high BP was assessed in 5 studies; only one study found significant inverse relationships with high BP. None of the longitudinal studies reviewed examined BP as a health outcome[250].

Epidemiological evidence of the relationship between sedentary time and BP is mixed. Method of assessment of sedentary time may influence relationships seen between sedentary time and BP. No associations between time spent in sedentary behavior per day and BP were found in a systematic review of 31 articles predominantly cross-sectional published before August 2014. Papers were predominantly from Europe (N=14) and North American (N=8) with few studies from South America (N=2)[251]. Adult participants were assessed in just over half of the studies (N=17) with remaining studies examining children and adolescents. Accelerometer measures of sedentary behavior were assessed in only 10 of the studies[251]. Positive relationships were found between sedentary time and BP in a meta-analysis of 28 papers from the previously described systematic[251]. Pooled results from 8 of the studies using accelerometer measures found a positive relationship with BP. Each additional hour of time spent in self-reported sedentary behavior per day was associated with an increase in 0.06 mm Hg of SBP and 0.20 mmHg of DBP. Pooled results from self-reported sedentary behaviors found an inverse relationship between sedentary time and BP[251]. Positive relationships were not consistently seen for objective measures of sedentary time and BP. Cross-sectional relationships between objective measures of sedentary time and BP were reviewed in a systematic review of 46 articles. Associations of BP without adjustment for MVPA were examined in 5 papers; only one study had a significant positive relationship. Associations of SBP was assessed in 19 papers; only 3 studies had significant positive relationships after adjustment for MVPA. Associations of DBP and sedentary time was assessed in 16 papers; only 2 studies had significant positive relationships after adjustment for MVPA[245].

3.4.3 Published studies of the relationships between physical activity and sedentary behaviors and overweight and obesity and BP in the HCHS/SOL cohort

Analyses have leveraged data in the HCHS/SOL cohort to discern relationships between physical activity and sedentary behaviors and cardiovascular risk factors within a diverse urban Hispanic/Latino population. Qi et al.[252] examined the cross-sectional relationship between accelerometer measured sedentary time and cardiometabolic biomarkers including BP. Accelerometer counts classified sedentary behavior as <100 counts per minute and MVPA as > 1535 counts per minute. Greater time spent sedentary was significantly associated with a higher DBP. Adjustment for MVPA attenuated these associations[252]. Palta et al.[253] examined the cross-sectional relationship of BMI with self-reported and objective measures of physical activity. Physical activity was assessed using the GPAQ and accelerometers. No differences were observed for self-reported moderate, vigorous or MVPA across BMI groups. Obese and overweight groups compared to the normal weight group had significantly less MVPA as measured by an accelerometer[253]. Singer et al.[254] examined the association of overweight and obesity with occupation physical activity. Occupations were groups into 13 categories with METs assigned to each occupational category based on the 2002 Census Occupational Classification System. Adjusted odds for being obese compared to normal weight were 3.2% and 14.4% higher for each 10 MET•hrs/wk unit higher occupation activity and each 10-hours per week unit of total hours worked respectively[254]. Studies in HCHS/SOL suggest potential relationships between sedentary behavior and BP. Relationships between physical activity including occupational physical activity are present in the cohort. Future analyses of physical activity, BP and measures of adiposity in this cohort are needed to continue to elucidate cardiovascular risk among this cohort.

3.4.4 Epidemiology of steps and overweight and obesity and BP

Steps are a basic unit of locomotion[13]. Steps per day is a measure of physical activity that allows for incorporation of light intensity activities as well as moderate to vigorous physical activities. Steps per day demonstrates consistency in capturing measures of moderate physical activity as opposed to the debated thresholds applied using accelerometer counts per minute[165, [255-258]. Step-based recommendations are not included in current physical activity guidelines due to the lack of research to make those recommendations. While formal step-based metric guidelines do not currently exist within the U.S., however, achieving 10,000 steps per day is a frequently cited recommendation without any authoritative endorsement. Genesis of the 10,000 steps per day recommendation can be traced back to Japanese walking clubs and a business slogan for a pedometer manufacturing company from the 1960's[160, 259].

Engaging in 10,000 steps per day is considered to reflect an active lifestyle associated with health benefits. Aggregated data from studies all using different pedometer brands have found healthy adults take approximately 7,000 to 13,000 steps per day[260]. Modern U.S. adults average between 5,900 and 6,900 steps per day[170, 261, 262]. Fewer than 10,000 steps may be needed to meet exercise recommendations and gain health benefit. Data from "America on the Move" found individuals reporting strenuous exercise 3, 4 and 6-7 days per week, levels likely meeting current physical activity guidelines, accumulated averages of 5486 $\pm$ 231, 6,200 $\pm$200 and 7,891 $\pm$ 540 steps per day respectively[263, 264]. Public health messaging of 10,000 steps is debated within the scientific community. Lee et al.[265] found fewer than 10,000 steps were needed to reduce the risk of all-cause mortality in the Women's Health Study. Publication of these findings included the statement, "these findings may serve as encouragement to the many sedentary individuals for whom 10,000 steps/day pose an unattainable goal". Researchers have responded to this message with the argument that the term "goal" is being conflated with a minimum threshold or standard of 4,400 steps per day; 4,400 steps is likely a lower than optimal threshold when considering additional health outcomes and behavioral factors[265].

Steps are easily understood metrics that can be leveraged as motivators for engaging in physical activity. Use of step goals has been found to be a predictor of increases in physical activity and significant decreases in BMI[266]. Walking interventions enhanced with pedometer feedback result in a larger step count and consequently increased physical activity[267]. Future formal physical activity guideline recommendations should consider inclusion of step-based metrics to promote increases in physical activity engagement. Several practitioners have suggested translation of current guidelines and levels of physical activity into step-based metrics using the following conversions for adults[160]:

3,000 to 4,000 steps = ~ 30 minutes of at least moderate-intensity walking

100 steps/min = lower bound of moderate intensity walking

≤ 5,000 steps per day = sedentary lifestyle

Simple translation of current guidelines into step-based metrics fails to incorporate relationships with health outcomes; a more tailored approach considers health outcomes in relation to step cut points. A criterion reference approach should be considered for multiple populations to provide the public with appropriate step-based recommendations.

3.4.5. Steps and overweight and obesity

Previous cross-sectional, longitudinal, walking trials and systematic reviews have examined relationships between step metrics and overweight and obesity. Studies varied in measurement instruments, populations assessed, and outcomes examined. Cross-sectional analyses of steps/day, and step intensity have primarily found inverse relationships with measures of adiposity (Table 8); only three studies reported no significant relationships[19, 27, 268]. Stanish et al. found no significant association between step volume and measures of adiposity among 103 individuals with intellectual disabilities. Similarly, Sumner et al. found no association with step volume and measures of adiposity among a multi-ethnic Asian population (N=635), however, significant inverse relationships were found for step intensity. Mitsui et al.

reported significant inverse relationships between step volume and measures of adiposity for females but not males in a Japanese cohort (N=182).

Few longitudinal studies have examined the relationship between step-based metrics with changes in adiposity and findings have been inconsistent[269, 270]. Dwyer et al. examined the relationship between step count and 5-year change in step count, BMI and waist-to-hip ratio among the Tasmanian component of the national AusDiab Study (N=592, mean age=51,4 years). Higher step counts at follow up but not baseline were found to be associated with lower BMI and waist-to-hip ratios after the 5-year period. Conversely, Preiss et al. found previously weight but not change in weight was associated with subsequent step-count in the Nateglinide and Valsartan in Impaired Glucose Tolerance Outcomes Research study.

Trials and interventions examining step-based and walking interventions have reported significant reductions in measures of adiposity associated with interventions among healthy and populations with morbid conditions (Table 8). Yamanouchi et al.[29] conducted the first trial to specify a daily step goal for weight loss. Hospitalized type 2 diabetic patients were randomized to a diet alone arm or a diet + exercise arm; the diet + exercise arm was required to walk at least 10,000 steps per day on a flat field. Body weight reductions were found in both arms; however, reduction was significantly greater in the diet + exercise group[29]. Thresholds lower than 10,000 steps (9,000 and 9,500 steps/day) have since been significantly associated with BMI status in cross-sectional studies[27, 271].

Systematic reviews and meta-analyses of pedometer-based interventions and walking trials have found favorable effects of interventions on measures of adiposity (Table 8). Pedometer use resulted in a mean average decrease in BMI of 0.38 in a systematic review of 26 studies (8 RCTs and 18 observational studies) published between 1996 and 2006[266]. Average participants in pedometer-based walking programs without dietary change were found to lose 1 kg of weight every week in a meta-analysis of 9 pedometer-based walking intervention studies. This translates to weight loss of approximately 1 pound every 10 weeks while adhering to an intervention[272].

Table 8. Studies of steps and overweight and obesity

Author, Year	Study Population	Step-Metrics and Measurement Method	Adiposity Measures	Findings
Cross-Sectional Observational Studies				
Tudor-Locke 2001[273]	Healthy adults (eight African American males, 23 African-American females, 33 Caucasian males, 45 Caucasian females, total N=109), mean age 44.9 yeras	Steps/day, pedometer (Yamax Digi-walker, Model DW-500, Accusplit, CA)	BMI and percentage body fat	Steps per day was inversely correlated with BMI and percentage body fat
Chan 2003[15]	Prince Edward Island cohort recruited from highly sedentary workplaces, mean age females: 43.3 ± 8.6, mean age males: 43.1 ± 12.7; (N=182)	Steps/day, pedometer (model SW-200, Yamax Corporation, Tokyo, Japan)	BMI (continuous), WC	Fewer steps/day are associated with increased BMI, WC
Thompson 2004[274]	Females in Tennessee 40-66 years; (N=80)	Steps/day (categorical) Digi-Walker pedometer model SW-200 (New Lifestyles Inc., Lees Summit, MO)	Percentage body fat, BMI, WC, waist-to-hip ratio	Significant differences were found between activity groups for body composition measures. Higher body composition was found in less active groups
Hornbuckle 2005[271]	African-American females, 40-62 years of age; (N=75)	Steps/day (categorical) New Lifestyles Digi-Walker SW-200 (New Lifestyles, Inc., Lees Summit, MO)	Percentage body fat, BMI, waist and hip circumferences, and waist-to-hip ratio	Steps/day are inversely associated with lower body fat percentages, BMI values, WCs, and hip circumferences.
Krumm 2006[275]	Postmenopausal women (N=93) ages 50-75 years	Steps/day, pedometer (Digi-Walker SW-200,	Percentage body fat, BMI, trunk fat, and	Steps/day are inversely

		New LifestylesInc., Lees Summit, MO	waist and hip circumference	associated with adiposity profiles
Stanish 2007[268]	Individuals with intellectual disabilities (N=103), 19-65 years	Steps/day (Yamax Digiwalkers (SW-500 and SW-700, Yamax Inc.,Tokyo, Japan)	Weight, BMI, skinfolds, wait, hip and abdomen circumference	No significant associations were seen with walking and body composition measures
Mitsui 2008[27]	Local residents in Japan, 48-69 years of age (N=182)	Steps/day Pedometer [EM-180 (EM), YAMASA, Tokyo, Japan]	Weight, percentage body fat, WC and BMI	Steps/day was not significantly associated with WC. Males did not have a significant relationship between steps/day and obesity. Correlations between steps/day and BMI and percentage body fat were significant for Japanese women
Jennersjö 2012[276]	Cardiovascular Risk factors in Patients with Diabetes – a Prospective study in Primary care, 54–66 years; (N=327)	Steps/day (categorical) pedometer, Yamax SW-200/KeepWalking LS2000 (Yamasa Tokei Keiki Co., Ltd., Tokyo, Japan)	BMI, WC	Higher steps/day were associated with lower BMI and WC
Tudor-Locke 2012[167]	NHANES 2005-2006 (N=3,522), 20+ years of age	Peak 1-minute and peak-30 minute cadence, accelerometer (ActiGraph model 7164)	BMI (categorical)	Peak 1-minute and peak-30 minute cadence declined with increasing levels of BMI
Pillay 2014[17]	Adults in Cape Town South Africa (N=70) 21-49 years of age	Steps/day and intensity categorized as “aerobic” and “non-aerobic”, Omron HJ 750 ITC	Percentage body fat, BMI, WC	Total steps/day and total time spent in aerobic activity was inversely associated with percentage body fat, BMI and WC

Pillay 2015[277]	South African employed adults 21-50 years of age; (N=312)	Steps/day and categorized as intensity-based categories, Omron HJ 720 ITC (Omron Corp., Kyoto, Japan)	Percentage body fat, BMI, WC	Total steps/day was inversely associated with measures of adiposity. Body fat percentage was significantly different in the "no aerobic activity" group from the "low aerobic activity" and "high aerobic activity" groups
Tudor-Locke 2017[86]	NHANES 2005-2006 (N=3388), 20+ years of age	Steps/day, peak 30 minute cadence, sedentary behavior, ActiGraph 7164 accelerometer	BMI, WC and weight	Inverse associations were found for quintiles of steps and peak 30 cadence and measures of adiposity. Positive associations were found for quintiles of sedentary behavior and WC and weight.
Hajna 2018[28]	Canadian Health Measures Survey ages (N=8,106) 18+ years of age, mean age 41.5	Step count examined categorically and a step threshold of 10,000 steps per day (yes/no) Accelerometer (Actical; Philips Respironics, Oregon, USA)	BMI	The "somewhat active" and "active" categories of step count had lower BMIs than the "inactive" group
Johansson 2019[278]	Copenhagen City Heart Study (N=1670), median years of age 6.18	Time spent walking, running, standing and sedentary, tri-axial accelerometers (ActiGraph GT3X+; ActiGraph, Pensacola, Florida,	BMI	Walking and running were less prevalent among those who are overweight or obese

		USA; sampling frequency: 30 Hz)		
Johansson 2020[279]	Copenhagen City Heart Study (N=1053), median years of age 48.326 for younger adults and 72.70 for older adults	Time spent walking, running, standing and sedentary, tri-axial accelerometers (ActiGraph GT3X+; ActiGraph, Pensacola, Florida, USA; sampling frequency: 30 Hz)	WC	Less sedentary behavior and increased high intensity physical activity was associated with a significantly smaller WC
Sumner 2020[19]	Multi-ethnic Asian population (N=635) mean age 48.4 years	Mean daily step count, peak 1, 30 and 60 minute cadence and time per day spent inactive, accelerometer (Actigraph GT3X+)	BMI and WC	Higher step intensity was associated with decreased WC and BMI. Step volume was not associated with measures of adiposity.
Longitudinal Observational Studies				
Dwyer 2011[269]	Tasmanian component of the national AusDiab Study in 2000 and 2005 (N=592), ages 25+	Step count, Pedometer, Omron HJ-003 and Omron HJ-102	BMI, waist to hip ratio	Over a 5-year period step-count decreased over time. Higher step counts in 2005 than 2000 was associated with a lower BMI and waist to hip ratio
Preiss 2015[270]	Nateglinide And Valsartan in Impaired Glucose Tolerance Outcomes Research (NAVIGATOR) study (N=2,811), $\geq$55 years	Step count and change in step count, pedometers (Accusplit, San Jose, CA, USA)	Weight and change in weight	Prior weight but not change in weight was inversely associated with subsequent step count. Change in step count was inversely associated with subsequent weight .
Walking Trials and Interventions				
Yamanouchi 1995[29]	Obese adults with non-insulin	Steps/day, pedometer (HJ-7,	Changes in body weight	Diet and exercise groups had larger

	dependent diabetes mellitus (N=24), 23-59 years of age	OMRON Industries)		decreases in body weight than diet groups alone
Miyatake 2002[30]	Obese Japanese males (N=31) ages 32-59	Steps/day Pedometer (WZ100A, SEIKO Corporation, Japan)	Intra-abdominal visceral adipose tissue	An inverse association was found between changes in adipose tissue and changes in steps/day
Swartz 2003[22]	Females with a family history of type 2 diabetes (N=18)	Steps/day, Pedometers (SW-200, Yamax Corp., Tokyo, Japan)	BMI	No changes in BMI were found due to the walking intervention
Wyatt 2005[261]	Adults in Colorado aged 18+ (N=742)	Steps/day, Step counters (Yamax Model SW-200, Yamasa Corporation, Tokyo, Japan)	BMI	Obese individuals walked approximately <2000 steps per day than normal-weight individuals
Kobayashi 2006[23]	Japanese males (N=44) mean age 37 years	Steps/day, pedometer (TANITA FB-714)	BMI	There were significant reductions in BMI over a 50 day period
Schneider 2006[280]	Overweight and obese adults (N=56)	10,000 step goal (adherent/non-adherent) Digi-Walk-er SW-200 electronic pedometer (Ya-max, Inc., Tokyo, Japan)	Body weight, percentage body fat, BMI, fat mass, WC and hip circumference	Over 36 weeks, significant decreases in all adiposity measures were seen with adherence to a 10,000 step goal
Savage 2008[281]	Recent cardiac event patients (N=107), 40-83 years of age	Steps/day Walk4Life pedometer (Walk4Life, Inc, Plainfield, Illinois)	WC and BMI	Total steps per day was correlated with WC and BMI
Schulz 2015[282]	Non-Hispanic Black and Hispanic residents of Detroit, Michigan (N=695), ages 18+, 36%	Steps/day, Omron peiso-electric pedometer.	WC and BMI	Increases in steps/day was associated with a reduction in WC and BMI at 8 weeks and maintained at 32 weeks.

	Hispanic, mean age 46.7. years			
Miyazaki 2015[25]	Older adults (N=36) mean age 68.3 years	Steps/day, electronic pedometer (Walking Style HJ-720IT, Omron Health Care Corporation, Kyoto, Japan)	BMI	At 21 weeks, with a mean increase in steps, there was a significant decrease in BMI
Systematic Reviews and Meta-analyses				
Tudor-Locke 2004[171]	29 articles published ≥1980 using pedometers	Pedometer determined physical activity	BMI, percentage overweight, seven skinfolds, percentage body fat	A weak inverse relationship was found for measures of body composition with pedometer measured physical activity. Several studies found positive relationships thought to be confounded by smoking
Bravata 2007[266]	26 studies (8 RCTs and 18 observational studies) published between 1996 and 2006	Pedometer determined physical activity	BMI	Pedometer use resulted in a mean average decrease in BMI of 0.38 95% CI (0.05-0.72)
Murphy 2007[283]	24 RCTs published between 1971 and 2004	Walking trials	Weight, BMI and percentage body fat	Walking interventions decreased BMI and percentage body fat
Richardson 2008[272]	9 RCT and prospective cohorts published after 1995	Pedometer-based walking interventions without a dietary intervention	Mean weight change	There was a mean weight change of -1.27 kg 95% CI (-1.85, -0.70) due to the intervention. Longer intervention duration was associated with greater change in weight. Participants

				lost 0.05 kg per week on average throughout the interventions.
Hanson 2015[284]	42 studies of walking group interventions	Walking group studies with outcomes directly attributable to the walking intervention	Percentage body fat, BMI	Walking groups were associated with statistically significant reductions in body fat and BMI
Murtagh 2015[285]	32 RCTs published from 1971-2012	Walking trials	WC, BMI, percentage body fat	Walking reduced all anthropometric measures
Oja 2018[286]	37 RCTs (1971-2012)	Walking interventions examining cardiovascular outcomes	Body mass, BMI and percentage body fat	Walking interventions had favorable effects for measures of adiposity

3.4.6. Steps and BP

Previous cross-sectional, longitudinal, walking trials and systematic reviews have examined relationships between step metrics and BP. Studies varied in measurement instruments, populations assessed, and outcomes examined. Cross-sectional analyses of steps/day, and step intensity have found varying relationships with measures of BP dependent on the population assessed (Table 9). Step intensity but not volume was significantly associated with a reduction in SBP and DBP in a multi-ethnic Asian population (N=635)[19]. Step volume and total time spent accumulating aerobic steps (intensity) were inversely associated with SBP but not DBP in a South African population (N=70)[17]. No significant relationships were found between step volume or intensity and BP for individuals with intellectual disabilities (N=103)[268]. Relationships between BP and step count was found to differ by sex and age. Manjoo et al.[287] found a 1,000 daily step increment among females was associated with a −2.6 mm Hg and -1.4 change in SBP and DBP respectively, whereas males had a −0.7 mm Hg and -0.6 mm Hg change in SBP and DBP respectively among type 2 diabetic patients (N=201). Tudor-Locke et al.[86] found significant associations between step volume for males only; conversely only females demonstrated a significant association with BP (DBP only) in the NHANES 2005-06 cohort. Johannson et al.[18] found sedentary behavior and increased walking was associated with lower SBP among older adults only whereas sedentary behavior and increased high intensity physical activity was associated with significantly lower SBP irrespective of age in the Copenhagen City Heart Study (N=1053).

Longitudinal assessment of step-based metrics and BP is minimal (Table 9). Longitudinal assessment has found associations between BP and steps per day differ by BMI status. Menai et al. leveraged data from the Withings' Pulse activity trackers across 37 countries (N=9238) and found 1 month increases in >3,000 steps/day was associated with decreases of SBP and DBP among overweight and obese individuals but not normal weight[288].

Trials and interventions examining step-based and walking interventions have reported mixed results for changes in BP associated with interventions among healthy and comorbid populations (Table 9). Several studies found SBP and DBP significantly decreased with walking interventions[22, 289] whereas numerous studies reported significant changes in SBP but not DBP in relation to walking interventions[21], [23, 25, 26, 282]. Conversely Baker et al. found no significant changes in SBP or DBP among participants of a pedometer-based trial in West Scotland University (N=79)[24]. Changes in SBP and DBP were found to differ by hypertensive status. SBP and DBP were significantly reduced among a group of hypertensive but not normotensive workers in a manufacturing industry undergoing a 12-week walking intervention[20].

Systematic reviews and meta-analyses have found pedometer and walking-based interventions to result in reductions in SBP and DBP (Table 9)[222, 267, 284, 285, 290]. Mean reductions of ~2% in SBP and DBP due to walking interventions were found in a meta-analysis of 16 studies with walking interventions[291]. Reductions in solely SBP were seen in a systematic review of 26 pedometer studies (8 RCTs and 18 observational studies)[266] whereas reductions in DBP only were seen in a systematic review of 24 RCTs walking trials[283].

Table 9. Studies of steps and BP

Author, Year	Study Population	Step-Metrics and Measurement Method	BP Measures	Findings
Cross-Sectional Observational Studies				
Chan 2003[15]	Prince Edward Island cohort recruited from highly sedentary workplaces, mean age females: 43.3 ± 8.6, mean age males: 43.1 ± 12.7; (N=182)	Steps/day, pedometer (model SW-200, Yamax Corporation, Tokyo, Japan)	DBP	There was a low correlation between steps/day and DBP
Stanish 2007[268]	Individuals with intellectual disabilities (N=103), 19-65 years	Steps/day (Yamax Digiwalkers (SW-500 and SW-700, Yamax Inc.,Tokyo, Japan)	SBP and DBP	No significant associations were seen with walking and lower BP
Manjoo 2010[287]	Type 2 diabetes patients N=201	Step/day, Yamax SW-200 pedometers	SBP & DBP	A 1,000 daily step increment among females was associated with a −2.6 mm Hg change in SBP and a −1.4 mm Hg change in DBP whereas males had a −0.7 mm Hg change in SBP and a −0.6 mm Hg, change in DBP.
Wuerzner 2013[16]	Patients admitted to the Lausanne University Hospital hospital for ambulatory BP monitoring (N=103), mean age 55.1 years	Step count (assessed categorically), SenseWear Pro Armband (Body Media, Pittsburgh, PA)	SBP & DBP monitored at night for dipping	Step count was significantly associated with SBP and DBP dipping. SBP was inversely associated with step count whereas DBP was positively associated with step count.
Pillay 2014[17]	Adults in Cape Town South Africa (N=70) 21-49 years of age	Steps/day and intensity categorized as “aerobic” and “non-	SBP and DBP	Total steps/day and total time spent accumulating aerobic steps were inversely

		aerobic", Omron HJ 750 ITC		associated with SBP but not DBP.
Tudor-Locke 2017[86]	NHANES 2005-2006 (N=3388), 20+ years of age	Steps/day, peak 30 minute cadence, sedentary behavior, ActiGraph 7164 accelerometer	SBP and DBP	Significant associations were seen for males and between steps/day and SBP and DBP but not for females. Peak 30 cadence was significantly associated with female's DBP only
Johansson 2020[18]	Copenhagen City Heart Study (N=1053), median years of age 48.326 for younger adults and 72.70 for older adults	Time spent walking, running, standing and sedentary, tri-axial accelerometers (ActiGraph GT3X+; ActiGraph, Pensacola, Florida, USA; sampling frequency: 30 Hz)	SBP and DBP	Less sedentary behavior and increased walking was associated with lower SBP among older adults only. Less sedentary behavior and increased high intensity physical activity was associated with significantly lower SBP irrespective of age
Sumner 2020[19]	Multi-ethnic Asian population (N=635) mean age 48.4 years	Mean daily step count, peak 1, 30 and 60 minute cadence and time per day spent inactive, accelerometer (Actigraph GT3X+)	SBP and DBP	Higher step intensity was associated with reduced SBP and DBP. No significant associations were seen with step volume and BP
		Longitudinal Observational Studies		
Menai 2017[288]	Users of the users of the Withings' Health Mate mobile application (users in 37 different countries N=9238), 19-90 years of age	Steps/day, Withings' Pulse activity trackers	SBP and DBP	A 1-month increase of > 3000 steps/day was associated with a decrease of SBP and DBP among those who were obese and overweight but not normal weight.
		Walking Trials and Interventions		

Iwane 2000[20]	Workers in a manufacturing industry (N=81), mean ages for hypertensive, normotensive and hypertensive control group were 48.5, 44.7 and 48.7 years respectively	Steps/day pedometer (Hello Walk; Tanita, Tokyo, Japan)	SBP and DBP measured in the office	After 12-weeks the walking intervention group (required to walk 10,000 steps or more) had a significantly lower SBP and DBP among the hypertensive group. The normotensive and hypertensive individuals with sedentary profiles (control group) did not have significant changes in BP.
Moreau 2001[21]	Postmenopausal women (N=24) with borderline to stage 1 hypertension, mean age 54 years	Steps/day, Yamax SW-200 pedometer (Yamax, Inc., Tokyo, Japan)	SBP and DBP	SBP but not DBP was significantly reduced in 12 weeks in the walking intervention group
Swartz 2003[22]	Females with a family history of type 2 diabetes (N=18)	Steps/day, Pedometers (SW-200, Yamax Corp., Tokyo, Japan)	SBP and DBP	Significant changes in SBP and DBP were seen with the walking intervention
Kobayashi 2006[23]	Japanese males (N=44) mean age 37 years	Steps/day, pedometer (TANITA FB-714)	SBP and DBP	There were significant reductions in SBP but not DBP over a 50 day period
Baker 2008[24]	West Scotland University recruited participants (N=79), 18-65 years of age	Steps/day, pedometer Omron HJ-109E Step-O-Meter (Omron Healthcare UK Ltd)	SBP and DBP	No significant changes in SBP and DBP were found
Miyazaki 2013[25]	Physically active older adults (N=36), mean age 68.3 years	Steps/day, electronic pedometer (Walking Style HJ-720IT, Omron Health Care Corporation, Kyoto, Japan)	SBP	By week 2, SBP significantly decreased while there were increases in steps/day in this year-long trial

Soroush 2013[289]	ASUKI step study (N=355), mean age 42.98 years	Steps/day, Yamax SW-200 pedometer	SBP and DBP	Over a 6-month period there were significant decreases in SBP and DBP
Schulz 2015[282]	Non-Hispanic Black and Hispanic residents of Detroit, Michigan (N=695), ages 18+, 36% Hispanic, mean age 46.7. years	Steps/day, Omron peiso-electric pedometer.	SBP and DBP	Increases in steps/day were associated with decreases in SBP at 8 weeks and maintained at 12 weeks
He 2017[26]	Patients with essential hypertension from the Baoshan Community Health Service Center (N=46)	Walking intensity, accelerometer (ActiGraph GT3X+, Actigraph Corporation, Pensacola, FL)	SBP and DBP	12 weeks of brisk walking reduced SBP. No significant effects were found for DBP.
Systematic Reviews and Meta-analyses				
Kelley 2001[291]	16 Studies with walking only interventions published between 1996 and 1997	Walking trials	SBP and DBP	Significant decreases of ~2% were found for SBP and DBP in interventions
Bravata 2007[266]	26 studies (8 RCTs and 18 observational studies) published between 1996 and 2006	Pedometer determined physical activity	SBP and DBP	SBP significantly decreased by 3.8 mmHg due to interventions. This association was associated with a greater baseline SBP and change in steps/day. No significant changes were seen for DBP.
Murphy 2007[283]	24 RCTs published between 1971 and 2004 with walking only interventions	Walking trials	SBP and DBP	Walking trials show evidence of decreasing DBP in previously sedentary adults
Lee 2010[290]	27 RCTs published through 2007 with walking only interventions	Walking trials	SBP and DBP	Walking trials show evidence of lowering both SBP and DBP

Hanson 2015[284]	42 studies of walking group interventions	Walking group studies with outcomes directly attributable to the walking intervention	SBP and DBP	Statistically significant reductions in SBP and DBP were seen in interventions
Murtagh 2015[285]	32 RCTs published from 1971-2012	Walking trials	SBP and DBP	Walking significantly reduced SBP and DBP
Igarashi 2018[267]	14 trials published until September 2017 involving healthy adults and a pedometer intervention with a BP outcome	Pedometer determined physical activity	SBP and DBP	Changes in SBP and DBP significantly improved with the intervention. When trials were categorized as achieving 10,000 steps or not, there were not significant differences between groups. Changes in SBP were significantly associated with increased step count of >2,000 steps per day. Changes in DBP were not significantly associated with increased step count

3.4.7. Gaps and limitations of step-based research

Generalizability of prior research examining steps in relation to BP and measures of adiposity is limited. Measurement of steps is not standardized and pooled analyses utilize a variety of measurement devices with varying sensitivities and specificities (Table 8 & 9). Step-based research is predominantly limited to cross-sectional analyses, trials, and intervention studies in small populations for limited time-periods. Minimal long-term step-based research exists which limits our understanding of step-based metrics relationship with CVD risk factors to year-long impacts. Trials are important in furthering our understanding of biological processes and advancing care for patients but are not necessarily translatable to real-world experiences. Trials often occur in environments with additional supportive care encouraging intervention and protected time to focus on the intervention[171]. Many observational studies have occurred outside of the U.S. Differences in culture, genetics and environmental factors reduce comparability of studies occurring in other countries to the U.S. population. Prior step-based research has frequently examined populations with specific morbid conditions including hypertension and overweight and obesity. Examining populations with pre-existing risk factors for CVD does not fully address primordial prevention of these risk factors among healthy populations. Interventions and trials conducted on small populations with pre-existing health risk factors produce research useful primarily for development of high-risk strategies. High-risk strategies require interventions to be specific to the individual and are subject to physician motivation. High-risk strategies are often palliative, temporary, behaviorally inappropriate and have limited potential for impacting the general population. Population-based strategies attempt to control the determinants of incidence to lower the mean level of risk factors in an attempt to shift the whole distribution of exposure in a favorable direction[292]. More generalizable research is needed to inform future step-related population-based strategies to alleviate the burden of high BP and overweight and obesity.

3.4.8. Summary

Epidemiologic evidence collected by meta-analyses and systematic reviews of walking trials and interventions demonstrated predominantly inverse relationships between physical activity, including light physical activity intensity and measures of adiposity. Associations of measures of adiposity with sedentary behaviors are less consistent. Inconsistencies observed among studies of sedentary behaviors may be a result of choice of physical activity measurement method, choice of body composition assessment and sociodemographic differences between populations assessed.

Epidemiologic evidence collected by meta-analyses and systematic reviews if walking trials and interventions demonstrated inverse relationships between physical activity and risk of hypertension. Associations of BP with light intensity physical activity and sedentary behaviors are less consistent. Inconsistencies observed among studies of light intensity physical activity and sedentary behaviors may be a result of choice of physical activity measurement method and sociodemographic differences between populations assessed. Relationships between step volume and intensity and measures of adiposity and BP vary among different demographic and comorbid populations. Achieving at least 10,000 steps per day to improve health outcomes may not be applicable to all populations and health conditions. Attainment of less than 10,000 steps per day can result in health benefits. Generalizability of current step-based research is limited. Few long-term studies have examined relationships between step-metrics and changes in adiposity and BP. Strengths of step-based research include the capabilities to capture a broader physical activity spectrum, reliability of objective measures and potential for easily understood public health interventions. Further research examining the relationship of step-based metrics with CVD risk factors is needed in diverse populations to develop of appropriate step-based recommendations and interventions for the U.S. population. This dissertation addressed gaps in current step-based metric research by examining the relationship between steps and measures of adiposity and BP in an urban U.S. Hispanic cohort. Findings from this study will be among the first to describe these associations among urban U.S. Hispanics; thus, improving generalizability in this field and laying groundwork for future targeted interventions for this population.

3.5. Hispanics in research

Hispanic/Latinos are one of the fastest growing ethnic populations within the U.S[293, 129]. By 2050, it is estimated that, one in every four people living in the U.S. will be of Latino/a descent[294-296]. Hispanics are an exceptionally vulnerable population for adverse health outcomes and have a high burden of heart disease and obesity[297]. Hispanic ethnicity has been associated with indicators of poor access to healthcare including a lack of health insurance, personal health care provider and capability to visit a doctor due to cost[129, 298].

Hispanics are a heterogeneous population. Rates of obesity and hypertension vary based on ancestry, cultural background and socioeconomic status[38]; consequently, pooling data may not accurately represent risk or associations present for individuals within the population. Obesity prevalence differs by ethnic background. Obesity prevalence was highest among Puerto Rican men (41%) and women (51.4%) and lowest among South American men (27%) and women (30%) in the HCHS/SOL cohort[297]. Acculturation may play a role in obesity risk among Hispanics. US-born Hispanics and foreign-born Hispanics have significant differences in obesity prevalence[297]. Higher degrees of acculturation correspond to greater levels of weight[299]. High BP prevalence differs by ethnic background. Prevalence of hypertension is lowest among South American Hispanic females (15.9%) and males (19.9%). Prevalence of hypertension is highest among Puerto Rican females (29.1%) and Dominican males (32.6%)[297]. Age-standardized hypertension-related mortality rates varied by ethnic background. Mortality rates were highest among Puerto Ricans (154 per 100,000 people) and lowest among Cubans (83 per 100,000 people)[129, 300]. Variance in hypertension prevalence between 7 Latin American cities outside of the U.S. in the Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) study provides evidence of ancestral differences in hypertension[129, 301]. Levels of physical activity differ by ethnic background. Mexicans have the highest average number of moderate to vigorous physical activity minutes per day and Cubans have the lowest[302]. Cubans and Dominicans report the least amount of leisure physical activity and Mexicans report the most[303]. Acculturation plays a role in levels of physical activity among Hispanics. Increased Acculturation is associated with increased physical activity among Hispanics[198, 304]. Asthma, low birthweight, cancer and mental health have all been found to vary by ethnic background[305]. Clear characterization of this population can help appropriately translate evidence to intervention among this heterogeneous population.

Disaggregation of Hispanic ethnicity is limited in data collection and research. Federal government data collection only allows for identification as either “Hispanic or Latino” and “Non-Hispanic or Latino”; “Hispanic or Latino” encompasses Cuban, Mexican, Puerto Rican, South or Central American or other Spanish culture or region[306, 307]. The U.S. Census Bureau is currently testing a combined race or origin question which will add “Hispanic, Latino or Spanish origin” as a race category, but will not capture granularity of Hispanic ethnic background[308]. Limited research explores variation in disease by Hispanic ethnicity. Between 2006 to 2016, only 9.7% of articles published examining Hispanic child and adult surveillance reported disaggregated estimates and only 8.3% of studies used validated instruments to capture sources of heterogeneity[296]. HCHS/SOL is one of the few cohorts that attempts to discern differences between Hispanic ethnicities and disease risk. Understanding sources of heterogeneity and association with health outcomes can help develop appropriate and optimal intervention to reduce health disparities among the largest growing population in the U.S.

CHAPTER 4: OVERARCHING RESEARCH METHODS

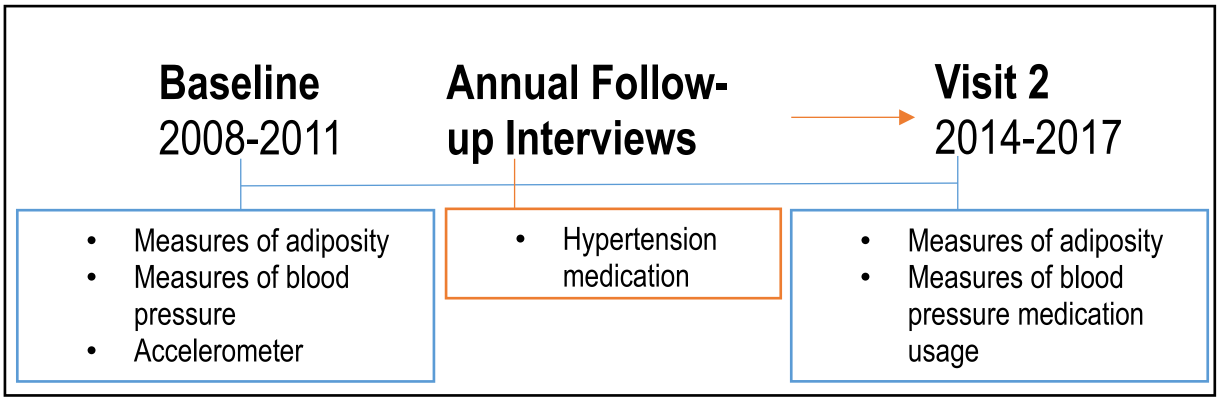
4.1 Study population and study design

All dissertation analyses were conducted using data from The Hispanic Community Health Study (HCHS)/Study of Latinos (SOL) cohort. HCHS/SOL is a community based prospective cohort study intended to describe the prevalence of risk and protective factors for chronic conditions and to quantify all-cause mortality, fatal and non-fatal CVD and pulmonary disease, and pulmonary exacerbation over time in Hispanics/Latinos. Details of the sampling method, design and implementation have been previously published[309, 310]. Briefly, this cohort consists of 16,415 self-identified Hispanic/Latino persons aged 18-74 years at screening from randomly selected households in four U.S. field centers (Chicago, IL; Miami, FL; Bronx, NY; San Diego, CA) with baseline examination (2008 to 2011) and yearly telephone follow-up assessment for at least three years. In 2008-2011, participants underwent an extensive clinic exam and assessment to determine baseline risk factors. In 2014-2017 a second clinic visit was scheduled, and participants were re-examined to assess predictive health outcomes of interest. The HCHS/SOL cohort includes participants who self-identified as having Hispanic/Latino background, the largest groups being Central American, Cuban, Dominican, Mexican, Puerto-Rican, and South American.

Recruitment involved a stratified 2-stage area probability sample of household addresses in each field center. Individuals from identified households were contacted and screened for eligibility (living in the household, aged 18-74 years), ability to attend a clinic visit and not planning to move within 6 months). All participants signed an informed consent. The institutional review boards of each field center, coordinating center, reading centers and the NHLBI approved this study. The trial was registered at clincaltrials.gov as NCT02060344.

Analyses leveraged cross-sectional and prospective HCHS/SOL data (Figure 1). Accelerometer data, measures of adiposity, BP and covariates were ascertained at baseline (2008-2011). Annual follow up interviews collected hypertension medication usage data. Measures of adiposity and BP were ascertained at Visit 2.

Figure 1: HCHS/SOL data collection timeline



4.1.1 Cross-sectional and longitudinal measures of adiposity exclusions

Of the 16,415 adults examined at baseline, for the cross-sectional analysis, we non-mutually excluded those missing anthropometric measures at Visit 1 (N=34) including weight (n=52), WC (N=66) or BMI data (N=47) as well as those with Actical related concerns including: missing step data (N=2,201), differences between clinic dates & Actical dates of >1 or missing (N=232), no reported sedentary time on all 6 days (N=5), <3 adherent days of step data (N=3,707), the same count per minute sustained repeatedly (N=3) device malfunction (N=68). From the remaining 12,596 sample, we excluded those who fell in the 1st and 99th percentile of average total steps (N=243). After exclusions, the final analytic set comprised 12,353 (75%) adults.

Of the 11,623 adults who had baseline and Visit 2 data, for the longitudinal analysis, we non-mutually excluded those missing Visit 1 and Visit 2 weight, WC or BMI data (N=467) as well as those with Actical related concerns including: missing step data (N=1,358), had a difference between clinic dates & Actical dates of >1 or missing (N=232), had no reported sedentary time on all 6 days (N=5), had <3 adherent days of Actical data (N=2,306), had the same count per minute sustained repeatedly (N=3) or had an identified device malfunction (N=39). We also excluded those who were pregnant between visits (N=551). From the remaining 8,577 sample, we excluded those who fell in the 1st and 99th percentile of average total steps (N=150). After exclusions, the final analytic set comprised 8,427 (73%) adults. All sedentary models were restricted to those with less than 23 hours of mean accelerometer total wear times (cross-sectional models, n=60; longitudinal models n=40).

4.1.2 Cross-sectional and longitudinal measures of BP exclusions

Of the 16,415 adults for the cross-sectional analysis, we non-mutually excluded those missing baseline SBP measures (N=14), DBP measures (n=21), and hypertension medication usage data (N=394) well as those with Actical related concerns including: missing step data (N=2,201), differences between clinic dates & Actical dates of >1 or missing (N=232), no reported sedentary time on all 6 days (N=5), <3 adherent days of step data (N=3,707), the same count per minute sustained repeatedly (N=3) device malfunction (N=68). After exclusions, the final analytic set comprised 12,141 (74%) adults.

Of the 11,623 adults who had baseline and Visit 2 data we non-mutually excluded those missing baseline (N=7) and Visit 2 (N=32) measures of SBP, baseline (N=12) and Visit 2 (N=28) measures of DBP as well as those with Actical related concerns including: missing step data (N=1,358), had a difference between clinic dates & Actical dates of >1 or missing (N=232), had no reported sedentary time on all 6 days (N=5), had <3 adherent days of Actical data (N=2,306), had the same count per minute sustained repeatedly (N=3) or had an identified device malfunction (N=39). After exclusions, the final analytic set comprised 9,077 (78%) adults. All sedentary models were restricted to those with less than 23 hours of mean accelerometer total wear times (cross-sectional models, n=60; longitudinal models n=44).

4.2 Outcomes

4.2.1 Measures of adiposity outcomes

Anthropometric outcomes examined are shown in Table 10. Anthropometric measurements were taken at baseline and Visit 2. Standing height was assessed with a fixed wall mounted stadiometer with a vertical backboard and moveable headboard. Participants weight was recorded using the Tanita scale which calculated the weight of the participant using a bioelectrical impedance method that provides the percentage of body fat, fat mass, lean body mass and total body water. Participant’s sex, age, clothes weight and height were entered into the scale prior to measurement. Participant’s WC was measured using a measuring tape held at the height of the lateral border of the ilium. The examiner held the measuring tape on the right side of each participant and placed the tape around the trunk with the measuring tape snug without compressing the skin in a horizontal plane while holding the zero value parallel to the floor after the participation breathed out. All examiners and field technicians were trained and certified at central trainings or by a local clinic coordinator for assurance of quality control of measurement[311].

Home visits that did not include height measurements consequently resulted in 3.2 % missingness of height at Visit 2; thereby, height from baseline was used to calculate both BMI at baseline and at Visit 2 relying on the assumption adults' heights will not be changing in between visits.

Table 10. Anthropometric outcomes

Outcome	Definition
	Measures of adiposity
Weight	kg, assessed independently at baseline
Change in weight	Change between baseline and visit 2
Percent change in weight	(Visit 2 weight-baseline weight)/baseline weight*100
WC	Cm
Change in WC	Change between baseline and visit 2
Percent change in WC	(Visit 2 WC-baseline WC)/baseline WC*100
BMI (continuous)	kg/m^2
BMI (categorical)	Underweight is defined as a BMI <18.5; normal 18.5 to <25; overweight 25.0 to <30; obese ≥ 30[66].
Change in BMI	Change between baseline and visit 2
Percent change in WC	(Visit 2 BMI-baseline BMI)/baseline BMI*100
Weight maintenance (categorical)	Substantial loss (>-5%), loss (-3 to –5%), weight maintenance (-3 to 3%), gain (3 to 5%) and substantial gain (>5%)[312]

4.2.2 Measures of Blood Pressure outcomes

BP outcomes examined are shown in Table 11. BP measurements were taken at baseline and Visit 2. Sitting BP was taken using a tested automatic sphygmomanometer (the OMRON HEM-907 XL) which has been validated in three additional studies including CARDIA, NHANES and is in line with the Environmental Protection Agency and American Hospital Association's push to eliminate mercury-based sphygmomanometers. Arm measurements were taken to guide selection of BP cuff size prior to taking a participant's BP. For standardization, BP was measured in the right arm over the brachial artery unless there were extenuating circumstances that prevented use or measurement in the right arm. If measurements could not be obtained from both arms, no measurements were taken. Initial arm measurements were followed by a period of quiet and rest then three measurements of SBP and DBP. The average of the three

BP measurements were recorded. Readings of greater than 200 mmHg SBP or 120 mmHg DBP required repeat measurements.

BP has a continuous relationship with health outcomes however, cut points are important for guiding clinical decisions made by physicians and providing context for patients. BP was assessed continuously as well as categorically to further advance our understanding of BP in relation to steps, as well as to provide practical application of this work to the community[311].

Table 11. Blood Pressure outcomes

Outcome	Definition
	Blood Pressure
BP Continuous	Systolic and diastolic (mm Hg) at baseline
BP Categorical	Normal BP: <120/<80 mm Hg; elevated BP: 120 to 129/<80 mm Hg; hypertension stage 1: 130 to 139 or 80 to 89 mm Hg, and hypertension stage 2: ≥140 or ≥90 mm Hg[12].
Hypertension (hypertensive/normotensive)	Hypertensive: BP ≥ 130 mmHg SBP or 80 DBP mmHg or hypertension medication usage[12].
Change in BP continuous	Change between baseline and visit 2

4.3 Exposures

Exposures examined are presented in Table 12. Accelerometer measures were taken at baseline. Epoch length was set to 1 minute and step function was enabled. The accelerometer model was an Actical™ (MiniMiter Respironics®, Bend, OR) accelerometer (model 198-0200-03). Devices were calibrated at the factory. HCHS/SOL adults were given accelerometers attached to a waist strap selected for size by the staff at the end of physical examination at a clinic visit. Participants were told to wear the Actical above the right hip mounted on the body above the iliac crest of the hip for 6 days and to engage in normal activities and only remove the accelerometer for swimming, showering and sleeping. Best practice research recommends wear of 7 days to capture intra-individual variability in total, moderate and vigorous activity and increases the probability of capturing at least four days of activity; the length of time at which reliability is expected to be 0.80[311]. Participants are told not to engage in activities that they would not normally participate in specifically because they are wearing the monitor. Participants returned the device to the clinic at the end of wear by mail[311].

Data cleaning of accelerometer data was conducted by the HCHS/SOL Coordinating Center. Start of wear, Day 1 was considered the day after the clinic visit with counts starting at 5:00am. Participants were excluded from the dataset if the start day was not within ± 1 day of the clinic visit. Adherent days were defined as inclusion of at least 10 hours of wear time. Participants were required to have at least 3 adherent days for inclusion into the dataset. Among cohort members 92.3% had at least one day with accelerometer data and 77.7% were considered adherent[313].

All step metrics were modeled as quartiles apart from time spent at brisk walking and faster ambulation as well as all bouted cadence metrics which were examined as 4 categories (no time spent at the specified cadence threshold and tertiles of steps/min >0). Step volume was additionally modeled as a graduated step index with categorization of sedentary, low activity, somewhat active, active and highly active (<5,000, 5,000-7,499, 7,500-9,999, 10,000-12,499 and ≥12,500 average total steps respectively)[160].

Table 12. Step Metrics Exposures

Metric- per day	Definition
	Step Volume
Number of steps	Mean number of steps taken on an average day
	Step Cadence
Minutes at a 0 steps/min	Mean minutes spent in sedentary behavior
Minutes in a stepping rate of 1 - 39 steps/min	Mean minutes spent in incidental or sporadic movement
Minutes in a stepping rate of ≥ 40 steps/min	Mean minutes spent in purposeful steps or higher (slow walking, medium walking, brisk walking, and faster movement)
Minutes at a stepping rate of ≥ 100 steps/min	Mean minutes spent at a brisk walking pace or higher (corresponds approximately to absolutely-defined moderate intensity [3 METs] and higher)
Peak 30-min cadence	Mean steps per minute for the highest 30 minutes of the day, does not have to be consecutive 30 minutes
Peak 60-min cadence	Mean steps per minute for the highest 60 minutes of the day, does not have to be consecutive 60 minutes
Bouts of ≥ 40 steps/minute	Mean minutes spent in ≥40 steps/min taken over 10 continuous minutes
Bouts of ≥ 70 steps/minute	Mean minutes spent in ≥70 steps/min taken over 10 continuous minutes
Bouts of ≥ 100 steps/minute	Mean minutes spent in ≥100 steps/min taken over 10 continuous minutes

4.4 Covariates

Covariates included in analyses for the relationships between step metrics and measures of adiposity as well as BP can be seen in Tables 13 and 14 respectively.

Table 13. Adjustment covariates for measures of adiposity analyses

Covariates for Measures of Adiposity		
Cross-sectional and prospective models		
Volume (step index)	**Steps per minute, peak cadence and bouts of steps/min**	**Sedentary**
Model 1: Adjusted for age, sex, center, background and years in the US		
Model 2: Adjusted for Model 1 + employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, and average accelerometer wear time per day	Model 2: Adjusted for Model 1+ employment and average accelerometer wear time per day	Model 2: Adjusted for Model 1+ education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking and average accelerometer wear time per day
N/A	Model 3: Adjusted for Model 2+percentage of time spent sedentary	N/A
N/A	Model 4: Adjusted for Model 2+total step volume*	N/A
N/A	Model 5: Adjusted for Model 4+percentage of time spent sedentary*	
Longitudinal models		
Volume (step index)	**Steps per minute, peak cadence and bouts**	**Sedentary**
Model 1: Adjusted for age, sex, center, background and years in the US		
Model 2: Adjusted for Model 1 + employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, average accelerometer wear time per day, and years between visits	Model 2: Adjusted for Model 1+ employment, average accelerometer wear time per day and years between visits	Model 2: Adjusted for Model 1+ education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking, average accelerometer wear time per day and years between visits
N/A	Model 3: Adjusted for Model 2+percentage of time spent sedentary	N/A

N/A	Model 4: Adjusted for Model 2+total step volume	N/A
N/A	Model 5: Adjusted for Model 4+percentage of time spent sedentary	

Table 14. Adjustment covariates for BP analyses

Covariates for BP		
Cross-sectional and prospective models		
Volume (step index)	**Steps per minute, peak cadence and bouts of steps/min**	**Sedentary**
Model 1: Adjusted for age, sex, center, background and years in the US		
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day		
N/A	Model 3: Adjusted for Model 2+percentage of time spent sedentary	N/A
N/A	Model 4: Adjusted for Model 2+total step volume	N/A
N/A	Model 5: Adjusted for model 4+percentage of time spent sedentary	
Longitudinal models		
Volume (step index)	**Steps per minute, peak cadence and bouts**	**Sedentary**
Model 1: Adjusted for age, sex, center, background and years in the US		
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, average accelerometer wear time per day and years between visits	Model 4: Adjusted for Model 2 - alcohol use	Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, alcohol use, cigarette use, marital status, income, average accelerometer wear time per day and years between visits
Model 3: Adjusted for Model 2 + alcohol use, cigarette use, marital status, income	Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, alcohol use, cigarette use, marital status, income, average accelerometer wear time per day and years between visits	Model 3: Adjusted for Model 2 + alcohol use, cigarette use, CESD10

N/A	Model 5: Adjusted for Model 4 + percentage of time spent sedentary	N/A
N/A	Model 6 Model2 + total step volume	N/A
N/A	Model 7: Model 2+ percentage of time spent sedentary	N/A

Collection of age, sex, smoking, ethnic background, center, alcohol consumption, occupation mobility, family size, years in the U.S. education, employment and annual household income were obtained at the participant's initial interview. Age is a continuous measure derived from the participant's date of birth. Sex was reported as male or female. Smoking was assessed as never smoker, former smoker and current smoker. Background was reported as Dominican, Central American, Cuban, Mexican, Puerto Rican, South American, more than one heritage and other. Center was reported as the Bronx, San Diego, Chicago or Miami. Alcohol consumption was recorded as never, former or current. Occupation (current) is defined as non-skilled worker, service worker, skilled worker, professional/technical- administrative/executive or staff, or other occupation. Income was grouped at 3 levels: < \$30,000, > \$30,000 and missing or not reported. Years spent in the U.S. were defined as U.S. born determined by immigrant status (yes/no), < 10 years in the U.S. and >10 years in the U.S. Education was grouped as no high school diploma or general education development test (GED), at most a High school diploma or GED, High school (or GED) education, university/college education.

Total predicted energy intake was used to address confounding by diet. Total predicted energy intake was calculated from an average of two 24-hour dietary recalls after using the National Cancer Institute (NCI) adjustment for usual intake. Recalls above the daily energy intake, below the sex specific 1st percentile or 99th percentile, or deemed unreliable according to the interviewer were excluded for both the alternative healthy eating index (AHEI) and total predicted energy intake.

Depression was assessed using the 10 item CES-D summary score. This score ranges from 0 to 30 and was considered missing if participants were missing more than the 10 items. Participant response items for each item are feeling this rarely or none of the time, some or a little of the time, occasionally or a moderate amount of time or all of the time. The 10 items include: feeling bothered by things that don't usually bother me, having trouble keeping my mind on what I was doing, feeling depressed, feeling that everything I did was an effort, feeling hopeful about the future, feeling fearful, having restless sleep, feeling happy, feeling lonely and feeling I could not "get going".

Mobility limitations and functional status were assessed using the Short Form-12 Version 2 (SF-12). The following two questions were extracted from the form: "Does your health limit you now in moderate activities such as moving a table, pushing a vacuum cleaner, bowling or playing golf" and "Does your health limit you now in climbing one flight of stairs" with the response options: yes, limited a lot; yes, limited a little; no, not limited at all.

4.5 Statistical Analysis

Cohort characteristics were summarized across a graduated step index of mean steps per day using means and standard deviations for continuous variables and percentages for categorical variables for measures of adiposity and BP analyses independently. Complex survey linear regression models with sampling weights were used to separately estimate the association of step volume and cadence with baseline measures of weight, WC, BMI, SBP and DBP well as measures of change and percent change in weight, WC and BMI and measures of change in SBP and DBP. Complex survey logistic regression models were used to estimate the association of step volume and cadence with baseline BMI and hypertension category and weight maintenance over a 6-year period. To alleviate multicollinearity with average wear time for sedentary models, we used residuals to account for site-specific wear time variations. We regressed sedentary time and average total steps on wear-time, field center and the interaction term (site*wear time) then added the resulting residuals to the site-specific mean predicted values at 16 hours of wear-time. This residual method was repeated to address multicollinearity between average total steps and cadence metrics when adjusting models for total volume.

Adjusted models minimally adjusted for age, sex, center, background and years in the US (Model 1). Models were further adjusted for relevant confounders. Variables resulting in greater a 10% change between minimally adjusted and additionally adjusted models were considered confounders. Further adjustment by percentage of time spent sedentary (Model 3) as well as total step volume (Model 4) was explored in additional cadence models.

Populations taking antihypertensive medications are likely different than those who are not; adults may have differing health behaviors that either led them to seek medication use, or modification of behavior after physicians recommended medication. Antihypertensive medication, by design, will lower and control an individual's BP and may do so independently of additional behavioral modifications. Stratification by antihypertensive medication use (yes/no) at baseline for cross-sectional analyses to address effect measure modification by these medications and discern the independent effect of steps among those with medication use and among those without. Stratification of participants by baseline hypertensive status is insufficient to examine change in BP over a 6-year period because there are individuals who begin treatment in-between visits. Exclusion of individuals who begin antihypertensive treatment would result in biased estimates. Initiation of antihypertensive treatment between study visits is related to untreated individual's BP at follow up since those with higher BP are more likely to start antihypertensive treatment; to address this issue, longitudinal analyses of BP leveraged a missing data method based on inverse probability weighting (IPW) and doubly robust estimating equations was used to account for post-treatment changes in BP[314].

Inverse probability weights were used to account for missingness due to non-adherence to the Actical protocol. Effect measure modification of the independent relationships between steps per day and weight, WC and BMI by sex, age, years in the U.S. and occupation were examined. Effect measure modification were assessed using interaction terms between step-metric and the modifier. Interactions for analyses were considered significant using a Bonferroni correction adjusting for the number of hypotheses tested. All analyses accounted for the complex survey design and survey weights using survey procedures in SAS version 9.4 (SAS Institute).

4.5 Study power

Using the R-Studio power analysis function for multiple regression, we estimated the sample size necessary to detect a 0.02 effect size, with an alpha of 0.05 and 80% power (Table 15). All required sample sizes to detect this effect size were met in our analyses.

Table 15. Required sample size for analyses

Analysis	Covariates	Required sample size
Cross-sectional measures of adiposity analysis		
Model 1	5	641
Model 2: Step Volume	14	914
Model 2: Cadence	8	750
Model 2: Sedentary	16	960
Model 3	9	781
Model 4	9	781
Model 5	10	810
Longitudinal measures of adiposity analysis		
Model 1	5	641
Model 2: Step Volume	15	937
Model 2: Cadence	9	781
Model 2: Sedentary	18	1002
Model 3	10	810
Model 4	10	810
Model 5	11	838
Cross-sectional measures of BP		
Model 1	5	641
Model 2: Step Volume	18	1002
Model 3	19	1022
Model 4	19	1022
Model 5	20	1043
Longitudinal measures of BP		
Model 1	5	641
Model 2: Step Volume	14	914
Model 2: Cadence	19	1022
Model 2: Sedentary	18	1002
Model 3: Step Volume	9	781
Model 3: Cadence	18	1002
Model 3: Sedentary	8	750
Model 4:	6	681
Model 5	7	717
Model 6	15	937
Model 7	15	937

*Models correspond to models in Tables 13 and 14

CHAPTER 5: THE ASSOCIATION OF STEP-BASED METRICS AND ADIPOSITY IN THE HISPANIC COMMUNITY HEALTH STUDY/STUDY OF LATINOS

5.1 Introduction

Obesity is a recognized burden to our nation's health (Hales 2020) with disproportionate prevalence by race/ethnicity. In 2017-2018, U.S. Hispanic/Latinos had a higher prevalence of obesity (45%) than non-Hispanic whites (33%) and non-Hispanic Asians (17%) but a lower prevalence than non-Hispanic blacks (50%)[7]. Obesity is linked with multiple organ-system complications including cardiovascular disease (CVD), stroke, type 2 diabetes and a multitude of additional comorbidities[31] that may lead to reduced quality of life, life-expectancy, and increased healthcare costs. The US Hispanic/Latino population is continuing to grow; by 2050, it is estimated that, one in every four people living in the U.S. will be of Latino/a descent[294-296]. If the disproportionate burden of obesity persists, a larger proportion of the U.S. Hispanic/Latino population will be impacted. Addressing the prevalence of obesity among Hispanic/Latino populations is necessary to alleviate obesity-related disease risk within the U.S.

Physical activity is a modifiable behavior important for maintaining a healthy weight or achieving weight loss among other benefits[83]. Engaging in 150 min/week of moderate intensity physical activity is recommended to prevent significant weight gain[316]. Sedentary behaviors are also a modifiable risk factor for obesity[84-86]. Greater amounts of television viewing, screen time, and other seated activities are associated with weight gain[11]. A previous study conducted on the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) found participants spent an average of 11.9 hours/day in sedentary behavior[317].

Steps are a basic unit of locomotion and a measurement of physical activity that encompasses light, moderate, and vigorous physical activity[13]. In epidemiologic research, step-based metrics of interest include step volume and intensity. Steps/day reflect volume of daily ambulatory activity. Cadence, or steps/min, is an indicator of intensity of ambulatory movement and is highly correlated with speed (r=0.97) and metabolic equivalents (METs) (r=0.94)[166]. Cadence can be used to describe free-living differences between incidental or sporadic movement, purposeful movement, or brisk walking and faster movement[166, 318, 319]. Peak 30-min cadence reflects the highest "natural best effort" in a day[86, 166].

Habitual step volume and intensity can both be characterized with use of a single 7-day accelerometer administration[168]. There is conflicting evidence for associations of step volume and intensity (henceforth referred to as cadence), with measures of adiposity and few studies have explored the longitudinal relationship[269, 270]. Inverse[15, 19, 28, 86, 167, 271, 274-277] and null relationships[19, 27, 268, 270] have been reported in cross-sectional and longitudinal studies.

The association between step-based metrics and measures of adiposity has not been examined in a community-based cohort of Hispanic/Latinos. The objective of this study was to examine the cross-sectional and longitudinal associations of daily step volume and cadence with measures of adiposity and 6-year changes in adiposity in the HCHS/SOL cohort, the largest well-characterized cohort of Hispanic/Latino adults in the U.S.

5.2 Methods

5.2.1 Study population

HCHS/SOL is a community-based prospective cohort study of Hispanics/Latinos designed to describe the prevalence of risk and protective factors for chronic conditions and to quantify all-cause mortality, fatal and non-fatal CVD and pulmonary disease, and pulmonary exacerbation over time in Hispanics/Latinos. Details of the sampling design, and implementation have been previously published[309, 310]. Briefly, this cohort consists of 16,415 self-identified Hispanic/Latino persons aged 18-74 years at screening from randomly selected households in four U.S. field centers (Chicago, IL; Miami, FL; Bronx, NY; San Diego, CA) with baseline clinic examination (2008 to 2011) and yearly telephone follow-up for primary cardiovascular and pulmonary endpoints. In 2014-2017 a second clinic visit was conducted. Recruitment involved a stratified two-stage area probability sample of household addresses in each field center. Individuals from identified households were contacted and screened for eligibility (living in the household, aged 18-74 years, able to attend a clinic visit and no plans to move within 6 months). All participants signed an informed consent. The institutional review boards of each field center, coordinating center, central laboratory, reading centers and the NHLBI approved this study. The study was registered at clincaltrials.gov as NCT02060344.

5.2.2 Physical activity and sedentary behavior

Physical activity was measured using an Actical (MiniMiter Respironics®, Bend, OR) accelerometer (model 198-0200-03) at baseline (Visit 1). The Actical was initialized to capture steps in one-minute epochs. Participants were asked to wear the Actical on the right hip for 7 days; to engage in normal activities; and to only remove the accelerometer for swimming, showering and sleeping. Non-wear time was defined by the Choi algorithm as at least 90 consecutive minutes of zero counts with allowance of 1 or 2 minutes of nonzero counts if no counts were detected in a 30-minute window upstream and downstream of the 90-minute period[320]. Adherence to the protocol was defined as having at least three days each with at least 10 hours of wear time each. Further details, including accelerometer wear adherence, is available elsewhere[313].

Step volume was defined by a graduated step index with categorization of inactive, low activity, somewhat active, active and highly active (<5,000; 5,000-7,499; 7,500-9,999; 10,000-12,499 and ≥12,500 average total steps/day respectively)[160]. Cadence indicators were defined by average minutes per day spent at sedentary behavior (0 steps/min), incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min), and brisk walking and faster ambulation (≥ 100 steps/min)[160, 166]. Average peak 30-minute cadence was defined as mean steps/min for the highest 30 minutes of the day, not necessarily in consecutive minutes. We examined bouted stepping at different cadence thresholds including minutes spent at purposeful steps and faster ambulation (≥40 steps/min), slow to medium steps and faster ambulation (≥ 70 steps/min) and brisk walking and faster ambulation (> 100 steps/min). The bout was defined by at least 10-minutes at the cadence threshold. Interruptions were allowed for up to 20% of the time below the cadence threshold and <5 consecutive minutes below the cadence threshold. Additionally, the bout had to start and end with the cadence threshold. Minutes spent at the brisk walking and faster ambulation were examined as four categories (no time spent at the specified cadence threshold and tertiles of steps/min >0). Bouted cadence measures were examined as 4 categories (no bouted time spent at the specified cadence threshold and tertiles of bouted steps/min >0). Minutes spent at different cadence thresholds were categorized as quartiles. Average wear time was calculated as the average hours the accelerometer was worn over the number of adherent days.

5.2.3 Measures of adiposity

Anthropometric measures were collected at both Visit 1 and Visit 2 by HCHS/SOL trained and certified technicians using standardized protocols[311]. Measurements of weight (kg) were obtained using a Tanita scale (TBF-300A). Waist circumference (WC) was measured at the uppermost lateral border of the right illium to the nearest 0.1 cm using a measuring tape. Standing height (cm) was measured using a fixed wall mounted stadiometer with a vertical backboard and moveable headboard. BMI was calculated as weight (kg)/height (m)^2. Home visits conducted at visit 2 (n=348) did not measure height, thereby height from baseline was used to calculate BMI at baseline and visit 2 as little change in height was expected between visits.

Adults were classified as underweight (<18.5 kg/m^2), normal weight ($\geq$18.5 to <25 kg/m^2), overweight ($\geq$25 to <30 kg/m^2) and obese ($\geq$ 30 kg/m^2), in accordance with CDC guidelines[2]. Changes in weight, WC, and BMI were computed as the measurement at visit 2 minus baseline measurement. Weight maintenance was categorized and examined as a substantial loss, loss, weight maintenance, gain and substantial gain defined as <-5%, -5 to -3%, -3% to 3%, 3% to 5%, and a >5% change in weight, respectively[312].

5.2.4 Covariates

Covariates included sociodemographic, behavioral and health characteristics collected at Visit 1. Sociodemographic characteristics were defined as the following: age (continuous), sex (male, female), background (Central American, Cuban, Dominican, Mexican, Puerto Rican, South American, other), center (Bronx, Chicago, Miami, San Diego), years lived in the U.S. (<10 years, $\geq$10 years, U.S. born), education (no high school diploma or GED, at most a high school diploma or GED and greater than high school [or GED] education), income (not reported, > $30,000 or $\leq$$30,000),longest held occupation (non-skilled worker, service worker, skilled worker, professional/technical-administrative/executive or staff, other), employment (retired, not retired and not currently employed, employed part-time, employed full-time) and marital status (single, married or living with a partner, separated/divorced or widower). Behavioral characteristics were defined by the following: smoker (never, former, current), alcohol consumption (never, former, current) and predicted total energy intake (National Cancer Institute predicted daily energy intake kcal derived from two 24-hour dietary recalls and a food propensity questionnaire)[322]. Two health characteristics were defined by the following: depressive symptoms assessed by the 10-item Center for Epidemiological Studies Depression Scale (CES-D 10) using a continuous summary score[323] and mobility limitations assessed using 3-level Likert responses to two items from the Short Form-12 Version 2 [SF-12])[324]. The two SF-12 items assessed participant's ability to conduct "moderate activities" (e.g., moving a table, pushing a vacuum cleaner, bowling, or playing golf) and their ability to climb several flights of stairs.

5.2.5 Statistical analysis

Among 16,415 cohort members, 12,353 were included in the cross-sectional analysis and of the 11,623 cohort members who returned to Visit 2, 8,427 in the longitudinal analysis (exclusions shown in Supplemental Figure 1). Sociodemographic, behavioral and health characteristics were summarized across step volume categories defined by a graduated step index using means and standard errors for continuous variables and percentages for categorical variables. To account for HCHS/SOL complex sample design (stratification, clustering and sampling weights), complex linear regression models were used to separately estimate the association of step volume and cadence with baseline measures of weight, WC, and BMI as well as measures of change in them. Complex survey logistic regression models were used to estimate the association of step volume and cadence with baseline BMI category and weight maintenance over a 6-year period. Inverse probability weights were used in the analyses to account for the high percentage of missingness due to non-adherence to the Actical protocol based on variables identified previously[313]. The sampling weights and IPW were multiplied together. Survey weights were trimmed and calibrated to the 2010 U.S. Census according to age, sex and Hispanic/Latino background of the field centers.

All models were adjusted for age, sex, center, Hispanic/Latino background, and years in the U.S (range, 3.4-9.6 years). Longitudinal models were further adjusted for years between visits. Models were additionally adjusted for relevant confounders as identified through a directed acyclic graph. Potential confounding variables resulting in greater than a 10% change between minimally adjusted and additionally adjusted models were considered relevant confounders. In consideration of the distinct constructs of step volume, cadence and sedentary time, confounders for each metric were evaluated independently; cross-sectional and longitudinal models were further considered independently. To examine intensity as a predictor independent of step volume and sedentary behavior, additional cadence models were further adjusted for total step volume and percentage of time spent sedentary.

To remove multicollinearity of average wear time with sedentary time we used the residual approach to account for site-specific wear time variations as previously done in another HCHS/SOL paper for sedentary models (time spent in 0 steps/min)[252]. Specifically, we regressed sedentary time on wear-time, field center, and included an interaction term between HCHS/SOL field center and wear time, and then added the resulting residuals to the site-specific mean predicted values at 16 hours of wear-time. This residual method was repeated to address multicollinearity between average total steps and cadence metrics when adjusting models for total volume.

Effect measure modification of the independent relationships between steps per day and weight, WC, and BMI by sex (female and male), age group (18-29, 30-39, 40-49, 50-59 years and $\geq$60 years), years in the U.S. (<10 years, $\geq$ 10 years and U.S. born), and occupation (non-skilled worker, service worker, skilled worker, professional/technical/other office worker and other occupation) were assessed using interaction terms between step-metric and the modifier. A Bonferroni correction was used for the test of interaction terms to adjust for the number of hypotheses tested (0.05/93[three outcomes*three interactions for volume and cadence metrics*nine volume and cadence metrics+ three outcomes*four interactions*one sedentary metrics] =<0.0005). All analyses accounted for the complex survey design and survey weights using survey procedures in SAS version 9.4 (SAS Institute).

5.3 Results

5.3.1 Study population characteristics of the cross-sectional analysis

The target population of HCHS/SOL was 60% female and had a mean (standard error [SE]) age of 41 (0.3) years (Table 1). The mean (SE) baseline weight, WC and BMI were 79 (0.3) kg, 97 (0.3) cm and 29 (0.1) kg/m^2, respectively. Adults had a mean step count of 7,829 steps/day (median, 6,998 steps/day; range, 1,238-22,355 steps/day), mean (SE) accelerometer wear time of 16 (0.1) hours/day (range, 10-23 hours/day), and a mean (SE) peak 30-minute cadence of 76 (0.4) steps/min. On average, adults spent 670 (3.8) min/day sedentary, 221 (1.3) min/day in incidental or sporadic movement, 51 (0.6) min/day in purposeful stepping and faster ambulation, and 12 (0.3) min/day in brisk walking and faster ambulation. Table 16 provides details on other baseline demographic and lifestyle characteristics by graduated step-index. More active adults were of Mexican background, were male, were employed full-time were non-skilled service workers, and were without mobility limitations (Table 16).

5.3.2 Cross-sectional associations of step volume and measures of adiposity

Step volume demonstrated inverse relationships with all measures of adiposity (Figure 3). When adjusted for confounders (age, sex, center, ethnic background, years in the U.S., employment, occupation, income, mobility limitations climbing stairs, smoking marital status, predicted total energy intake and average accelerometer wear time) (Appendix Table 17, Model 2) those who were inactive had an adjusted mean weight, WC, and BMI of 85.3 kg, 102.7 cm, and 31.3 kg/m^2, respectively. Alternatively, those who were highly active had an adjusted mean weight, WC and BMI of 79.1 kg, 97.9 cm and 29.9 kg/m^2, respectively. Those who took the fewest daily steps (Q1) compared to those who took the most steps (Q4) had a 1.42 95% CI (1.19, 1.70) times the odds of obesity (Figure 4).

5.3.3 Cross-sectional associations of step cadence and measures of adiposity

Peak 30-minute cadence, minutes spent at a brisk walk and faster ambulation, and minutes spent in bouted stepping at purposeful steps or faster ambulation demonstrated inverse associations with all measures of adiposity (Figure 3, Tables 18-20). Adjusted mean weight (Model 2), for those in the lowest quartile and categories of mean peak 30-minute cadence, minutes spent in a brisk walk and faster ambulation, and minutes spent in bouted steps of purposeful steps and faster ambulation (Q1) were 86.6 kg, 89.9 kg, and 85.8 kg, respectively whereas those in the highest quartile and categories (Q4) were 77.0 kg, 76.9 kg, and 79.6 kg, respectively. Adjusted mean WC for those in the lowest quartile and category of mean peak 30-minute cadence, minutes spent at a brisk walk and faster ambulation and minutes spent in bouted purposeful steps and faster ambulation were 103.8 cm, 106.0 cm and 103.2 cm respectively, whereas those in the highest quartile and category were 96.4 cm, 96.7 cm and 98.5 cm, respectively (Model 2). Adjusted mean BMI for the lowest quartile and category of mean peak 30-minute cadence, minutes spent at a brisk walk and faster ambulation and minutes spent in bouted steps of purposeful steps and faster ambulation (Q1) were 31.9 kg/m^2, 32.9 kg/m^2 and 31.7 kg/m^2, respectively whereas those in the highest quartile and category were 28.8 kg/m^2, 30.3 kg/m^2 and 29.6 kg/m^2, respectively (Model 2). Adults in the lowest quartile and category of mean peak 30-minute cadence, minutes spent at a brisk walk and faster ambulation and minutes spent in bouted purposeful steps and faster ambulation had a 1.62 95% CI (1.36, 1.93), 2.12 95% CI (1.63, 2.75) and 1.41 95% CI (1.16, 1.70) times the odds of obesity compared to adults in the highest quartiles and categories, respectively (Figure 4). Minutes spent sedentary was not associated with measures of adiposity Table 21).

5.3.4 Cross-sectional interactions of step metrics and measures of adiposity

Significant interactions between minutes spent in incidental or sporadic movement and age were found for weight and BMI (Table 22-24). Among those ≥60 years of age, those in the highest quartile of minutes spent in incidental or sporadic movement had significantly higher mean measures of weight and BMI than those in the lowest quartile. No significant differences in measures of adiposity across quartiles or categories of step-based metrics were found for all other age categories (Tables 23-24). Interactions between step-based metrics and sex, years in the U.S. and occupation were non-significant for all measures of adiposity.

5.3.5 Longitudinal associations of step volume and cadence with changes in measures of adiposity

Adults who accumulated more steps per day had a greater increase in weight and BMI over 6 years compared to adults who accumulated less steps per day (Figure 5). With further adjustment for confounders the associations were attenuated (Table 25). A faster peak 30-minute cadence, and more minutes spent in a brisk walk and faster ambulation and in bouted purposeful steps and faster ambulation were associated with greater weight and BMI change (Figure 5, Tables 26-28) Adjusted mean changes in weight (Model 2) for those in the lowest quartile and categories of mean peak 30-minute cadence, minutes spent at a brisk walk and faster ambulation, and minutes spent in bouted purposeful steps and faster ambulation were -0.5 kg, 0.31 kg, and -

0.66 kg, respectively whereas, in the highest quartile they were 1.5 kg, 1.6 kg and 1.3 kg, respectively. Consistently, in examination of weight maintenance, those in the lowest compared to highest quartile and categories of peak 30-minute cadence and minutes spent in bouts of purposeful steps and faster ambulation (Q1) had 0.72 95% CI (0.57, 0.89) and 0.82 95% CI (0.60, 1.14) times the odds of gaining weight, respectively (Figure 6). Minutes spent sedentary (Table 29) and minutes spent in incidental or sporadic movement (Table 27) were not associated with changes in measures of adiposity. No significant interactions were found between step-based metrics and age, sex, occupation and years in the U.S. for the associations with changes in measures of adiposity (Table 30).

5.4 Discussion

In this large community-based cohort of U.S. Hispanic/Latino adults with accelerometer-measured physical activity, we found step volume and cadence had inverse cross-sectional relationships with weight, BMI, and WC. Adults taking as few as 5,000-7,499 steps per day (considered low activity) had lower baseline measures of adiposity than those who were considered inactive (<5,000 steps/day). Similarly, adults who spent more average daily time in bouts of purposeful steps and faster ambulation had lower baseline measures of adiposity than those who spent less average daily time in these bouts. In contrast to the cross-sectional findings, adults who accumulated more steps per day had a greater weight change over six years than adults who accumulated less steps per day. We observed comparable associations with cadence indicators - adults who had a faster peak 30-min cadence and spent more time at faster cadences also had a greater weight change than adults who had a slower peak 30-min cadence and spent less time at each cadence indicator. Similarly, adults who spent greater average daily time in at least ten-minute bouts of purposeful steps and faster ambulation had larger changes in weight and BMI over a 6-year period than those who spent less average daily time in ten-minute bouts of purposeful steps and faster ambulation. Sedentary behavior had no association with baseline measures of adiposity or changes in measures of adiposity. The relationship between minutes spent in incidental or sporadic movement and baseline measures of adiposity was modified by age. Higher mean measures of weight and BMI were found for those in higher compared to lower quartiles of incidental or sporadic movement only among adults 60+ years.

Previous studies have found inverse cross-sectional relationships with adiposity and both step volume[15, 28, 271, 274-277] and cadence[19, 86, 167]. Many of these prior studies were conducted on non-U.S. based populations[15, 17, 19, 27, 28, 276], utilized pedometers rather than accelerometers[15, 271, 274-277], consisted of cohorts of less than 100 participants[271, 274-275] and examined non-Hispanic populations[15, 19, 28, 271, 274- 277]. In support of these findings, we also observed inverse cross-sectional relationships between step volume, cadence, and measures of adiposity but extend these findings to a large Hispanic/Latino U.S. based cohort.

Conversely our null findings for the association between step-volume and 6-year changes in adiposity differed from previous studies including the AusDiab study[269] as well as randomized control trials of walking interventions[286]. The AusDiab study demonstrated increments of 1,000 baseline steps were associated with a -0.06 decrease in BMI over a 5-year period among Tasmanian adults (mean age, 51.4 years)[269]. A meta-analysis of 37 randomized controlled walking interventions (mean ages, 30-72 years) reported declines in BMI over the trial periods[286]. Contrasting findings between the current study and the AusDiab study may have been driven by differences between changes in steps over time. Over 33% of participants in the AusDiab study increased their step count and 16.7% remained in a high step volume category[269]. Due to collection of step-based metrics solely at baseline, we are unable to discern changes in steps over time for our analytic population. Intervention length may account for differential findings from the meta-analysis; intervention length ranged from 8-52 weeks whereas the current study examined a 6-year observational period. Our results however, align with the multinational Nateglinide And Valsartan in Impaired Glucose Tolerance Outcomes Research (NAVIGATOR) study, conducted with 2,811 predominantly Caucasian adults over 3 years, that found no relationship between previous step count and subsequent weight[270]. The NAVIGATOR study reported a median decrease in baseline steps of 372 steps/day[270]. Additional studies examining associations between long-term changes in step-based metrics and anthropometrics are needed.

This definition of bouts applied to steps is unique. Previous epidemiologic studies have reported mixed associations when comparing moderate-to-vigorous physical activity accumulated in less than 10-minute bouts compared to accumulated in 10-minute bouts with adiposity outcomes[133, 334-340].We observed in our cross-sectional analyses that adults who spent more time in bouted stepping at a cadence of purposeful steps and faster ambulation had lower weight, WC, and BMI.

Previously, in a cohort of older women, Lee et al. found that inverse associations between steps/day and all-cause mortality were attenuated when step cadence was adjusted for step volume[265]. The current study further examined cadence adjusted for total step volume to ensure that our findings were not driven by step volume (Tables 18, 20, 26 & 28; Model 4). Cross-sectional and longitudinal associations between step-cadence and measures of adiposity, remained robust upon adjustment for total step volume, suggesting step-cadence has an independent relationship with adiposity. These findings highlight the importance of examining health outcome relationships with step cadence in addition to step volume.

Our analyses found that Hispanic/Latino adults who spent more time at purposeful steps and faster ambulation or had a faster peak 30-minute cadence had larger increases in measures of adiposity than those who spent less time or were at a slower peak 30-minute cadence. Changes in physical activity over time may partially explain these findings. Over a 6-year period, it is plausible that step cadence declined unevenly across baseline quartiles of physical activity, but we cannot assess this since steps were not assessed at visit 2. Step volume and cadence may have declined more among those who were in the highest quartiles of physical activity due to an inability to sustain levels of activity, resulting in larger gains in adiposity than those who accumulated fewer steps and spent less time at a faster cadence between baseline and Visit 2.

Our study has several strengths. We studied a large diverse group of Hispanic/Latinos living in the U.S. with robust measures of adiposity and accelerometer measured physical activity. The step count function of the Actical accelerometer has demonstrated good validity at a typical walk (83 $m \cdot min^{-1}$) and run (133 $m \cdot min^{-1}$) speed[326]. Further, we were able to control for multiple confounders that may have introduced bias. Our results should be considered in light of some limitations. Longitudinal analyses examining change in measures of adiposity are bound by our baseline assessment of step-based metrics. An additional limitation of this study is that generalizability is limited to the HCHS/SOL cohort's target population of non-institutionalized Hispanic/Latino adults aged 18-74 years residing in the four sampled areas.

5.5 Conclusion

This study of accelerometer measured step-based metrics and measures of adiposity among the HCHS/SOL cohort demonstrated inverse cross-sectional relationships between step volume and cadence with measures of adiposity. Contrary to our hypotheses, adults who accumulated more steps per day gained more weight and had a higher BMI over six years than adults who accumulated fewer steps. Similar findings were observed with step cadence. Step-metrics capture a broad spectrum of physical activities and are easily understood metrics that can be translated into public health guidelines and interventions. To our knowledge, the present study was the first to examine the relationship of step-based metrics with cross-sectional and longitudinal changes of adiposity among U.S. Hispanics. Additional longitudinal studies with follow-up measures of physical activity are needed to understand relationships between changes in physical activity and changes in measures of adiposity over time, as well as to extend these findings to other populations.

Table 16. Baseline Characteristics by Graduated Step Index Distribution among U.S. Hispanic/Latino adults (n=12,353); HCHS/SOL (2008-2011)**

	N	Inactive (<5,000 average total steps) (*n*= 3585)	Low activity (5,000-7,499 average total steps) (*n*= 3268)	Somewhat active (7,500-9,999 average total steps) (*n*= 2408)	Active (10,000 - 12,499 average total steps) (*n*= 1505)	Highly Active (>12,500 average total steps) (*n*= 1587)
%		29.0	26.5	19.5	12.2	12.8
Age (SE), years		44.1 (0.5)	40.7 (0.4)	39.0 (0.5)	39.3 (0.6)	39.4 (0.5)
Sex (%)						
Men	4896	37.1	42.8	50.0	57.5	65.9
Women	7457	62.9	57.3	50.0	42.6	34.1
Hispanic/Latino background (%)						
Central American	1250	7.6	7.1	8.7	7.6	5.9
Cuban	1641	31.2	19.2	15.5	14.3	11.6
Dominican	1136	7.5	11.6	11.1	12.0	8.8
Mexican	5107	4.1	5.4	5.8	5.1	5.2
Puerto Rican	2027	3.5	4.4	3.5	3.3	4.0
South American	831	7.6	7.1	8.7	7.6	5.9
Mixed/Other/Missing	335	31.2	19.2	15.5	14.3	11.6
Center (%)						
Bronx	3065	21.4	27.4	31.5	33.7	36.8
Chicago	3252	14.0	15.1	16.0	17.7	18.6
Miami	2845	40.4	29.0	25.9	21.9	19.9
San Diego	3191	24.2	28.5	26.6	26.8	24.7
Education (%)						
No High School or GED	4757	31.7	30.5	33.4	32.4	34.6
High School or GED	3094	26.8	27.4	28.0	27.0	32.9
Above High School or GED	4477	41.5	42.1	38.6	40.5	32.6
Employment*						
Employed full time	4239	22.4	32.3	37.1	40.5	49.3

Employed part time	2088	15.0	15.3	18.3	19.3	21.6
Not currently employed	5889	62.6	52.4	44.6	40.2	29.2
Income (%)						
<$30,000	7891	66.0	63.8	62.2	61.7	64.0
≥$30,000	3773	26.5	30.6	32.9	34.4	32.3
Not reported	689	7.5	5.6	4.9	4.0	3.7
Longest held occupation (%)						
Non-skilled worker	3673	21.5	23.9	23.6	31.4	32.5
Service worker	1747	17.6	14.3	17.6	13.5	14.3
Skilled worker	2680	20.4	21.1	23.3	22.0	22.2
Professional/technical, administrative/executive	1751	18.2	18.1	16.8	13.1	9.3
Other	2374	22.3	22.6	18.8	20.0	21.7
Years in the U.S. (%)						
U.S. born	2003	20.7	22.0	23.3	24.9	24.7
>10 years in the U.S.	7463	50.0	49.4	47.6	49.6	48.1
<10 years in the U.S.	2873	29.3	28.6	29.1	25.6	27.2
Smoking (%)						
Never	7562	60.7	62.9	64.0	62.5	58.4
Former	2538	18.8	16.9	15.1	16.9	19.4
Current	2237	20.5	20.2	20.9	20.6	22.2
Marital Status (%)						
Single	3135	32.4	31.9	37.8	37.2	36.8
Married/Living with a Partner	6631	46.9	51.5	48.9	49.5	49.6
Separated/Divorced/Widow(er)	2559	20.6	16.6	13.2	13.4	13.7
Symptoms of Depression						
CESD10[†] score mean (SE)		7.4 (0.2)	7.0 (0.2)	6.7 (0.2)	6.3 (0.2)	6.6 (0.2)
Accelerometer wear time mean (SE)		15.2 (0.1)	15.7 (0.1)	16.1 (0.1)	16.4 (0.1)	17.1 (0.1)
Total energy intake (kcal) mean (SE)		1901.7 (14.6)	1955.6 (15.3)	1993.2 (19.1)	2057.5 (23.2)	2128.7 (23.3)
Baseline weight (kg) mean (SE)		80.8 (0.6)	78.2 (0.5)	77.7 (0.7)	78.2 (0.8)	78.0 (0.7)
Baseline waist circumference (cm)		100.0 (0.5)	97.0 (0.4)	96.0 (0.7)	96.0 (0.6)	95.1 (0.5)
Baseline BMI (kg/m^2)		30.45 (0.2)	29.3 (0.2)	28.9 (0.3)	28.6 (0.2)	28.5 (0.2)

BMI Category¥						
Normal	2433	19.3	22.7	25.4	22.1	23.3
Overweight	5091	45.8	37.8	36.5	35.1	34.7
Obese	4740	33.1	38.6	37.3	41.6	41.6
Underweight	89	1.7	0.9	0.8	1.3	0.4
Mobility limitations, moderate¥¥						
Yes, limited a lot	1003	10.0	6.4	4.9	4.1	5.8
Yes, limited a little	1879	15.7	11.6	11.3	11.2	9.9
No, not limited at all	9452	74.3	82.0	83.8	84.7	84.3
Mobility limitations climbing several flights of stairs						
Yes, limited a lot	1445	13.1	9.7	7.8	5.9	8.0
Yes, limited a little	2676	22.5	17.8	18.1	15.3	16.0
No, not limited at all	8208	64.4	72.4	74.1	78.8	76.1

* Employed full time: >35 hours/week in one job or more than one job, employed part time ($\leq$ 35 hours/week)

†10-Item Center for Epidemiology Depression Scale (CES-D10)

††Global Physical Activity Questionnaire (GPAQ)

¥ Normal weight: 18.5 to <25 kg/m^2, overweight: 25.0 to <30 kg/m^2, obese: $\geq$30 kg/m^2, underweight: <18.5 kg/m^2

¥¥ Activities such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

**All statistics are weighted and account for HCHS/SOL complex survey design

Table 17: Baseline adjusted means (95% CI) of weight (kg), waist circumference (cm) and BMI by graduated step index level, HCHS/SOL (2008-2011).

	Weight (kg)	
Average total steps	Model 1	Model 2
Inactive (<5,000)	82.74 (81.29, 84.19)	85.32 (83.65, 86.98)
Low Activity (5,000-7,499)	79.57 (78.5, 80.64)	82.23 (80.92, 83.55)
Somewhat Active (7,500-9,999)	78.32 (77.01, 79.63)	80.61 (79.21, 82.01)
Active (10,000 -12,499)	77.78 (76.27, 79.29)	80.67 (79.04, 82.29)
Highly Active (>12,500)	76.64 (75.22, 78.07)	79.14 (77.54, 80.74)
p-value	<0.01	<0.01
	Waist Circumference (cm)	
	Model 1	Model 2
Inactive (<5,000)	100.52 (99.46, 101.59)	102.68 (101.57, 103.79)
Low Activity (5,000-7,499)	97.88 (96.98, 98.78)	100.31 (99.32, 101.29)
Somewhat Active (7,500-9,999)	97 (95.93, 98.06)	99.06 (98.02, 100.11)
Active (10,000 -12,499)	96.66 (95.4, 97.91)	99.38 (98.08, 100.69)
Highly Active (>12,500)	95.38 (94.24, 96.52)	97.93 (96.74, 99.12)
p-value	<0.01	<0.01
	Body Mass Index (kg/m²)	
	Model 1	Model 2
Inactive (<5,000)	30.48 (30.04, 30.92)	31.34 (30.89, 31.79)
Low Activity (5,000-7,499)	29.45 (29.09, 29.81)	30.41 (30.02, 30.81)
Somewhat Active (7,500-9,999)	29.1 (28.66, 29.55)	29.92 (29.5, 30.35)
Active (10,000 -12,499)	28.8 (28.33, 29.27)	29.88 (29.39, 30.36)
Highly Active (>12,500)	28.68 (28.21, 29.15)	29.68 (29.19, 30.18)
p-value	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, occupation, income, mobility limitations (climbing stairs), smoking, marital status, predicted total energy intake and average accelerometer wear time
p-value: From 3 df test from overall test of graduated step index

Table 18: Baseline adjusted means (95% CI) of weight (kg), waist circumference (cm) and BMI by quartile of average peak 30-minute cadence, HCHS/SOL (2008-2011).

Peak 30-minute cadence				
		Weight (kg)		
Steps/min	Model 1	Model 2	Model 3	Model 4
Q1 (<64.00)	84.49 (83.17, 85.81)	86.55 (85.19, 87.91)	87.51 (86.11, 88.92)	86.02 (84.73, 87.31)
Q2 (64.00->73.32	81.45 (80.05, 82.86)	83.66 (82.18, 85.13)	83.87 (82.39, 85.35)	83.81 (82.53, 85.09)
Q3 (73.32->84.55	78.21 (77.16, 79.27)	80.89 (79.69, 82.1)	80.63 (79.42, 81.84)	81.84 (80.49, 83.19)
Q4 (84.5+)	74.07 (72.96, 75.18)	76.97 (75.76, 78.17)	76.44 (75.22, 77.66)	77.45 (76.02, 78.88)
p-value	<0.01	<0.01	<0.01	<0.01
		Waist Circumference (cm)		
	Model 1	Model 2	Model 3	Model 4
Q1 (<64.00)	101.8 (100.78, 102.82)	103.8 (102.77, 104.83)	104.45 (103.36, 105.55)	103.45 (102.48, 104.43)
Q2 (64.00->73.32	99.38 (98.33, 100.44)	101.49 (100.47, 102.5)	101.63 (100.61, 102.64)	101.63 (100.7, 102.55)
Q3 (73.32->84.55	96.97 (96.1, 97.83)	99.58 (98.66, 100.49)	99.4 (98.49, 100.31)	100.16 (99.13, 101.19)
Q4 (84.5+)	93.59 (92.62, 94.56)	96.41 (95.4, 97.41)	96.05 (95.05, 97.06)	96.83 (95.75, 97.91)
p-value	<0.01	<0.01	<0.01	<0.01
		Body Mass Index (kg/m^2)		
	Model 1	Model 2	Model 3	Model 4
Q1 (<64.00)	31.14 (30.7, 31.58)	31.9 (31.46, 32.35)	32.28 (31.81, 32.75)	31.81 (31.39, 32.22)
Q2 (64.00->73.32	29.96 (29.54, 30.37)	30.77 (30.38, 31.17)	30.86 (30.45, 31.26)	30.87 (30.46, 31.27)
Q3 (73.32->84.55	29.05 (28.69, 29.4)	30.05 (29.67, 30.43)	29.94 (29.57, 30.32)	30.3 (29.87, 30.73)
Q4 (84.5+)	27.72 (27.33, 28.11)	28.82 (28.42, 29.22)	28.62 (28.22, 29.02)	28.89 (28.49, 29.29)
p-value	<0.01	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ total step volume

Table 19: Baseline adjusted means (95% CI) of weight (kg), waist circumference (cm) and BMI by minutes per day spent in brisk walking and faster ambulation (100+ steps/min) HCHS/SOL (2008-2011).

Brisk walking and faster ambulation (≥100 steps per minute)			
	Weight (kg)		
Minutes	Model 1	Model 2	Model 3
0	88.06 (85.64, 90.47)	89.94 (87.61, 92.27)	90.1 (87.75, 92.46)
<0-<3.62	83.55 (82.33, 84.77)	85.88 (84.57, 87.18)	85.96 (84.66, 87.26)
3.62->12.84	79.66 (78.5, 80.82)	81.91 (80.56, 83.26)	81.95 (80.61, 83.29)
≥12.84	74.09 (73.03, 75.14)	76.94 (75.83, 78.05)	76.9 (75.79, 78.01)
p-value	<0.01	<0.01	<0.01
	Waist Circumference (cm)		
	Model 1	Model 2	Model 3
0	104.24 (102.49, 105.99)	105.96 (104.26, 107.66)	106.01 (104.28, 107.73)
<0-<3.62	100.87 (99.91, 101.83)	103.16 (102.17, 104.16)	103.18 (102.19, 104.18)
3.62->12.84	98.09 (97.24, 98.95)	100.29 (99.36, 101.22)	100.3 (99.37, 101.23)
≥12.84	93.85 (92.91, 94.79)	96.65 (95.72, 97.57)	96.63 (95.71, 97.56)
p-value	<0.01	<0.01	<0.01
	Body Mass Index (kg/m^2)		
	Model 1	Model 2	Model 3
0	32.27 (31.5, 33.03)	32.92 (32.19, 33.64)	33 (32.26, 33.75)
<0-<3.62	30.69 (30.28, 31.09)	31.57 (31.15, 31.98)	31.61 (31.19, 32.03)
3.62->12.84	29.48 (29.13, 29.82)	30.32 (29.94, 30.7)	30.34 (29.96, 30.72)
≥12.84	27.79 (27.41, 28.17)	28.88 (28.51, 29.25)	28.86 (28.49, 29.22)
p-value	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Table 20: Baseline adjusted means (95% CI) of weight (kg), waist circumference (cm) and BMI by minutes per day spent in 10 minute bouts of ≥ 40 steps/min HCHS/SOL (2008-2011).

Bouts purposeful steps and faster ambulation (≥ 40 steps per minute)				
		Weight (kg)		
Minutes	Model 1	Model 2	Model 3	Model 4
>0	83.37 (82, 84.73)	85.82 (84.43, 87.2)	86.06 (84.67, 87.46)	82.38 (81.12, 83.63)
<0->10.46	80.79 (79.64, 81.95)	83.63 (82.36, 84.9)	83.77 (82.49, 85.04)	83.53 (82.31, 84.76)
10.46->28.86	79.13 (77.79, 80.47)	81.52 (80, 83.03)	81.55 (80.05, 83.06)	83.73 (82.14, 85.32)
28.86	76.51 (75.35, 77.68)	79.58 (78.37, 80.78)	79.39 (78.16, 80.63)	80.26 (78.99, 81.53)
p-value	<0.01	<0.01	<0.01	<0.01
		Waist Circumference (cm)		
	Model 1	Model 2	Model 3	Model 4
>0	100.87 (99.82, 101.92)	103.2 (102.14, 104.26)	103.31 (102.22, 104.41)	100.51 (99.56, 101.46)
<0->10.46	98.79 (97.86, 99.72)	101.48 (100.54, 102.42)	101.54 (100.59, 102.49)	101.24 (100.26, 102.23)
10.46->28.86	97.74 (96.72, 98.75)	100.01 (98.91, 101.1)	100.03 (98.93, 101.12)	101.83 (100.74, 102.92)
28.86	95.56 (94.62, 96.5)	98.48 (97.57, 99.38)	98.39 (97.48, 99.3)	99.1 (98.12, 100.08)
p-value	<0.01	<0.01	<0.01	0.01
		Body Mass Index (kg/m^2)		
	Model 1	Model 2	Model 3	Model 4
>0	30.77 (30.34, 31.2)	31.67 (31.24, 32.1)	31.8 (31.36, 32.24)	30.58 (30.19, 30.97)
<0->10.46	29.79 (29.4, 30.18)	30.84 (30.45, 31.24)	30.91 (30.51, 31.32)	30.75 (30.37, 31.13)
10.46->28.86	29.34 (28.93, 29.75)	30.21 (29.77, 30.65)	30.23 (29.79, 30.67)	30.96 (30.51, 31.4)
28.86	28.5 (28.12, 28.88)	29.64 (29.26, 30.02)	29.55 (29.17, 29.92)	29.87 (29.44, 30.31)
p-value	<0.01	<0.01	<0.01	0.05

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ total step volume

Table 21: Baseline adjusted means (95% CI) of weight (kg), waist circumference (cm) and BMI by quartile of minutes per day spent sedentary (0 steps/min) adjusted for average accelerometer wear time HCHS/SOL (2008-2011).

Sedentary Time (0 steps per minute)		
	Weight (kg)	
Minutes/day	Model 1	Model 2
Q1 (>589.27)	78.88 (77.73, 80.02)	79.66 (78.12, 81.2)
Q2 (589.27->672.69)	78.93 (77.79, 80.07)	79.53 (77.9, 81.15)
Q3 (672.69->739.04)	80.32 (79.08, 81.55)	81.5 (79.83, 83.17)
Q4 (739.04+)	80.57 (79.1, 82.04)	81.69 (79.89, 83.48)
p-value	0.05	<0.01
	Waist Circumference (cm)	
	Model 1	Model 2
Q1 (>589.27)	97.41 (96.5, 98.33)	98.78 (97.62, 99.93)
Q2 (589.27->672.69)	97.36 (96.42, 98.3)	98.36 (97.04, 99.69)
Q3 (672.69->739.04)	98.37 (97.36, 99.37)	99.86 (98.6, 101.12)
Q4 (739.04+)	99.04 (97.92, 100.15)	100.37 (99.13, 101.62)
p-value	0.03	<0.01
	Body Mass Index (kg/m^2)	
	Model 1	Model 2
Q1 (>589.27)	29.36 (28.98, 29.73)	29.85 (29.38, 30.31)
Q2 (589.27->672.69)	29.29 (28.91, 29.68)	29.68 (29.18, 30.19)
Q3 (672.69->739.04)	29.62 (29.19, 30.04)	30.22 (29.69, 30.75)
Q4 (739.04+)	29.81 (29.36, 30.26)	30.34 (29.84, 30.84)
p-value	0.21	0.03

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking, and average accelerometer wear time per day

Table 22: p-values for interactions of step-metrics* with sex, years in the U.S., occupation and age categories for adjusted baseline means of weight, waist circumference and BMI

	Sex	Years in the U.S.	Age	Occupation
Step index				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.82	0.17	0.02	0.21
Waist circumference (cm)	0.9	0.02	<0.01	0.14
BMI	0.26	0.04	<0.01	0.21
Peak 30-minute cadence				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.56	<0.01	0.44	0.45
Waist circumference (cm)	0.42	<0.01	0.15	0.34
BMI	0.2	<0.01	0.65	0.30
Peak 60-minute cadence				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.27	0.02	0.18	0.68
Waist circumference (cm)	0.11	<0.01	0.1	0.42
BMI	0.06	0.01	0.56	0.40
Sedentary behavior (0 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.74	0.58	0.05	0.4
Waist circumference (cm)	0.94	0.46	0.01	0.17
BMI	0.39	0.67	<0.01	0.53
Incidental or sporadic movement (1-39 steps per minute)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.69	0.08	<0.01	0.11
Waist circumference (cm)	0.82	0.03	<0.01	0.18
BMI	0.28	0.22	<0.01	0.21
Purposeful steps and faster ambulation (40-99 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.52	0.21	<0.01	0.30
Waist circumference (cm)	0.67	0.12	<0.01	0.07
BMI	0.44	0.23	<0.01	0.33

Brisk walking and faster ambulation (≥100 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.49	<0.01	0.31	0.67
Waist circumference (cm)	0.91	<0.01	0.24	0.80
BMI	0.02	<0.01	0.36	0.51
Bouts of purposeful stepping and faster ambulation (≥ 40 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.78	0.09	0.03	0.29
Waist circumference (cm)	0.97	0.02	0.01	0.48
BMI	0.31	0.07	0.01	0.71
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.1	0.09	0.39	0.89
Waist circumference (cm)	0.15	0.01	0.33	0.85
BMI	0.07	0.04	0.23	0.98
Bouts of brisk walking and faster ambulation (≥100 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Weight (kg)	0.26	<0.01	0.27	0.99
Waist circumference (cm)	0.69	<0.01	0.17	1.00
BMI	0.11	<0.01	0.26	0.98

*Step volume models: Adjusted for age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations (climbing stairs), smoking, marital status, predicted total energy intake and average accelerometer wear time

Sedentary models: Adjusted for age, sex, center, background, years in the U.S., education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking, and average accelerometer wear time per day

Cadence indicator models: Adjusted for age, sex, center, background, years in the U.S., mobility limitations climbing stairs, smoking and average accelerometer wear time per day

Table 23. p-values for multivariable adjusted means of baseline weight (kg), waist circumference (cm) and BMI (kg/m^2) by quartile of incidental or sporadic movement (1-39 steps/min) and age category.

			Weight (kg)		
	18-29	30-39	40-49	50-59	≥60
Q1	REF	REF	REF	REF	REF
Q2	0.04	0.21	0.69	0.64	0.08
Q3	0.02	0.24	0.01	0.06	0.03
Q4	<0.001	0.03	0.02	<0.001	<0.0001
			Waist Circumference (cm)		
	18-29	30-39	40-49	50-59	≥60
Q1	REF	REF	REF	REF	REF
Q2	0.09	0.19	0.83	0.49	<0.01
Q3	0.02	0.19	0.03	0.15	<0.01
Q4	<0.001	0.03	0.14	<0.01	<0.001
			BMI (kg/m^2)		
	18-29	30-39	40-49	50-59	≥60
Q1	REF	REF	REF	REF	REF
Q2	0.06	0.32	0.93	0.40	0.05
Q3	0.02	0.27	0.11	0.02	0.03
Q4	<0.01	0.06	0.36	0.01	<0.0001

Models adjusted for age, sex, center, background, years in the U.S., mobility limitations climbing stairs, smoking and average accelerometer wear time per day

Table 24. Mean baseline weight (kg), waist circumference (cm) and BMI (kg/m^2) by quartile of incidental or sporadic movement (1-39 steps/min) and age category.

	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
			Weight (kg)		
Q1	77.69 (75.15, 80.24)	88.59 (83.96, 93.22)	87.06 (84.84, 89.28)	84.07 (82.36, 85.78)	81.00 (79.24, 82.75)
Q2	81.77 (78.71, 84.83)	85.65 (83.14, 88.17)	86.43 (84.12, 88.75)	83.56)81.69, 85.43)	78.93 (77.21, 80.65)
Q3	81.44 (78.93, 83.95)	85.75 (83.57, 87.93)	84.06 (82.37, 85.75)	82.22)80.77, 83.68)	78.30 (76.45, 80.16)
Q4	83.63 (81.01, 86.24)	83.55 (81.22, 85.88)	84.22 (82.60, 85.84)	81.38 (79.82, 82.93)	75.93 (73.88, 77.98)
			Waist Circumference (cm)		
Q1	93.76 (91.78, 95.75)	102.97 (100.01, 105.93)	102.42 (100.61, 104.23)	102.96 (101.64, 104.28)	104.29 (102.90, 105.69)
Q2	96.44 (94.06, 98.81)	100.81 (98.84, 102.78)	102.16 (100.45, 103.87)	102.38 (100.99, 103.77)	101.49 (100.05, 102.92)
Q3	96.86 (94.85, 98.88)	100.86 (99.12, 102.60)	100.32 (99.07, 101.57)	101.78 (100.46, 103.09)	101.14 (99.41, 102.87)
Q4	98.43 (96.31, 100.54)	99.58 (97.95, 101.21)	100.93 (99.66, 102.20)	100.60 (99.42, 101.79)	98.97 (97.30, 100.63)
			BMI (kg/m^2)		
Q1	28.23 (27.41, 29.04)	32.04 (30.86, 33.21)	31.62 (30.84, 32.40)	31.35 (30.76, 31.94)	30.73 (30.14, 31.32)
Q2	29.42 (28.46, 30.37)	31.35 (30.45, 32.24)	31.67 (30.93, 32.41)	31.05 (30.46, 31.63)	29.95 (29.41, 30.49)
Q3	29.53 (28.67, 30.39)	31.32 (30.64, 32.00)	30.96 (30.41. 31.51)	30.54 (30.03, 31.04)	29.82 (29.19, 30.44)
Q4	30.30 (29.50, 31.09)	30.81 (30.11, 31.50)	31.22 (30.68, 31.76)	30.41 (29.93, 30.89)	28.91 (28.25, 29.57)

Models adjusted for age, sex, center, background, years in the U.S., mobility limitations climbing stairs, smoking and average accelerometer wear time per day

Table 25. Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by graduated step index level, HCHS/SOL (2008-2017).

	Change in Weight (kg)	
Average total steps	Model 1	Model 2
Inactive (<5,000)	-0.17 (-0.84, 0.5)	0.32 (-0.51, 1.15)
Low Activity (5,000-7,499)	0.37 (-0.42, 1.17)	0.91 (-0.06, 1.87)
Somewhat Active (7,500-9,999)	0.51 (-0.19, 1.22)	0.94 (-0.02, 1.91)
Active (10,000 -12,499)	1.22 (0.4, 2.04)	1.8 (0.74, 2.86)
Highly Active (>12,500)	1.46 (0.54, 2.38)	2.01 (0.86, 3.16)
p-value	0.01	0.01
	Change in Waist Circumference (cm)	
	Model 1	Model 2
Inactive (<5,000)	1.1 (0.45, 1.75)	1.22 (0.35, 2.09)
Low Activity (5,000-7,499)	1.61 (0.9, 2.32)	1.82 (0.98, 2.67)
Somewhat Active (7,500-9,999)	1.3 (0.55, 2.05)	1.31 (0.36, 2.27)
Active (10,000 -12,499)	1.91 (1.02, 2.8)	2.07 (0.95, 3.2)
Highly Active (>12,500)	2.31 (1.45, 3.16)	2.43 (1.39, 3.47)
p-value	0.09	0.11
	Change in Body Mass Index (kg/m^2)	
	Model 1	Model 2
Inactive (<5,000)	-0.09 (-0.33, 0.15)	0.07 (-0.23, 0.36)
Low Activity (5,000-7,499)	0.12 (-0.16, 0.39)	0.29 (-0.05, 0.63)
Somewhat Active (7,500-9,999)	0.15 (-0.09, 0.4)	0.29 (-0.05, 0.63)
Active (10,000 -12,499)	0.4 (0.1, 0.7)	0.59 (0.2, 0.98)
Highly Active (>12,500)	0.48 (0.16, 0.8)	0.65 (0.25, 1.05)
p-value	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, and average accelerometer wear time per day

Table 26: Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by quartile of average peak 30-minute cadence, HCHS/SOL (2008-2017).

Peak 30-minute cadence				
	Change in Weight (kg)			
	Model 1	Model 2	Model 3	Model 4
Q1 (<59.63)	-0.52 (-1.35, 0.32)	-0.51 (-1.38, 0.36)	-0.61 (-1.52, 0.29)	-0.18 (-0.86, 0.5)
Q2 (59.63->74.67)	-0.07 (-0.76, 0.61)	-0.11 (-0.83, 0.62)	-0.13 (-0.85, 0.59)	0.25 (-0.56, 1.06)
Q3 (74.67->91.27)	1 (0.37, 1.63)	0.97 (0.32, 1.62)	1 (0.34, 1.66)	0.74 (-0.08, 1.57)
Q4 (+91.27)	1.49 (0.82, 2.15)	1.52 (0.84, 2.2)	1.58 (0.88, 2.27)	1.05 (0.41, 1.69)
p-value	<0.01	<0.01	<0.01	0.02
	Change in Waist Circumference (cm)			
	Model 1	Model 2	Model 3	Model 4
Q1 (<59.63)	1.1 (0.36, 1.83)	1.01 (0.26, 1.76)	1.02 (0.22, 1.83)	1.26 (0.53, 1.99)
Q2 (59.63->74.67)	1.08 (0.36, 1.8)	0.96 (0.19, 1.73)	0.96 (0.19, 1.73)	1.22 (0.49, 1.95)
Q3 (74.67->91.27)	1.74 (1.03, 2.45)	1.6 (0.86, 2.34)	1.6 (0.84, 2.36)	1.4 (0.59, 2.21)
Q4 (+91.27)	2.15 (1.48, 2.82)	2.11 (1.41, 2.81)	2.11 (1.37, 2.84)	1.81 (1.08, 2.53)
p-value	0.03	0.02	0.04	0.45
	Change in Body Mass Index (kg/m^2)			
	Model 1	Model 2	Model 3	Model 4
Q1 (<59.63)	-0.21 (-0.51, 0.08)	-0.2 (-0.51, 0.1)	-0.25 (-0.57, 0.07)	-0.11 (-0.36, 0.13)
Q2 (59.63->74.67)	-0.05 (-0.3, 0.19)	-0.06 (-0.33, 0.2)	-0.07 (-0.33, 0.19)	0.08 (-0.2, 0.36)
Q3 (74.67->91.27)	0.34 (0.11, 0.57)	0.33 (0.1, 0.57)	0.35 (0.11, 0.59)	0.24 (-0.06, 0.53)
Q4 (+91.27)	0.49 (0.26, 0.73)	0.51 (0.27, 0.75)	0.54 (0.29, 0.78)	0.36 (0.13, 0.59)
p-value	<0.01	<0.01	<0.01	0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2 + total step-volume

Table 27: Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min) and minutes spent in brisk walking and faster ambulation (≥100 steps/min) HCHS/SOL (2008-2017).

Incidental or sporadic movement (1-39 steps/min)			
Change in Weight (kg)			
Minutes	Model 1	Model 2	Model 3
Q1 (161.81<)	0.3 (-0.38, 0.98)	0.35 (-0.31, 1.02)	1.32 (0.29, 2.34)
Q2 (161.81->213.84)	0.41 (-0.4, 1.23)	0.43 (-0.44, 1.31)	0.79 (-0.02, 1.6)
Q3 (213.84->275.99)	0.77 (0.05, 1.49)	0.79 (0.05, 1.53)	0.58 (-0.17, 1.33)
Q4 (275.99+)	0.41 (-0.21, 1.03)	0.37 (-0.28, 1.02)	-0.68 (-1.67, 0.31)
p-value	0.68	0.68	0.06
Change in Waist Circumference (cm)			
	Model 1	Model 2	Model 3
Q1 (161.81<)	1.46 (0.79, 2.12)	1.39 (0.66, 2.13)	2.31 (1.31, 3.31)
Q2 (161.81->213.84)	1.58 (0.85, 2.31)	1.5 (0.75, 2.25)	1.83 (1.05, 2.62)
Q3 (213.84->275.99)	1.56 (0.82, 2.31)	1.49 (0.71, 2.27)	1.29 (0.49, 2.1)
Q4 (275.99+)	1.45 (0.73, 2.17)	1.34 (0.61, 2.08)	0.35 (-0.79, 1.49)
p-value	0.99	0.98	0.18
Change in Body Mass Index (kg/m^2)			
	Model 1	Model 2	Model 3
Q1 (161.81<)	0.1 (-0.15, 0.34)	0.13 (-0.12, 0.37)	0.47 (0.11, 0.83)
Q2 (161.81->213.84)	0.12 (-0.17, 0.4)	0.13 (-0.17, 0.44)	0.26 (-0.03, 0.55)
Q3 (213.84->275.99)	0.24 (-0.01, 0.5)	0.25 (-0.01, 0.52)	0.18 (-0.09, 0.45)
Q4 (275.99+)	0.11 (-0.12, 0.33)	0.09 (-0.15, 0.32)	-0.29 (-0.64, 0.06)
p-value	0.73	0.68	0.04
Brisk walking and faster ambulation (≥100 steps/min)			
Change in Weight (kg)			
Minutes	Model 1	Model 2	Model 3
≤0	0.29 (-0.82, 1.41)	0.31 (-0.81, 1.44)	0.36 (-0.78, 1.51)
0->3.40	-0.46 (-1.12, 0.2)	-0.49 (-1.15, 0.16)	-0.47 (-1.12, 0.17)
3.40->12.07	0.34 (-0.25, 0.92)	0.34 (-0.29, 0.96)	0.35 (-0.28, 0.97)
≥12.07	1.54 (0.94, 2.14)	1.62 (1.01, 2.23)	1.6 (0.99, 2.21)
p-value	<0.01	<0.01	<0.01

	Model 1	Model 2	Model 3
Change in Waist Circumference (cm)			
≤0	1.8 (0.58, 3.03)	1.74 (0.48, 3)	1.81 (0.54, 3.08)
0->3.40	1.03 (0.43, 1.62)	0.91 (0.31, 1.51)	0.94 (0.34, 1.54)
3.40->12.07	1.41 (0.77, 2.05)	1.3 (0.61, 1.99)	1.31 (0.62, 2)
≥12.07	2.05 (1.45, 2.65)	2.02 (1.38, 2.66)	1.99 (1.34, 2.64)
p-value	0.05	0.03	0.04
Change in Body Mass Index (kg/m^2)			
≤0	0.04 (-0.38, 0.45)	0.05 (-0.37, 0.47)	0.06 (-0.37, 0.49)
0->3.40	-0.18 (-0.42, 0.06)	-0.19 (-0.42, 0.05)	-0.18 (-0.42, 0.05)
3.40->12.07	0.09 (-0.12, 0.3)	0.09 (-0.14, 0.32)	0.09 (-0.14, 0.32)
≥12.07	0.52 (0.31, 0.74)	0.56 (0.34, 0.77)	0.55 (0.34, 0.77)
p-value	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day

Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Table 28: Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by minutes per day spent in 10 minute bouts of ≥ 40 steps/min HCHS/SOL (2008-2017).

Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)				
		Change in Weight (kg)		
Minutes	Model 1	Model 2	Model 3	Model 4
0	-0.62 (-1.53, 0.28)	-0.66 (-1.6, 0.28)	-0.68 (-1.63, 0.27)	0.27 (-0.4, 0.95)
<0->9.92	0.17 (-0.52, 0.86)	0.2 (-0.5, 0.9)	0.19 (-0.52, 0.9)	0.33 (-0.45, 1.12)
9.92->28.85	0.89 (0.28, 1.51)	0.86 (0.23, 1.49)	0.86 (0.23, 1.49)	0.23 (-0.48, 0.93)
≥28.85	1.15 (0.5, 1.8)	1.26 (0.59, 1.92)	1.28 (0.6, 1.96)	1.07 (0.38, 1.76)
p-value	<0.01	<0.01	<0.01	0.15
		Change in Waist Circumference (cm)		
	Model 1	Model 2	Model 3	Model 4
0	0.55 (-0.28, 1.39)	0.43 (-0.46, 1.32)	0.45 (-0.46, 1.35)	1.22 (0.46, 1.97)
<0->9.92	1.56 (0.84, 2.28)	1.49 (0.76, 2.22)	1.5 (0.75, 2.24)	1.61 (0.92, 2.31)
9.92->28.85	1.84 (1.22, 2.46)	1.73 (1.06, 2.4)	1.73 (1.06, 2.4)	0.98 (0.23, 1.72)
≥28.85	1.86 (1.22, 2.5)	1.82 (1.15, 2.5)	1.81 (1.09, 2.53)	1.87 (1.15, 2.6)
p-value	0.02	0.02	0.05	0.1
		Change in Body Mass Index (kg/m^2)		
	Model 1	Model 2	Model 3	Model 4
0	-0.23 (-0.55, 0.08)	-0.24 (-0.57, 0.09)	-0.26 (-0.59, 0.08)	0.07 (-0.17, 0.31)
<0->9.92	0.04 (-0.21, 0.28)	0.05 (-0.2, 0.3)	0.04 (-0.22, 0.3)	0.09 (-0.19, 0.37)
9.92->28.85	0.28 (0.06, 0.5)	0.27 (0.04, 0.5)	0.27 (0.04, 0.5)	0.06 (-0.2, 0.32)
≥28.85	0.37 (0.14, 0.61)	0.42 (0.18, 0.66)	0.43 (0.19, 0.67)	0.37 (0.13, 0.61)
p-value	<0.01	<0.01	<0.01	0.19

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2 + total step volume

Table 29: Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by quartile of minutes per day spent sedentary (0 steps/min) adjusted for average accelerometer wear time HCHS/SOL (2008-2011).

Sedentary time (0 steps per minute)		
	Change in Weight (kg)	
Minutes	Model 1	Model 2
Q1 (567.89<)	0.4 (-0.22, 1.03)	0.75 (-0.19, 1.68)
Q2 (567.89->655.59)	1.01 (0.33, 1.7)	1.37 (0.41, 2.33)
Q3 (655.59->725.88)	0.27 (-0.47, 1.02)	0.59 (-0.37, 1.54)
Q4 (725.88+)	0.23 (-0.44, 0.9)	0.51 (-0.37, 1.39)
p-value	0.23	0.17
	Mean Change in Waist Circumference (cm)	
	Model 1	Model 2
Q1 (567.89<)	1.48 (0.78, 2.18)	1.66 (0.72, 2.61)
Q2 (567.89->655.59)	1.86 (1.14, 2.57)	2.12 (1.19, 3.04)
Q3 (655.59->725.88)	1.6 (0.93, 2.26)	1.82 (0.98, 2.66)
Q4 (725.88+)	1.15 (0.47, 1.83)	1.38 (0.5, 2.26)
p-value	0.43	0.4
	Change in Body Mass Index (kg/m^2)	
	Model 1	Model 2
Q1 (567.89<)	0.11 (-0.12, 0.33)	0.2 (-0.14, 0.53)
Q2 (567.89->655.59)	0.31 (0.08, 0.55)	0.42 (0.08, 0.75)
Q3 (655.59->725.88)	0.09 (-0.18, 0.35)	0.18 (-0.16, 0.52)
Q4 (725.88+)	0.06 (-0.18, 0.31)	0.14 (-0.18, 0.46)
p-value	0.32	0.24

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking years between visits and average accelerometer wear time per day

Table 30: p-values for interactions of SSB or ASB with sex, years in the U.S. and age categories for mean changes in weight, waist circumference and BMI

	Sex	Years in the U.S.	Age	Occupation
Step index				
Change in weight (kg)	0.33	0.27	0.44	0.03
Change in waist circumference (cm)	0.13	0.15	0.73	<0.01
Change in BMI (kg/m^2)	0.51	0.31	0.45	0.03
Peak 30-minute cadence				
Change in weight (kg)	0.23	0.05	0.83	0.59
Change in waist circumference (cm)	0.05	<0.01	0.55	0.03
Change in BMI (kg/m^2)	0.37	0.06	0.8	0.62
Peak 60-minute cadence				
Change in weight (kg)	0.37	<0.01	0.91	0.38
Change in waist circumference (cm)	0.06	0.02	0.82	0.10
Change in BMI (kg/m^2)	0.53	0.17	0.93	0.44
Sedentary behavior (0 steps/min)				
Change in weight (kg)	0.28	0.21	0.42	0.48
Change in waist circumference (cm)	0.07	0.06	0.41	0.38
Change in BMI (kg/m^2)	0.27	0.21	0.44	0.56
Incidental or Sporadic Movement (1-39 steps/min)				
Change in weight (kg)	0.37	0.83	0.32	0.75
Change in waist circumference (cm)	0.48	0.44	0.67	0.54
Change in BMI (kg/m^2)	0.37	0.85	0.3	0.74
Purposeful Stepping and faster ambulation (40-99 steps/min)				
Change in weight (kg)	0.2	0.17	0.84	0.22
Change in waist circumference (cm)	0.02	0.09	0.65	0.01
Change in BMI (kg/m^2)	0.26	0.2	0.8	0.22

	Sex	Years in the U.S.	Age	Occupation
Brisk Walking and faster ambulation (≥100 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Change in weight (kg)	<0.01	0.04	0.08	0.48
Change in waist circumference (cm)	0.04	0.01	0.17	0.72
Change in BMI (kg/m^2)	<0.01	0.05	0.11	0.59
Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Change in weight (kg)	0.15	0.02	0.18	0.35
Change in waist circumference (cm)	0.02	<0.01	0.09	0.37
Change in BMI (kg/m^2)	0.18	0.03	0.21	0.32
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Change in weight (kg)	0.3	0.23	0.25	0.70
Change in waist circumference (cm)	0.01	0.09	0.35	0.54
Change in BMI (kg/m^2)	0.24	0.28	0.35	0.77
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)				
	Sex	Years in the U.S.	Age	Occupation
Change in weight (kg)	0.79	0.09	0.6	0.30
Change in waist circumference (cm)	0.1	0.11	0.32	0.55
Change in BMI (kg/m^2)	0.92	0.09	0.7	0.32

*Step Index Models: Adjusted for age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, years between visits and average accelerometer wear time per day

**Sedentary Models: Adjusted for age, sex, center, background, years in the U.S., education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking years between visits and average accelerometer wear time per day

***Peak 30 Cadence, Peak 60 Cadence, Light PA, Purposeful Stepping, Brisk Walking, Bouts of 40 steps/min, Bouts of 70 steps/min and Bouts of 100+ steps/min Models: Adjusted for age, sex, center, background and years in the U.S., employment, years between visits and average accelerometer wear time per day and total step volume

Figure 2: Cross-sectional and longitudinal analyses exclusions, HCHS/SOL.

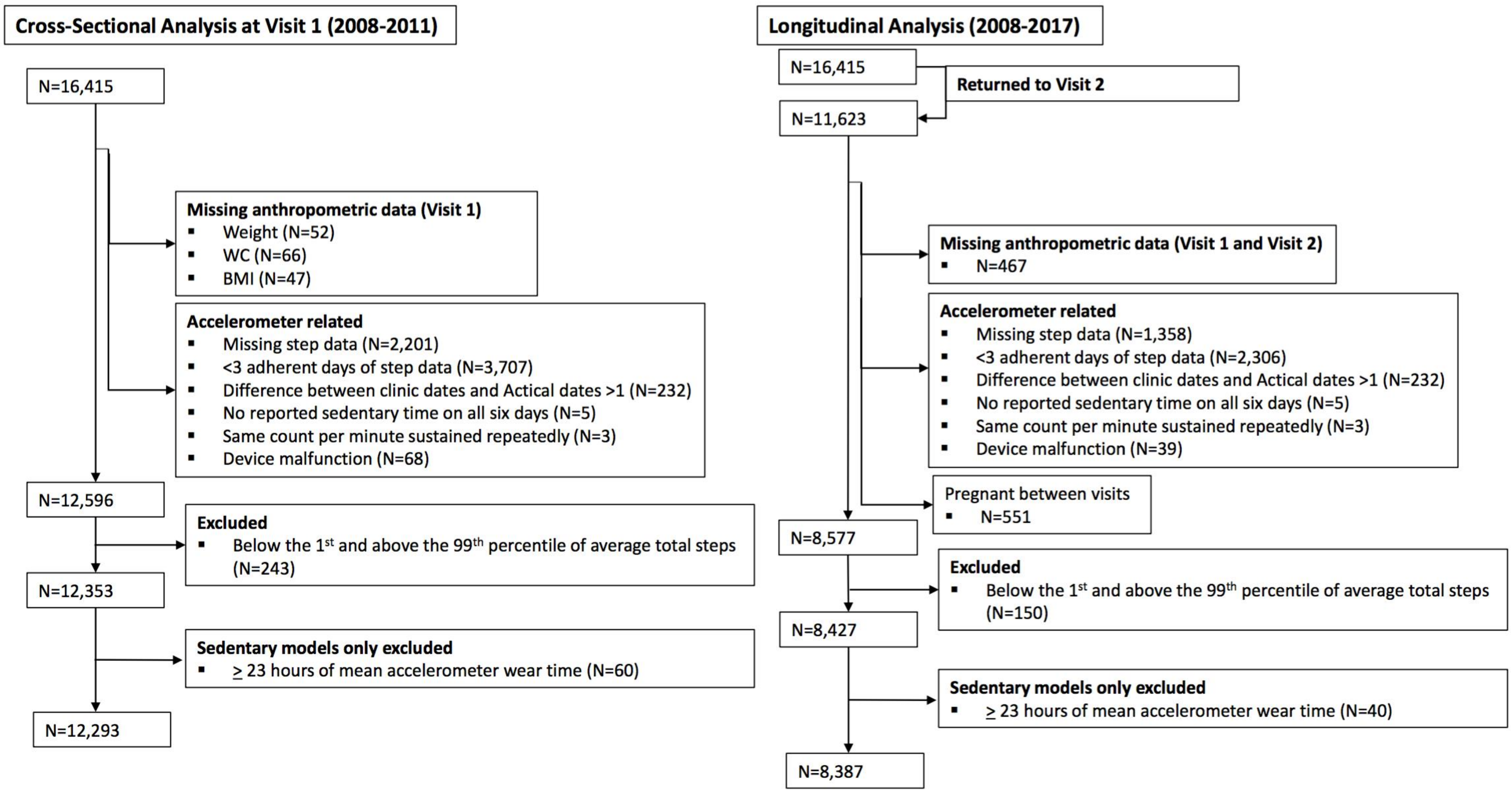
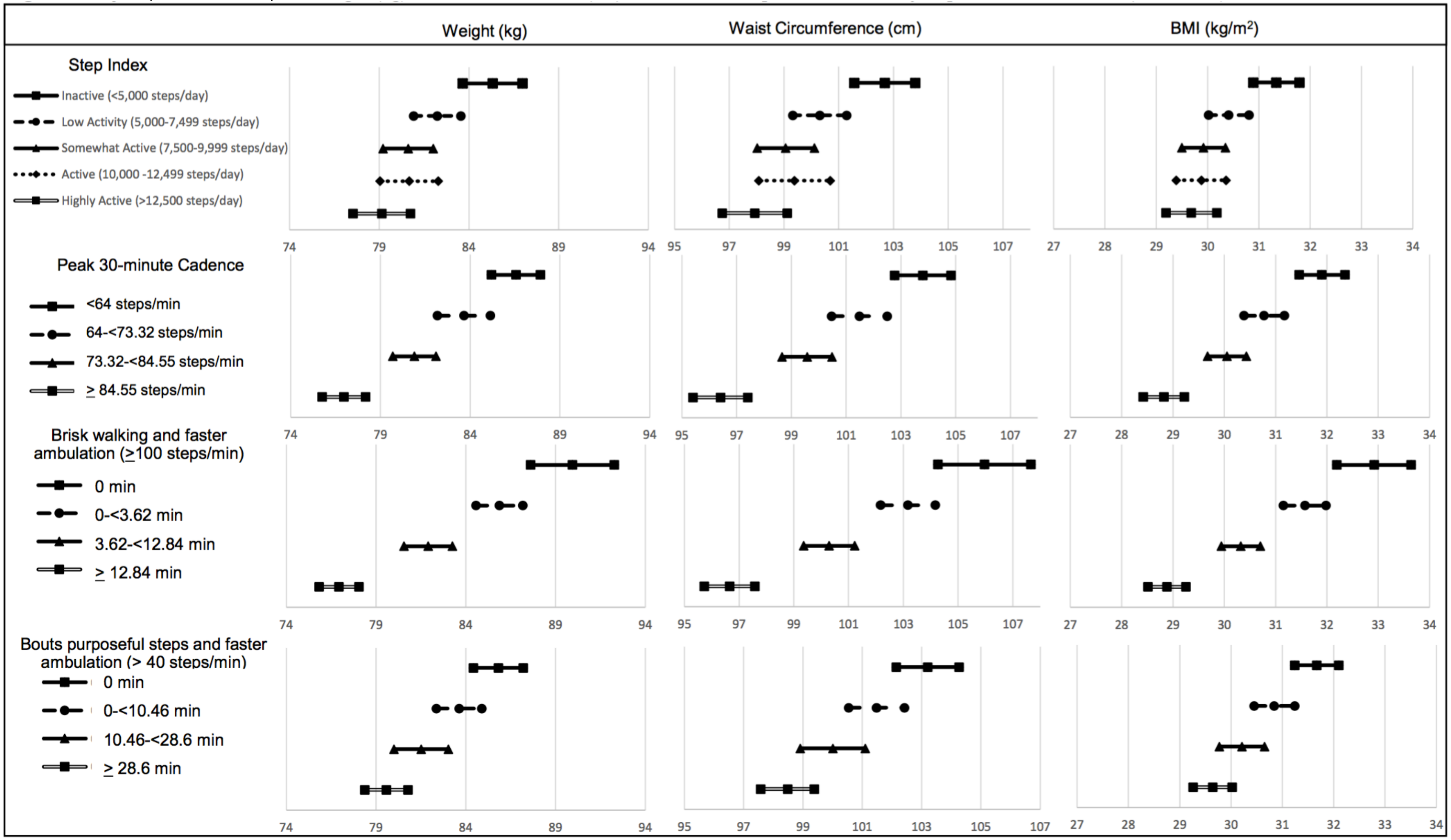


Figure 3: Adjusted means of baseline weight (kg), waist circumference (cm) and BMI and respective 95% CIs by step metrics HCHS/SOL (2008-2011).

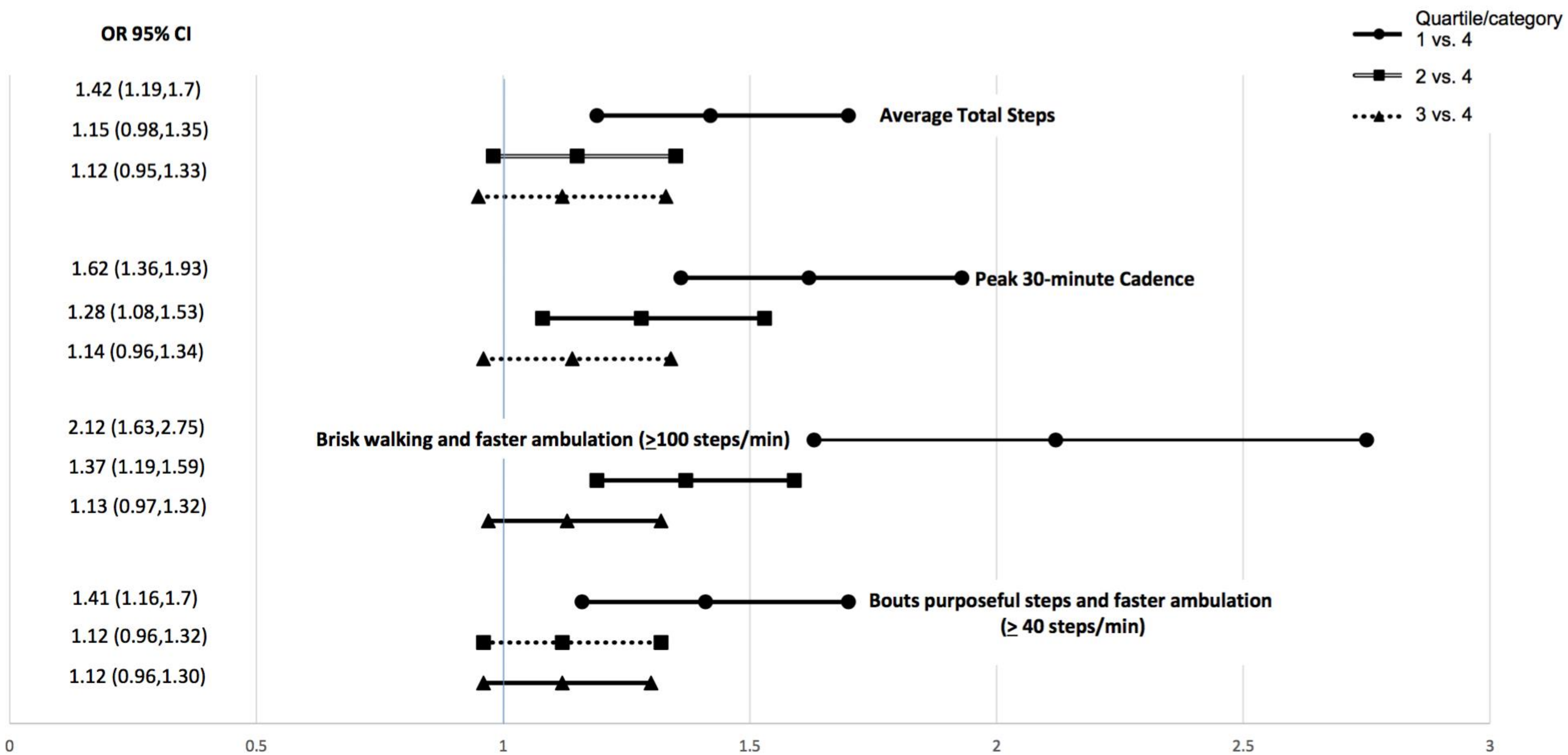


Step index adjusted for: age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations (climbing stairs), smoking, marital status, predicted total energy intake and average accelerometer wear time

Step cadence adjusted for: age, sex, center, background, years in the U.S., mobility limitations climbing stairs, smoking and average accelerometer wear time per day

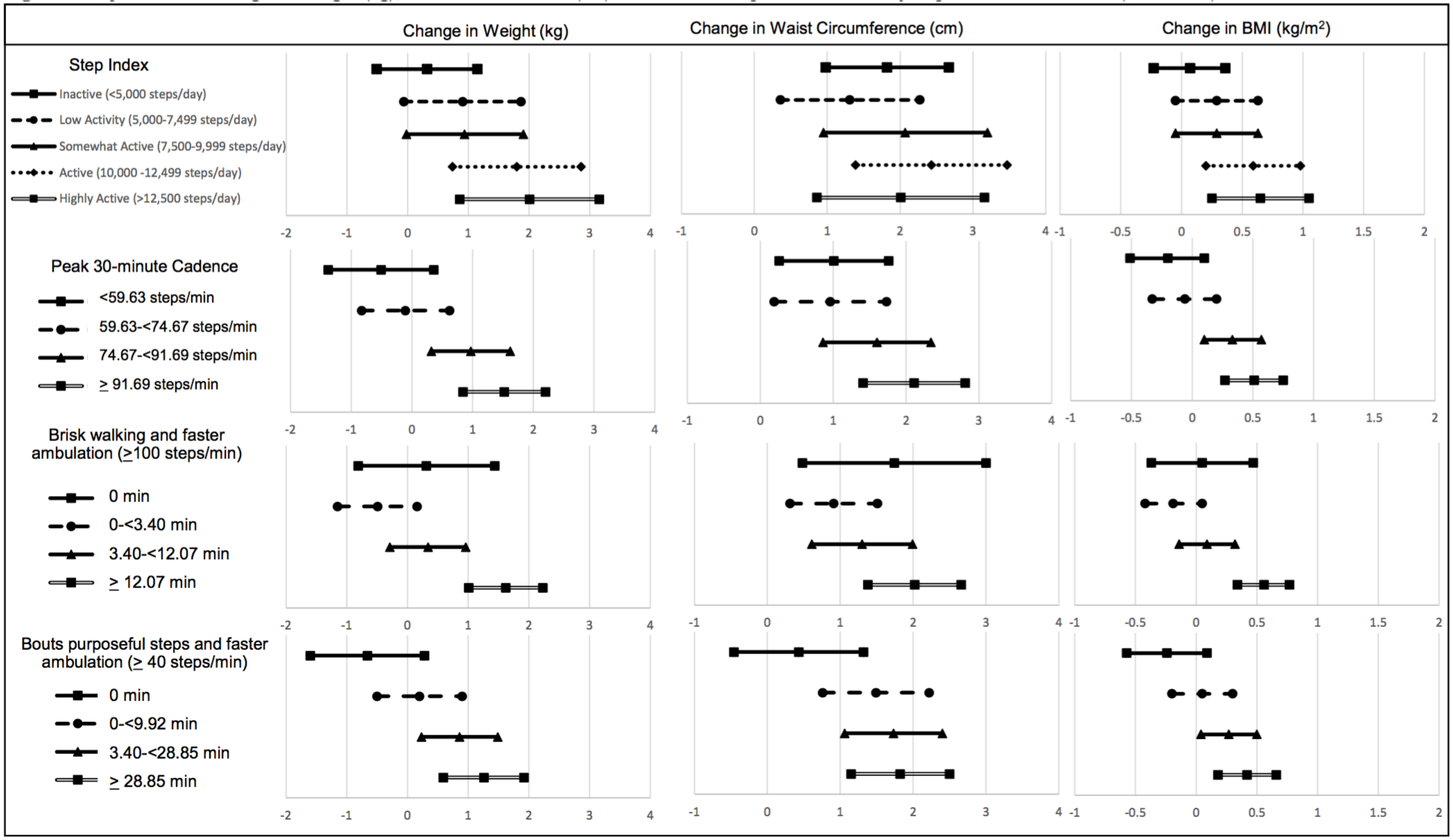
Abbreviations: CI=confidence interval

Figure 4: The odds of obesity and 95% CIs in quartiles 1-3 of step-metrics compared to quartile 4 at baseline HCHS/SOL (2008-2011).



Step index adjusted for: age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations (climbing stairs), smoking, marital status, predicted total energy intake and average accelerometer wear time
Step cadence adjusted for: age, sex, center, background, years in the U.S., mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Abbreviations: OR=odds ratio, CI=confidence interval

Figure 5: Adjusted mean changes in weight (kg), waist circumference (cm) and BMI and respective 95% CIs by step-metrics HCHS/SOL (2008-2011).

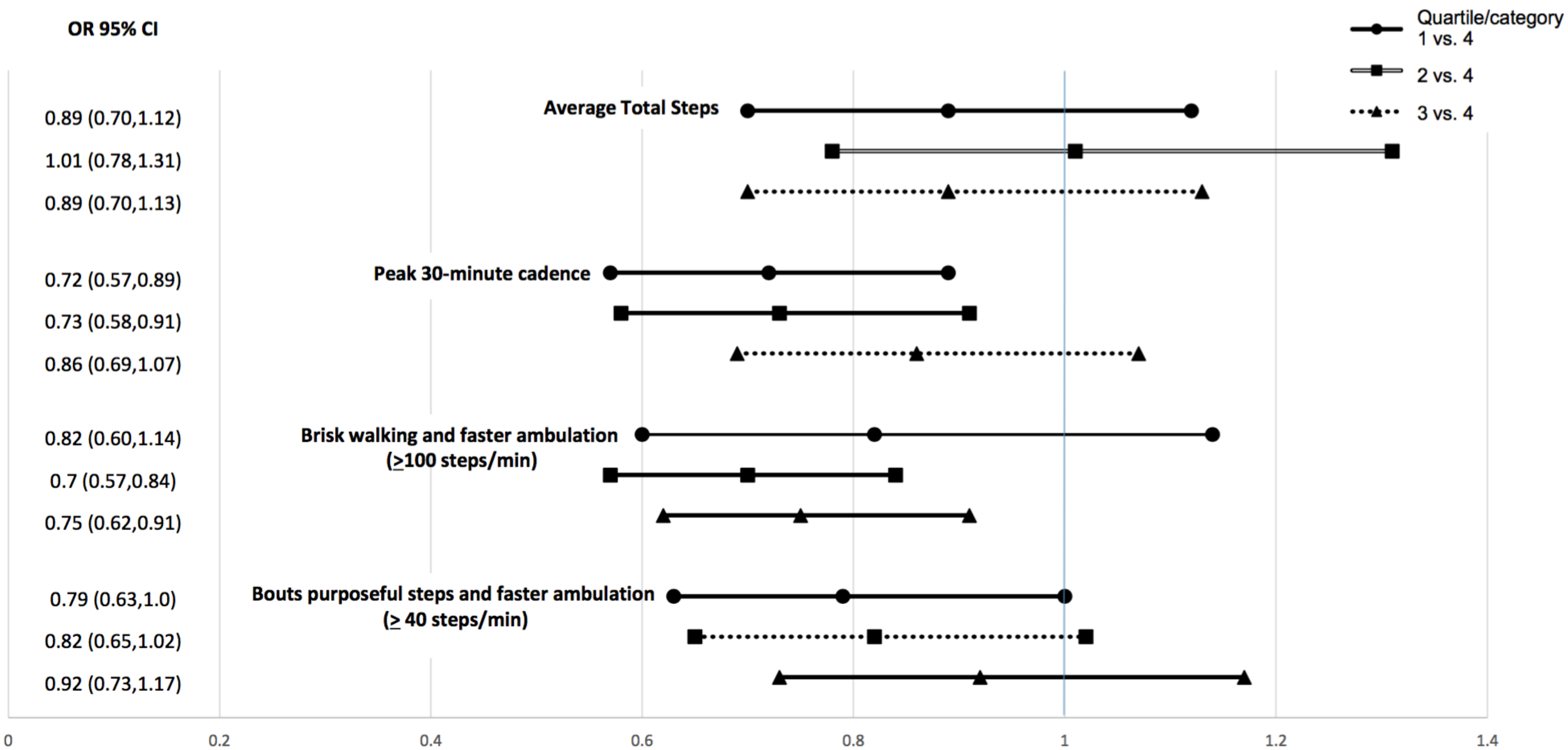


Step index adjusted for age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, and average accelerometer wear time per day

Step cadence adjusted for age, sex, center, background, years in the U.S., employment, years between visits and average accelerometer wear time per day

Abbreviations: CI=confidence interval

Figure 6: The odds of substantially gaining weight and 95% CIs in quartiles 1-3 of step-metrics compared to quartile 4 between baseline and visit 2 HCHS/SOL (2008-2011).



Step index adjusted for age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, and average accelerometer wear time per day

Step cadence adjusted for age, sex, center, background, years in the U.S., employment, years between visits and average accelerometer wear time per day

Abbreviations: CI=confidence interval

CHAPTER 6: THE CROSS-SECTIONAL AND PROSPECTIVE ASSOCIATION OF STEP-BASED METRICS AND BLOOD PRESSURE IN THE HISPANIC COMMUNITY HEALTH STUDY/STUDY OF LATINOS

6.1 Introduction

High BP, defined as a systolic blood pressure (SBP) of >130 mmHg and a diastolic blood pressure (DBP) of >80 mmHg[12], is a global concern. High BP is one of the most important risk factors for cardiovascular disease (CVD)[4] and can be attributed to an estimated 9.7 million CVD-related deaths per year worldwide[5]. Hypertensive individuals are estimated to have approximately $2,000 greater annual healthcare expenditure costs than their non-hypertensive counterparts[6]. Prevalence of hypertension differs by race/ethnicity. In 2017-2018, U.S. (U.S.) Hispanic/Latinos had a lower prevalence of hypertension (44%) than non-Hispanic blacks (57%) and a similar prevalence to non-Hispanic whites (44%)[117]. Hispanic/Latinos are an important population for hypertension prevention efforts as they are a fast-growing population segment with a high 40-year risk of developing hypertension (92%)[8, 295]. Further, in 2016, the age-adjusted mortality rate primarily attributable to hypertension for Hispanic males and females was 20.1 and 15.6 per 100000 persons respectively[38].

Physical activity is a modifiable risk factor for hypertension that can contribute to reductions in BP. A meta-analysis of forty-seven clinical trials found that engaging in aerobic exercise resulted in estimated reductions (exercise-minus-control) in SBP (6 and 2 mm mercury (Hg)) and DBP (5 and 1 mmHg) for normotensive and hypertensive individuals respectively[222].

Step volume (steps/day) and cadence (steps/min) are quantifications of physical activity that can be prescribed to individuals to achieve physical activity recommendations[14]. Inverse dose-response relationships have been found for step volume and health outcomes including all-cause mortality, cardiovascular events, and type 2 diabetes[328]. Relationships between step cadence and health outcomes are less concordant. Null associations between step cadence and all-cause mortality were observed when adjusting for total step volume[265, 329], whereas an inverse association between step cadence and cardiometabolic health was observed specifically among females[86]. Epidemiologic studies exploring relationships between step-based metrics and cardiovascular risk factors including hypertension are needed to inform public health guidance surrounding step volume and cadence and health outcomes.

Associations between step volume, cadence and BP have not been examined among ethnically diverse U.S. of Hispanics/Latinos. This study investigates the cross-sectional and longitudinal relationships of daily step-based metrics and BP.

6.2 Methods

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a community based prospective cohort study designed to describe the prevalence of risk and protective factors for chronic conditions and to quantify all-cause mortality, fatal and non-fatal CVD and pulmonary disease, and pulmonary exacerbation over time in Hispanics/Latinos. Details of the sampling method, design, and implementation have been previously published[309, 310]. The cohort consists of 16,415 self-identified Hispanic/Latino persons aged 18-74 years at screening from randomly selected households in four U.S. field centers (Chicago, IL; Miami, FL; Bronx, NY; San Diego, CA) with baseline clinic examination (2008 to 2011), yearly telephone follow-up for primary endpoints and a follow-up visit in 2014-2017. All participants signed an informed consent. The institutional review boards of each field center, coordinating center, reading centers and the National Heart, Lung, and Blood Institute approved this study. The study was registered at clincaltrials.gov as NCT02060344.

6.2.1 Physical activity and sedentary behavior

At baseline (Visit 1) (2008-2011) cohort members were asked to wear the Actical (model 198-0200-03) on the right hip for 7 days. The Actical captured accelerations in 1-minute epochs. Non-wear time was considered >90 consecutive minutes of zero counts with allowance of 1 or 2 minutes of nonzero counts if no counts occurred in a 30-minute window upstream and downstream of the 90-minute period[320]. Adherence to the accelerometer protocol was defined as at least three days each with > 10 hours of wear time. Additional information regarding accelerometer wear adherence, is available elsewhere[313].

Step volume was categorized as inactive, low activity, somewhat active, active and highly active (<5,000, 5,000-7,499, 7,500-9,999, 10,000-12,499 and, ≥12,500 average total steps respectively)[160]. Step volume was additionally examined by increments of 2,000 steps/day. Cadence indicators were defined by average minutes per day spent sedentary (0 steps/min), in incidental or sporadic movement (1-39 steps/min), in purposeful steps and faster ambulation (40-99 steps/min), and brisk walking and faster ambulation (≥ 100 steps/min)[160, 166, 167]. Average peak 30-minute and 60-minute cadence were defined as the mean steps/min for the highest 30 and 60 minutes of the day, not necessarily consecutive minutes, respectively. Bouts of steps/min were defined by at least 10-minute bouts of purposeful steps and faster ambulation, slow-to-medium steps and faster ambulation, and brisk walking and faster ambulation (≥40 steps/min, ≥ 70 steps/min, ≥ 100 steps/min respectively) with allowance for interruptions up to 20% of the time below the threshold and <5 consecutive minutes below the threshold. Additionally, the bout had to start and end with the defined cadence. Minutes at brisk walking and faster ambulation (>

100 steps/min) were examined as 4 categories (time spent at 0 steps/min and tertiles of steps/min >0). Bouted cadence measures were examined as 4 categories (no bouted time spent at the specified cadence threshold and tertiles of bouted steps/min >0). Minutes spent at different cadence thresholds were categorized as quartiles. Average wear time was calculated as the average hours the accelerometer was worn over the number of adherent days.

6.2.2 Measures of BP

Sitting BP measurements following a 5-minute rest were collected at baseline and Visit 2 using a calibrated automatic sphygmomanometer (the OMRON HEM-907 XL) using a standardized protocol[311]. Three total readings were taken of SBP and DBP and the average of three was recorded. SBP and DBP measurements were analyzed continuously and categorically. Categorization of BP was binary [normal (<120 mm Hg SBP/<80 mm Hg DBP) vs. elevated (120 to 129 mm Hg SBP/<80 mm Hg DBP), hypertensive stage 1 (130 to 139 mm Hg SBP or 80 to 89 mm Hg DBP), hypertensive stage 2 (≥140 mm Hg SBP or ≥90 mm Hg DBP) or taking hypertensive medication (self-reported use for either high BP or hypertension)][12]. Hypertension was also assessed as a binary variable (yes/no) and defined as BP > 130 mm Hg SBP or 80 mm Hg DBP or taking hypertensive medication (self-reported use for either high BP or hypertension). Change in BP was assessed from Visit 1 to Visit 2.

6.2.3 Covariates

Covariates included sociodemographic, behavioral and health characteristics collected at Visit 1. Sociodemographic characteristics were defined as the following: age (continuous), sex (male, female), background (Central American, Cuban, Dominican, Mexican, Puerto Rican, South American, other), center (Bronx, San Diego, Chicago, Miami), years lived in the U.S (<10 years, ≥ 10 years, U.S. born), annual household income (not reported, ≥$30,000 or <$30,000), reported longest held occupation (non-skilled worker, service worker, skilled worker, professional/technical-administrative/executive or staff, other), employment (retired, not retired and not currently employed, employed part-time, employed full-time) and marital status (single, married or living with a partner, separated/divorced or widower). Behavioral characteristics were defined by the following: smoker (never, former, current), alcohol consumption (never, former, current) and predicted total energy intake (National Cancer Institute predicted daily energy intake kcal derived from two 24-hour dietary recalls and a food propensity questionnaire)[322]. Health characteristics were defined by the following: BMI (continuous), depressive symptoms (10 item CES-D summary score continuous)[323] and mobility limitations. Mobility limitations were assessed using 3-point Likert responses to two items assessing moderate activities and their ability to climb a flight of stairs from the Short Form-12 Version 2 (SF-12)[324].

6.2.4 Exclusions

From the 16,415 adults in the study cohort, we included 12,141 cohort members in the cross-sectional analysis. We non-mutually excluded those missing baseline data for SBP (n=14), DBP (n=21), and hypertension medication usage (n=394). We also excluded those missing Actical step data (n=2,201) or those who had <3 adherent days of step data (n=3,707) as well as those with data quality concerns including: differences between clinic dates and Actical dates of > 1 day or missing (n=232), no reported sedentary time on all 6 days (n=5), the same count per minute sustained repeatedly for a large percentage of the day (n=3) or device malfunction (n=68). Lastly, from the remaining sample (n=12,372) we excluded those who fell below the 1st or above the 99th percentile of average total steps (n=231). All sedentary models were further restricted to those with less than 23 hours of mean accelerometer total wear times (cross-sectional models, n=60).

From the 11,623 adults who had Visit 1 and Visit 2 data, we included 9,077 cohort members in the longitudinal analysis. We non-mutually excluded those missing baseline (n=7) and Visit 2 (n=32) measures of SBP as well as baseline (n=12) and Visit 2 (n=28) measures of DBP. We also excluded those missing Actical step data (n=1,358) or those who were not adherent with the accelerometer (n=2,306). We additionally excluded those with Actical data quality concerns including: differences between clinic dates and Actical dates of >1 days or missing (n=232), no reported sedentary time on all 6 days (n=5), the same count per minute sustained repeatedly for a large percentage of the day (n=3) or had an identified device malfunction (n=39). Lastly, from the remaining sample (n=9,246) we excluded those who fell below the 1st or above the 99th percentile of average total steps (n=169). All sedentary models were restricted to those with less than 23 hours of mean accelerometer total wear times (n=40).

6.2.2 Statistical analysis

Sociodemographic, behavioral and health characteristics were summarized by categorized step-volume using means and standard errors for continuous variables and percentages for categorical variables. Complex survey linear regression models were used to separately estimate the association of step volume and cadence with baseline measures of SBP and DBP as well as with measures of change in SBP and DBP. Complex survey logistic regression models were used to separately estimate the baseline odds of hypertension and the odds of elevated BP or higher by quartiles of step volume and cadence. All models were adjusted for age, sex, center, background, and years in the U.S. Longitudinal models were additionally adjusted for years between visits. Models were further adjusted for relevant confounders as identified through a directed acyclic graph. Variables independently resulting in greater than a 10% change between minimally adjusted and additionally adjusted models were considered confounders. In consideration of the distinct constructs step volume, cadence and sedentary time, confounders for each metric were evaluated independently; cross-sectional and longitudinal models were further considered independently. To examine cadence as a predictor independent of step volume and sedentary behavior, additional cadence models was further adjusted for total step volume and percentage of time spent sedentary. All models assessed are show in Appendix Table 1.

A residual approach to account for site-specific wear time variations was used to address multicollinearity between average wear time and sedentary time[252]. Sedentary time and average total steps were regressed on wear-time, field center and the interaction term (site*wear time), and then the resulting residuals were added to the site-specific mean predicted values at 16 hours of wear-time. This method was repeated to address multicollinearity between average total steps and cadence metrics in cadence models adjusting for step volume.

Antihypertensive medication users are different than non-users. Participants may have differing health behaviors that either led them to seek medication use, or modification of behavior after physicians recommended medication. Antihypertensive medication, by design, will lower and control an individual's BP and may do so independently of additional behavioral modifications. We stratified by baseline self-reported antihypertensive medication use (yes/no) for all cross-sectional analyses to address effect measure modification by these medications. Stratification by baseline hypertensive status is insufficient to examine changes in BP over a 6-year period as it does not account for initiation of treatment in-between visits. Exclusion of those beginning antihypertensive treatment between study visits would result in biased estimates as treatment initiation is related to BP status. To prevent bias and address antihypertensive medication use in-between visits, a methodology accounting for systematic differences in BP between those who were and were not treated was used to model longitudinal change in BP under the condition of no treatment (i.e., if no one had received hypertension treatment between study visits). A Cox proportional hazard model was fit for time to the initiation of antihypertensive treatment (estimated based on data from annual telephone follow-up surveys) among those with hypertension at Visit 2, and this fitted model was used to predict the probability of being untreated at Visit 2 for the sub-sample with untreated hypertension at Visit 2. In addition, separate linear regression models were fit for SBP and DBP change between study visits among those with untreated hypertension at Visit 2, and this fitted model was used to obtain predicted values for SBP and DBP change for the sub-sample with untreated hypertension at Visit 2. The Cox proportional hazard model for time to initiation of antihypertensive treatment and the linear regression models for SBP and DBP change controlled for age, sex, center, education, BMI, occupation, income, marital status, alcohol use, cigarette use, years in the U.S., and depression. Modified BP change variables were calculated separately for SBP and DBP in the following way: (1) equal to the observed BP change for the subgroup without hypertension at Visit 2, (2) equal to the predicted value of BP change for the subgroup that used antihypertensive medication at Visit 2, and (3) equal to a weighted combination of the observed BP change and the predicted value of BP change for the subgroup with untreated hypertension at Visit 2, where the weight for the observed BP change equaled the inverse of the predicted probability of being untreated at Visit 2, and the weight for the predicted value of BP change equaled one minus this inverse probability. Then complex survey linear regression models with sampling weights were fit using these modified BP change variables as the response variables[314].

Inverse probability weights (IPW) were used to account for the high percentage of missingness due to non-adherence to the Actical protocol based on variables identified previously[313]. Effect measure modification of the independent relationships between steps per day and BP by sex (female and male), age (18-29, 30-39, 40-49, 50-59 years and >60 years), years in the U.S. (<10, ≥ 10 and U.S. born), and occupation (non-skilled worker, service worker, skilled worker, professional/technical/other office worker and other occupation) were assessed using interaction terms between step-metric and the modifier. A Bonferroni correction was used for the test of interaction terms to adjust for the number of hypotheses tested (0.05/160=<0.00031). All analyses accounted for the complex survey design and survey weights using survey procedures in SAS version 9.4 (SAS Institute).

6.3 Results

6.3.1 Study population characteristics of the cross-sectional analysis

The target population was 60% female and had a mean (± standard error (SE)) age of 41±0.3 years. Adults had a mean baseline SBP and DBP of 120 ± 0.3 mm Hg and 72 ± 0.2 mm Hg and 25% reported hypertension medication use. Adults had a mean step count of 7,818 steps/day (median, 6990 steps/day), mean accelerometer wear time of 16 ± 0.1 hours/day and a mean peak 30 cadence of 76 ± 0.3 steps/min. On average, adults spent 671± 3.8 min/day sedentary, 221± 1.3 min/day in incidental or sporadic movement, 51± 0.6 min/day in purposeful stepping and 12± 0.3 min/day in brisk walking and faster ambulation. Table 32 provides more detail on baseline sociodemographic and lifestyle characteristics by graduated step index.

6.3.2 Cross-sectional associations of step volume and cadence with measures of BP

No consistent associations were observed for cross-sectional relationships between step volume and cadence and continuous measures of BP. No association was observed between step volume and measures of DBP or SBP at baseline (Figure 7). Inverse relationships were observed between DBP and peak 30-minute cadence as well as time spent in bouts of slow to medium steps and faster ambulation (> 70 steps/min) for non-medication users at baseline (Table 33-34). Mean DBP among non-medication users in minimally adjusted models was higher in quartile and category 1 (Q1) (peak 30-minute cadence: 74.0 mmHg (95% CI: 73.3, 74.8) and time spent in bouts of slow to medium steps and faster ambulation: 73.4 mmHg (95% CI: 72.8, 74.1)) than quartile and category 4 (Q4) (peak 30 cadence: 71.8 mmHg (95% CI: 71.1, 72.5) and time spent in bouts of slow to medium steps and faster ambulation: 71.7 mmHg (95% CI: 71.0, 72.4)) (Table 33-34). An inverse relationship was also observed for measures of DBP and minutes spent in 10-minute bouts at purposeful steps and faster ambulation ($\geq$40 steps/min) for hypertension medication users. Mean DBP of time spent in purposeful steps and faster ambulation was higher in category 1 (78.3 mmHg (95% CI: 76.7, 80.0) than category 4 (74.5 mmHg (95% CI: 72.67, 76.4)). All associations were attenuated when adjusted for additional confounders (Table 33-34).

Cross-sectionally, step volume, cadence and time spent sedentary were associated with the odds of hypertension. Those who took the fewest steps (Q1) compared to those who took the most steps (Q4) had odds that were 1.5 times as high (95% CI :1.2, 1.8) and 1.2 times as high (95% CI: 1.0, 1.5) for hypertension and elevated BP or hypertension at baseline respectively (Figure 8). Those in the lowest quartiles and categories of mean peak 30 cadence, time spent in brisk walking and faster ambulation and time spent in bouts of purposeful steps and faster ambulation had 1.4 (95% CI: 1.2, 1.7), 1.5 (95% CI: 1.1, 2.0) and 1.4 times (95% CI:1.1, 1.7) times the odds of baseline hypertension respectively, compared to those in the highest quartile and categories, respectively (Figure 2). Those who spent the least time sedentary (Q1) had odds that were 0.7 (95% CI: 0.6, 0.9) as high for hypertension at baseline compared to those who spent the least amount of time sedentary (Q4) (Figure 8).

Significant interactions between age and the following cadence measures were found for SBP and DBP among solely hypertension medication users: peak 30-minute cadence, peak 60-minute cadence, time spent in incidental or sporadic movement, time spent in bouts of purposeful movement and faster ambulation and time spent in bouts of brisk walking and faster ambulation. No interaction was found between step-based metrics and sex, occupation or years in the U.S. for SBP or DBP among either hypertensive medication users or non-medication users. No consistent patterns were demonstrated between quartiles of step-metrics by age category. However, 18–29-year-olds demonstrated significant differences between mean SBP and DBP by categories of physical activity; all other ages did not have significant differences in SBP or DBP by category of physical activity (Appendix Tables 36-46).

6.3.3 Longitudinal associations of step volume and cadence with measures of BP

Over a 6-year period, the cohort had a mean change in SBP and DBP of 1.3 (95% CI: 0.8, 1.8) and 0.4 (95% CI: 0.0, 0.7), respectively and 46% of the cohort was considered hypertensive. No associations were found for longitudinal analyses of step-based metrics and 6-year changes in continuous SBP or DBP. Interactions between age, sex, occupation and years in the U.S. and step-based metrics for changes in BP were non-significant.

6.4 Discussion

In this large community-based cohort with accelerometer measured physical activity, we found cross-sectional associations between step volume, cadence and sedentary behaviors with the prevalence of hypertension. The odds of hypertension was greater among those who took fewer average daily steps, spent less time at a faster cadence and spent more time sedentary. No cross-sectional associations were found between step-based metrics and continuous BP levels nor between step-based metrics and 6-year changes in BP.

The present study is the first to our knowledge to assess the cross-sectional and longitudinal relationships between accelerometer measured physical activity (i.e. step volume, cadence and sedentary time) and BP among a diverse urban Hispanic/Latino cohort. Previous literature has examined the cross-sectional relationships between step volume and cadence in non-Hispanic populations[15-19, 86, 268, 287]. Sumner et al.[19] examined the relationship between step volume and intensity and cardiometabolic outcomes in the cross-sectional Singapore Health Study (N=635, mean age=48.4 years) and found significant inverse associations between average peak 30 and 60-minute cadence with measures of SBP and DBP as well as positive associations between time spent sedentary and DBP. However, these findings were attenuated with the addition of BMI to the models. The study also found no associations between step volume and measures of BP. In the present study, relationships found for step volume, cadence and sedentary behavior and hypertension, conceptually align with the inverse findings of Sumner et al. Contrastingly, our continuous assessment of SBP and DBP demonstrated no associations with either step volume or cadence. Further, our study found that inclusion of BMI did not attenuate categorical findings. Previous studies have found that Asian populations have a higher risk of hypertension at the same BMI as non-Hispanic whites, suggesting population variations for relationships between BMI and BP[333]. Relationships between BMI and BP may differ between Hispanic and non-Hispanic populations and can potentially explain our contrasting findings.

Previous cross-sectional analyses have demonstrated differing findings compared to the present study, for interactions with step-based metrics. Johansen et. al[18] conducted a cross-sectional analysis of the Copenhagen City Heart Study consisting of non-Hispanic adults > 20 years of age (N= 4543). This study found significant interactions between physical activity and age where reduced sedentary time with increased walking time resulted in lower SBP among older adults. While we found significant interactions with age, relationships between step-based metrics and mean adjusted SBP and DBP were found among younger adults (18-29 years of age) rather than older adults[18]. Within the U.S., Tudor-Locke et al.[86] used the National Health and Nutrition Examination Survey (NHANES) 2005-06 dataset to examine the relationships between step volume and peak 30-minute cadence with cardiometabolic outcomes by sex in a heterogeneous U.S. population (49.6% Caucasian, 23.2% African American, 20.2% Mexican American, and 7.0% Other). Tudor-Locke et al. found significant inverse cross-sectional associations between step volume and BP amongst males and inverse associations for peak 30-minute cadence for females[86]. Antithetically, we found non-significant interactions between either sex and step volume and sex and average peak 30-minute cadence, suggesting non-differential associations between males and females in our study.

The present study found no linear associations between changes in BP and step-volume or cadence. Contrastingly, there is a large body of research demonstrating BP reduction in response to randomized control trials (RCTs) of walking interventions. Several meta-analyses of these trials found engaging in walking interventions resulted in reductions in both SBP and DBP [267, 284-286, 290, 291] with two finding significant inverse relationships for DBP only[266, 283]. In observational research, Menai et al.[288] examined the longitudinal relationship between step-volume and a one-month change in BP across 37 countries and found an increase of >3,000 steps/day was associated with decreases in SBP and DBP among overweight and obese populations but not normal weight populations. Shorter study lengths of prior research may be contributing to these differing findings.

Methods to account for hypertensive medication use may be driving the differences seen for cross-sectional associations of step metrics with continuous versus categorical BP outcomes.

BP examined continuously was stratified by baseline hypertensive medication usage, whereas, BP examined categorically included hypertensive medication usage (yes/no) as part of the definition of hypertension (BP > 130 mmHg SBP or 80 DBP mmHg or taking hypertensive medication (self-reported use for either high BP or hypertension). Decisions in evaluating BP continuously and categorically should consider the impact of how to address hypertensive medication use

Our study has several strengths. We studied a large diverse group of U.S. Hispanics/Latinos with robust measures of BP and accelerometer measured physical activity. Quality control measures were put in place by HCHS/SOL protocols to ensure proper calibration and standardization of equipment and readings which reduces variability and observer bias. Assessment of BP at multiple visits allows for longitudinal assessment of changes in BP. Use of a validated device for this analysis provides robust estimates of physical activity among the cohort. The step count function of the Actical accelerometer has good validity at a usual walk (83 m·min−1) and run speeds (133 m·min−1)[326]. Further, we were able to control for multiple confounders. Additional strengths include our methods to account for the complex survey sampling design, attrition and beginning antihypertensive medication use between visits. Use of sampling weights, IPW and doubly robust estimating equations help limit bias that would otherwise have been introduced in our estimates. Our results should be considered in light of several limitations. Potential misclassification of steps is a limitation. Driving in a vehicle such as a truck may have simulated step movement that the accelerometer captured, thus inflating the amount of steps an individual may have taken. Careful examination has been given to accelerometer readings of prolonged or abnormal amounts of steps to avoid misclassification. An additional limitation is that longitudinal analyses examining change in measures of BP are bound by our lack of assessment of physical activity and steps over the follow-up period. An additional limitation of this study is that generalizability is limited to the HCHS/SOL cohort's target population of non-institutionalized Hispanic/Latino adults aged 18-74 years residing in the four sampled areas.

6.5 Conclusion

This study of accelerometer measured step-based metrics and measures of BP in a cohort of Hispanic/Latinos in the US demonstrated cross-sectional associations between step volume and cadence with hypertension. No associations between step-based metrics and changes in BP over a 6-year period were found. Additional longitudinal studies are needed to further understand the relationship between changes in step-based metrics and changes in BP over time.

Table 31: Models assessed for each step-metric.

Cross-sectional and prospective models	Volume (step index)	Steps per minute, peak cadence and bouts of steps/min	Sedentary
Minimally adjusted models	Model 1: Adjusted for age, sex, center, background and years in the U.S.		
Further adjusted based on 10% significant change from minimally adjusted models	Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day		
Adjusted for percentage of time spent sedentary	N/A	Model 3: Adjusted for Model 2+percentage of time spent sedentary	N/A
Adjusted for total step volume	N/A	Model 4: Adjusted for Model 2+total step volume*	N/A
Adjusted for total step volume and percentage of time spent sedentary	N/A	Model 5: Adjusted for model 4+percentage of time spent sedentary*	
Longitudinal models (change in BP)	**Volume (step index)**	**Steps per minute, peak cadence and bouts**	**Sedentary**
Minimally adjusted models	Model 1: Adjusted for age, sex, center, background and years in the U.S.		
Further adjusted based on 10% significant change from minimally adjusted models	Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, average accelerometer wear time per day and years between visits	Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, cigarette use, marital status, income, average accelerometer wear time per day and years between visits	Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, alcohol use, cigarette use, marital status, income, average accelerometer wear time per day and years between visits
Adjusted for percentage of time spent sedentary	N/A	Model 3: Adjusted for Model 2 + percentage of time spent sedentary	N/A

Adjusted for total step volume	N/A	Model 4: Model2 + total step volume	N/A
Adjusted for total step volume and percentage of time spent sedentary	N/A	Model 5: Model 2+ percentage of time spent sedentary	N/A

***** Only assessed among peak cadence and bouts of steps/min

Table 32. Graduated Step Index Distribution by Baseline Characteristics among adults (*n*=12,141); HCHS/SOL (2008-2011) **

	N	Sedentary (<5,000 average total steps) (*n*= 3527)	Low active (5,000-7,499 average total steps) (*n* =3209)	Somewhat active (7,500-9,999 average total steps) (*n* =2371)	Active (10,000 - 12,499 average total steps) (*n* = 1472)	Highly Active (>12,500 average total steps) (*n* = 1533)
%		29.1	26.5	19.6	12.2	12.7
Age (SE), years		39.4 (0.6)	39.3 (0.5)	40.7 (0.4)	44.2 (0.5)	39.0 (0.5)
Sex (%)						
Men	4785	57.0	65.3	42.6	37.1	50.1
Women	7327	43.0	34.7	57.4	63.0	49.9
Ethnicity (%)						
Central American	1233	7.8	5.9	7.1	7.8	8.7
Cuban	1637	14.8	11.8	19.6	31.7	15.7
Dominican	1119	12.3	9.1	11.4	7.5	11.2
Mexican	4963	39.9	43.6	37.9	31.2	38.8
Puerto Rican	1986	16.8	20.5	14.2	14.1	16.3
South American	819	5.1	5.3	5.4	4.2	5.8
Mixed Other or missing	329	3.2	4.0	4.4	3.6	3.6
Center (%)						
Bronx	3015	34.0	37.4	27.3	21.4	31.6
Chicago	3180	17.5	18.1	15.2	14.0	16.2
Miami	2836	22.5	20.0	29.6	41.1	26.3
San Diego	3081	25.9	24.5	27.9	23.5	26.0
Education (%)						
No High School or GED	4640	32.7	34.7	30.3	31.7	33.3
High School or GED	3035	26.9	32.5	27.4	26.5	27.9
Above High School or GED	4413	40.4	32.8	42.3	41.8	38.8
Employment*						
Employed full time	4143	40.2	49.1	32.8	22.3	37.0
Employed part time	2057	19.2	21.2	15.2	15.1	18.5
Not currently employed	5780	40.6	29.7	52.0	62.6	44.5

Income						
<$30,000	7736	71.5	67.3	65.3	64.2	66.7
≥$30,000	3699	28.5	32.7	34.7	35.8	33.3
Longest held occupation						
Non-skilled worker	3578	31.7	32.0	23.8	21.3	23.4
Service worker	1721	13.6	14.6	14.5	17.7	17.7
Skilled worker	2635	21.9	22.2	20.9	20.8	23.3
Professional/technical, administrative/executive	1729	13.1	9.1	18.0	18.3	16.9
Other	2325	19.8	22.1	22.8	22.0	18.7
Years in the U.S.						
U.S. born	1956	24.6	24.7	21.8	20.8	23.1
>10 years in the U.S.	7312	49.7	48.2	49.1	49.7	47.7
<10 years in the U.S.	2830	25.7	27.1	29.1	29.5	29.2
Smoking (%)						
Never	7435	62.5	58.9	63.6	60.9	64.0
Former	2481	17.0	19.2	16.9	18.9	15.2
Current	2182	20.4	21.9	19.5	20.2	20.9
Marital Status (%)						
Single	3067	37.1	36.7	31.9	32.4	37.7
Married/Living with a Partner	6508	49.7	49.5	51.6	46.8	48.9
Separated/Divorced/Widow(er)	2509	13.3	13.8	16.5	20.9	13.4
Symptoms of Depression						
CESD10[†] score mean ± SE		6.2 (0.2)	6.6 (0.2)	6.9 (0.2)	7.4 (0.2)	6.7 (0.2)
Accelerometer wear time mean ± SE		16.4 (0.1)	17.2 (0.1)	15.7 (0.1)	15.2 (0.1)	16.1 (0.1)
Total energy intake (kcal) mean ± SE		2048.3 (23.4)	2120.0 (23.9)	1954.4 (15.1)	1895.5 (14.2)	1994.6 (19.2)
Baseline SBP (mmHg) mean ± SE		121.4 (0.5)	119.3 (0.4)	118.7 (0.6)	119.0 (0.6)	120.0 (0.5)
Baseline DBP (mmHg) mean ± SE		73.2 (0.3)	71.8 (0.4)	71.6 (0.4)	71.4 (0.4)	71.3 (0.4)
Baseline BMI (kg/m^2)		28.6 (0.2)	28.5 (0.2)	29.3 (0.2)	30.4 (0.2)	29.0 (0.3)
Hypertension medication use (%)						
No	10021	90.8	92.7	87.6	81.5	90.5
Yes	2091	9.2	7.3	12.5	18.5	9.5
Mobility limitations moderate[¥]						

Yes, limited a lot	979	4.2	5.6	6.5	10.1	4.7
Yes, limited a little	1844	10.7	10.1	11.5	15.9	11.4
No, not limited at all	9272	85.1	84.3	82.0	74.0	83.9
Mobility limitations climbing several flights of stairs						
Yes, limited a lot	1414	5.7	7.7	9.8	13.1	7.8
Yes, limited a little	2622	15.2	16.3	17.5	22.5	18.2
No, not limited at all	8054	79.1	76.0	72.7	64.4	74.0

*Employed full time: >35 hours/week in one job or more than one job, employed part time ($\leq$ 35 hours/week)

†10-Item Center for Epidemiology Depression Scale (CES-D10)

¥ Activities such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

**All statistics are weighted and account for HCHS/SOL complex survey design

Table 33: Cross-sectional adjusted means of SBP (mmHg) and DBP (mmHg) by baseline hypertension medication use and quartile of average peak 30-minute cadence, HCHS/SOL (2008-2011).

Peak 30-minute Cadence			
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Steps/min	Model 1	Model 2	Model 3
Q1 (<60.18)	122.1 (121.28, 122.93)	121.85 (120.65, 123.04)	122.13 (120.88, 123.39)
Q2 (60.18->74.83)	120.53 (119.64, 121.42)	120.84 (119.61, 122.06)	120.91 (119.69, 122.13)
Q3 (74.83->91.65)	121.23 (120.39, 122.08)	121.34 (120.12, 122.57)	121.28 (120.05, 122.51)
Q4 (91.65+)	120.81 (119.94, 121.69)	121.06 (119.69, 122.43)	120.91 (119.51, 122.31)
p-value	0.03	0.26	0.14
Mean Diastolic Blood Pressure (mmHg)			
Q1 (<60.18)	74.02 (73.25, 74.79)	72.53 (71.65, 73.42)	72.28 (71.34, 73.23)
Q2 (60.18->74.83)	72.7 (71.88, 73.52)	71.92 (70.96, 72.88)	71.86 (70.9, 72.81)
Q3 (74.83->91.65)	72.78 (72.1, 73.46)	72.16 (71.31, 73.01)	72.22 (71.36, 73.07)
Q4 (91.65+)	71.81 (71.14, 72.47)	71.94 (71.02, 72.86)	72.07 (71.14, 73.01)
p-value	<0.01	0.47	0.81
Hypertension Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Steps/min	Model 1	Model 2	Model 3
Q1 (<60.18)	133.09 (130.62, 135.57)	133.52 (130.48, 136.56)	133.52 (130.41, 136.63)
Q2 (60.18->74.83)	134.17 (131.33, 137)	134.1 (130.83, 137.37)	134.1 (130.84, 137.36)
Q3 (74.83->91.65)	133.44 (130.8, 136.09)	133.38 (130.22, 136.54)	133.37 (130.28, 136.47)
Q4 (91.65+)	131.44 (128.14, 134.73)	130.79 (127.14, 134.44)	130.79 (127.08, 134.5)
p-value	0.53	0.27	0.31
Mean Diastolic Blood Pressure (mmHg)			
Q1 (<60.18)	77.63 (76.12, 79.14)	77.66 (75.77, 79.54)	77.81 (75.91, 79.72)
Q2 (60.18->74.83)	77.91 (76.2, 79.61)	77.81 (75.94, 79.67)	77.77 (75.9, 79.63)
Q3 (74.83->91.65)	75.51 (74, 77.01)	75.81 (74.16, 77.45)	75.65 (74.01, 77.3)
Q4 (91.65+)	75.56 (73.23, 77.9)	76.2 (73.7, 78.7)	76.03 (73.49, 78.58)
p-value	0.02	0.1	0.05

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Table 34: Cross-sectional adjusted means of SBP (mmHg) and DBP (mmHg) by baseline hypertension medication use and minutes per day spent in 10 minute bouts of ≥ 40 steps/min and ≥70 steps/min HCHS/SOL (2008-2011).

Bouts purposeful steps and faster ambulation (≥ 40 steps per minute)			
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Minutes	Model 1	Model 2	Model 3
<0	121.22 (120.3, 122.14)	121.2 (119.93, 122.48)	121.35 (120.02, 122.69)
0->10.47	121.58 (120.73, 122.42)	121.81 (120.56, 123.06)	121.89 (120.64, 123.13)
10.47->28.80	120.68 (119.8, 121.56)	120.89 (119.62, 122.16)	120.91 (119.64, 122.18)
≥28.80	121.27 (120.48, 122.07)	121.37 (120.15, 122.6)	121.26 (120.01, 122.52)
p-value	0.43	0.33	0.27
Mean Diastolic Blood Pressure (mmHg)			
<0	73.62 (72.79, 74.45)	72.26 (71.32, 73.2)	72.01 (71.03, 72.98)
0->10.47	72.98 (72.21, 73.74)	72.17 (71.25, 73.09)	72.04 (71.1, 72.98)
10.47->28.80	72.67 (71.98, 73.36)	72.18 (71.31, 73.04)	72.14 (71.28, 73.01)
≥28.80	72.29 (71.63, 72.95)	72.03 (71.15, 72.9)	72.21 (71.32, 73.11)
p-value	0.03	0.95	0.97
Hypertension Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Steps/min	Model 1	Model 2	Model 3
<0	132.98 (130.27, 135.69)	133.39 (129.87, 136.91)	133.55 (129.91, 137.19)
0->10.47	134.92 (132.2, 137.65)	134.84 (131.69, 138)	134.89 (131.73, 138.05)
10.47->28.80	133.94 (131.56, 136.32)	133.92 (131.13, 136.71)	133.87 (131.1, 136.64)
≥28.80	130.47 (127.32, 133.61)	129.96 (126.44, 133.47)	129.68 (126.01, 133.35)
p-value	0.04	0.02	0.02
Mean Diastolic Blood Pressure (mmHg)			
<0	78.32 (76.67, 79.98)	78.16 (76.04, 80.28)	78.36 (76.23, 80.5)
0->10.47	78.1 (76.49, 79.71)	78.17 (76.36, 79.97)	78.23 (76.45, 80.01)
10.47->28.80	76.5 (74.99, 78.02)	76.62 (74.96, 78.27)	76.55 (74.89, 78.21)
≥28.80	74.53 (72.66, 76.4)	75.01 (72.99, 77.04)	74.65 (72.54, 76.77)
p-value	<0.01	<0.01	<0.01
Bouts slow to medium walking and faster ambulation (≥ 70 steps per minute)			
No Medication Use			

	Mean Systolic Blood Pressure (mmHg)		
Minutes	Model 1	Model 2	Model 3
<0	121.57 (120.88, 122.27)	121.69 (120.55, 122.83)	121.76 (120.61, 122.91)
0->6.57	120.84 (119.94, 121.74)	120.87 (119.54, 122.19)	120.91 (119.58, 122.23)
6.57->16.83	121.1 (120.15, 122.04)	121.36 (120.11, 122.61)	121.36 (120.11, 122.6)
≥16.83	120.79 (119.77, 121.81)	120.89 (119.51, 122.27)	120.85 (119.47, 122.24)
p-value	0.4	0.34	0.28
	Mean Diastolic Blood Pressure (mmHg)		
<0	73.41 (72.77, 74.05)	72.26 (71.45, 73.08)	72.17 (71.34, 72.99)
0->6.57	73.11 (72.34, 73.89)	72.28 (71.36, 73.2)	72.23 (71.3, 73.15)
6.57->16.83	72.55 (71.73, 73.36)	72.15 (71.2, 73.1)	72.15 (71.2, 73.1)
≥16.83	71.69 (70.97, 72.42)	71.73 (70.8, 72.66)	71.78 (70.85, 72.71)
p-value	<0.01	0.54	0.73
	Hypertension Medication Use		
	Mean Systolic Blood Pressure (mmHg)		
	Model 1	Model 2	Model 3
<0	133.11 (130.95, 135.26)	133.28 (130.38, 136.17)	133.27 (130.36, 136.17)
0->6.57	135.91 (132.98, 138.85)	135.53 (132.14, 138.93)	135.55 (132.18, 138.93)
6.57->16.83	132.68 (129.74, 135.63)	132.75 (129.63, 135.86)	132.76 (129.66, 135.87)
≥16.83	130.28 (127.21, 133.36)	129.62 (126.21, 133.04)	129.66 (126.21, 133.1)
p-value	0.01	0.01	0.01
	Mean Diastolic Blood Pressure (mmHg)		
<0	77.36 (76, 78.72)	77.34 (75.58, 79.11)	77.35 (75.59, 79.11)
0->6.57	78.27 (76.56, 79.98)	78.12 (76.29, 79.95)	78.11 (76.28, 79.94)
6.57->16.83	76.23 (74.36, 78.1)	76.51 (74.41, 78.61)	76.5 (74.4, 78.61)
≥16.83	74.52 (72.42, 76.61)	75.07 (72.8, 77.34)	75.05 (72.76, 77.35)
p-value	0.01	0.07	0.07

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Table 35: Longitudinal adjusted mean changes of SBP (mmHg) and DBP (mmHg) by and graduated step index level, HCHS/SOL (2008-2011).

	Mean Change in Systolic Blood Pressure (mmHg)		
Average total steps	Model 1	Model 2	Model 3
Inactive (<5,000)	1.12 (-0.11, 2.34)	0.97 (-0.39, 2.32)	0.83 (-0.86, 2.52)
Low Activity (5,000-7,499)	1.42 (0.18, 2.67)	1.17 (-0.26, 2.59)	1.02 (-0.79, 2.82)
Somewhat Active (7,500-9,999)	3.04 (1.76, 4.32)	2.68 (1.25, 4.12)	2.52 (0.77, 4.27)
Active (10,000 -12,499)	2.04 (0.67, 3.4)	1.32 (-0.15, 2.79)	1.1 (-0.65, 2.86)
Highly Active (>12,500)	1.5 (0.01, 2.99)	1.03 (-0.66, 2.72)	0.79 (-1.21, 2.78)
p-value	0.13	0.17	0.16
	Mean Change in Diastolic Blood Pressure (mmHg)		
	Model 1	Model 2	Model 3
Inactive (<5,000)	-1.24 (-2.09, -0.39)	-1.16 (-2.1, -0.22)	-0.99 (-2.16, 0.18)
Low Activity (5,000-7,499)	-0.7 (-1.61, 0.21)	-0.72 (-1.72, 0.28)	-0.55 (-1.8, 0.71)
Somewhat Active (7,500-9,999)	0.56 (-0.4, 1.51)	0.36 (-0.7, 1.42)	0.55 (-0.78, 1.88)
Active (10,000 -12,499)	0.19 (-1.01, 1.4)	-0.11 (-1.39, 1.17)	0.07 (-1.34, 1.48)
Highly Active (>12,500)	-0.2 (-1.18, 0.78)	-0.38 (-1.44, 0.68)	-0.25 (-1.52, 1.03)
p-value	0.02	0.09	0.09

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, average accelerometer wear time per day and years between visits
Model 3: Adjusted for Model 2 + alcohol use, cigarette use, marital status, income

Table 36: p-values for interactions of step-metrics with sex, years in the U.S. and age categories for mean BP by baseline hypertensive medication use

				Step Index				
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.74	0.18	0.25	<0.01	0.33	0.54	0.82	0.03
DBP	0.48	0.1	0.16	<0.01	0.31	0.58	0.18	0.28
				Peak 30-minute Cadence				
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.25	0.97	0.06	<0.01	0.27	0.43	0.31	0.55
DBP	0.77	0.38	0.13	<0.01	0.64	0.56	0.15	0.53
				Peak 60-minute Cadence				
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.36	0.73	0.32	<0.01	0.16	0.4	0.26	0.04
DBP	0.3	0.01	0.41	<0.01	0.67	0.3	0.27	0.19
				Minutes per day Spent Sedentary (0 steps/min)				
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.9	0.36	0.02	0.6	0.67	0.87	0.76	0.41
DBP	0.22	0.39	0.35	0.31	0.69	0.86	0.03	0.08
				Minutes per day Spent in Incidental or Sporadic Movement (1-39 steps/min)				
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.57	0.35	0.17	<0.01	0.83	0.54	0.46	0.06
DBP	0.23	0.94	0.3	<0.01	0.98	0.62	0.07	0.01
				Minutes per day Spent in Purposeful Stepping and Faster Ambulation (40-99 steps/min)				
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.4	0.4	0.62	0.34	0.32	0.07	0.77	0.23
DBP	0.29	<0.01	0.42	0.05	0.04	0.09	0.11	0.16

Minutes per day Spent in Brisk Walking and Faster Ambulation (≥100 steps/min)								
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.44	0.03	0.05	0.08	0.06	0.07	0.39	0.14
DBP	0.43	0.06	<0.01	0.12	0.2	0.25	0.32	0.65
Bouts Purposeful Steps and Faster Ambulation (≥ 40 steps per minute)								
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.03	0.3	<0.01	<0.01	0.5	0.41	0.43	0.19
DBP	0.23	0.23	0.01	<0.01	0.1	0.26	0.44	0.25
Bouts Slow-to-medium Steps and Faster Ambulation (≥ 70 steps per minute)								
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.29	0.05	0.28	0.12	0.7	0.72	0.67	0.37
DBP	0.01	0.1	0.06	0.11	0.53	0.28	0.11	0.58
Bouts Brisk Walking and Faster Ambulation (≥ 100 steps per minute)								
	Hypertension Medication Use				***No Medication Use***			
	Sex	Occupation.	Years in the U.S	Age	Sex	Occupation.	Years in the U.S	Age
SBP	0.46	0.2	0.46	<0.01	0.45	0.7	0.43	0.05
DBP	0.02	0.22	0.06	<0.01	0.43	0.77	0.58	0.87

Step volume models adjusted for: age, sex, center, background, years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use, average accelerometer wear time per day and interaction term

Step cadence models adjusted for: age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use, average accelerometer wear time per day and interaction term

Sedentary models adjusted for: age, sex, center, background and years in the U.S., education, employment, occupation, income mobility limitation moderate, mobility limitation climbing stairs, marital status, predicted energy intake, alcohol usage, smoking, accelerometer wear time per day and interaction term

Table 37. p-values for cross-sectional multivariable adjusted means of SBP and DBP by quartile of average peak 30-minute cadence and age category.

No Medication Use					
Mean SBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.95	0.44	0.63	0.14	0.40
Q3	0.11	0.42	0.91	0.27	0.32
Q4	0.14	0.16	0.80	0.59	0.05
Mean DBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.05	0.26	0.64	1.00	0.92
Q3	0.63	0.01	0.96	0.78	0.51
Q4	0.10	0.03	1.00	0.63	0.84
Hypertensive Medication Use					
Mean SBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	<0.0001	0.10	0.45	0.34	0.15
Q3	<0.0001	0.18	0.19	0.74	0.80
Q4	0.0001	0.92	0.77	0.35	0.04
Mean DBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.09	0.12	0.53	0.85	0.33
Q3	<0.0001	0.54	0.20	0.09	0.03
Q4	<0.01	0.77	0.87	0.04	0.82

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 38. Mean baseline SBP and DBP by quartile of average peak 30-minute cadence and age category.

			No Medication Use		
			Mean SBP		
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
Q1	114.83 (113.24,116.43)	118.69 (117.02,120.37)	126.98 (124.92,129.03)	135.98 (133.48,138.49)	110.53 (108.87,112.18)
Q2	114 (111.89,116.11)	118.21 (116.54,119.88)	125.14 (123.33,126.95)	134.35 (131.2,137.5)	110.47 (108.77,112.16)
Q3	114.08 (112.26,115.9)	118.58 (116.89,120.27)	125.41 (123.31,127.5)	133.96 (130.92,137.01)	111.96 (110.38,113.54)
Q4	113.43 (111.53,115.32)	118.46 (116.83,120.08)	126.14 (123.45,128.83)	131.34 (127.18,135.5)	111.82 (110.04,113.6)
			Mean DBP		
Q1	68.2 (66.8,69.61)	72.22 (70.87,73.56)	73.64 (72.39,74.88)	74.99 (73.86,76.12)	73.98 (72.27,75.68)
Q2	66.61 (65.25,67.96)	71.1 (69.37,72.84)	73.24 (71.84,74.65)	75 (73.84,76.16)	73.85 (71.54,76.16)
Q3	67.85 (66.64,69.06)	70.35 (69.03,71.68)	73.6 (72.47,74.74)	75.22 (73.87,76.58)	73.24 (71.68,74.8)
Q4	66.88 (65.64,68.11)	70.56 (69.28,71.83)	73.63 (72.37,74.89)	74.55 (72.89,76.2)	73.71 (71.5,75.93)
			Hypertensive Medication Use		
			Mean SBP		
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
Q1	125 (112.09,137.9)	127.16 (122,132.33)	129.84 (126.13,133.55)	138.46 (134.53,142.38)	109.66 (103.05,116.27)
Q2	139.29 (127.6,150.99)	130.17 (123,137.33)	132.07 (127.61,136.52)	135.04 (130.78,139.3)	131.5 (122,140.99)
Q3	114.07 (105.37,122.77)	130.95 (126.31,135.59)	130.51 (126.56,134.47)	139.12 (134.21,144.03)	76.46 (69.73,83.19)
Q4	125.74 (118.12,133.36)	126.21 (120.46,131.96)	127.44 (122.55,132.33)	133.2 (128.26,138.14)	132.63 (121.62,143.64)
			Mean DBP		
Q1	71.99 (67.37,76.62)	80.13 (69.1,91.16)	79.74 (76.37,83.1)	79.03 (76.91,81.16)	75.52 (73.24,77.79)
Q2	78.3 (71.92,84.67)	90.9 (83.03,98.77)	81.4 (76.78,86.02)	79.29 (76.8,81.79)	74.27 (71.84,76.69)
Q3	41.89 (37.98,45.81)	75.86 (69.27,82.45)	82.22 (79.38,85.06)	76.93 (74.72,79.13)	73.1 (71,75.2)
Q4	62.2 (56.86,67.54)	82.11 (74.47,89.75)	79.33 (75.2,83.46)	75.91 (73.07,78.75)	75.11 (71.57,78.64)

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 39. p-values for multivariable baseline adjusted means of SBP and DBP by quartile of average peak 60-minute cadence and age category.

	18-29	30-39	40-49	50-59	≥60 years
No Medication Use					
Mean SBP					
Q1	REF	REF	REF	REF	REF
Q2	0.56	0.65	0.84	0.06	0.40
Q3	0.07	0.01	0.57	0.38	0.39
Q4	0.33	0.39	0.94	0.35	0.02
Mean DBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.18	0.24	0.33	0.25	1.00
Q3	0.59	<0.01	0.39	0.53	0.94
Q4	0.04	0.03	0.94	0.41	0.66
Hypertensive Medication Use					
Mean SBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	<0.0001	0.50	0.51	0.55	0.02
Q3	<0.0001	0.16	0.28	0.34	0.76
Q4	0.001	0.43	0.55	0.23	0.03
Mean DBP					
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.11	0.43	0.55	0.36	0.16
Q3	<0.0001	0.64	0.26	0.001	0.02
Q4	0.001	0.63	0.38	0.01	0.49

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 40. Mean baseline SBP and DBP by quartile of average peak 60-minute cadence and age category.

	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
No Medication Use					
Mean SBP					
Q1	114.99 (113.38,116.6)	118.68 (117.03,120.33)	127.1 (125.02,129.17)	135.28 (132.72,137.85)	110.45 (108.74,112.16)
Q2	114.53 (112.49,116.56)	118.48 (116.76,120.2)	124.93 (123.28,126.58)	137 (133.78,140.22)	110.93 (109.34,112.52)
Q3	112.63 (110.95,114.3)	118.1 (116.52,119.67)	125.92 (123.87,127.98)	133.6 (130.73,136.46)	112.16 (110.5,113.81)
Q4	114.12 (112.23,116)	118.61 (116.97,120.25)	125.6 (122.98,128.22)	129.31 (125.05,133.57)	111.28 (109.52,113.04)
Mean DBP					
Q1	68.18 (66.77,69.59)	72.39 (71.05,73.73)	73.91 (72.68,75.15)	75.2 (74.05,76.34)	73.87 (72.16,75)
Q2	67.13 (65.83,68.44)	71.27 (69.62,72.92)	73.1 (71.66,74.53)	74.47 (73.37,75.56)	73.87 (71.56,76.19)
Q3	67.77 (66.51,69.03)	69.85 (68.54,71.17)	73.3 (72.21,74.38)	75.67 (74.36,76.98)	73.79 (72.29,75.29)
Q4	66.54 (65.29,67.79)	70.74 (69.5,71.98)	73.86 (72.6,75.11)	74.4 (72.76,76.05)	73.25 (70.86,75.64)
Hypertensive Medication Use					
Mean SBP					
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
Q1	129.46 (114.07,144.85)	126.98 (121.73,132.23)	130.76 (127,134.53)	139.29 (135.47,143.11)	110.12 (103.34,116.89)
Q2	136.04 (124.3,147.79)	129.44 (122.69,136.18)	132.13 (127.86,136.41)	134.47 (130.43,138.5)	131.34 (122.08,140.6)
Q3	116.52 (107.57,125.48)	130.19 (125.7,134.69)	128.81 (124.78,132.84)	138.48 (133.4,143.56)	76.84 (70.18,83.49)
Q4	122.51 (113.99,131.03)	129.13 (122.53,135.73)	127.59 (122.71,132.47)	133.02 (127.88,138.15)	132.56 (120.97,144.15)
Mean DBP					
Q1	72.11 (67.52,76.7)	82.54 (70.93,94.16)	79.36 (75.92,82.8)	80.01 (77.9,82.12)	75.79 (73.59,77)
Q2	77.9 (71.62,84.18)	88.3 (79.74,96.86)	80.88 (76.52,85.23)	78.8 (76.54,81.06)	74.04 (71.69,76.4)
Q3	42.01 (38.15,45.88)	79.26 (73.69,84.84)	81.52 (78.82,84.22)	75.83 (73.58,78.08)	72.97 (70.73,75.22)
Q4	61.96 (56.94,66.99)	78.97 (70.45,87.49)	81.75 (76.99,86.51)	76.17 (73.35,78.99)	74.58 (71.19,77.96)

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 41. p-values for multivariable cross-sectional adjusted means of SBP and DBP by quartile of incidental or sporadic movement and age category.

			No Medication Use		
			Mean SBP		
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.05	0.74	0.33	0.62	0.18
Q3	0.90	0.04	0.81	0.77	0.14
Q4	0.18	0.80	0.23	0.29	0.31
			Mean DBP		
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	0.57	0.53	0.23	0.54	0.42
Q3	<0.01	0.40	0.36	0.77	0.70
Q4	0.08	0.59	0.91	0.69	0.64
			Hypertensive Medication Use		
			Mean SBP		
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	<0.0001	0.86	0.09	0.32	0.08
Q3	0.60	0.94	0.07	0.96	0.61
Q4	0.01	0.63	0.62	0.58	1.00
			Mean DBP		
	18-29	30-39	40-49	50-59	≥60 years
Q1	REF	REF	REF	REF	REF
Q2	<0.0001	0.04	0.10	0.54	0.55
Q3	0.33	0.90	0.10	0.28	0.25
Q4	0.12	<0.01	0.21	0.09	0.41

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 42. Mean baseline SBP and DBP by quartile of incidental or sporadic movement and age category.

No Medication Use					
Mean SBP					
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
Q1	110.66 (109.05,112.27)	113.79 (111.86,115.72)	125.49 (123.31,127.67)	132.58 (129.81,135.35)	118.41 (116.58,120.24)
Q2	112.32 (110.64,114)	113.43 (111.65,115.2)	126.22 (124.01,128.42)	135.43 (131.98,138.88)	117.43 (115.9,118.96)
Q3	110.76 (109.2,112.33)	116.15 (114.2,118.11)	125.83 (123.9,127.75)	135.18 (132.48,137.87)	118.66 (117.08,120.23)
Q4	112.02 (110.23,113.8)	113.53 (111.74,115.32)	126.75 (124.77,128.74)	134.57 (131.73,137.41)	119.74 (118.16,121.31)
Mean DBP					
Q1	68.29 (67.06,69.51)	72.07 (70.65,73.49)	73.89 (72.52,75.27)	74.94 (73.66,76.22)	73.24 (71.62,74.85)
Q2	67.93 (66.7,69.15)	70.46 (69.25,71.67)	72.94 (71.74,74.13)	75.44 (74.25,76.64)	74.29 (71.91,76.68)
Q3	66.16 (64.87,67.45)	72.19 (70.55,73.82)	73.11 (71.76,74.46)	74.71 (73.47,75.96)	73.62 (72.17,75.06)
Q4	66.84 (65.43,68.26)	69.49 (68.16,70.81)	74 (72.83,75.16)	74.63 (73.23,76.02)	73.74 (72.17,75.3)
Hypertensive Medication Use					
Mean SBP					
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
Q1	115.23 (103.27,127.2)	123.34 (113.33,133.35)	129.08 (125.4,132.77)	137.58 (133.75,141.41)	124.45 (118.58,130.32)
Q2	76.38 (69.68,83.09)	125.13 (110.54,139.72)	131.48 (126.77,136.19)	133.04 (128.7,137.38)	131.18 (124.5,137.85)
Q3	121.83 (99.45,144.21)	123.92 (114.53,133.31)	129.19 (124.74,133.63)	138.94 (134.06,143.82)	130.84 (126.05,135.63)
Q4	132.57 (124.81,140.33)	127.38 (114.04,140.71)	130.24 (126.19,134.28)	137.59 (132.12,143.06)	126.2 (120.9,131.49)
Mean DBP					
Q1	69.66 (64.06,75.25)	78.61 (70.65,86.57)	77.64 (73.94,81.35)	79.15 (76.89,81.42)	74.36 (72.02,76.69)
Q2	42.18 (38.38,45.99)	82.34 (74.34,90.35)	81.93 (77.77,86.09)	78.3 (75.85,80.75)	73.5 (71.2,75.81)
Q3	77.87 (61.99,93.75)	84.36 (75.54,93.18)	81.6 (78.06,85.13)	77.64 (75.22,80.06)	75.95 (73.52,78.38)
Q4	76.33 (69.29,83.37)	82.26 (71.96,92.55)	80.53 (77.21,83.85)	76.98 (74.76,79.19)	75.56 (72.9,78.22)

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 43. p-values for multivariable cross-sectional adjusted means of SBP and DBP by minutes spent in bouts of ≥ purposeful steps and faster ambulation (≥ 40 steps/min) and age category.

No Medication Use					
Mean SBP					
Minutes	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->10.47	0.01	0.86	0.21	0.61	0.53
10.47->28.80	0.02	0.42	0.77	0.53	0.03
≥28.80	0.03	0.86	0.47	0.91	0.02
Mean DBP					
	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->10.47	0.75	0.84	0.45	0.69	0.10
10.47->28.80	0.32	0.45	1.00	0.96	0.06
≥28.80	0.51	0.52	0.35	0.65	0.15
Hypertensive Medication Use					
Mean SBP					
	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->10.47	0.08	0.44	0.47	0.88	0.06
10.47->28.80	<0.0001	0.44	0.97	0.35	0.87
≥28.80	<0.001	0.09	0.43	0.07	0.43
Mean DBP					
	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->10.47	0.10	0.56	0.54	0.97	0.35
10.47->28.80	<0.0001	0.70	0.85	0.39	0.06
≥28.80	0.08	0.15	0.66	0.002	0.15

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 44. Mean baseline SBP and DBP by time spent in bouts of purposeful steps and faster ambulation (≥ 40 steps/min)and age category.

	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
Hypertensive Medication Use					
Mean SBP					
<0	109.51 (107.76,111.26)	117.9 (116.05,119.74)	126.33 (124.23,128.44)	136.99 (133.97,140)	114.41 (112.02,116.8)
0->10.47	112 (110.3,113.7)	119.23 (117.63,120.83)	125.68 (123.69,127.66)	135.77 (133.09,138.44)	114.19 (112.44,115.93)
10.47->28.80	111.75 (110.03,113.48)	118.21 (116.54,119.88)	125.53 (123.69,127.37)	132.12 (128.74,135.5)	113.39 (111.59,115.19)
≥28.80	111.5 (109.9,113.1)	118.59 (117.02,120.15)	126.51 (124.04,128.98)	131.77 (128.4,135.14)	114.65 (112.94,116.36)
Mean DBP					
<0	67.19 (65.54,68.84)	71.48 (69.39,73.58)	73.15 (71.8,74.49)	74.9 (73.69,76.12)	75.34 (73.3,77.39)
0->10.47	67.5 (66.1,68.9)	71.26 (69.98,72.54)	73.78 (72.42,75.13)	74.61 (73.44,75.79)	73.26 (71.4,75.12)
10.47->28.80	68.1 (66.98,69.22)	70.67 (69.42,71.93)	73.15 (71.97,74.32)	74.94 (73.77,76.11)	73.04 (71.46,74.61)
≥28.80	66.63 (65.46,67.79)	70.77 (69.54,71.99)	73.83 (72.64,75.01)	75.32 (73.72,76.91)	73.28 (71.21,75.36)
Hypertensive Medication Use					
Mean SBP					
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
<0	107.86 (98.78,116.94)	130.55 (121.81,139.29)	130.88 (126.43,135.32)	136.36 (132.23,140.48)	134.98 (117.09,152.87)
0->10.47	121.9 (108.94,134.86)	127.26 (122.32,132.2)	130.52 (126.62,134.42)	140.91 (136.43,145.4)	126.53 (114.17,138.89)
10.47->28.80	77.54 (70.7,84.39)	130.7 (126,135.41)	132.87 (128.96,136.77)	136.72 (133.27,140.16)	127.23 (118.31,136.16)
≥28.80	132.09 (120.73,143.45)	126.79 (121.69,131.89)	126.26 (121.95,130.57)	133.98 (128.17,139.8)	118.65 (111.54,125.77)
Mean DBP					
<0	68.7 (62.09,75.32)	87.31 (74.96,99.65)	81.94 (76.02,87.86)	79.38 (77.07,81.69)	75.44 (73.19,77.68)
0->10.47	75.97 (70.03,81.92)	82.75 (73.74,91.76)	80.02 (77.09,82.96)	79.42 (77.25,81.6)	76.65 (74.16,79.14)

10.47- >28.80	42.59 (38.76,46.41)	84.56 (78.1,91.03)	81.37 (78.44,84.3)	78.37 (76.28,80.47)	73.43 (71.49,75.37)
≥28.80	61.78 (56.52,67.04)	77.25 (71.3,83.2)	80.46 (76.9,84.01)	75.06 (72.54,77.57)	73.2 (70.32,76.08)

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 45. p-values for multivariable adjusted means of SBP and DBP by quartile of bouts of ≥ 100 steps/min and age category.

			No Medication Use		
			Mean SBP		
Minutes	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->4.77	0.26	0.83	0.15	0.93	0.02
4.77->11.61	0.30	0.73	0.62	0.39	0.01
≥11.61	0.49	0.45	0.74	0.16	0.13
			Mean DBP		
	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->4.77	0.64	0.84	0.71	0.62	0.10
4.77->11.61	0.93	0.48	0.22	0.87	0.27
≥11.61	0.23	0.54	0.85	0.36	0.19
			Hypertensive Medication Use		
			Mean SBP		
	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->4.77	<0.0001	0.93	0.94	0.92	0.66
4.77->11.61	0.53	0.97	0.83	0.02	0.53
≥11.61	0.15	0.45	0.77	0.34	0.02
			Mean DBP		
	18-29	30-39	40-49	50-59	≥60 years
<0	REF	REF	REF	REF	REF
0->4.77	<0.0001	0.84	0.88	0.75	0.52
4.77->11.61	0.42	0.15	0.71	0.002	0.42
≥11.61	<0.0001	0.16	0.96	0.35	0.58

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Table 46. Mean baseline SBP and DBP by time spent in bouts of brisk walking and faster ambulation (≥ 100 steps/min) and age category.

	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
No Medication Use					
Mean SBP					
Minutes	111.09 (109.67,112.51)	114.08 (112.58,115.59)	118.45 (117.16,119.74)	136.2 (134.34,138.06)	125.76 (124.36,127.15)
<0	112.1 (110.22,113.98)	114.36 (111.92,116.8)	119.91 (117.74,122.08)	132.15 (128.96,135.33)	125.89 (122.82,128.96)
0->4.77	111.99 (110.04,113.94)	114.52 (112,117.04)	117.92 (115.86,119.97)	129.96 (125.31,134.61)	124.75 (122.39,127.11)
4.77->11.61	110.5 (108.61,112.38)	113.26 (111.05,115.47)	118.06 (115.76,120.36)	130.5 (123.25,137.75)	128.16 (124.58,131.73)
Mean DBP					
<0	67.55 (66.49,68.61)	71.18 (70.05,72.32)	73.63 (72.67,74.6)	74.76 (73.84,75.68)	74.36 (73.06,75.66)
0->4.77	67.18 (65.62,68.74)	71.03 (69.28,72.78)	73.94 (72.26,75.63)	75.24 (73.36,77.12)	72.49 (70.32,74.65)
4.77->11.61	67.48 (65.96,69)	70.42 (68.35,72.49)	72.73 (71.34,74.12)	74.64 (73.18,76.11)	72.65 (69.79,75.51)
<0	66.65 (65.17,68.14)	70.7 (69.14,72.26)	73.43 (71.47,75.39)	75.88 (73.47,78.3)	72.53 (69.87,75.19)
Hypertensive Medication Use					
Mean SBP					
	18-29 years	30-39 years	40-49 years	50-59 years	≥60 years
<0	120.02 (108.38,131.67)	125.77 (117.21,134.34)	128.84 (124.32,133.36)	137.5 (134.19,140.8)	130.72 (127.35,134.08)
0->4.77	76.64 (69.85,83.43)	126.47 (114.66,138.28)	129.08 (123,135.16)	138.83 (132.96,144.69)	130.98 (126.35,135.61)
4.77->11.61	Non-est	125.97 (118.23,133.71)	127.96 (120.31,135.6)	135.22 (128.32,142.12)	125.5 (120.69,130.32)
<0	131.97 (119.75,144.19)	121.42 (113.75,129.08)	127.82 (121.68,133.97)	131.18 (125.61,136.74)	128.01 (121.99,134.02)
Mean DBP					
<0	74.93 (69.52,80.33)	82.78 (76.66,88.89)	80.84 (78,83.67)	78.46 (76.7,80.22)	74.99 (73.13,76.84)

0->4.77	41.94 (38.11,45.76)	81.84 (74.89,88.78)	81.17 (76.85,85.49)	79.01 (75.66,82.36)	73.95 (70.62,77.28)
4.77->11.61	Non-est	88.41 (83.98,92.85)	79.78 (74.71,84.84)	74.86 (72.43,77.29)	73.59 (70.2,76.97)
<0	61.86 (56.88,66.83)	76.87 (71.34,82.4)	80.72 (76.95,84.5)	76.99 (73.64,80.34)	73.84 (69.86,77.82)

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Figure 7: Adjusted means of SBP mmHg and DBP mmHg by increments of daily average total steps; HCHS/SOL (2008-2011).

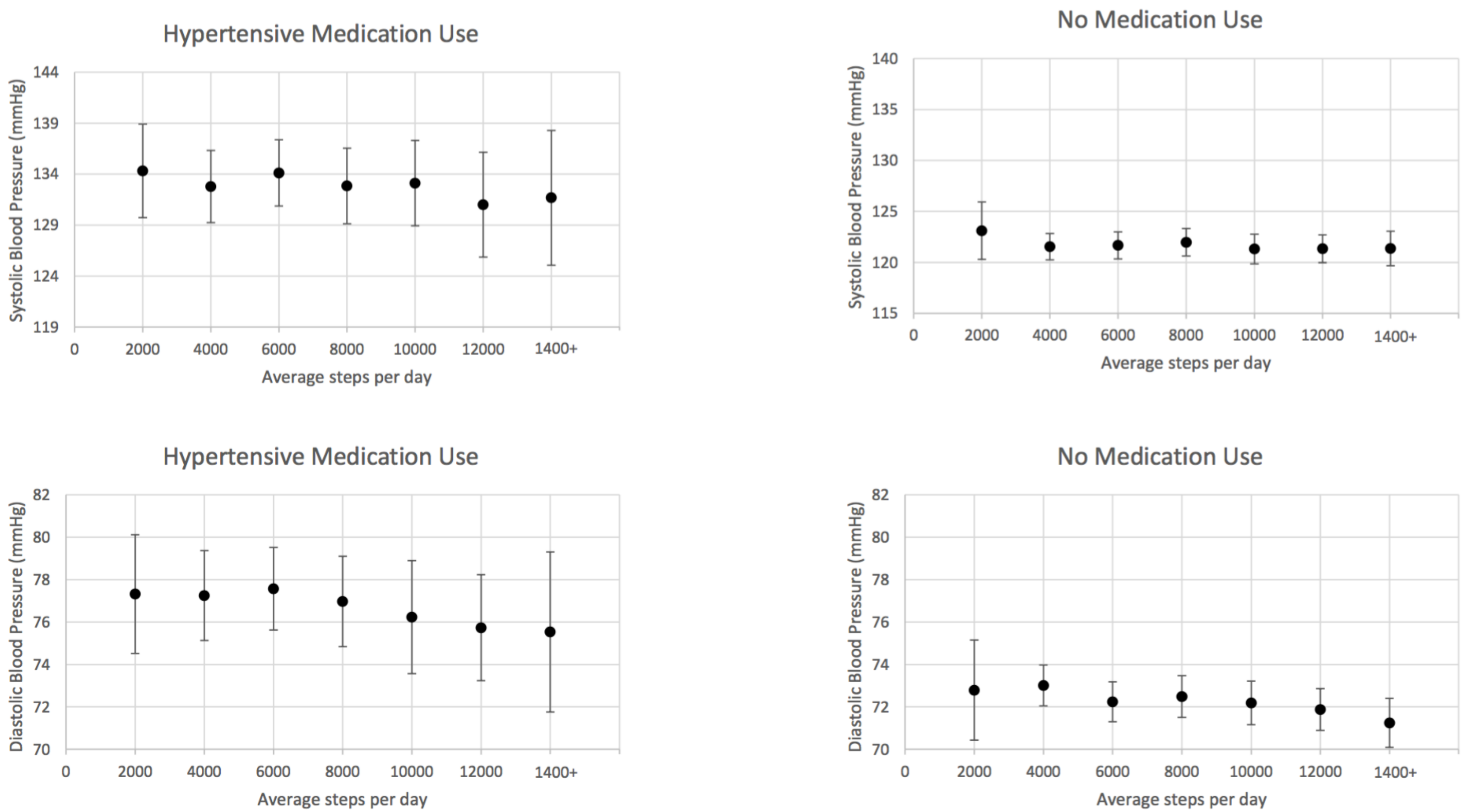
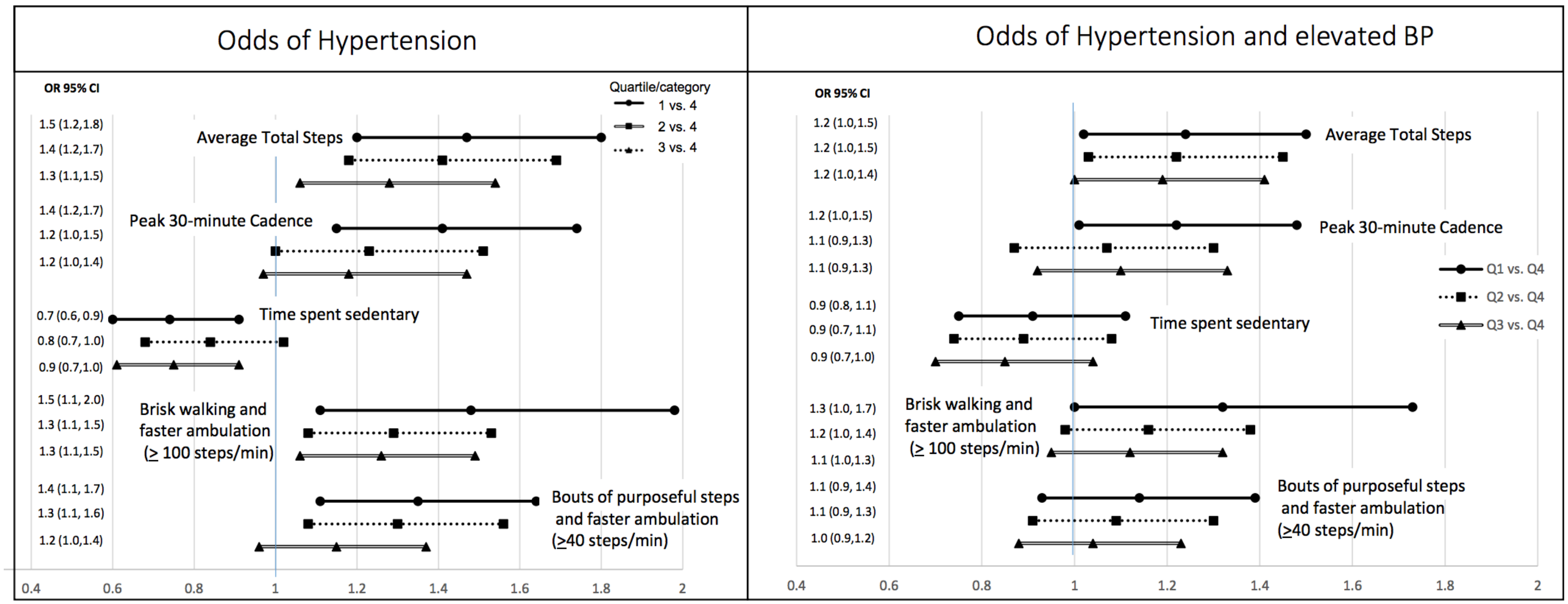


Figure 8: Adjusted odds of AHA defined hypertension status by quartiles of average total steps, average peak 30 cadence, average time spent in brisk walking and faster ambulation and average time spent in bouts of 10 minutes of purposeful steps and faster ambulation (≥40 steps/min; HCHS/SOL (2008-2011)).



Abbreviations: OR=odds ratio, CI=confidence interval

CHAPTER 7: CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

7.1 Summary of findings

This doctoral research investigated how step volume and cadence are associated with cross-sectional and longitudinal measures of adiposity and BP in a U.S. Hispanic/Latino cohort. These findings support the conclusion that higher step volumes and cadence have an inverse cross-sectional relationship with weight, WC, BMI and odds of hypertension. Moreover, engaging in higher step cadence has a positive longitudinal relationship with weight and BMI.

The cross-sectional association of step volume and cadence and measures of adiposity

Engaging in higher step volume was inversely associated with continuous measures of adiposity. Inactive adults with step volumes of <5,000 steps/day had higher measures of weight (kg), WC (cm) and BMI (kg/m^2) compared to highly active adults talking >12,500 steps/day. Additionally, those in the lowest quartile of step volume had 1.4 95% CI (1.2, 1.7) times the odds of obesity than those in the highest quartile of step volume. An inverse relationship was observed between quartiles of peak 30-minute cadence, time spent in brisk walking and faster ambulation ($\geq$100 steps/min) and time spent in bouts of purposeful stepping and faster ambulation ($\geq$ 40 steps/min) and all measures of adiposity. Compared to those in the highest quartiles of peak 30-minute cadence, those in the lowest quartiles had 1.6 95% CI (1.4, 1.9) times the odds of obesity. Compared to those who spent the most time in brisk walking and faster ambulation, those who spent the least time had 2.1 95% CI (1.6, 2.8) times the odds of obesity. Compared to those who spent the most time in bouts of purposeful stepping and faster ambulation those who spent the least amount of time had 1.4 95% CI (1.2, 1.7) times the odds of obesity. Time spent sedentary was not associated with baseline measures of adiposity. Associations demonstrated between step volume and cadence and cross-sectional measures of adiposity are consistent with prior research. Given the cross-sectional nature of these findings, the potential for reverse causation cannot be ruled out, however, our findings suggest engaging in higher step-volumes and cadences may promote improved measures of adiposity.

The longitudinal association of step volume and cadence and measures of adiposity

Step volume and time spent sedentary were not associated with changes in measures of adiposity over a 6-year time period. Step cadence was positively associated with changes in weight and BMI. Those in the lowest quartiles and categories of peak 30-minute cadence and time spent in bouts of purposeful stepping and faster ambulation (≥ 40 steps/min) had smaller changes in weight and BMI. Those in the second lowest category of time spent in brisk walking and faster ambulation had smaller changes in weight and BMI compared to the highest category. Consistently, those in the lowest compared to highest quartile and category of peak 30-minute cadence and minutes spent in bouts of purposeful steps and faster ambulation had 0.7 95% CI (0.6, 0.9) and 0.8 95% CI (0.6, 1) times the odds of substantially gaining weight, respectively. Despite greater increases in weight and BMI for those in the highest categories of stepping cadences, their weight and BMI remained lower than those in the lower categories of stepping cadences at visit 2. This positive association conflicts with prior literature examining longitudinal associations of step-based metrics and adiposity. This unanticipated positive relationship may be due to uneven declines in stepping cadence across categories. Those categorized with a higher stepping cadences at baseline may have had a larger decline in stepping cadence than those initially with slower cadences, thereby resulting in larger changes in weight and BMI in the higher stepping cadence categories. These findings suggest the need for additional research examining relationships between long-term changes in stepping cadence and consequent changes in adiposity.

The cross-sectional association of step volume and cadence and BP

Step volume, cadence and time spent sedentary were not cross-sectionally associated with continuous measures of BP for either hypertensive medication users or non-hypertensive medication users. However, when hypertension was examined as a categorical variable, the odds of hypertension was associated with step volume, cadence and time spent sedentary. Those in the lowest quartile and category of step volume, mean peak 30 cadence, time spent in brisk walking and faster ambulation and time spent in bouts of purposeful steps and faster ambulation had a 1.5, 95% CI (1.2, 1.8), 1.4 95% CI (1.2, 1.7), 1.5 95% CI (1.1, 2.0) and 1.4 95% CI (1.1, 1.7) times the odds of hypertension than those who were in the highest quartile and category, respectively. Those who spent the most time sedentary had 0.7 95% CI (0.6, 0.9) times the odds of hypertension than those who spent the least amount of time sedentary. These results suggest engaging in higher step volume and cadences and reducing sedentary time may lead to reductions in hypertension prevalence among this population using contemporary cut points of hypertension. Compared to categorical examination of hypertension, contrasting null associations for continuous measures of BP highlight the importance of decisions in modeling BP and hypertensive medication use.

The longitudinal association of step volume and cadence and BP

Step volume, cadence and time spent sedentary were not associated with changes in BP over a 6-year period. Interventions, trials and previous observational research examining changes in blood pressure conflict with our findings. Prior studies trial length and observational periods were shorter than the 6-year period of the present research. This longer observational period may have diluted associations and thus partially explain differential results. Alternatively, a longer time period may be needed to see sustained changes in BP.

7.2 Strengths

This dissertation has numerous strengths including use of the HCHS/SOL cohort's rich dataset and robust measures of physical activity, measures of adiposity and BP, methods to account for potential biases, interpretability of step-based metrics as well as the capability to examine both cross-sectional and longitudinal associations.

The HCHS/SOL study was a heterogeneously diverse cohort in regard to ethnic background. Richness of the data enabled assessment of modification by a variety of potential modifiers as well as control of confounders. HCHS/SOL protocols ensured high quality measurement of our exposure and outcomes. Quality control measures were put in place by HCHS/SOL protocols to ensure proper calibration and standardization of equipment and readings which reduces variability and observer bias. Physical activity was captured using a validated device. The step count function of the Actical accelerometer has been previously validated at a typical walk (83 $m \cdot min^{-1}$) and run (133 $m \cdot min^{-1}$) speed[326]. Measures of adiposity and BP were obtained by trained technicians and BP readings were taken three times and averaged.

Methodologic strengths of the dissertation include addressing the complex survey sampling design, non-adherence to Actical protocols and initiation of antihypertensive medication between visits. We employed sampling weights to address the complex survey design of the HCHS/SOL study. IPW were used to account for missingness due to non-adherence to the Actical protocol. IPW and doubly robust estimating equations were leveraged to address initiation of hypertensive medication use between visits. Our methods limit bias that would otherwise have been introduced in our estimates.

The metrics chosen for assessment is a strength of this work. Steps-based metrics are easily interpretable measures of physical activity that can be prescribed to populations to meet physical activity recommendations. Further, steps are trackable by participants and interventionists, lending themselves for ease of implementation of interventions. Translation of step-based research to future guidelines is broadly applicable given steps are a basic unit of locomotion.

To our knowledge, this is the first study to examine cross-sectional and longitudinal relationships between step-based metrics and measures of adiposity and BP in a U.S. Hispanic/Latino cohort. Generalizability of prior research to U.S. Hispanic/Latino populations is limited due to a variety of cultural, genetic, and environmental factors such as dietary patterns and neighborhood safety. Further, few studies have examined longitudinal relationships. This dissertation extends implications of these associations to a heterogeneous U.S. Hispanic/Latino population. Additionally, assessment of measures of adiposity and blood pressure at multiple visits allowed for examination of changes in outcomes and adding to the limited body of longitudinal research.

7.3 Limitations

This research should be considered in light of several limitations. Longitudinal analyses examining changes in outcomes are bound by our lack of assessment of physical activity and steps over the follow-up period. Measurements of steps were only taken at baseline, thus limiting our capacity to understand changes in step metrics over time. Potential misclassification of steps is another limitation. Driving in a vehicle, such as in a truck may have simulated step movement that the accelerometer captured, thus inflating the amount of steps an individual may have taken. Careful examination has been given to accelerometer readings of prolonged or abnormal amounts of steps to avoid misclassification. Residual confounding may exist as well as potential recall bias of self-reported confounders. Further, there is inherent measurement error in several covariates such as diet and depression. Additionally, we are adjusting for covariates assessed at baseline which may not accurately reflect status at visit 2. A final limitation of this study is that generalizability is limited to the HCHS/SOL cohort's target population of non-institutionalized Hispanic/Latino adults aged 18-74 residing in the four sampled areas.

7.4 Public health significance

Obesity and high BP are modifiable risk factors for CVD that contribute to a large proportion of CVD-related morbidity and mortality[5, 315]. Obesity has grown to pandemic proportions over the past fifty years[315] and while improvements have been made in BP management, hypertension prevalence remains high worldwide[5, 116]. Cross-sectional inverse associations found between step volume and cadence and measures of adiposity and BP are promising findings in regards to developing step-based recommendations and interventions to address obesity and hypertension in U.S. Hispanic/Latinos. While potential for reverse causality cannot be ruled out, these results in conjunction with previous trials conducted in additional populations support promotion of engaging in higher step volumes and cadences to alleviate these CVD risk factors.

Elucidating relationships between CVD risk factors and step volume and cadence are of interest to reduce CVD burden. While there is a large body of research on walking trials and interventions in relation to CVD risk factors, step-based metrics are not identical constructs to trial and intervention-based walking. Step-based metrics are easily interpretable and have high utility for informing interventions recommendations and self-monitoring strategies. Steps are a basic unit of locomotion and are applicable to almost all populations. Further, they are a form of physical activity available outside of organized physical activity. These measures capture a range of intensity for most forms of physical activity and thereby likely portray an accurate representation of an individual's daily activity. Translating steps into public health guidance and interventions is of interest for the aforementioned reasons.

Targeted step-based recommendations that acknowledge factors influencing step-accumulation and cadence are needed to effectively increase step volume and cadence. Differential patterns of occupational, transportation and leisure time step accumulation as well as external influences such as weather and neighborhood safety, which may impact transportation method and leisure time activity decisions, need to considered to optimize guidance. As age has been identified as a modifier of step-based metrics and health outcomes, development of age dependent recommendations may be appropriate.

In addition to public health messaging and publication of step-based physical activity recommendations, population-based interventions will be needed to increase daily step volume and cadence. Prior trials have demonstrated step-based goals are predictors of increased step volume[266]. This dissertation found taking as few as 5,000 steps/day was cross-sectionally associated with lower measures of adiposity, a volume much lower than the frequently cited 10,000 steps/day goal. Future interventions utilizing step goals should consider the consequences of proposing lower step count goals that may be more sustainable over time. Cadence, independent of step volume, was associated with measures of adiposity and hypertension. Existing technologies such as audio fitness programs that guide listeners through intensity varied workouts may serve as a model for development of similar programs that can be used daily to increase cadence among populations. Increasing step volume and cadence if implemented on a population level has the potential to reduce CVD risk factors and therefore risk of downstream disease burden.

7.5 Future directions

This dissertation has brought to light several key areas for future research. Additional longitudinal studies are needed to further discern the long-term associations between step-based metrics and changes in measures of adiposity and BP; prior literature in this area is limited and while this dissertation examined longitudinal associations, findings were bound by baseline measures of step-based metrics. Further, positive associations found for our longitudinal analysis of step-cadence and changes in weight and BMI were against the a priori hypothesis. Discerning if there was differential decline in step-cadence across quartiles would have provided additional key information in interpreting this result. This example highlights the importance of investigating long-term changes in step volume and cadence in relation to changes in health outcomes. Moreover, changes in step volume and cadence due to the natural aging process may differ by population. Discerning how step-based metrics change over time in varying populations is important for developing meaningful targeted and sustainable step-based interventions.

In conjunction with investigating long-term changes in step-based metrics and health outcomes, further cross-sectional and longitudinal studies are needed in additional U.S. Hispanic/Latino populations to examine potential modifiers not captured in the HCHS/SOL cohort. The HCHS/SOL cohort, while the largest cohort of Hispanic/Latinos in the U.S., is not generalizable to Hispanic/Latinos residing in rural regions and other non-sampled states. Differences between urban and rural communities such as neighborhood walkability, predominant occupations, and food availability all likely impact both levels of physical activity and the CVD risk factors we explored. Further research examining modification of these relationships by urbanicity is needed to provide guidance for these understudied U.S. Hispanic/Latino communities.

Obesity trajectory in relation to step-based metrics in adolescents is another area that would benefit from further research. Adolescents who are obese in childhood are more likely to remain obese as adults[74]. Step-based research examining transitions from adolescence to adulthood can enhance our understanding of how to intervene and alter the obesity trajectory at an earlier stage in life.

An additional area for future research is the examination of relationships between time spent in incidental or sporadic movement and health outcomes among older populations. Our examination of interaction by age demonstrated time spent in incidental or sporadic movement was solely associated with measures of adiposity among older adults (60 years of age and older). As older adults likely spend much of their time in incidental or sporadic movement, it is important to understand any meaningful health implications.

To optimize future interventions, it is important to understand the context behind high step-volume and cadence accumulation periods. Seasonality of step-based metrics by geographic regions should be explored. In addition, examining daily step-accumulation by domains of physical activity such as occupational, transportation and leisure time further provides context surrounding step-based metrics. Discerning contextual information regarding step accumulation improves interventionists capability to target periods with low step volume and cadences to maximize benefits on CVD risk profiles.

Leveraging increases in accessibility of wearable devices as well as step tracking devices in phones is an additional area for future research. Step tracking technologies are becoming increasingly available and provide immediate feedback to users. Regular examination of validity of these continuously advancing technologies as well as feasibility of use among a multitude of populations and across sociodemographic groups will be important for developing future interventions. Research surrounding use of these devices in concurrence with behavioral strategies may lead to effective methods to increase levels of step volume and cadence among the population.

7.6 Conclusion

This dissertation contributes to the growing body of step-based literature. Engaging in a higher step volume and cadence was cross-sectionally associated with lower measures of adiposity and odds of hypertension. Engaging in higher step cadence but not volume was associated with greater increases in measures of weight and BMI. Greater amounts of time spent sedentary was associated with a higher odds of hypertension but had no association with measures of adiposity. No associations between step-based metrics and changes in measures of BP. In light of previous studies, this work suggests increases in step volume and cadence are positively associated with improved CVD risk profiles among U.S. Hispanic/Latinos. To our knowledge, this present work was the first to examine the cross-sectional and longitudinal relationships between step-based metrics and measures of adiposity and BP among a U.S. Hispanic/Latino population. Further research examining the relationship between step-based metrics and additional health outcomes in diverse populations is needed to develop future step-based public health guidance and interventions.

APPENDIX A: ADDITIONAL ADIPOSITY ANALYSIS TABLES

Appendix Table 1: Baseline adjusted means (95% CI) of weight (kg), waist circumference (cm) and BMI by quartile of average peak 60-minute cadence, HCHS/SOL (2008-2011).

Peak 60-minute cadence				
		Weight (kg)		
	Model 1	Model 2	Model 3	Model 4
Q1 (<46.58)	83.65 (82.29, 85)	85.84 (84.46, 87.22)	87.22 (85.77, 88.68)	85.29 (84.02, 86.56)
Q2 (46.58->60.07)	81.42 (80.05, 82.79)	84.08 (82.61, 85.55)	84.44 (82.96, 85.91)	84.44 (83.12, 85.77)
Q3 (60.07->75.86)	78.58 (77.43, 79.73)	80.89 (79.65, 82.12)	80.43 (79.18, 81.69)	82.41 (80.92, 83.9)
Q4 (75.86+)	74.51 (73.36, 75.67)	77.48 (76.26, 78.7)	76.61 (75.35, 77.87)	77.21 (76.05, 78.38)
p-value	<0.01	<0.01	<0.01	<0.01
		Waist Circumference (cm)		
	Model 1	Model 2	Model 3	Model 4
Q1 (<46.58)	101.26 (100.19, 102.33)	103.38 (102.32, 104.44)	104.34 (103.19, 105.48)	102.9 (101.93, 103.88)
Q2 (46.58->60.07)	99.09 (98.12, 100.07)	101.64 (100.64, 102.64)	101.88 (100.87, 102.89)	102.29 (101.28, 103.31)
Q3 (60.07->75.86)	97.38 (96.41, 98.34)	99.6 (98.64, 100.56)	99.28 (98.32, 100.24)	100.25 (99.22, 101.28)
Q4 (75.86+)	93.97 (92.98, 94.95)	96.83 (95.83, 97.82)	96.22 (95.2, 97.24)	96.89 (95.9, 97.88)
p-value	<0.01	<0.01	<0.01	<0.01
		Body Mass Index (kg/m^2)		
	Model 1	Model 2	Model 3	Model 4
Q1 (<46.58)	30.89 (30.42, 31.35)	31.7 (31.24, 32.16)	32.22 (31.73, 32.72)	31.56 (31.16, 31.97)
Q2 (46.58->60.07)	29.88 (29.5, 30.27)	30.88 (30.48, 31.28)	31.01 (30.61, 31.42)	31.2 (30.76, 31.64)
Q3 (60.07->75.86)	29.22 (28.83, 29.61)	30.06 (29.67, 30.46)	29.89 (29.5, 30.29)	30.35 (29.93, 30.77)
Q4 (75.86+)	27.87 (27.48, 28.26)	28.99 (28.59, 29.39)	28.66 (28.26, 29.06)	28.87 (28.48, 29.25)
p-value	<0.01	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ total step volume

Appendix Table 2: Adjusted means of weight (kg), waist circumference (cm) and BMI by quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min) and purposeful steps and faster ambulation (40-99 steps/min) HCHS/SOL (2008-2011).

Minutes/day	Model 1	Model 2	Model 3
Incidental or sporadic movement (1-39 steps per minute)			
Weight (kg)			
Q1 (>158.66)	79.8 (78.32, 81.28)	82.45 (80.89, 84.01)	80.16 (78.3, 82.01)
Q2 (158.66->211.30)	80.27 (79.01, 81.54)	83.19 (81.78, 84.6)	82.28 (80.79, 83.77)
Q3 (211.30->274.18)	79.26 (78.17, 80.36)	82.35 (81.18, 83.51)	82.69 (81.52, 83.87)
Q4 (274.18+)	79.73 (78.55, 80.9)	82.29 (81.04, 83.54)	84.57 (82.77, 86.37)
p-value	0.54	0.58	0.02
Waist Circumference (cm)			
	Model 1	Model 2	Model 3
Q1 (>158.66)	98.37 (97.27, 99.47)	100.88 (99.82, 101.95)	98.99 (97.63, 100.36)
Q2 (158.66->211.30)	98.26 (97.26, 99.26)	101.01 (99.91, 102.12)	100.26 (99.08, 101.45)
Q3 (211.30->274.18)	97.65 (96.74, 98.56)	100.56 (99.62, 101.5)	100.84 (99.89, 101.79)
Q4 (274.18+)	98.12 (97.16, 99.08)	100.49 (99.56, 101.42)	102.37 (101.03, 103.7)
p-value	0.55	0.72	0.02
Body Mass Index (kg/m^2)			
	Model 1	Model 2	Model 3
Q1 (>158.66)	29.5 (29.06, 29.95)	30.47 (30.02, 30.91)	29.75 (29.16, 30.33)
Q2 (158.66->211.30)	29.64 (29.22, 30.07)	30.72 (30.25, 31.19)	30.43 (29.94, 30.93)
Q3 (211.30->274.18)	29.36 (28.98, 29.73)	30.5 (30.12, 30.88)	30.61 (30.23, 30.99)
Q4 (274.18+)	29.67 (29.28, 30.07)	30.6 (30.21, 30.99)	31.32 (30.76, 31.87)
p-value	0.58	0.79	0.01
Purposeful steps and faster ambulation (40-99 steps per minute)			
Weight (kg)			
	Model 1	Model 2	Model 3
Q1 (>24.92)	81.59 (80.13, 83.05)	84.08 (82.57, 85.58)	84.31 (82.74, 85.88)
Q2 (24.92-> 40.68)	79.79 (78.51, 81.08)	82.65 (81.28, 84.01)	82.75 (81.36, 84.13)
Q3(40.68->65.16)	78.7 (77.58, 79.83)	81.36 (80.11, 82.6)	81.33 (80.08, 82.57)

Q4 (65.16+)	78.63 (77.45, 79.8)	81.63 (80.36, 82.9)	81.39 (79.85, 82.92)
p-value	<0.01	<0.01	<0.01
Waist Circumference (cm)			
	Model 1	Model 2	Model 3
Q1 (>24.92)	99.92 (98.86, 100.98)	102.27 (101.25, 103.3)	102.5 (101.35, 103.65)
Q2 (24.92-> 40.68)	97.87 (96.78, 98.95)	100.56 (99.45, 101.68)	100.66 (99.52, 101.8)
Q3(40.68->65.16)	97.22 (96.3, 98.14)	99.68 (98.71, 100.65)	99.65 (98.68, 100.62)
Q4 (65.16+)	97.05 (96.13, 97.97)	99.89 (98.95, 100.84)	99.65 (98.56, 100.74)
p-value	<0.01	<0.01	<0.01
Body Mass Index (kg/m^2)			
	Model 1	Model 2	Model 3
Q1 (>24.92)	30.16 (29.73, 30.6)	31.08 (30.65, 31.5)	31.34 (30.85, 31.82)
Q2 (24.92-> 40.68)	29.56 (29.1, 30.01)	30.61 (30.13, 31.08)	30.72 (30.24, 31.2)
Q3(40.68->65.16)	29.16 (28.79, 29.53)	30.13 (29.74, 30.51)	30.09 (29.71, 30.48)
Q4 (65.16+)	29.15 (28.78, 29.52)	30.26 (29.86, 30.65)	29.98 (29.52, 30.44)
p-value	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day

Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 3: Adjusted means of weight (kg), waist circumference (cm) and BMI by minutes per day spent in 10 minute bouts of <70 steps/min and <100 steps/min HCHS/SOL (2008-2011).

Bouts slow to medium steps and faster ambulation (≥ 70 steps per minute)				
Mean Weight (kg)				
Minutes	Model 1	Model 2	Model 3	Model 4
>0	82.22 (81.22, 83.23)	84.81 (83.72, 85.91)	84.75 (83.66, 85.84)	82.71 (81.44, 83.98)
<0->6.6	80.46 (78.81, 82.12)	83.02 (81.25, 84.79)	82.99 (81.23, 84.74)	84.17 (82.88, 85.46)
6.6->16.83	78.29 (76.97, 79.62)	80.6 (79.33, 81.87)	80.59 (79.33, 81.86)	83.44 (81.97, 84.91)
≥16.83	75.34 (74.11, 76.58)	78.48 (77.22, 79.73)	78.5 (77.25, 79.75)	79.73 (78.52, 80.93)
p-value	<0.01	<0.01	<0.01	<0.01
Waist Circumference (cm)				
	Model 1	Model 2	Model 3	Model 4
>0	99.99 (99.18, 100.8)	102.46 (101.61, 103.31)	102.39 (101.54, 103.24)	100.75 (99.77, 101.72)
<0->6.6	98.62 (97.41, 99.84)	101.07 (99.81, 102.32)	101.03 (99.78, 102.28)	101.69 (100.68, 102.69)
6.6->16.83	97 (95.86, 98.13)	99.21 (98.22, 100.19)	99.19 (98.21, 100.18)	101.66 (100.64, 102.68)
≥16.83	94.67 (93.63, 95.71)	97.66 (96.65, 98.68)	97.69 (96.68, 98.7)	98.61 (97.67, 99.55)
p-value	<0.01	<0.01	<0.01	<0.01
Men Body Mass Index (kg/m^2)				
	Model 1	Model 2	Model 3	Model 4
>0	30.34 (30.01, 30.67)	31.29 (30.95, 31.63)	31.29 (30.95, 31.63)	30.69 (30.3, 31.09)
<0->6.6	29.75 (29.27, 30.24)	30.71 (30.21, 31.22)	30.72 (30.21, 31.22)	31.01 (30.59, 31.42)
6.6->16.83	29.15 (28.68, 29.63)	29.99 (29.56, 30.41)	29.99 (29.56, 30.41)	30.87 (30.42, 31.31)
≥16.83	28.01 (27.61, 28.42)	29.18 (28.78, 29.57)	29.18 (28.78, 29.57)	29.63 (29.25, 30)
p-value	<0.01	<0.01	<0.01	<0.01
Bouts brisk walking and faster ambulation (≥ 100 steps per minute)				
Weight (kg)				
Minutes	Model 1	Model 2	Model 3	Model 4
>0	82.21 (81.21, 83.22)	84.61 (83.46, 85.76)	84.54 (83.4, 85.68)	82.59 (81.3, 83.87)
<0->4.48	76.79 (75.37, 78.21)	79.45 (77.97, 80.94)	79.42 (77.93, 80.91)	83.51 (82.04, 84.97)
4.48->11.35	76.02 (74.77, 77.27)	78.93 (77.59, 80.28)	78.91 (77.56, 80.25)	84.63 (83.13, 86.12)

≥11.35	74.85 (73.54, 76.15)	77.96 (76.61, 79.3)	77.97 (76.63, 79.31)	78.86 (77.73, 79.99)
p-value	<0.01	<0.01	<0.01	<0.01
Waist Circumference (cm)				
	Model 1	Model 2	Model 3	Model 4
>0	99.89 (99.15, 100.62)	102.18 (101.35, 103.01)	102.11 (101.27, 102.94)	100.5 (99.53, 101.48)
<0->4.48	96.25 (95.07, 97.43)	98.82 (97.65, 99.99)	98.79 (97.61, 99.96)	101.27 (100.13, 102.41)
4.48->11.35	95.36 (94.31, 96.4)	98.15 (97.09, 99.22)	98.12 (97.06, 99.19)	102.57 (101.53, 103.61)
≥11.35	94.15 (93.03, 95.27)	97.16 (96.04, 98.29)	97.18 (96.05, 98.31)	97.99 (97.11, 98.88)
p-value	<0.01	<0.01	<0.01	<0.01
Body Mass Index (kg/m^2)				
	Model 1	Model 2	Model 3	Model 4
>0	30.3 (30, 30.6)	31.19 (30.85, 31.53)	31.18 (30.84, 31.52)	30.59 (30.2, 30.99)
<0->4.48	28.65 (28.15, 29.15)	29.64 (29.14, 30.14)	29.63 (29.13, 30.13)	30.8 (30.32, 31.28)
4.48->11.35	28.43 (27.97, 28.88)	29.5 (29.04, 29.96)	29.49 (29.03, 29.96)	31.26 (30.84, 31.69)
≥11.35	27.88 (27.44, 28.33)	29.06 (28.61, 29.51)	29.06 (28.61, 29.51)	29.37 (29.01, 29.74)
p-value	<0.01	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ total step volume

Appendix Table 4: Adjusted means, mean changes of weight (kg), waist circumference (cm) and BMI by quartile of average peak 60-minute cadence, HCHS/SOL (2008-2017).

Peak 60-minute cadence				
Change in Weight (kg)				
	Model 1	Model 2	Model 3	Model 4
Q1 (46.26<)	-0.08 (-0.76, 0.59)	-0.06 (-0.71, 0.59)	-0.14 (-0.89, 0.62)	0.01 (-0.7, 0.72)
Q2 (46.26->59.79)	-0.13 (-0.95, 0.69)	-0.16 (-1.03, 0.71)	-0.18 (-1.02, 0.67)	-0.13 (-0.98, 0.71)
Q3 (59.79->75.69)	0.68 (0.1, 1.25)	0.61 (0, 1.21)	0.63 (0.02, 1.25)	0.67 (-0.11, 1.44)
Q4 (+ 75.69)	1.45 (0.78, 2.12)	1.51 (0.83, 2.2)	1.56 (0.85, 2.27)	1.3 (0.67, 1.92)
p-value	<0.01	<0.01	<0.01	<0.01
Change in Waist Circumference (cm)				
	Model 1	Model 2	Model 3	Model 4
Q1 (46.26<)	1.45 (0.78, 2.12)	1.38 (0.72, 2.05)	1.49 (0.7, 2.28)	1.22 (0.47, 1.98)
Q2 (46.26->59.79)	1.09 (0.36, 1.82)	0.97 (0.18, 1.76)	0.99 (0.22, 1.77)	1.23 (0.54, 1.93)
Q3 (59.79->75.69)	1.41 (0.74, 2.08)	1.26 (0.56, 1.97)	1.23 (0.5, 1.96)	1.28 (0.51, 2.05)
Q4 (+ 75.69)	2.13 (1.45, 2.8)	2.08 (1.38, 2.79)	2.02 (1.25, 2.79)	1.96 (1.27, 2.66)
p-value	0.07	0.04	0.08	0.21
Change in Body Mass Index (kg/m^2)				
	Model 1	Model 2	Model 3	Model 4
Q1 (46.26<)	-0.07 (-0.31, 0.18)	-0.05 (-0.29, 0.19)	-0.09 (-0.37, 0.19)	-0.03 (-0.28, 0.23)
Q2 (46.26->59.79)	-0.07 (-0.36, 0.23)	-0.07 (-0.38, 0.23)	-0.09 (-0.39, 0.22)	-0.08 (-0.37, 0.22)
Q3 (59.79->75.69)	0.22 (0.01, 0.42)	0.2 (-0.02, 0.41)	0.21 (-0.01, 0.43)	0.22 (-0.06, 0.49)
Q4 (+ 75.69)	0.48 (0.25, 0.72)	0.51 (0.27, 0.75)	0.54 (0.29, 0.79)	0.45 (0.23, 0.67)
p-value	<0.01	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2 + total step-volume

Appendix Table 5: Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by quartile of minutes per day spent in purposeful steps and faster ambulation (40-99 steps/min) HCHS/SOL (2008-2017).

Purposeful walking and faster ambulation (40-99 steps/min)			
	Change in Weight (kg)		
	Model 1	Model 2	Model 3
Q1 (24.90<)	0.24 (-0.41, 0.89)	0.27 (-0.37, 0.91)	0.25 (-0.57, 1.07)
Q2 (24.90->41.18)	-0.01 (-0.86, 0.84)	0 (-0.91, 0.9)	-0.01 (-0.91, 0.9)
Q3 (41.18->65.16)	0.64 (0.01, 1.27)	0.68 (0.02, 1.33)	0.68 (0.01, 1.34)
Q4 (65.16+)	1.08 (0.4, 1.77)	1.03 (0.31, 1.75)	1.04 (0.17, 1.92)
p-value	0.12	0.24	0.43
	Change in Waist Circumference (cm)		
	Model 1	Model 2	Model 3
Q1 (24.90<)	1.27 (0.59, 1.94)	1.18 (0.45, 1.91)	1.33 (0.46, 2.19)
Q2 (24.90->41.18)	1.45 (0.7, 2.2)	1.38 (0.59, 2.16)	1.44 (0.63, 2.25)
Q3 (41.18->65.16)	1.62 (0.92, 2.32)	1.53 (0.79, 2.27)	1.51 (0.76, 2.25)
Q4 (65.16+)	1.78 (1.11, 2.45)	1.66 (0.96, 2.36)	1.5 (0.63, 2.38)
p-value	0.63	0.7	0.99
	Change in Body Mass Index (kg/m^2)		
	Model 1	Model 2	Model 3
Q1 (24.90<)	0.06 (-0.18, 0.3)	0.08 (-0.16, 0.31)	0.06 (-0.24, 0.36)
Q2 (24.90->41.18)	-0.01 (-0.32, 0.3)	0 (-0.33, 0.32)	-0.01 (-0.34, 0.32)
Q3 (41.18->65.16)	0.19 (-0.03, 0.41)	0.21 (-0.02, 0.44)	0.21 (-0.02, 0.44)
Q4 (65.16+)	0.35 (0.11, 0.59)	0.33 (0.07, 0.58)	0.34 (0.03, 0.65)
p-value	0.17	0.32	0.49

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 6: Adjusted mean changes of weight (kg), waist circumference (cm) and BMI by minutes per day spent in 10-minute bouts of ≥70 and ≥100 steps/min HCHS/SOL (2008-2017).

Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
Change in Weight (kg)				
Minutes	Model 1	Model 2	Model 3	Model 4
0	-0.1 (-0.66, 0.45)	-0.15 (-0.72, 0.42)	-0.12 (-0.68, 0.44)	-0.19 (-0.9, 0.51)
<0->6.20	-0.2 (-0.9, 0.51)	-0.17 (-0.92, 0.58)	-0.16 (-0.91, 0.59)	0.16 (-0.63, 0.95)
6.20->16.8	1.36 (0.63, 2.09)	1.38 (0.62, 2.14)	1.37 (0.61, 2.13)	0.43 (-0.21, 1.07)
≥16.8)	1.4 (0.63, 2.17)	1.59 (0.81, 2.36)	1.56 (0.79, 2.33)	1.44 (0.74, 2.14)
p-value	<0.01	<0.01	<0.01	<0.01
Change in Waist Circumference (cm)				
	Model 1	Model 2	Model 3	Model 4
0	1.07 (0.53, 1.6)	0.93 (0.38, 1.48)	0.96 (0.41, 1.51)	0.92 (0.18, 1.66)
<0->6.20	1.37 (0.67, 2.08)	1.29 (0.52, 2.06)	1.3 (0.53, 2.07)	1.34 (0.64, 2.03)
6.20->16.8	2.16 (1.42, 2.91)	2.1 (1.32, 2.88)	2.09 (1.31, 2.88)	1.31 (0.6, 2.01)
≥16.8)	1.92 (1.18, 2.66)	1.94 (1.16, 2.72)	1.92 (1.13, 2.7)	2.1 (1.34, 2.86)
p-value	0.03	0.01	0.02	0.04
Change in Body Mass Index (kg/m²)				
	Model 1	Model 2	Model 3	Model 4
0	-0.06 (-0.26, 0.14)	-0.07 (-0.28, 0.13)	-0.06 (-0.27, 0.14)	-0.09 (-0.35, 0.16)
<0->6.20	-0.11 (-0.37, 0.16)	-0.09 (-0.37, 0.18)	-0.09 (-0.37, 0.19)	0.02 (-0.26, 0.3)
6.20->16.8	0.46 (0.2, 0.72)	0.47 (0.19, 0.74)	0.46 (0.19, 0.74)	0.13 (-0.1, 0.36)
≥16.8)	0.47 (0.2, 0.74)	0.54 (0.27, 0.81)	0.54 (0.26, 0.81)	0.51 (0.26, 0.75)
p-value	<0.01	<0.01	<0.01	<0.01
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)				
Mean Change in Weight (kg)				
Minutes	Model 1	Model 2	Model 3	Model 4
0	-0.03 (-0.51, 0.45)	-0.04 (-0.54, 0.46)	-0.02 (-0.51, 0.48)	0.4 (-0.22, 1.01)
<0->4.58	0.76 (-0.03, 1.55)	0.79 (-0.03, 1.61)	0.78 (-0.04, 1.6)	-0.15 (-1.05, 0.75)
4.58->11.46	1.42 (0.51, 2.33)	1.63 (0.7, 2.55)	1.62 (0.7, 2.55)	0.29 (-0.36, 0.95)
≥11.46	1.62 (0.63, 2.62)	1.73 (0.74, 2.73)	1.71 (0.72, 2.7)	1.35 (0.64, 2.06)

p-value	<0.01	<0.01	<0.01	0.01
	Change in Waist Circumference (cm)			
	Model 1	Model 2	Model 3	Model 4
0	1.17 (0.72, 1.63)	1.07 (0.58, 1.56)	1.09 (0.6, 1.58)	1.44 (0.75, 2.13)
<0->4.58	1.77 (0.93, 2.61)	1.71 (0.82, 2.61)	1.71 (0.82, 2.6)	0.98 (0.21, 1.76)
4.58->11.46	2.19 (1.32, 3.05)	2.22 (1.31, 3.13)	2.21 (1.3, 3.12)	1.18 (0.48, 1.87)
≥11.46	2.23 (1.31, 3.15)	2.22 (1.27, 3.16)	2.19 (1.25, 3.14)	2.09 (1.38, 2.81)
p-value	0.03	0.01	0.02	0.03
	Change in Body Mass Index (kg/m^2)			
	Model 1	Model 2	Model 3	Model 4
0	-0.04 (-0.21, 0.14)	-0.04 (-0.22, 0.14)	-0.03 (-0.21, 0.15)	0.1 (-0.11, 0.32)
<0->4.58	0.23 (-0.06, 0.51)	0.24 (-0.06, 0.54)	0.24 (-0.06, 0.54)	-0.08 (-0.4, 0.23)
4.58->11.46	0.48 (0.14, 0.81)	0.56 (0.22, 0.89)	0.56 (0.22, 0.89)	0.1 (-0.14, 0.33)
≥11.46	0.56 (0.22, 0.9)	0.6 (0.26, 0.95)	0.6 (0.26, 0.94)	0.46 (0.21, 0.71)
p-value	<0.01	<0.01	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2 + total step volume

Appendix Table 7: Adjusted odds of BMI category by quartile of average total steps; HCHS/SOL (2008-2011).

	Model 1	Model 2	Model 3
Obese, overweight, and normal vs. underweight			
quartile 1 vs 4	0.51 (0.23,1.14)	0.65 (0.3,1.4)	0.98 (0.38,2.56)
quartile 2 vs 4	1.07 (0.49,2.37)	1.27 (0.55,2.91)	1.98 (0.53,7.38)
quartile 3 vs 4	1.1 (0.52,2.3)	1.29 (0.58,2.84)	1.15 (0.25,5.27)
Obese and overweight vs. underweight and normal weight			
quartile 1 vs 4	1.43 (1.11,1.84)	1.32 (1.02,1.71)	1.13 (0.76,1.68)
quartile 2 vs 4	1.24 (0.98,1.58)	1.21 (0.96,1.54)	1.07 (0.69,1.66)
quartile 3 vs 4	1.05 (0.83,1.32)	1.04 (0.83,1.31)	1.11 (0.75,1.65)
Obese vs. underweight, normal weight and overweight			
quartile 1 vs 4	1.56 (1.31,1.85)	1.42 (1.19,1.7)	1.06 (0.79,1.42)
quartile 2 vs 4	1.21 (1.04,1.41)	1.15 (0.98,1.35)	1.05 (0.76,1.44)
quartile 3 vs 4	1.15 (0.98,1.36)	1.12 (0.95,1.33)	1.49 (1.16,1.93)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2+ mobility limitations climbing stairs, alcohol use and smoking

Appendix Table 8: Adjusted odds of BMI category by quartile of average peak 30-minute and 60-minute cadences; HCHS/SOL (2008-2011).

	Model 1	Model 2	Model 3	Model 4
Peak 30-minute Cadence				
Obese, overweight, and normal vs. underweight				
quartile 1 vs 4	0.49 (0.23,1.07)	0.48 (0.22,1.05)	0.88 (0.44,1.76)	0.52 (0.26,1.04)
quartile 2 vs 4	1.1 (0.52,2.33)	1.11 (0.52,2.36)	1.48 (0.67,3.28)	1.23 (0.53,2.85)
quartile 3 vs 4	0.91 (0.45,1.84)	0.91 (0.45,1.84)	1.06 (0.52,2.14)	0.99 (0.49,2.02)
Obese and overweight vs. underweight and normal weight				
quartile 1 vs 4	1.86 (1.43,2.41)	1.77 (1.36,2.3)	2 (1.51,2.64)	1.72 (1.32,2.25)
quartile 2 vs 4	1.57 (1.23,2)	1.56 (1.23,1.98)	1.65 (1.29,2.11)	1.49 (1.17,1.89)
quartile 3 vs 4	1.28 (1.05,1.55)	1.26 (1.04,1.53)	1.28 (1.06,1.56)	1.25 (1.02,1.52)
Obese vs. underweight, normal weight and overweight				
quartile 1 vs 4	1.73 (1.45,2.06)	1.62 (1.36,1.93)	1.67 (1.37,2.03)	1.61 (1.34,1.92)
quartile 2 vs 4	1.33 (1.11,1.59)	1.28 (1.08,1.53)	1.3 (1.09,1.56)	1.24 (1.05,1.48)
quartile 3 vs 4	1.15 (0.97,1.36)	1.14 (0.96,1.34)	1.14 (0.97,1.35)	1.14 (0.96,1.35)
Peak 60-minute Cadence				
Obese, overweight, and normal vs. underweight				
		Model 2	Model 3	Model 4
quartile 1 vs 4	0.59 (0.28,1.26)	0.59 (0.27,1.25)	1.26 (0.63,2.53)	0.63 (0.33,1.23)
quartile 2 vs 4	1.3 (0.63,2.66)	1.33 (0.64,2.77)	2 (0.86,4.65)	1.48 (0.67,3.27)
quartile 3 vs 4	1.39 (0.66,2.93)	1.37 (0.64,2.92)	1.6 (0.75,3.44)	1.42 (0.65,3.08)
Obese and overweight vs. underweight and normal weight				
quartile 1 vs 4	1.74 (1.35,2.24)	1.65 (1.28,2.13)	1.97 (1.47,2.64)	1.58 (1.22,2.06)
quartile 2 vs 4	1.58 (1.24,2.02)	1.58 (1.24,2.01)	1.73 (1.34,2.23)	1.51 (1.19,1.92)
quartile 3 vs 4	1.31 (1.06,1.6)	1.26 (1.03,1.55)	1.3 (1.05,1.6)	1.22 (0.99,1.51)

Obese vs. underweight, normal weight and overweight				
quartile 1 vs 4	1.7 (1.42,2.04)	1.6 (1.33,1.92)	1.71 (1.37,2.12)	1.57 (1.3,1.89)
quartile 2 vs 4	1.38 (1.17,1.64)	1.35 (1.14,1.6)	1.4 (1.18,1.66)	1.32 (1.12,1.56)
quartile 3 vs 4	1.21 (1.02,1.43)	1.17 (0.99,1.38)	1.18 (1,1.39)	1.16 (0.99,1.38)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ employment, occupation, income, marital status, predicted total energy intake, CESD10, mobility limitations moderate and alcohol use

Appendix Table 9: Adjusted odds of BMI category by quartile of time spent sedentary adjusted for total accelerometer wear time; HCHS/SOL (2008-2011).

	Model 1	Model 2	Model 3
Obese, overweight, and normal vs. underweight			
quartile 1 vs 4	3.42 (1.34,8.78)	3.04 (1.1,8.43)	3.01 (1.09,8.28)
quartile 2 vs 4	2.07 (1.03,4.18)	2.21 (1.14,4.3)	2.21 (1.14,4.27)
quartile 3 vs 4	2.01 (0.92,4.4)	2.46 (1.13,5.38)	2.48 (1.14,5.39)
Obese and overweight vs. underweight and normal weight			
quartile 1 vs 4	0.91 (0.71,1.15)	0.97 (0.76,1.24)	0.97 (0.76,1.24)
quartile 2 vs 4	0.84 (0.65,1.07)	0.89 (0.69,1.15)	0.89 (0.68,1.15)
quartile 3 vs 4	0.89 (0.7,1.15)	0.98 (0.76,1.25)	0.98 (0.76,1.26)
Obese vs. underweight, normal weight and overweight			
quartile 1 vs 4	0.88 (0.75,1.04)	0.97 (0.81,1.15)	0.97 (0.81,1.15)
quartile 2 vs 4	0.89 (0.76,1.04)	0.94 (0.8,1.1)	0.94 (0.8,1.1)
quartile 3 vs 4	1.03 (0.87,1.21)	1.1 (0.93,1.29)	1.1 (0.93,1.3)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + education, employment, occupation, income mobility limitation moderate, mobility limitation climbing stairs, marital status, predicted energy intake, alcohol usage, smoking, accelerometer wear time per day
Model 3: Adjusted for Model 2 + CESD10

Appendix Table 10: Adjusted odds of BMI category by quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and minutes of brisk walking and faster ambulation ($\geq$ 100 steps/min); HCHS/SOL (2008-2011).

Incidental or sporadic movement (1-39 steps/min)				
Obese, overweight, and normal vs. underweight				
	Model 1	Model 2	Model 3	Model 4
quartile 1 vs 4	0.34 (0.14,0.82)	0.38 (0.16,0.89)	3.36 (0.55,20.51)	0.46 (0.18,1.18)
quartile 2 vs 4	0.62 (0.27,1.44)	0.68 (0.28,1.63)	2.9 (0.63,13.26)	0.83 (0.32,2.19)
quartile 3 vs 4	0.69 (0.27,1.72)	0.76 (0.29,1.98)	1.78 (0.59,5.37)	0.82 (0.29,2.27)
Obese and overweight vs. underweight and normal weight				
quartile 1 vs 4	0.92 (0.72,1.17)	0.87 (0.68,1.12)	0.56 (0.35,0.89)	0.87 (0.68,1.12)
quartile 2 vs 4	0.98 (0.78,1.24)	0.97 (0.77,1.22)	0.71 (0.49,1.02)	0.97 (0.77,1.23)
quartile 3 vs 4	0.92 (0.72,1.16)	0.9 (0.71,1.14)	0.74 (0.55,1)	0.92 (0.73,1.16)
Obese vs. underweight, normal weight and overweight				
quartile 1 vs 4	1.11 (0.95,1.31)	1.07 (0.92,1.26)	0.75 (0.54,1.03)	1.04 (0.88,1.22)
quartile 2 vs 4	1.03 (0.87,1.21)	1.02 (0.86,1.2)	0.79 (0.61,1.03)	0.99 (0.84,1.17)
quartile 3 vs 4	0.95 (0.8,1.12)	0.95 (0.8,1.12)	0.81 (0.67,0.99)	0.94 (0.8,1.11)
Purposeful steps and faster ambulation (40-99 steps/min)				
Obese, overweight, and normal vs. underweight				
	Model 1	Model 2	Model 3	Model 4
quartile 1 vs 4	0.37 (0.15,0.88)	0.38 (0.16,0.9)	1.44 (0.42,4.95)	0.41 (0.18,0.93)
quartile 2 vs 4	1.05 (0.42,2.65)	1.12 (0.44,2.83)	2.96 (0.79,11.04)	1.43 (0.54,3.8)
quartile 3 vs 4	0.82 (0.35,1.94)	0.87 (0.36,2.08)	1.57 (0.53,4.66)	0.9 (0.38,2.09)
Obese and overweight vs. underweight and normal weight				
quartile 1 vs 4	1.36 (1.05,1.76)	1.32 (1.02,1.72)	1.87 (1.31,2.69)	1.29 (0.99,1.67)
quartile 2 vs 4	1.16 (0.91,1.48)	1.16 (0.91,1.47)	1.49 (1.09,2.05)	1.18 (0.93,1.49)

quartile 3 vs 4	0.98 (0.78,1.23)	0.99 (0.79,1.24)	1.16 (0.91,1.48)	1.03 (0.81,1.29)
Obese vs. underweight, normal weight and overweight				
quartile 1 vs 4	1.42 (1.2,1.67)	1.35 (1.14,1.6)	1.44 (1.1,1.88)	1.28 (1.07,1.54)
quartile 2 vs 4	1.1 (0.95,1.28)	1.08 (0.93,1.26)	1.14 (0.91,1.42)	1.06 (0.9,1.24)
quartile 3 vs 4	1.05 (0.89,1.24)	1.04 (0.88,1.22)	1.07 (0.89,1.29)	1.03 (0.87,1.22)
Brisk walking and faster ambulation (≥ 100 steps/min)				
Obese, overweight, and normal vs. underweight				
	Model 1	Model 2	Model 3	Model 4
category 1 vs 4	1.55 (0.33,7.21)	1.47 (0.32,6.64)	2.33 (0.5,10.83)	1.29 (0.29,5.74)
category 2 vs 4	0.84 (0.42,1.68)	0.83 (0.41,1.67)	1.11 (0.55,2.22)	0.8 (0.41,1.57)
category 3 vs 4	1.23 (0.6,2.49)	1.2 (0.6,2.42)	1.46 (0.76,2.79)	1.33 (0.69,2.55)
Obese and overweight vs. underweight and normal weight				
category 1 vs 4	1.69 (1.15,2.48)	1.7 (1.16,2.5)	1.74 (1.18,2.57)	1.69 (1.14,2.52)
category 2 vs 4	1.63 (1.31,2.03)	1.58 (1.27,1.96)	1.6 (1.28,1.98)	1.51 (1.21,1.88)
category 3 vs 4	1.2 (0.98,1.47)	1.16 (0.95,1.43)	1.17 (0.96,1.44)	1.11 (0.9,1.37)
Obese vs. underweight, normal weight and overweight				
category 1 vs 4	2.24 (1.74,2.89)	2.12 (1.63,2.75)	2.07 (1.58,2.71)	2.19 (1.67,2.86)
category 2 vs 4	1.42 (1.23,1.65)	1.37 (1.19,1.59)	1.36 (1.17,1.57)	1.38 (1.19,1.6)
category 3 vs 4	1.18 (1.01,1.37)	1.13 (0.97,1.32)	1.12 (0.97,1.31)	1.13 (0.97,1.31)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ employment, occupation, income, marital status, predicted total energy intake, CESD10, mobility limitations moderate and alcohol use

Appendix Table 11: Adjusted odds of BMI category by minutes spent in 10-minute bouts of ≥40 steps/min, ≥70 steps/min,100+ steps/min; HCHS/SOL (2008-2011).

Bouts purposeful steps and faster ambulation (≥ 40 steps per minute)				
Obese, overweight, and normal vs. underweight				
	Model 1	Model 2	Model 3	Model 4
category 1 vs 4	0.73 (0.27,1.93)	0.72 (0.26,1.97)	1.38 (0.53,3.58)	0.68 (0.25,1.91)
category 2 vs 4	0.95 (0.42,2.15)	0.98 (0.45,2.16)	1.57 (0.75,3.29)	0.97 (0.47,2)
category 3 vs 4	0.98 (0.5,1.94)	0.95 (0.48,1.87)	1.35 (0.65,2.78)	0.9 (0.44,1.83)
Obese and overweight vs. underweight and normal weight				
category 1 vs 4	1.67 (1.26,2.21)	1.59 (1.2,2.11)	1.69 (1.26,2.26)	1.51 (1.14,2.01)
category 2 vs 4	1.17 (0.93,1.49)	1.16 (0.92,1.47)	1.22 (0.94,1.58)	1.12 (0.88,1.42)
category 3 vs 4	1.05 (0.85,1.29)	1 (0.82,1.22)	1.03 (0.83,1.28)	0.97 (0.79,1.19)
Obese vs. underweight, normal weight and overweight				
category 1 vs 4	1.48 (1.22,1.78)	1.41 (1.16,1.7)	1.37 (1.11,1.69)	1.39 (1.15,1.68)
category 2 vs 4	1.15 (0.98,1.34)	1.12 (0.96,1.32)	1.1 (0.93,1.31)	1.11 (0.94,1.3)
category 3 vs 4	1.16 (1,1.36)	1.12 (0.96,1.3)	1.1 (0.94,1.29)	1.1 (0.94,1.28)
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
Obese, overweight, and normal vs. underweight				
	Model 1	Model 2	Model 3	Model 4
category 1 vs 4	1.24 (0.58,2.67)	1.22 (0.56,2.65)	1.61 (0.79,3.32)	1.16 (0.52,2.61)
category 2 vs 4	0.56 (0.26,1.22)	0.55 (0.26,1.16)	0.71 (0.35,1.44)	0.53 (0.27,1.04)
category 3 vs 4	1.35 (0.64,2.85)	1.27 (0.61,2.65)	1.47 (0.72,3.03)	1.22 (0.57,2.61)
Obese and overweight vs. underweight and normal weight				
category 1 vs 4	1.49 (1.18,1.86)	1.44 (1.15,1.8)	1.44 (1.15,1.81)	1.39 (1.1,1.76)
category 2 vs 4	1.17 (0.91,1.5)	1.12 (0.87,1.45)	1.13 (0.88,1.45)	1.07 (0.83,1.38)

	Model 1	Model 2	Model 3	Model 4
category 3 vs 4	1.13 (0.89,1.44)	1.08 (0.85,1.37)	1.08 (0.85,1.37)	1.06 (0.83,1.35)
Obese vs. underweight, normal weight and overweight				
category 1 vs 4	1.47 (1.23,1.75)	1.42 (1.18,1.69)	1.39 (1.16,1.67)	1.44 (1.21,1.73)
category 2 vs 4	1.21 (1.01,1.45)	1.16 (0.97,1.39)	1.15 (0.96,1.37)	1.17 (0.98,1.4)
quartile 3 vs 4	1.32 (1.1,1.58)	1.27 (1.07,1.52)	1.26 (1.06,1.51)	1.28 (1.08,1.53)
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)				
Obese, overweight, and normal vs. underweight				
	Model 1	Model 2	Model 3	Model 4
category 1 vs 4	1.34 (0.62,2.91)	1.33 (0.62,2.86)	1.61 (0.77,3.39)	1.31 (0.61,2.82)
category 2 vs 4	0.66 (0.24,1.83)	0.63 (0.23,1.69)	0.72 (0.29,1.77)	0.6 (0.26,1.36)
category 3 vs 4	1.73 (0.72,4.16)	1.65 (0.69,3.93)	1.82 (0.76,4.36)	1.6 (0.64,4)
Obese and overweight vs. underweight and normal weight				
category 1 vs 4	1.19 (0.93,1.51)	1.15 (0.9,1.46)	1.15 (0.9,1.46)	1.15 (0.9,1.48)
category 2 vs 4	0.8 (0.59,1.09)	0.77 (0.56,1.04)	0.77 (0.56,1.04)	0.76 (0.55,1.04)
category 3 vs 4	0.8 (0.58,1.09)	0.79 (0.58,1.08)	0.79 (0.58,1.08)	0.81 (0.59,1.11)
Obese vs. underweight, normal weight and overweight				
category 1 vs 4	1.29 (1.07,1.55)	1.22 (1.02,1.47)	1.21 (1,1.45)	1.28 (1.06,1.54)
category 2 vs 4	0.98 (0.79,1.21)	0.94 (0.76,1.17)	0.93 (0.75,1.16)	0.96 (0.77,1.19)
category 3 vs 4	1.03 (0.83,1.26)	1.01 (0.81,1.25)	1 (0.81,1.24)	1.04 (0.85,1.28)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + mobility limitations climbing stairs, smoking and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary
Model 4: Adjusted for Model 2+ employment, occupation, income, marital status, predicted total energy intake, CESD10, mobility limitations moderate and alcohol use

Appendix Table 12: Adjusted means of weight (kg), waist circumference (cm) and BMI by quartile and category of cadence indicator adjusted for total step volume; HCHS/SOL (2008-2011).

Peak 30-minute Cadence						
	Obese, overweight, and normal vs. underweight		*Obese and overweight vs. underweight and normal weight*		*Obese vs. underweight, normal weight and overweight*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
quartile 1 vs 4	1.41 (0.63,3.18)	1.27 (0.57,2.83)	1.84 (1.46,2.31)	1.89 (1.49,2.39)	1.41 (1.18,1.68)	1.48 (1.23,1.77)
quartile 2 vs 4	1.08 (0.5,2.36)	1.02 (0.47,2.2)	1.41 (1.11,1.78)	1.42 (1.12,1.81)	1.24 (1.03,1.48)	1.26 (1.05,1.51)
quartile 3 vs 4	1.01 (0.44,2.29)	1.01 (0.47,2.16)	1.37 (1.09,1.71)	1.37 (1.1,1.72)	1.17 (0.99,1.38)	1.18 (1,1.39)
Peak 60-minute Cadence						
	Obese, overweight, and normal vs. underweight		*Obese and overweight vs. underweight and normal weight*		*Obese vs. underweight, normal weight and overweight*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
quartile 1 vs 4	1.11 (0.54,2.25)	0.99 (0.48,2.02)	1.63 (1.29,2.06)	1.67 (1.32,2.13)	1.37 (1.14,1.64)	1.44 (1.19,1.73)
quartile 2 vs 4	1.06 (0.46,2.45)	1.06 (0.49,2.3)	1.47 (1.16,1.85)	1.48 (1.17,1.87)	1.32 (1.11,1.59)	1.34 (1.12,1.61)
quartile 3 vs 4	1.68 (0.88,3.2)	1.68 (0.88,3.2)	1.19 (0.93,1.51)	1.19 (0.94,1.51)	1.13 (0.94,1.35)	1.13 (0.94,1.36)
Bouts purposeful steps and faster ambulation (≥ 40 steps per minute)						
	Obese, overweight, and normal vs. underweight		*Obese and overweight vs. underweight and normal weight*		*Obese vs. underweight, normal weight and overweight*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	2.27 (1.01,5.08)	1.21 (0.5,2.97)	1.14 (0.9,1.46)	1.17 (0.89,1.54)	1 (0.85,1.19)	1.06 (0.87,1.29)
category 2 vs 4	1.23 (0.66,2.31)	1.02 (0.54,1.92)	1.21 (0.97,1.52)	1.22 (0.97,1.53)	1.09 (0.94,1.26)	1.11 (0.95,1.29)
category 3 vs 4	0.96 (0.4,2.3)	1.07 (0.46,2.47)	1.2 (0.92,1.57)	1.2 (0.92,1.57)	1.16 (0.99,1.37)	1.15 (0.98,1.35)
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)						
	Obese, overweight, and normal vs. underweight		*Obese and overweight vs. underweight and normal weight*		*Obese vs. underweight, normal weight and overweight*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	1.55 (0.82,2.91)	0.74 (0.32,1.67)	1.15 (0.92,1.43)	1.24 (0.96,1.61)	1.06 (0.89,1.26)	1.16 (0.94,1.42)
category 2 vs 4	1.62 (0.87,3.01)	1.55 (0.83,2.9)	1.2 (0.96,1.5)	1.2 (0.97,1.5)	1.18 (1,1.38)	1.18 (1.01,1.38)
category 3 vs 4	1.05 (0.45,2.46)	1.39 (0.68,2.85)	0.97 (0.76,1.24)	0.94 (0.73,1.21)	1.14 (0.97,1.35)	1.11 (0.94,1.31)
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)						

	Obese, overweight, and normal vs. underweight		*Obese and overweight vs. underweight and normal weight*		*underweight, normal weight and overweight vs. obese)*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	1.74 (0.73,4.12)	0.78 (0.31,1.95)	1.1 (0.87,1.39)	1.07 (0.82,1.42)	1.09 (0.93,1.27)	1.17 (0.96,1.42)
category 2 vs 4	2.21 (0.96,5.07)	1.99 (0.91,4.38)	1.17 (0.92,1.48)	1.16 (0.92,1.48)	1.13 (0.96,1.33)	1.14 (0.97,1.34)
category 3 vs 4	1.15 (0.48,2.72)	1.5 (0.64,3.51)	1.28 (1,1.64)	1.29 (1,1.67)	1.31 (1.11,1.54)	1.28 (1.08,1.51)

Model 1: Adjusted for age, sex, center, background and years in the U.S., mobility limitations climbing stairs, smoking and average accelerometer wear time per day

Model 2: Adjusted for Model 1 + percentage of time spent sedentary

Appendix Table 13. Adjusted mean percent changes of weight (kg), waist circumference (cm) and BMI by graduated step index level, HCHS/SOL (2008-2017).

Percent Change in Weight (kg) Between Visit 1 and Visit 2	
Sedentary (<5,000)	0.94 (0.02, 1.87)
Low Activity (5,000-7,499)	1.47 (0.39, 2.54)
Somewhat Active (7,500-9,999)	1.36 (0.31, 2.42)
Active (10,000 -12,499)	2.41 (1.17, 3.65)
Highly Active (>12,500)	2.4 (1.11, 3.7)
p-value	0.07
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2	
Sedentary (<5,000)	1.34 (0.09, 2.59)
Low Activity (5,000-7,499)	2.26 (1.39, 3.13)
Somewhat Active (7,500-9,999)	2.2 (0.78, 3.63)
Active (10,000 -12,499)	2.2 (0.78, 3.63)
Highly Active (>12,500)	2.55 (1.27, 3.83)
p-value	0.1
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2	
Sedentary (<5,000)	1.23 (0.31, 2.16)
Low Activity (5,000-7,499)	1.54 (0.47, 2.61)
Somewhat Active (7,500-9,999)	1.55 (0.48, 2.61)
Active (10,000 -12,499)	2.66 (1.43, 3.89)
Highly Active (>12,500)	2.65 (1.39, 3.92)
p-value	0.07

Adjusted for age, sex, center, background, years in the U.S., employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, years between visits and average accelerometer wear time per day

Appendix Table 14. Adjusted mean percent changes of weight (kg), waist circumference (cm) and BMI by peak 30 and 60-minute cadence HCHS/SOL (2008-2017).

Peak 30-minute cadence		
Percent Change in Weight (kg) Between Visit 1 and Visit 2		
	Model 1	Model 2
Q1 (<59.63)	-0.01 (-0.92, 0.9)	-0.27 (-1.24, 0.7)
Q2 (59.63->74.67)	0.19 (-0.61, 0.99)	0.13 (-0.67, 0.93)
Q3 (74.67->91.69)	1.29 (0.52, 2.05)	1.37 (0.59, 2.15)
Q4 (+91.27)	1.99 (1.19, 2.78)	2.13 (1.31, 2.94)
p-value	<0.01	<0.01
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2		
	Model 1	Model 2
Q1 (<59.63)	1.56 (0.75, 2.37)	1.57 (0.61, 2.53)
Q2 (59.63->74.67)	1.07 (0.05, 2.09)	1.07 (0.07, 2.06)
Q3 (74.67->91.69)	1.66 (0.65, 2.66)	1.65 (0.6, 2.71)
Q4 (+91.27)	2.33 (1.38, 3.29)	2.33 (1.28, 3.38)
p-value	0.02	0.04
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2		
	Model 1	Model 2
Q1 (<59.63)	-0.01 (-0.92, 0.9)	-0.27 (-1.24, 0.7)
Q2 (59.63->74.67)	0.19 (-0.61, 0.99)	0.13 (-0.67, 0.93)
Q3 (74.67->91.69)	1.29 (0.52, 2.05)	1.37 (0.59, 2.15)
Q4 (+91.27)	1.99 (1.19, 2.78)	2.13 (1.31, 2.94)
p-value	<0.01	<0.01
Peak 60-minute cadence		
Percent Change in Weight (kg) Between Visit 1 and Visit 2		
	Model 1	Model 2
Q1 (46.26<)	0.44 (-0.32, 1.2)	0.18 (-0.73, 1.08)
Q2 (46.26->59.79)	0.22 (-0.7, 1.15)	0.16 (-0.75, 1.07)
Q3 (59.79->75.69)	0.8 (0.1, 1.5)	0.89 (0.17, 1.61)
Q4 (+ 75.69)	2.01 (1.23, 2.8)	2.18 (1.35, 3.01)
p-value	<0.01	<0.01
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2		

	Model 1	Model 2
Q1 (46.26<)	1.91 (1.16, 2.66)	2.02 (1, 3.03)
Q2 (46.26->59.79)	1.12 (0.07, 2.17)	1.15 (0.15, 2.15)
Q3 (59.79->75.69)	1.29 (0.32, 2.26)	1.25 (0.19, 2.31)
Q4 (+ 75.69)	2.32 (1.36, 3.28)	2.25 (1.12, 3.37)
p-value	0.02	0.03
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2		
	Model 1	Model 2
Q1 (46.26<)	0.44 (-0.32, 1.2)	0.18 (-0.73, 1.08)
Q2 (46.26->59.79)	0.22 (-0.7, 1.15)	0.16 (-0.75, 1.07)
Q3 (59.79->75.69)	0.8 (0.1, 1.5)	0.89 (0.17, 1.61)
Q4 (+ 75.69)	2.01 (1.23, 2.8)	2.18 (1.35, 3.01)
p-value	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background, years in the U.S., employment, years between visits and average accelerometer wear time per day

Model 2: Adjusted for Model 1 + percentage of time spent sedentary

Appendix Table 15. Adjusted mean percent changes of weight (kg), waist circumference (cm) and BMI by time spent sedentary HCHS/SOL (2008-2017).

Percent Change in Weight (kg) Between Visit 1 and Visit 2	
Q1 (567.89<)	1.07 (-0.01, 2.15)
Q2 (567.89->655.59)	1.8 (0.74, 2.86)
Q3 (655.59->725.88)	1.16 (0.11, 2.21)
Q4 (725.88+)	1.29 (0.26, 2.33)
p-value	0.4
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2	
Q1 (567.89<)	1.84 (0.69, 2.99)
Q2 (567.89->655.59)	2.3 (1.18, 3.42)
Q3 (655.59->725.88)	2.31 (1.39, 3.23)
Q4 (725.88+)	1.7 (0.61, 2.8)
p-value	0.51
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2	
Q1 (567.89<)	1.07 (-0.01, 2.15)
Q2 (567.89->655.59)	1.8 (0.74, 2.86)
Q3 (655.59->725.88)	1.16 (0.11, 2.21)
Q4 (725.88+)	1.29 (0.26, 2.33)
p-value	0.4

Adjusted for age, sex, center, background, years in the U.S., education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking years between visits and average accelerometer wear time per day

Appendix Table 16: Adjusted mean percent changes of weight (kg), waist circumference (cm) and BMI by quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and time spent in brisk walking and faster ambulation (≥100 steps/min) HCHS/SOL (2008-2017).

			Percent Change in Weight (kg) Between Visit 1 and Visit 2		
	1-39 steps/min		**40-99 steps/min**		**≥ 100 steps/min**
Q1	0.93 (0.17, 1.69)	Q1	0.71 (-0.03, 1.45)	Category 1	0.83 (-0.62, 2.28)
Q2	1.07 (0.14, 2)	Q2	0.59 (-0.41, 1.59)	Category 2	-0.11 (-0.82, 0.6)
Q3	1.06 (0.19, 1.92)	Q3	1 (0.24, 1.76)	Category 3	0.64 (-0.08, 1.36)
Q4	0.42 (-0.31, 1.16)	Q4	1.24 (0.43, 2.05)	Category 4	2.1 (1.38, 2.82)
p-value	0.47	p-value	0.54	p-value	<0.01
			Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2		
	1-39 steps/min		**40-99 steps/min**		**≥ 100 steps/min**
Q1	1.59 (0.55, 2.63)	Q1	1.36 (0.34, 2.38)	Category 1	1.97 (0.6, 3.35)
Q2	2.01 (1.2, 2.81)	Q2	1.94 (1.09, 2.78)	Category 2	1.31 (0.69, 1.92)
Q3	1.62 (0.59, 2.66)	Q3	1.66 (0.64, 2.67)	Category 3	1.42 (0.47, 2.37)
Q4	1.42 (0.49, 2.34)	Q4	1.72 (0.84, 2.61)	Category 4	2.22 (1.28, 3.15)
p-value	0.78	p-value	0.81	p-value	0.11
			Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2		
	1-39 steps/min		**40-99 steps/min**		**≥ 100 steps/min**
Q1	0.93 (0.17, 1.69)	Q1	0.71 (-0.03, 1.45)	Category 1	0.83 (-0.62, 2.28)
Q2	1.07 (0.14, 2)	Q2	0.59 (-0.41, 1.59)	Category 2	-0.11 (-0.82, 0.6)
Q3	1.06 (0.19, 1.92)	Q3	1 (0.24, 1.76)	Category 3	0.64 (-0.08, 1.36)
Q4	0.42 (-0.31, 1.16)	Q4	1.24 (0.43, 2.05)	Category 4	2.1 (1.38, 2.82)
p-value	0.46	p-value	0.51	p-value	<0.01

Adjusted for age, sex, center, background, years in the U.S., employment, years between visits and average accelerometer wear time per day

Appendix Table 17: Adjusted means percent changes of weight (kg), waist circumference (cm) and BMI by minutes per day spent in 10-minute bouts of ≥ 40 steps/min, ≥70 steps/min and ≥100 steps/min HCHS/SOL (2008-2017).

Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)		
Percent Change in Weight (kg) Between Visit 1 and Visit 2		
Minutes	Model 1	Model 2
0	-0.21 (-1.15, 0.73)	-0.36 (-1.32, 0.6)
<0->9.92	0.68 (-0.13, 1.49)	0.61 (-0.22, 1.44)
9.92->28.85	1.17 (0.42, 1.92)	1.16 (0.41, 1.91)
≥28.85	1.62 (0.84, 2.39)	1.75 (0.96, 2.55)
p-value	<0.01	<0.01
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2		
	Model 1	Model 2
0	0.64 (-0.49, 1.77)	0.62 (-0.48, 1.73)
<0->9.92	1.96 (1.16, 2.77)	1.95 (1.11, 2.8)
9.92->28.85	1.81 (0.88, 2.75)	1.81 (0.88, 2.74)
≥28.85	2 (1.06, 2.94)	2.02 (1, 3.04)
p-value	0.03	0.05
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2		
	Model 1	Model 2
0	-0.21 (-1.15, 0.73)	-0.36 (-1.32, 0.6)
<0->9.92	0.68 (-0.13, 1.49)	0.61 (-0.22, 1.44)
9.92->28.85	1.17 (0.42, 1.92)	1.16 (0.41, 1.91)
≥28.85	1.62 (0.84, 2.39)	1.75 (0.96, 2.55)
p-value	0.01	<0.01
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)		
Percent Change in Weight (kg) Between Visit 1 and Visit 2		
Minutes	Model 1	Model 2
0	0.3 (-0.33, 0.93)	0.28 (-0.35, 0.91)
<0->6.20	-0.04 (-0.89, 0.82)	-0.04 (-0.9, 0.81)
6.20->16.8	1.9 (1.01, 2.79)	1.91 (1.02, 2.8)
≥16.8	2 (1.09, 2.9)	2.01 (1.11, 2.92)
p-value	<0.01	<0.01
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2		

	Model 1	Model 2
0	1.29 (0.73, 1.86)	1.31 (0.74, 1.88)
<0->6.20	1.35 (0.35, 2.35)	1.36 (0.36, 2.35)
6.20->16.8	2.27 (1.25, 3.29)	2.27 (1.25, 3.29)
≥16.8	2.16 (1.09, 3.23)	2.15 (1.06, 3.23)
p-value	0.07	0.08
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2		
	Model 1	Model 2
0	0.3 (-0.33, 0.93)	0.28 (-0.35, 0.91)
<0->6.20	-0.04 (-0.89, 0.82)	-0.04 (-0.9, 0.81)
6.20->16.8	1.9 (1.01, 2.79)	1.91 (1.02, 2.8)
≥16.8	2 (1.09, 2.9)	2.01 (1.11, 2.92)
p-value	<0.01	<0.01
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)		
Percent Change in Weight (kg) Between Visit 1 and Visit 2		
Minutes	Model 1	Model 2
0	0.3 (-0.28, 0.88)	0.3 (-0.28, 0.87)
<0->4.58	1.11 (0.12, 2.11)	1.11 (0.12, 2.11)
4.58->11.46	2.26 (1.13, 3.39)	2.26 (1.13, 3.39)
≥11.46	2.23 (1.09, 3.36)	2.23 (1.1, 3.36)
p-value	<0.01	<0.01
Percent Change in Waist Circumference (cm) Between Visit 1 and Visit 2		
	Model 1	Model 2
0	1.32 (0.76, 1.88)	1.33 (0.77, 1.89)
<0->4.58	1.92 (0.79, 3.06)	1.92 (0.79, 3.06)
4.58->11.46	2.42 (1.28, 3.56)	2.42 (1.28, 3.56)
≥11.46	2.44 (1.2, 3.67)	2.42 (1.18, 3.67)
p-value	0.08	0.1
Percent Change in Body Mass Index (kg/m^2) Between Visit 1 and Visit 2		
	Model 1	Model 2
0	0.3 (-0.28, 0.88)	0.3 (-0.28, 0.87)
<0->4.58	1.11 (0.12, 2.11)	1.11 (0.12, 2.11)
4.58->11.46	2.26 (1.13, 3.39)	2.26 (1.13, 3.39)

≥11.46	2.23 (1.09, 3.36)	2.23 (1.1, 3.36)
p-value	<0.01	<0.01

Model 1: Adjusted for age, sex, center, background years in the United State, employment, years between visits and average accelerometer wear time per day

Model 2: Adjusted for Model 1 + percentage of time spent sedentary

Appendix Table 18: Adjusted odds of weight maintenance category at Visit 2 by quartile of average total steps; HCHS/SOL (2008-2017).

	Model 1	Model 2
Substantial gain, gain, substantial loss and loss vs. maintenance		
quartile 1 vs 4	0.73 (0.56,0.94)	0.78 (0.6,1.01)
quartile 2 vs 4	0.86 (0.67,1.11)	0.9 (0.7,1.16)
quartile 3 vs 4	0.79 (0.61,1.01)	0.81 (0.63,1.03)
Substantial gain, gain and substantial loss vs. loss and maintenance		
quartile 1 vs 4	0.74 (0.6,0.91)	0.77 (0.62,0.96)
quartile 2 vs 4	0.94 (0.75,1.19)	0.98 (0.78,1.24)
quartile 3 vs 4	0.88 (0.71,1.08)	0.91 (0.74,1.12)
Substantial gain and gain vs. substantial loss, loss and maintenance		
quartile 1 vs 4	0.93 (0.76,1.14)	0.94 (0.76,1.16)
quartile 2 vs 4	0.92 (0.73,1.16)	0.96 (0.77,1.21)
quartile 3 vs 4	0.89 (0.72,1.11)	0.9 (0.72,1.11)
Substantial gain vs. gain, substantial loss, loss and maintenance		
quartile 1 vs 4	0.89 (0.71,1.11)	0.89 (0.7,1.12)
quartile 2 vs 4	0.97 (0.75,1.26)	1.01 (0.78,1.31)
quartile 3 vs 4	0.9 (0.71,1.13)	0.89 (0.7,1.13)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, years between visits and average accelerometer wear time per day

Appendix Table 19: Adjusted odds of weight maintenance category at Visit 2 by quartile of average peak 30 and 60-minute cadences; HCHS/SOL (2008-2011).

Peak 30-minute Cadence			
Substantial gain, gain, substantial loss and loss vs. maintenance			
	Model 1	Model 2	Model 3
quartile 1 vs 4	0.73 (0.57,0.94)	0.76 (0.59,0.98)	0.71 (0.54,0.95)
quartile 2 vs 4	0.79 (0.63,0.99)	0.78 (0.62,0.98)	0.76 (0.6,0.96)
quartile 3 vs 4	1 (0.8,1.24)	0.96 (0.77,1.2)	0.96 (0.76,1.2)
Substantial gain, gain and substantial loss vs. loss and maintenance			
quartile 1 vs 4	0.76 (0.6,0.95)	0.78 (0.62,0.98)	0.74 (0.56,0.97)
quartile 2 vs 4	0.86 (0.71,1.06)	0.86 (0.7,1.05)	0.84 (0.68,1.03)
quartile 3 vs 4	0.98 (0.81,1.19)	0.95 (0.78,1.16)	0.95 (0.78,1.15)
Substantial gain and gain vs. substantial loss, loss and maintenance			
quartile 1 vs 4	0.87 (0.71,1.07)	0.87 (0.7,1.07)	0.78 (0.62,0.98)
quartile 2 vs 4	0.77 (0.62,0.96)	0.76 (0.61,0.94)	0.72 (0.58,0.9)
quartile 3 vs 4	0.91 (0.75,1.11)	0.89 (0.73,1.09)	0.88 (0.72,1.07)
Substantial gain vs. gain, substantial loss, loss and maintenance			
quartile 1 vs 4	0.72 (0.58,0.9)	0.72 (0.57,0.89)	0.6 (0.47,0.78)
quartile 2 vs 4	0.74 (0.59,0.93)	0.73 (0.58,0.91)	0.67 (0.53,0.84)
quartile 3 vs 4	0.89 (0.71,1.1)	0.86 (0.69,1.07)	0.84 (0.68,1.05)
Peak 60-minute Cadence			
Substantial gain, gain, substantial loss and loss vs. maintenance			
	Model 1	Model 2	Model 3
quartile 1 vs 4	0.75 (0.6,0.95)	0.78 (0.62,0.99)	0.72 (0.55,0.96)
quartile 2 vs 4	0.78 (0.6,1.01)	0.77 (0.59,1)	0.74 (0.56,0.98)

quartile 3 vs 4	0.92 (0.74,1.13)	0.89 (0.72,1.1)	0.88 (0.71,1.1)
Substantial gain, gain and substantial loss vs. loss and maintenance			
quartile 1 vs 4	0.78 (0.63,0.96)	0.8 (0.65,0.99)	0.75 (0.57,0.98)
quartile 2 vs 4	0.86 (0.69,1.08)	0.86 (0.69,1.07)	0.83 (0.65,1.06)
quartile 3 vs 4	0.96 (0.8,1.16)	0.94 (0.77,1.13)	0.92 (0.76,1.12)
Substantial gain and gain vs. substantial loss, loss and maintenance			
quartile 1 vs 4	0.89 (0.73,1.1)	0.89 (0.73,1.1)	0.78 (0.61,1)
quartile 2 vs 4	0.73 (0.59,0.91)	0.72 (0.58,0.9)	0.67 (0.54,0.84)
quartile 3 vs 4	0.83 (0.68,1)	0.81 (0.67,0.98)	0.79 (0.65,0.96)
Substantial gain vs. gain, substantial loss, loss and maintenance			
quartile 1 vs 4	0.78 (0.64,0.96)	0.78 (0.63,0.96)	0.63 (0.48,0.82)
quartile 2 vs 4	0.73 (0.58,0.91)	0.71 (0.57,0.89)	0.64 (0.5,0.81)
quartile 3 vs 4	0.77 (0.63,0.95)	0.75 (0.61,0.92)	0.72 (0.59,0.88)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 20: Adjusted odds of weight maintenance category at Visit 2 by quartile of time spent sedentary adjusted for total accelerometer wear time; HCHS/SOL (2008-2017).

	Model 1	Model 2
Substantial gain, gain, substantial loss and loss vs. maintenance		
quartile 1 vs 4	1.15 (0.9,1.48)	1.06 (0.81,1.37)
quartile 2 vs 4	1.06 (0.86,1.31)	1.02 (0.82,1.27)
quartile 3 vs 4	1.12 (0.88,1.42)	1.14 (0.89,1.45)
Substantial gain, gain and substantial loss vs. loss and maintenance		
quartile 1 vs 4	1.11 (0.9,1.37)	1.05 (0.84,1.3)
quartile 2 vs 4	1.1 (0.9,1.33)	1.09 (0.89,1.34)
quartile 3 vs 4	1.13 (0.92,1.38)	1.15 (0.94,1.42)
Substantial gain and gain vs. substantial loss, loss and maintenance		
quartile 1 vs 4	0.82 (0.66,1.02)	0.82 (0.65,1.04)
quartile 2 vs 4	0.95 (0.78,1.15)	0.97 (0.79,1.2)
quartile 3 vs 4	0.81 (0.65,1.01)	0.84 (0.67,1.04)
Substantial gain vs. gain, substantial loss, loss and maintenance		
quartile 1 vs 4	0.81 (0.63,1.05)	0.8 (0.61,1.06)
quartile 2 vs 4	0.95 (0.76,1.19)	0.98 (0.77,1.24)
quartile 3 vs 4	0.84 (0.66,1.06)	0.86 (0.68,1.1)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking years between visits and average accelerometer wear time per day

Appendix Table 21: Adjusted odds of weight maintenance category at Visit 2 by quartile of minutes per day spent in light physical activity (1-39 steps/min), purposeful walking (40-99 steps/min) and minutes in brisk walking or higher (100+ steps/min); HCHS/SOL (2008-2017).

Incidental or sporadic movement (1-39 steps/min)			
Substantial gain, gain, substantial loss and loss vs. maintenance			
	Model 1	Model 2	Model 3
quartile 1 vs 4	1.01 (0.82,1.25)	1.13 (0.9,1.41)	1.67 (1.07,2.62)
quartile 2 vs 4	1.09 (0.87,1.36)	1.16 (0.92,1.46)	1.52 (1.1,2.1)
quartile 3 vs 4	1.17 (0.93,1.46)	1.25 (1,1.58)	1.48 (1.15,1.9)
Substantial gain, gain and substantial loss vs. loss and maintenance			
quartile 1 vs 4	0.98 (0.81,1.19)	1.08 (0.88,1.32)	1.04 (0.84,1.31)
quartile 2 vs 4	1.03 (0.85,1.25)	1.09 (0.9,1.33)	1.09 (0.89,1.33)
quartile 3 vs 4	1.13 (0.92,1.39)	1.21 (0.98,1.5)	1.15 (0.93,1.42)
Substantial gain and gain vs. substantial loss, loss and maintenance			
quartile 1 vs 4	1.19 (0.98,1.44)	1.27 (1.03,1.55)	1.48 (0.97,2.27)
quartile 2 vs 4	1.07 (0.88,1.29)	1.13 (0.93,1.37)	1.26 (0.91,1.73)
quartile 3 vs 4	1.08 (0.88,1.34)	1.13 (0.92,1.39)	1.21 (0.94,1.57)
Substantial gain vs. gain, substantial loss, loss and maintenance			
quartile 1 vs 4	1.21 (0.97,1.5)	1.3 (1.04,1.62)	1.64 (1.02,2.62)
quartile 2 vs 4	1.27 (1.03,1.56)	1.35 (1.09,1.67)	1.59 (1.11,2.28)
quartile 3 vs 4	1.18 (0.95,1.48)	1.25 (1.01,1.56)	1.38 (1.03,1.86)
Purposeful steps and faster ambulation (40-99 steps/min)			
Substantial gain, gain, substantial loss and loss vs. maintenance			
	Model 1	Model 2	Model 3
quartile 1 vs 4	0.74 (0.57,0.96)	0.81 (0.62,1.07)	0.65 (0.41,1.01)
quartile 2 vs 4	0.75 (0.57,0.97)	0.79 (0.6,1.04)	0.67 (0.47,0.97)
quartile 3 vs 4	0.8 (0.62,1.04)	0.85 (0.66,1.1)	0.77 (0.57,1.04)

	Substantial gain, gain and substantial loss vs. loss and maintenance		
quartile 1 vs 4	0.73 (0.59,0.92)	0.8 (0.63,1)	0.62 (0.42,0.92)
quartile 2 vs 4	0.79 (0.63,1)	0.84 (0.67,1.06)	0.7 (0.52,0.96)
quartile 3 vs 4	0.8 (0.64,1.01)	0.85 (0.67,1.07)	0.76 (0.59,0.98)
	Substantial gain and gain vs. substantial loss, loss and maintenance		
quartile 1 vs 4	1.01 (0.81,1.26)	1.05 (0.83,1.33)	0.86 (0.61,1.21)
quartile 2 vs 4	0.93 (0.74,1.16)	0.96 (0.76,1.21)	0.83 (0.61,1.11)
quartile 3 vs 4	0.9 (0.73,1.13)	0.93 (0.75,1.17)	0.85 (0.67,1.08)
	Substantial gain vs. gain, substantial loss, loss and maintenance		
quartile 1 vs 4	1 (0.78,1.28)	1.04 (0.8,1.35)	0.83 (0.58,1.19)
quartile 2 vs 4	1.01 (0.78,1.3)	1.04 (0.81,1.35)	0.89 (0.65,1.2)
quartile 3 vs 4	0.93 (0.74,1.17)	0.96 (0.76,1.21)	0.87 (0.68,1.11)
	Brisk walking and faster ambulation ($\geq$ 100 steps/min)		
	Substantial gain, gain, substantial loss and loss vs. maintenance		
	Model 1	Model 2	Model 3
category 1 vs 4	0.63 (0.46,0.85)	0.62 (0.46,0.84)	0.61 (0.45,0.84)
category 2 vs 4	0.87 (0.7,1.08)	0.85 (0.69,1.06)	0.85 (0.68,1.05)
category 3 vs 4	0.91 (0.75,1.1)	0.87 (0.72,1.06)	0.87 (0.71,1.06)
	Substantial gain, gain and substantial loss vs. loss and maintenance		
category 1 vs 4	0.71 (0.54,0.93)	0.71 (0.54,0.93)	0.7 (0.53,0.93)
category 2 vs 4	0.92 (0.76,1.11)	0.9 (0.75,1.08)	0.9 (0.74,1.09)
category 3 vs 4	0.89 (0.74,1.06)	0.86 (0.72,1.03)	0.86 (0.71,1.04)
	Substantial gain and gain vs. substantial loss, loss and maintenance		
category 1 vs 4	0.82 (0.61,1.11)	0.81 (0.61,1.09)	0.77 (0.57,1.03)
category 2 vs 4	0.86 (0.72,1.01)	0.84 (0.7,0.99)	0.81 (0.68,0.96)
category 3 vs 4	0.79 (0.66,0.95)	0.78 (0.65,0.94)	0.76 (0.64,0.91)

Substantial gain vs. gain, substantial loss, loss and maintenance			
category 1 vs 4	0.84 (0.6,1.16)	0.82 (0.6,1.14)	0.76 (0.55,1.06)
category 2 vs 4	0.72 (0.59,0.87)	0.7 (0.57,0.84)	0.66 (0.55,0.81)
category 3 vs 4	0.76 (0.63,0.93)	0.75 (0.62,0.91)	0.73 (0.6,0.89)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 22: Adjusted odds of weight maintenance category at Visit 2 by minutes spent in at least 10-minute bouts of ≥40 steps/min, ≥70 steps/min,100+ steps/min adjusted for total step volume; HCHS/SOL (2008-2011).

Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)			
Substantial gain, gain, substantial loss and loss vs. maintenance			
	Model 1	Model 2	Model 3
category 1 vs 4	0.81 (0.62,1.06)	0.77 (0.59,1)	0.74 (0.55,0.98)
category 2 vs 4	0.91 (0.72,1.15)	0.88 (0.7,1.11)	0.86 (0.66,1.11)
category 3 vs 4	0.94 (0.77,1.15)	0.89 (0.73,1.1)	0.87 (0.71,1.08)
Substantial gain, gain and substantial loss vs. loss and maintenance			
category 1 vs 4	0.8 (0.64,1.01)	0.77 (0.61,0.97)	0.74 (0.57,0.96)
category 2 vs 4	0.88 (0.7,1.1)	0.86 (0.68,1.08)	0.83 (0.64,1.07)
category 3 vs 4	0.94 (0.77,1.14)	0.9 (0.74,1.09)	0.88 (0.72,1.07)
Substantial gain and gain vs. substantial loss, loss and maintenance			
category 1 vs 4	0.85 (0.68,1.06)	0.83 (0.67,1.04)	0.74 (0.58,0.94)
category 2 vs 4	0.88 (0.71,1.08)	0.87 (0.71,1.08)	0.8 (0.64,1)
category 3 vs 4	0.98 (0.8,1.2)	0.97 (0.79,1.18)	0.91 (0.74,1.11)
Substantial gain vs. gain, substantial loss, loss and maintenance			
category 1 vs 4	0.81 (0.65,1.02)	0.79 (0.63,1)	0.68 (0.53,0.87)
category 2 vs 4	0.83 (0.67,1.03)	0.82 (0.65,1.02)	0.73 (0.58,0.93)
category 3 vs 4	0.94 (0.75,1.19)	0.92 (0.73,1.17)	0.86 (0.68,1.07)
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)			
Substantial gain, gain, substantial loss and loss vs. maintenance			
	Model 1	Model 2	Model 3
category 1 vs 4	0.96 (0.76,1.21)	0.87 (0.68,1.1)	0.87 (0.68,1.1)
category 2 vs 4	0.95 (0.75,1.2)	0.88 (0.7,1.12)	0.88 (0.69,1.12)
category 3 vs 4	1.05 (0.81,1.36)	0.99 (0.76,1.28)	0.99 (0.76,1.28)

	Substantial gain, gain and substantial loss vs. loss and maintenance		
category 1 vs 4	0.96 (0.77,1.19)	0.88 (0.71,1.09)	0.88 (0.7,1.1)
category 2 vs 4	0.9 (0.72,1.14)	0.85 (0.67,1.07)	0.85 (0.66,1.07)
category 3 vs 4	0.98 (0.78,1.23)	0.93 (0.74,1.17)	0.93 (0.74,1.17)
	Substantial gain and gain vs. substantial loss, loss and maintenance		
category 1 vs 4	0.87 (0.71,1.06)	0.84 (0.68,1.03)	0.81 (0.66,1)
category 2 vs 4	0.81 (0.65,1.01)	0.78 (0.62,0.98)	0.77 (0.61,0.97)
category 3 vs 4	0.97 (0.76,1.23)	0.93 (0.73,1.2)	0.93 (0.72,1.19)
	Substantial gain vs. gain, substantial loss, loss and maintenance		
category 1 vs 4	0.79 (0.64,0.98)	0.75 (0.61,0.94)	0.72 (0.58,0.91)
category 2 vs 4	0.71 (0.55,0.92)	0.68 (0.52,0.89)	0.67 (0.51,0.87)
category 3 vs 4	0.99 (0.76,1.29)	0.96 (0.73,1.26)	0.95 (0.72,1.25)
	Bouts of brisk walking and faster ambulation ($\geq$ 100 steps/min)		
	Substantial gain, gain, substantial loss and loss vs. maintenance		
	Model 1	Model 2	Model 3
category 1 vs 4	0.98 (0.76,1.24)	0.93 (0.73,1.19)	0.93 (0.73,1.19)
category 2 vs 4	0.89 (0.65,1.23)	0.9 (0.66,1.24)	0.9 (0.66,1.24)
category 3 vs 4	1.05 (0.76,1.45)	1.11 (0.81,1.52)	1.11 (0.81,1.53)
	Substantial gain, gain and substantial loss vs. loss and maintenance		
category 1 vs 4	0.98 (0.79,1.22)	0.94 (0.76,1.17)	0.94 (0.76,1.18)
category 2 vs 4	0.83 (0.61,1.13)	0.82 (0.6,1.12)	0.82 (0.6,1.12)
category 3 vs 4	1.03 (0.75,1.43)	1.06 (0.78,1.46)	1.07 (0.78,1.46)
	Substantial gain and gain vs. substantial loss, loss and maintenance		
category 1 vs 4	0.81 (0.65,0.99)	0.79 (0.64,0.97)	0.78 (0.63,0.96)
category 2 vs 4	0.82 (0.6,1.13)	0.81 (0.58,1.12)	0.81 (0.58,1.12)
category 3 vs 4	0.92 (0.69,1.24)	0.95 (0.71,1.28)	0.94 (0.7,1.27)

Substantial gain vs. gain, substantial loss, loss and maintenance			
category 1 vs 4	0.7 (0.56,0.88)	0.68 (0.54,0.86)	0.67 (0.53,0.85)
category 2 vs 4	0.83 (0.59,1.16)	0.81 (0.57,1.15)	0.81 (0.57,1.15)
category 3 vs 4	0.92 (0.68,1.24)	0.94 (0.7,1.26)	0.93 (0.69,1.25)

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + employment, years between visits and average accelerometer wear time per day

Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 23: Adjusted odds of weight maintenance category adjusted for total volume of steps and cadence indicators; HCHS/SOL (2008-2011).

Peak 30-minute Cadence								
	Substantial gain, gain, substantial loss and loss vs. maintenance		*Substantial gain, gain and substantial loss vs. loss and maintenance*		*Substantial gain and gain vs. substantial loss, loss and maintenance*		*Substantial gain vs. gain, substantial loss, loss and maintenance*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
quartile 1 vs 4	0.77 (0.62,0.96)	0.76 (0.61,0.95)	0.82 (0.67,1.02)	0.81 (0.66,1.01)	0.8 (0.66,0.97)	0.82 (0.68,0.99)	0.67 (0.54,0.83)	0.68 (0.55,0.84)
quartile 2 vs 4	0.98 (0.78,1.24)	0.98 (0.77,1.23)	1.02 (0.83,1.26)	1.02 (0.82,1.26)	0.96 (0.76,1.21)	0.97 (0.77,1.22)	0.86 (0.67,1.09)	0.86 (0.68,1.09)
quartile 3 vs 4	0.89 (0.73,1.1)	0.89 (0.73,1.09)	0.92 (0.76,1.11)	0.92 (0.76,1.1)	0.93 (0.76,1.13)	0.93 (0.77,1.14)	0.84 (0.68,1.05)	0.85 (0.69,1.05)
Peak 60-minute Cadence								
	Substantial gain, gain, substantial loss and loss vs. maintenance		*Substantial gain, gain and substantial loss vs. loss and maintenance*		*Substantial gain and gain vs. substantial loss, loss and maintenance*		*Substantial gain vs. gain, substantial loss, loss and maintenance*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
quartile 1 vs 4	0.78 (0.62,0.97)	0.77 (0.62,0.96)	0.8 (0.64,0.99)	0.79 (0.63,0.98)	0.78 (0.63,0.96)	0.8 (0.65,0.98)	0.68 (0.54,0.87)	0.7 (0.56,0.87)
quartile 2 vs 4	0.85 (0.67,1.08)	0.84 (0.66,1.07)	0.89 (0.72,1.1)	0.89 (0.72,1.09)	0.86 (0.7,1.06)	0.86 (0.7,1.06)	0.81 (0.65,1.01)	0.81 (0.65,1.01)
quartile 3 vs 4	0.9 (0.73,1.11)	0.9 (0.73,1.11)	0.88 (0.73,1.07)	0.88 (0.73,1.07)	0.83 (0.69,1.01)	0.83 (0.69,1.01)	0.87 (0.71,1.07)	0.87 (0.71,1.07)
Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)								
	Substantial gain, gain, substantial loss and loss vs. maintenance		*Substantial gain, gain and substantial loss vs. loss and maintenance*		*Substantial gain and gain vs. substantial loss, loss and maintenance*		*Substantial gain vs. gain, substantial loss, loss and maintenance*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	0.83 (0.65,1.06)	0.8 (0.62,1.04)	0.87 (0.69,1.1)	0.86 (0.67,1.1)	0.88 (0.7,1.11)	0.92 (0.71,1.21)	0.79 (0.62,1.01)	0.83 (0.63,1.09)
category 2 vs 4	0.94 (0.76,1.16)	0.93 (0.75,1.15)	0.88 (0.71,1.09)	0.88 (0.71,1.09)	0.92 (0.75,1.13)	0.93 (0.75,1.15)	0.85 (0.68,1.07)	0.86 (0.68,1.08)

category 3 vs 4	0.85 (0.69,1.06)	0.86 (0.69,1.06)	0.81 (0.66,0.99)	0.81 (0.66,1)	0.95 (0.78,1.15)	0.94 (0.78,1.14)	0.87 (0.71,1.08)	0.86 (0.7,1.06)
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)								
	Substantial gain, gain, substantial loss and loss vs. maintenance		*Substantial gain, gain and substantial loss vs. loss and maintenance*		*Substantial gain and gain vs. substantial loss, loss and maintenance*		*Substantial gain vs. gain, substantial loss, loss and maintenance*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	0.95 (0.73,1.23)	0.94 (0.71,1.25)	0.95 (0.74,1.21)	0.95 (0.73,1.24)	0.76 (0.61,0.95)	0.77 (0.6,0.98)	0.65 (0.51,0.83)	0.65 (0.5,0.85)
category 2 vs 4	0.9 (0.72,1.11)	0.9 (0.72,1.11)	0.86 (0.69,1.07)	0.86 (0.69,1.07)	0.86 (0.72,1.03)	0.86 (0.72,1.03)	0.8 (0.65,0.98)	0.8 (0.65,0.98)
category 3 vs 4	0.9 (0.72,1.14)	0.91 (0.72,1.15)	0.89 (0.71,1.1)	0.88 (0.71,1.11)	0.91 (0.77,1.09)	0.91 (0.76,1.1)	0.76 (0.63,0.93)	0.76 (0.62,0.94)
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)								
	Substantial gain, gain, substantial loss and loss vs. maintenance		*Substantial gain, gain and substantial loss vs. loss and maintenance*		*Substantial gain and gain vs. substantial loss, loss and maintenance*		*Substantial gain vs. gain, substantial loss, loss and maintenance*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	1.08 (0.83,1.39)	1.09 (0.84,1.42)	1.05 (0.85,1.31)	1.1 (0.88,1.38)	0.77 (0.61,0.95)	0.78 (0.61,0.99)	0.68 (0.52,0.89)	0.7 (0.53,0.92)
category 2 vs 4	0.97 (0.78,1.22)	0.98 (0.78,1.22)	0.97 (0.78,1.21)	0.98 (0.79,1.22)	0.8 (0.65,0.98)	0.8 (0.65,0.98)	0.76 (0.61,0.94)	0.76 (0.61,0.94)
category 3 vs 4	1.01 (0.8,1.27)	1 (0.79,1.27)	0.91 (0.75,1.1)	0.89 (0.73,1.09)	0.91 (0.76,1.08)	0.9 (0.75,1.09)	0.78 (0.64,0.95)	0.77 (0.63,0.95)

Model 1: Adjusted for age, sex, center, background and years in the U.S., employment, years between visits and average accelerometer wear time per day and total step volume

Model 2: Adjusted for Model 1 + percentage of time spent sedentary

Appendix Table 24: Adjusted means and changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by graduated step index; HCHS/SOL (2008-2017).

	Weight (kg)	*Change in weight (kg)*
Sedentary (<5,000)	82.79 (81.35,84.23)	-0.19 (-0.86,0.48)
Low Activity (5,000-7,499)	79.59 (78.52,80.66)	0.37 (-0.43,1.16)
Somewhat Active (7,500-9,999)	78.31 (77.01,79.62)	0.52 (-0.19,1.22)
Active (10,000 -12,499)	77.76 (76.25,79.26)	1.24 (0.43,2.05)
Highly Active (>12,500)	76.55 (75.12,77.99)	1.5 (0.57,2.44)
p-value	<0.0001	0.01
	WC (cm)	*Change in WC (cm)*
Sedentary (<5,000)	100.56 (99.5,101.62)	1.09 (0.44,1.74)
Low Activity (5,000-7,499)	79.59 (78.52,80.66))	1.6 (0.9,2.31)
Somewhat Active (7,500-9,999)	96.99 (95.93,98.06)	1.3 (0.55,2.06)
Active (10,000 -12,499)	96.64 (95.38,97.89)	1.93 (1.04,2.81)
Highly Active (>12,500)	95.31 (94.17,96.46)	2.34 (1.48,3.2)
p-value	<0.0001	0.07
	BMI (kg/m^2)	*Change in BMI (kg/m^2)*
Sedentary (<5,000)	30.5 (30.06,30.94)	-0.1 (-0.34,0.15)
Low Activity (5,000-7,499)	29.46 (29.1,29.82)	0.12 (-0.16,0.39)
Somewhat Active (7,500-9,999)	29.1 (28.66,29.55)	0.16 (-0.09,0.4)
Active (10,000 -12,499)	28.79 (28.32,29.26)	0.41 (0.11,0.7)
Highly Active (>12,500)	28.65 (28.18,29.11)	0.49 (0.17,0.81)
p-value	<0.0001	0.01

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 25: Adjusted means and changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by peak 30 and peak 60-minute cadence indicators; HCHS/SOL (2008-2017).

	Mean Weight (kg)		*Mean Change in Weight (kg)*	
	Peak 30-minute Cadence	Peak 60-minute Cadence	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	84.52 (83.2,85.84)	83.68 (82.32,85.03)	-0.53 (-1.36,0.31)	-0.09 (-0.77,0.58)
Q2	81.47 (80.06,82.87)	81.43 (80.07,82.79)	-0.08 (-0.76,0.61)	-0.14 (-0.96,0.69)
Q3	78.2 (77.15,79.26)	78.57 (77.43,79.72)	1.01 (0.38,1.64)	0.68 (0.11,1.26)
Q4	74.06 (72.95,75.17)	74.5 (73.34,75.65)	1.49 (0.83,2.16)	1.46 (0.79,2.13)
p-value	<0.0001	<0.0001	<0.0001	<0.01
	Mean Waist Circumference (cm)		*Mean Change in Waist Circumference (cm)*	
	Peak 30-minute Cadence	Peak 60-minute Cadence	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	101.82 (100.79,102.84)	101.28 (100.21,102.35)	1.09 (0.36,1.82)	1.44 (0.77,2.11)
Q2	99.39 (98.34,100.44)	99.1 (98.13,100.07)	1.08 (0.35,1.8)	1.08 (0.35,1.81)
Q3	96.96 (96.1,97.83)	97.37 (96.41,98.33)	1.75 (1.04,2.46)	1.42 (0.75,2.08)
Q4	93.59 (92.62,94.56)	93.96 (92.97,94.94)	2.16 (1.49,2.83)	2.14 (1.46,2.81)
p-value	<0.0001	<0.0001	0.02	0.07
	Mean Body Mass Index (kg/m^2)		*Mean Change in Body Mass Index (kg/m^2)*	
	Peak 30-minute Cadence	Peak 60-minute Cadence	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	31.15 (30.71,31.6)	30.9 (30.43,31.36)	-0.22 (-0.51,0.08)	-0.07 (-0.31,0.18)
Q2	29.96 (29.55,30.38)	29.89 (29.5,30.27)	-0.06 (-0.3,0.19)	-0.07 (-0.36,0.23)
Q3	29.04 (28.69,29.39)	29.22 (28.82,29.61)	0.34 (0.12,0.57)	0.22 (0.01,0.43)
Q4	27.72 (27.33,28.11)	27.87 (27.47,28.26)	0.49 (0.26,0.73)	0.49 (0.25,0.72)
p-value	<0.0001	<0.0001	<0.0001	<0.01

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 26: Adjusted means and changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time spent in incidental or sporadic movement (1-39 steps/min), time spent in purposeful walking and faster ambulation (40-99 steps/min) and minutes spent in brisk walking and faster ambulation (≥ 100 steps/min); HCHS/SOL (2008-2017).

	Mean Weight (kg)					*Mean Change in Weight (kg)*			
	1-39 steps/min	40-99 steps/min		>100 steps/min		1-39 steps/min	40-99 steps/min		>100 steps/min
Q1	79.8 (78.34,81.27)	81.61 (80.16,83.06)	Category 1	88.08 (85.66,90.5)	Q1	0.28 (-0.4,0.96)	0.23 (-0.43,0.89)	Category 1	0.28 (-0.83,1.4)
Q2	80.27 (79,81.55)	79.8 (78.52,81.08)	Category 2	83.56 (82.34,84.78)	Q2	0.41 (-0.41,1.23)	-0.01 (-0.86,0.84)	Category 2	-0.46 (-1.12,0.2)
Q3	79.27 (78.17,80.36)	78.71 (77.58,79.83)	Category 3	79.66 (78.51,80.82)	Q3	0.77 (0.05,1.49)	0.64 (0.01,1.27)	Category 3	0.34 (-0.25,0.92)
Q4	79.72 (78.52,80.93)	78.61 (77.43,79.79)	Category 4	74.08 (73.03,75.13)	Q4	0.44 (-0.17,1.06)	1.1 (0.41,1.78)	Category 4	1.55 (0.95,2.15)
p-value	0.54	<0.01	p-value	<0.0001	p-value	0.66	<0.0001	p-value	<0.0001
	Mean Waist Circumference (cm)					*Mean Change in Waist Circumference (cm)*			
	1-39 steps/min	40-99 steps/min		>100 steps/min		1-39 steps/min	40-99 steps/min		>100 steps/min
Q1	98.37 (97.28,99.46)	99.93 (98.88,100.99)	Category 1	104.25 (102.5,106.01)	Q1	1.44 (0.76,2.12)	1.26 (0.58,1.94)	Category 1	1.8 (0.57,3.03)
Q2	98.26 (97.26,99.27)	97.87 (96.79,98.96)	Category 2	100.87 (99.91,101.83)	Q2	1.58 (0.85,2.31)	1.45 (0.7,2.2)	Category 2	1.02 (0.43,1.62)
Q3	97.65 (96.73,98.56)	97.22 (96.31,98.14)	Category 3	98.1 (97.25,98.95)	Q3	1.57 (0.82,2.31)	1.62 (0.92,2.32)	Category 3	1.41 (0.77,2.05)
Q4	98.12 (97.14,99.09)	97.04 (96.12,97.95)	Category 4	93.85 (92.91,94.78)	Q4	1.48 (0.77,2.2)	1.79 (1.13,2.46)	Category 4	2.05 (1.46,2.65)
p-value	0.55	<0.01	p-value	0.05	p-value	0.99	0.6	p-value	0.05
	Mean Body Mass Index (kg/m^2)					*Mean Change in Body Mass Index (kg/m^2)*			
	1-39 steps/min	40-99 steps/min		>100 steps/min		1-39 steps/min	40-99 steps/min		>100 steps/min

Q1	29.5 (29.05,29.95)	30.17 (29.74,30.61)	Category 1	32.28 (31.51,33.04)	Q1	0.09 (-0.15,0.34)	0.06 (-0.18,0.3)	Category 1	0.03 (-0.38,0.45)
Q2	29.64 (29.21,30.07)	29.56 (29.1,30.02)	Category 2	30.69 (30.29,31.1)	Q2	0.12 (-0.17,0.4)	-0.01 (-0.32,0.3)	Category 2	-0.18 (-0.42,0.06)
Q3	29.36 (28.98,29.73)	29.16 (28.79,29.53)	Category 3	29.48 (29.14,29.82)	Q3	0.24 (-0.01,0.5)	0.19 (-0.03,0.41)	Category 3	0.09 (-0.12,0.3)
Q4	29.67 (29.27,30.07)	29.14 (28.77,29.51)	Category 4	27.79 (27.41,28.17)	Q4	0.11 (-0.11,0.33)	0.35 (0.11,0.59)	Category 4	0.53 (0.31,0.74)
p-value	0.58	<0.01	p-value	<0.0001	p-value	0.73	0.17	p-value	<0.0001

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 27: Adjusted means and changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time in at least 10-minute bouts of ≥ 40 steps/min, ≥70 steps/min and ≥ 100 steps/min; HCHS/SOL (2008-2017).

Mean Weight (kg)				*Mean Change in Weight (kg)*			
Bouts	≥40 steps/min	≥70 steps/min	≥100 steps/min	Bouts	≥40 steps/min	≥70 steps/min	≥100 steps/min
Category 1	83.4 (82.03,84.77)	82.24 (81.22,83.25)	82.22 (81.22,83.22)	Category 1	-0.63 (-1.55,0.28)	-0.11 (-0.67,0.45)	-0.04 (-0.52,0.45)
Category 2	80.8 (79.65,81.95)	80.46 (78.81,82.12)	76.79 (75.36,78.21)	Category 2	0.17 (-0.51,0.86)	-0.19 (-0.9,0.51)	0.77 (-0.02,1.56)
Category 3	79.13 (77.79,80.47)	78.29 (76.96,79.62)	76.01 (74.76,77.26)	Category 3	0.89 (0.28,1.51)	1.37 (0.64,2.1)	1.43 (0.52,2.34)
Category 4	76.5 (75.33,77.66)	75.34 (74.11,76.57)	74.85 (73.54,76.15)	Category 4	1.16 (0.5,1.82)	1.4 (0.64,2.17)	1.62 (0.63,2.62)
p-value	0.54	<0.01	<0.0001	p-value	<0.01	<0.0001	<0.01
Mean Waist Circumference (cm)				*Mean Change in Waist Circumference (cm)*			
Bouts	≥40 steps/min	≥70 steps/min	≥100 steps/min	Bouts	≥40 steps/min	≥70 steps/min	≥100 steps/min
Category 1	100.89 (99.83,101.95)	100 (99.18,100.81)	99.89 (99.16,100.62)	Category 1	0.55 (-0.3,1.39)	1.06 (0.52,1.6)	1.17 (0.71,1.63)
Category 2	98.8 (97.87,99.73)	98.62 (97.41,99.84)	96.24 (95.06,97.43)	Category 2	1.56 (0.84,2.28)	1.38 (0.67,2.08)	1.78 (0.94,2.62)
Category 3	97.74 (96.72,98.75)	96.99 (95.86,98.13)	95.35 (94.31,96.4)	Category 3	1.84 (1.22,2.46)	2.17 (1.43,2.91)	2.2 (1.33,3.06)
Category 4	95.55 (94.61,96.49)	94.67 (93.63,95.71)	94.15 (93.03,95.27)	Category 4	1.87 (1.23,2.51)	1.92 (1.18,2.66)	2.23 (1.31,3.15)
p-value	0.55	<0.01	0.05	p-value	0.03	0.03	0.03
Mean Body Mass Index (kg/m^2)				*Mean Change in Body Mass Index (kg/m^2)*			
Bouts	≥40 steps/min	≥70 steps/min	≥100 steps/min	Bouts	≥40 steps/min	≥70 steps/min	≥100 steps/min
Category 1	30.78 (30.35,31.22)	30.34 (30.01,30.67)	30.3 (30,30.6)	Category 1	-0.23 (-0.55,0.08)	-0.06 (-0.26,0.14)	-0.04 (-0.21,0.14)
Category 2	29.8 (29.4,30.19)	29.75 (29.27,30.24)	28.65 (28.15,29.14)	Category 2	0.04 (-0.21,0.28)	-0.11 (-0.37,0.16)	0.23 (-0.06,0.52)
Category 3	29.34 (28.93,29.75)	29.15 (28.67,29.63)	28.42 (27.97,28.88)	Category 3	0.28 (0.06,0.5)	0.46 (0.2,0.72)	0.48 (0.15,0.81)

Category 4	28.49 (28.11,28.87)	28.01 (27.6,28.41)	27.88 (27.44,28.33)	Category 4	0.38 (0.14,0.61)	0.47 (0.2,0.74)	0.56 (0.22,0.9)
p-value	0.58	<0.01	<0.0001	p-value	0.05	<0.01	<0.01

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 28: Adjusted means and changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time spent sedentary; HCHS/SOL (2008-2017).

	Mean Weight (kg)	*Mean Change in Weight (kg)*
Q1	78.88 (77.73,80.03)	0.41 (-0.22,1.03)
Q2	78.93 (77.78,80.07)	1.01 (0.32,1.7)
Q3	80.31 (79.07,81.55)	0.27 (-0.48,1.03)
Q4	80.58 (79.09,82.06)	0.24 (-0.43,0.9)
p-value	0.05	0.23
	Mean Waist Circumference (cm)	
	Mean Waist Circumference (cm)	*Mean Change in Waist Circumference (cm)*
Q1	97.42 (96.5,98.33)	1.48 (0.78,2.18)
Q2	97.36 (96.41,98.3)	1.85 (1.14,2.57)
Q3	98.36 (97.36,99.37)	1.59 (0.93,2.26)
Q4	99.04 (97.92,100.16)	1.16 (0.48,1.83)
p-value	0.03	0.44
	Mean Body Mass Index (kg/m^2)	
	Mean Body Mass Index (kg/m^2)	*Mean Change Body Mass Index (kg/m^2)*
Q1	29.36 (28.98,29.73)	0.11 (-0.12,0.33)
Q2	29.29 (28.91,29.68)	0.31 (0.07,0.55)
Q3	29.62 (29.19,30.04)	0.09 (-0.18,0.35)
Q4	29.81 (29.36,30.27)	0.06 (-0.18,0.31)
p-value	0.21	0.31

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 29: Adjusted means and changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time spent sedentary independent of time spent in purposeful steps and faster ambulation; HCHS/SOL (2008-2017).

	Mean Weight (kg)	*Mean Change in Weight (kg)*
Q1	80.75 (79.18,82.33)	0.24 (-0.72,1.21)
Q2	79.65 (78.04,81.26)	1.3 (0.35,2.25)
Q3	81.18 (79.53,82.84)	0.69 (-0.26,1.64)
Q4	80.96 (79.17,82.74)	0.82 (-0.07,1.72)
p-value	0.11	0.23
	Mean Waist Circumference (cm)	
	Mean Waist Circumference (cm)	*Mean Change in Waist Circumference (cm)*
Q1	99.68 (98.5,100.86)	1.41 (0.41,2.41)
Q2	98.47 (97.16,99.78)	2.08 (1.16,3)
Q3	99.6 (98.35,100.85)	1.87 (1.03,2.71)
Q4	99.77 (98.54,101)	1.54 (0.65,2.43)
p-value	0.05	0.44
	Mean Body Mass Index (kg/m^2)	
	Mean Body Mass Index (kg/m^2)	*Mean Change Body Mass Index (kg/m^2)*
Q1	30.22 (29.75,30.7)	0.02 (-0.33,0.36)
Q2	29.73 (29.23,30.23)	0.39 (0.06,0.72)
Q3	30.11 (29.59,30.63)	0.22 (-0.12,0.55)
Q4	30.09 (29.59,30.58)	0.25 (-0.07,0.58)
p-value	0.1	0.31

Adjusted for age, sex, center, background, years in the U.S. education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking, time spent in purposeful steps and faster ambulation and average accelerometer wear time per day

Appendix Table 30: Adjusted mean changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by graduated step-index and adjusted by baseline anthropometric status.

	Change in weight (kg)
Sedentary (<5,000)	0.76 (-0.09,1.61)
Low Activity (5,000-7,499)	1.1 (0.16,2.03)
Somewhat Active (7,500-9,999)	0.97 (-0.02,1.96)
Active (10,000 -12,499)	1.75 (0.69,2.81)
Highly Active (>12,500)	1.9 (0.73,3.07)
p-value	0.13
	Change in WC (cm)
Sedentary (<5,000)	1.63 (0.79,2.47)
Low Activity (5,000-7,499)	1.97 (1.13,2.81)
Somewhat Active (7,500-9,999)	1.24 (0.27,2.21)
Active (10,000 -12,499)	1.84 (0.73,2.95)
Highly Active (>12,500)	2.18 (1.12,3.23)
p-value	0.43
	Change in BMI (kg/m^2)
Sedentary (<5,000)	0.14 (-0.16,0.44)
Low Activity (5,000-7,499)	0.27 (-0.06,0.61)
Somewhat Active (7,500-9,999)	0.22 (-0.12,0.56)
Active (10,000 -12,499)	0.46 (0.08,0.85)
Highly Active (>12,500)	0.55 (0.15,0.94)
p-value	0.17

Adjusted for age, sex, center, background and years in the U.S., employment, occupation, income, mobility limitations moderate, marital status, predicted total energy intake, CESD10, years between visits, average accelerometer wear time per day and baseline anthropometric measure

Appendix Table 31: Adjusted mean changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by quartile of peak-30 and peak-60 cadence and adjusted by baseline anthropometric status.

	Mean Change in Weight (kg)	
	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	0.21 (-0.54,0.96)	0.54 (-0.1,1.17)
Q2	0.25 (-0.45,0.96)	0.29 (-0.48,1.07)
Q3	1.09 (0.44,1.74)	0.75 (0.15,1.35)
Q4	1.31 (0.63,1.99)	1.3 (0.62,1.98)
p-value	0.01	0.11
	Mean Change in Waist Circumference (cm)	
	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	1.64 (0.93,2.35)	1.85 (1.2,2.51)
Q2	1.24 (0.52,1.95)	1.36 (0.66,2.06)
Q3	1.57 (0.83,2.3)	1.26 (0.58,1.95)
Q4	1.61 (0.89,2.33)	1.59 (0.86,2.31)
p-value	0.77	0.55
	Mean Change in Body Mass Index (kg/m^2)	
	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	-0.03 (-0.3,0.24)	0.07 (-0.16,0.31)
Q2	-0.04 (-0.29,0.21)	-0.02 (-0.3,0.26)
Q3	0.27 (0.04,0.5)	0.14 (-0.07,0.35)
Q4	0.31 (0.07,0.55)	0.32 (0.08,0.56)
p-value	0.02	0.16

Adjusted for age, sex, center, background years in the United State, employment, years between visits, average accelerometer wear time per day and baseline anthropometric measure

Appendix Table 32: Adjusted mean changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time spent in incidental or sporadic movement (1-39 steps/min), time spent in purposeful walking and faster ambulation (40-99 steps/min) and time spent in brisk walking and faster ambulation ($\geq$ 100 steps/min) and baseline anthropometric status; HCHS/SOL (2008-2017).

	Mean Change in Weight (kg)		
	1-39 steps/min	40-99 steps/min	$\geq$100 steps/min
Q1	0.61 (-0.04,1.25)	0.71 (0.09,1.34)	1.39 (0.22,2.55)
Q2	0.77 (-0.01,1.55)	0.33 (-0.47,1.14)	0.1 (-0.49,0.68)
Q3	1 (0.24,1.75)	0.69 (0.06,1.33)	0.56 (-0.06,1.18)
Q4	0.56 (-0.09,1.21)	1.21 (0.48,1.93)	1.39 (0.78,1.99)
p-value	0.7	0.37	<0.01
	Mean Change in Waist Circumference (cm)		
	1-39 steps/min	40-99 steps/min	$\geq$100 steps/min
Q1	1.51 (0.83,2.2)	1.53 (0.85,2.2)	2.76 (1.56,3.96)
Q2	1.62 (0.92,2.32)	1.51 (0.78,2.24)	1.41 (0.82,1.99)
Q3	1.55 (0.78,2.31)	1.35 (0.64,2.06)	1.41 (0.74,2.07)
Q4	1.38 (0.67,2.08)	1.67 (0.98,2.37)	1.52 (0.86,2.18)
p-value	0.96	0.9	0.18
	Mean Change in Body Mass Index (kg/m^2)		
	1-39 steps/min	40-99 steps/min	$\geq$100 steps/min
Q1	0.1 (-0.13,0.34)	0.14 (-0.09,0.36)	0.34 (-0.07,0.76)
Q2	0.12 (-0.16,0.41)	0.01 (-0.29,0.31)	-0.08 (-0.29,0.14)
Q3	0.22 (-0.04,0.48)	0.1 (-0.12,0.31)	0.07 (-0.16,0.29)
Q4	0.07 (-0.16,0.29)	0.28 (0.03,0.53)	0.36 (0.14,0.57)
p-value	0.74	0.43	0.01

Adjusted for age, sex, center, background years in the United State, employment, years between visits, average accelerometer wear time per day and baseline anthropometric measure

Appendix Table 33: Adjusted mean changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time in at least 10-minute bouts of ≥ 40 steps/min, ≥70 steps/min and ≥ 100 steps/min and baseline anthropometric status; HCHS/SOL (2008-2017).

	Mean Change in Weight (kg)		
	≥ 40 steps/min	≥ 70 steps/min	≥100 steps/min
Category 1	-0.01 (-0.83,0.81)	0.34 (-0.19,0.87)	0.41 (-0.05,0.87)
Category 2	0.55 (-0.14,1.24)	0.12 (-0.61,0.85)	0.72 (-0.07,1.52)
Category 3	0.96 (0.33,1.59)	1.45 (0.7,2.19)	1.53 (0.62,2.43)
Category 4	1.23 (0.57,1.9)	1.44 (0.65,2.22)	1.56 (0.53,2.58)
p-value	0.04	<0.01	0.01
	Mean Change in Waist Circumference (cm)		
	≥ 40 steps/min	≥ 70 steps/min	≥100 steps/min
Category 1	1.01 (0.21,1.82)	1.33 (0.81,1.85)	1.42 (0.96,1.87)
Category 2	1.65 (0.94,2.36)	1.45 (0.7,2.19)	1.46 (0.62,2.31)
Category 3	1.71 (1.06,2.35)	2 (1.24,2.75)	1.88 (0.97,2.79)
Category 4	1.57 (0.9,2.25)	1.5 (0.7,2.29)	1.73 (0.76,2.71)
p-value	0.5	0.4	0.71
	Mean Change in Body Mass Index (kg/m^2)		
	≥ 40 steps/min	≥ 70 steps/min	≥100 steps/min
Category 1	-0.11 (-0.4,0.19)	0.01 (-0.18,0.2)	0.03 (-0.14,0.19)
Category 2	0.07 (-0.18,0.32)	-0.08 (-0.35,0.19)	0.12 (-0.17,0.4)
Category 3	0.21 (-0.02,0.43)	0.38 (0.12,0.65)	0.41 (0.07,0.74)
Category 4	0.3 (0.06,0.53)	0.35 (0.07,0.62)	0.41 (0.06,0.75)
p-value	0.08	<0.01	0.02

Adjusted for age, sex, center, background years in the United State, employment, years between visits, average accelerometer wear time per day and baseline anthropometric measure

Appendix Table 34: Adjusted mean changes in mean weight (kg), WC (cm) and BMI (kg/m^2) by time spent sedentary and adjusted by baseline anthropometric status.

	Change in Weight (kg)
Q1	0.94 (-0.02,1.89)
Q2	1.55 (0.59,2.52)
Q3	0.91 (-0.01,1.84)
Q4	0.85 (-0.01,1.7)
p-value	0.28
	Change in WC (cm)
Q1	1.84 (0.91,2.76)
Q2	2.31 (1.41,3.2)
Q3	2.07 (1.23,2.91)
Q4	1.79 (0.96,2.63)
p-value	0.6
	Change in BMI (kg/m^2)
Q1	0.21 (-0.13,0.54)
Q2	0.41 (0.08,0.74)
Q3	0.19 (-0.14,0.52)
Q4	0.19 (-0.12,0.5)
p-value	0.33

Adjusted for age, sex, center, background, years in the U.S., education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted energy intake, alcohol use, smoking years between visits, average accelerometer wear time per day and baseline anthropometric status.

APPENDIX B: ADDITIONAL BLOOD PRESSURE ANALYSIS TABLES

Appendix Table 35: Adjusted means of systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertension medication use and graduated step index level, HCHS/SOL (2008-2011).

	Hypertension Medication Use	
	Mean Systolic Blood Pressure (mmHg)	
Average total steps	Model 1	Model 2
Sedentary (<5,000)	132.98 (130.54, 135.42)	133.25 (130.34, 136.16)
Low Activity (5,000-7,499)	133.44 (130.91, 135.97)	133.58 (130.42, 136.74)
Somewhat Active (7,500-9,999)	134.92 (131.65, 138.18)	134.81 (131.34, 138.29)
Active (10,000 -12,499)	131.34 (127.33, 135.34)	131.64 (127.06, 136.22)
Highly Active (>12,500)	131.96 (127.85, 136.07)	130.83 (126.3, 135.36)
p-value	0.59	0.46
	Mean Diastolic Blood Pressure (mmHg)	
	Model 1	Model 2
Sedentary (<5,000)	77.46 (75.98, 78.94)	77.28 (75.52, 79.05)
Low Activity (5,000-7,499)	76.75 (75.22, 78.29)	77.19 (75.39, 78.99)
Somewhat Active (7,500-9,999)	77.38 (75.36, 79.4)	77.8 (75.56, 80.03)
Active (10,000 -12,499)	76.04 (73.82, 78.27)	76.91 (74.49, 79.32)
Highly Active (>12,500)	74.47 (72.23, 76.7)	74.76 (72.33, 77.19)
p-value	0.09	0.22
	No Medication Use	
	Mean Systolic Blood Pressure (mmHg)	
	Model 1	Model 2
Sedentary (<5,000)	121.62 (120.83, 122.41)	121.43 (120.24, 122.61)
Low Activity (5,000-7,499)	121.15 (120.31, 122)	121.4 (120.15, 122.64)
Somewhat Active (7,500-9,999)	120.8 (119.88, 121.73)	121.2 (119.84, 122.57)
Active (10,000 -12,499)	120.8 (119.69, 121.9)	120.95 (119.67, 122.24)
Highly Active (>12,500)	121.18 (120.18, 122.18)	121.17 (119.74, 122.6)
p-value	0.55	0.94
	Mean Diastolic Blood Pressure (mmHg)	
	Model 1	Model 2
Sedentary (<5,000)	73.65 (72.9, 74.41)	72.55 (71.69, 73.41)

Low Activity (5,000-7,499)	72.71 (72, 73.43)	72.06 (71.15, 72.96)
Somewhat Active (7,500-9,999)	72.6 (71.85, 73.35)	72.21 (71.25, 73.18)
Active (10,000 -12,499)	72.29 (71.46, 73.13)	71.68 (70.74, 72.63)
Highly Active (>12,500)	72.13 (71.25, 73)	71.61 (70.59, 72.64)
p-value	<0.01	0.18

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Appendix Table 36: Cross-sectional adjusted means of systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertension medication use and quartile of average peak 60-minute cadence, HCHS/SOL (2008-2011).

Peak 60-minute Cadence			
Hypertension Medication Use			
Mean Systolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
Q1 (<46.52)	134.01 (131.54, 136.48)	134.44 (131.41, 137.47)	134.77 (131.63, 137.92)
Q2 (46.52->59.97)	133.3 (130.64, 135.95)	133.42 (130.23, 136.6)	133.35 (130.18, 136.53)
Q3 (59.97->75.85)	133.01 (130.28, 135.74)	132.71 (129.45, 135.97)	132.43 (129.25, 135.61)
Q4 (75.85+)	131.53 (128.18, 134.88)	131.08 (127.46, 134.7)	130.71 (126.92, 134.5)
p-value	0.49	0.27	0.23
Mean Diastolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
Q1 (<46.52)	78.01 (76.51, 79.5)	78.11 (76.25, 79.96)	78.52 (76.64, 80.4)
Q2 (46.52->59.97)	77.42 (75.84, 78.99)	77.33 (75.51, 79.16)	77.25 (75.44, 79.07)
Q3 (59.97->75.85)	75.37 (73.76, 76.99)	75.62 (73.81, 77.42)	75.26 (73.43, 77.1)
Q4 (75.85+)	75.56 (73.28, 77.85)	76.24 (73.84, 78.64)	75.78 (73.32, 78.24)
p-value	0.02	0.05	0.01
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
Q1 (<46.52)	121.97 (121.12, 122.81)	121.78 (120.58, 122.99)	122.23 (120.95, 123.52)
Q2 (46.52->59.97)	121.24 (120.43, 122.06)	121.35 (120.12, 122.59)	121.49 (120.25, 122.73)
Q3 (59.97->75.85)	120.69 (119.84, 121.55)	120.99 (119.77, 122.22)	120.87 (119.62, 122.12)
Q4 (75.85+)	120.79 (119.91, 121.66)	120.96 (119.61, 122.3)	120.69 (119.29, 122.09)
p-value	0.1	0.43	0.14
Mean Diastolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
Q1 (<46.52)	73.97 (73.19, 74.75)	72.65 (71.76, 73.53)	72.4 (71.43, 73.38)
Q2 (46.52->59.97)	72.89 (72.1, 73.68)	71.96 (71.01, 72.91)	71.89 (70.93, 72.85)
Q3 (59.97->75.85)	72.61 (71.92, 73.3)	72.06 (71.2, 72.91)	72.12 (71.26, 72.98)
Q4 (75.85+)	71.86 (71.16, 72.55)	71.88 (70.94, 72.81)	72.02 (71.06, 72.98)

p-value	<0.01	0.25	0.75

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 37: Adjusted means of SBP (mmHg) and DBP (mmHg) by baseline hypertension medication use and quartile of minutes per day spent sedentary (0 steps/min) adjusted for average accelerometer wear time HCHS/SOL (2008-2011).

	Hypertension Medication Use	
	Mean Systolic Blood Pressure (mmHg)	
Average total steps	Model 1	Model 2
Q1 (>585.34)	132.15 (129.15, 135.14)	131.67 (128.21, 135.13)
Q2 (585.34->668.79)	133.51 (130.76, 136.25)	133.77 (130.34, 137.2)
Q3 (668.79->735.83)	133.43 (130.68, 136.17)	133 (129.76, 136.23)
Q4 (735.83+)	133.21 (130.59, 135.82)	133.25 (130.26, 136.23)
p-value	0.86	0.66
	Mean Diastolic Blood Pressure (mmHg)	
Q1 (>585.34)	76.32 (74.53, 78.11)	76.45 (74.47, 78.43)
Q2 (585.34->668.79)	76.35 (74.69, 78)	76.87 (74.95, 78.78)
Q3 (668.79->735.83)	77.71 (76.06, 79.36)	77.64 (75.73, 79.55)
Q4 (735.83+)	77.1 (75.44, 78.75)	76.86 (74.92, 78.8)
p-value	0.48	0.7
	No Medication Use	
	Mean Systolic Blood Pressure (mmHg)	
	Model 1	Model 2
Q1 (>585.34)	121.15 (120.33, 121.97)	121.4 (120.18, 122.63)
Q2 (585.34->668.79)	121.04 (120.21, 121.87)	121.63 (120.35, 122.9)
Q3 (668.79->735.83)	121.17 (120.33, 122)	121.17 (119.95, 122.39)
Q4 (735.83+)	121.21 (120.34, 122.08)	121.06 (119.82, 122.3)
p-value	0.99	0.68
	Mean Diastolic Blood Pressure (mmHg)	
Q1 (>585.34)	72.55 (71.86, 73.25)	72.07 (70.89, 73.24)
Q2 (585.34->668.79)	72.69 (72.03, 73.35)	71.84 (70.79, 72.89)
Q3 (668.79->735.83)	72.66 (71.93, 73.38)	71.9 (70.78, 73.02)
Q4 (735.83+)	73.37 (72.65, 74.09)	71.03 (69.9, 72.16)
p-value	0.17	0.05

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + education, employment, occupation, income mobility limitation moderate, mobility limitation climbing stairs, marital status, predicted energy intake, alcohol usage, smoking, accelerometer wear time per day

Appendix Table 38: Adjusted means of systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertension medication use and quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and brisk walking and faster ambulation (> 100 steps/min) HCHS/SOL (2008-2011).

1-39 steps per minute			
Hypertension Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Steps/min	Model 1	Model 2	Model 3
Q1 (<158.43)	132.87 (130.32, 135.43)	132.85 (129.74, 135.96)	130.63 (126.76, 134.5)
Q2 (158.43->211.31)	132.41 (129.48, 135.35)	132.43 (128.98, 135.89)	131.82 (128.18, 135.46)
Q3 (211.31->274.18)	134.02 (131.13, 136.9)	134.31 (130.96, 137.67)	135.21 (131.88, 138.54)
Q4 (274.18+)	133.76 (130.99, 136.53)	133.41 (130.08, 136.74)	136.27 (131.98, 140.55)
p-value	0.77	0.7	0.15
Mean Diastolic Blood Pressure (mmHg)			
Q1 (<158.43)	76.91 (75.22, 78.59)	76.51 (74.55, 78.47)	74.94 (72.61, 77.27)
Q2 (158.43->211.31)	76.52 (74.71, 78.33)	76.78 (74.77, 78.78)	76.34 (74.26, 78.43)
Q3 (211.31->274.18)	77.36 (75.57, 79.16)	77.98 (75.99, 79.97)	78.61 (76.56, 80.66)
Q4 (274.18+)	76.75 (75.08, 78.42)	77.21 (75.3, 79.11)	79.23 (76.51, 81.95)
p-value	0.89	0.53	0.06
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
Q1 (<158.43)	120.72 (119.9, 121.55)	120.8 (119.55, 122.05)	120.53 (118.94, 122.12)
Q2 (158.43->211.31)	121.4 (120.56, 122.24)	121.35 (120.12, 122.59)	121.24 (119.95, 122.53)
Q3 (211.31->274.18)	121.37 (120.55, 122.19)	121.66 (120.45, 122.86)	121.69 (120.49, 122.9)
Q4 (274.18+)	121.18 (120.31, 122.06)	121.51 (120.25, 122.77)	121.78 (120.26, 123.3)
p-value	0.53	0.34	0.44
Mean Diastolic Blood Pressure (mmHg)			
Q1 (<158.43)	72.98 (72.24, 73.72)	72.61 (71.72, 73.51)	72.26 (71.13, 73.4)
Q2 (158.43->211.31)	72.98 (72.29, 73.67)	72.17 (71.37, 72.97)	72.03 (71.19, 72.87)
Q3 (211.31->274.18)	72.66 (71.95, 73.36)	71.96 (71.04, 72.88)	72.01 (71.09, 72.93)
Q4 (274.18+)	72.72 (72.02, 73.43)	71.79 (70.87, 72.7)	72.13 (70.99, 73.27)
p-value	0.81	0.16	0.92

	40-99 steps per minute		
	Hypertension Medication Use		
	Mean Systolic Blood Pressure (mmHg)		
	Model 1	Model 2	Model 3
Q1 (<24.87)	132.94 (130.46, 135.42)	133.34 (130.38, 136.3)	133.52 (130.19, 136.85)
Q2 (24.87->40.66)	134.12 (131.45, 136.8)	134.08 (130.91, 137.24)	134.12 (130.95, 137.29)
Q3 (40.66->65.02)	132.95 (129.93, 135.97)	132.85 (129.17, 136.52)	132.76 (129.03, 136.49)
Q4 (65.02+)	132.52 (129.43, 135.62)	132.47 (128.85, 136.09)	132.19 (127.97, 136.4)
p-value	0.76	0.81	0.8
	Mean Diastolic Blood Pressure (mmHg)		
Q1 (<24.87)	77.1 (75.51, 78.7)	77.07 (75.18, 78.96)	77.43 (75.35, 79.5)
Q2 (24.87->40.66)	77.93 (76.38, 79.48)	78.15 (76.31, 79.99)	78.24 (76.4, 80.09)
Q3 (40.66->65.02)	75.97 (74.04, 77.9)	76.53 (74.47, 78.6)	76.36 (74.21, 78.51)
Q4 (65.02+)	75.97 (74.33, 77.6)	76.51 (74.62, 78.4)	75.95 (73.68, 78.21)
p-value	0.15	0.33	0.24
	No Medication Use		
	Mean Systolic Blood Pressure (mmHg)		
	Model 1	Model 2	Model 3
Q1 (<24.87)	121.72 (120.84, 122.59)	121.68 (120.44, 122.91)	122.42 (121.03, 123.81)
Q2 (24.87->40.66)	121.31 (120.5, 122.11)	121.26 (119.98, 122.54)	121.6 (120.26, 122.94)
Q3 (40.66->65.02)	120.59 (119.72, 121.45)	121.07 (119.79, 122.36)	121 (119.72, 122.27)
Q4 (65.02+)	121.03 (120.23, 121.84)	121.07 (119.88, 122.27)	120.32 (119.03, 121.6)
p-value	0.24	0.61	0.05
	Mean Diastolic Blood Pressure (mmHg)		
Q1 (<24.87)	73.4 (72.67, 74.13)	72.53 (71.69, 73.37)	72.31 (71.36, 73.27)
Q2 (24.87->40.66)	73.14 (72.42, 73.87)	72.37 (71.44, 73.3)	72.27 (71.29, 73.25)
Q3 (40.66->65.02)	72.29 (71.56, 73.01)	71.87 (70.89, 72.84)	71.89 (70.92, 72.86)
Q4 (65.02+)	72.47 (71.81, 73.12)	71.75 (70.92, 72.58)	71.97 (71.05, 72.89)
p-value	0.03	0.11	0.81
	100+ steps per minute		
	Hypertension Medication Use		
	Mean Systolic Blood Pressure (mmHg)		
Minutes	Model 1	Model 2	Model 3

<0	134.06 (130.84, 137.28)	134.83 (130.8, 138.85)	134.82 (130.75, 138.89)
0->3.42	133.25 (131.02, 135.47)	133.39 (130.56, 136.22)	133.39 (130.55, 136.22)
3.42->12.14	134.11 (131.38, 136.85)	134.21 (131.02, 137.4)	134.21 (131.03, 137.39)
≥12.14	131.45 (128.57, 134.33)	130.77 (127.51, 134.03)	130.78 (127.5, 134.05)
p-value	0.26	0.08	0.17
Mean Diastolic Blood Pressure (mmHg)			
<0	77.73 (75.52, 79.95)	77.93 (75.43, 80.43)	77.95 (75.45, 80.44)
0->3.42	77.4 (76.04, 78.76)	77.32 (75.58, 79.06)	77.32 (75.58, 79.06)
3.42->12.14	76.78 (75.13, 78.43)	76.98 (75.24, 78.71)	76.97 (75.22, 78.71)
≥12.14	75.78 (73.86, 77.7)	76.34 (74.21, 78.46)	76.32 (74.17, 78.47)
p-value	0.34	0.67	0.66
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
<0	123.23 (121.46, 125.01)	122.89 (120.87, 124.91)	123.06 (121.03, 125.1)
0->3.42	121.68 (120.93, 122.43)	121.63 (120.44, 122.81)	121.71 (120.51, 122.91)
3.42->12.14	120.74 (119.96, 121.52)	120.96 (119.78, 122.14)	121 (119.83, 122.18)
≥12.14	120.74 (119.9, 121.59)	120.87 (119.58, 122.17)	120.82 (119.53, 122.12)
p-value	0.05	0.19	0.14
Mean Diastolic Blood Pressure (mmHg)			
<0	73.43 (71.97, 74.88)	71.57 (70.25, 72.89)	71.36 (70.04, 72.68)
0->3.42	73.92 (73.25, 74.6)	72.61 (71.73, 73.49)	72.51 (71.62, 73.4)
3.42->12.14	72.63 (71.94, 73.31)	72.03 (71.2, 72.86)	71.98 (71.15, 72.8)
≥12.14	71.87 (71.24, 72.5)	71.99 (71.1, 72.87)	72.05 (71.16, 72.93)
p-value	<0.01	0.15	0.09

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 39: Cross-sectional adjusted means of systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertension medication use and minutes per day spent in at least 10-minute bouts of ≥100 steps/min HCHS/SOL (2008-2011).

Bouts ≥ 100 steps per minute			
Hypertension Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Minutes	Model 1	Model 2	Model 3
<0	134.06 (130.84, 137.28)	133.67 (131.04, 136.31)	133.67 (131.04, 136.31)
0->4.77	133.62 (131.63, 135.61)	133.8 (129.81, 137.79)	133.81 (129.84, 137.78)
4.77->11.61	133.89 (130.23, 137.55)	131.45 (127.28, 135.61)	131.47 (127.29, 135.66)
≥11.61)	131.68 (127.8, 135.57)	130.4 (126.4, 134.39)	130.41 (126.41, 134.41)
p-value	131.24 (127.58, 134.9)	0.2	0.21
Mean Diastolic Blood Pressure (mmHg)			
<0	77.47 (76.25, 78.69)	77.47 (75.93, 79.02)	77.47 (75.93, 79.02)
0->4.77	76.8 (74.26, 79.34)	76.68 (74.06, 79.31)	76.68 (74.05, 79.31)
4.77->11.61	75.53 (73.33, 77.73)	75.89 (73.48, 78.29)	75.87 (73.42, 78.32)
≥11.61)	74.96 (72.57, 77.35)	75.66 (73.08, 78.23)	75.65 (73.07, 78.23)
p-value	0.08	0.26	0.26
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 3
<0	121.29 (120.69, 121.89)	121.37 (120.25, 122.48)	121.41 (120.29, 122.53)
0->4.77	121.49 (120.36, 122.63)	121.68 (120.3, 123.07)	121.69 (120.31, 123.07)
4.77->11.61	120.94 (119.83, 122.06)	121.02 (119.6, 122.44)	121.03 (119.61, 122.45)
≥11.61)	120.56 (119.37, 121.74)	120.7 (119.18, 122.22)	120.68 (119.16, 122.2)
p-value	0.55	0.52	0.48
Mean Diastolic Blood Pressure (mmHg)			
<0	73.36 (72.8, 73.93)	72.3 (71.53, 73.08)	72.23 (71.45, 73.01)
0->4.77	72.31 (71.38, 73.23)	72.02 (71, 73.04)	72 (70.98, 73.03)
4.77->11.61	72.05 (71.11, 72.99)	71.77 (70.7, 72.84)	71.76 (70.69, 72.83)
≥11.61)	71.74 (70.85, 72.64)	71.9 (70.87, 72.94)	71.94 (70.91, 72.97)
p-value	<0.01	0.57	0.71

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 40: Adjusted odds of AHA defined hypertension status by quartile of average total steps; HCHS/SOL (2008-2011).

	Model 1	Model 2
Hypertensive vs. normotensive		
quartile 1 vs 4	1.76 (1.47,2.1)	1.47 (1.2,1.8)
quartile 2 vs 4	1.5 (1.26,1.78)	1.41 (1.18,1.69)
quartile 3 vs 4	1.26 (1.06,1.5)	1.28 (1.06,1.54)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive		
quartile 1 vs 4	1.41 (1.18,1.68)	1.24 (1.02,1.5)
quartile 2 vs 4	1.23 (1.04,1.47)	1.22 (1.03,1.45)
quartile 3 vs 4	1.14 (0.96,1.34)	1.19 (1,1.41)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Appendix Table 41: Adjusted odds of AHA defined hypertension status by quartile of average peak cadences; HCHS/SOL (2008-2011).

Peak 30-minute Cadence			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
quartile 1 vs 4	1.91 (1.57,2.33)	1.41 (1.15,1.74)	1.33 (1.06,1.68)
quartile 2 vs 4	1.42 (1.15,1.75)	1.23 (1,1.51)	1.19 (0.97,1.47)
quartile 3 vs 4	1.31 (1.09,1.57)	1.18 (0.97,1.42)	1.16 (0.96,1.41)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
quartile 1 vs 4	1.53 (1.26,1.85)	1.22 (1.01,1.48)	1.22 (0.98,1.52)
quartile 2 vs 4	1.14 (0.92,1.41)	1.07 (0.87,1.3)	1.07 (0.87,1.31)
quartile 3 vs 4	1.18 (0.98,1.42)	1.1 (0.92,1.33)	1.1 (0.91,1.33)
Peak 60-minute Cadence			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
quartile 1 vs 4	1.92 (1.57,2.35)	1.49 (1.2,1.84)	1.44 (1.12,1.87)
quartile 2 vs 4	1.5 (1.23,1.83)	1.31 (1.07,1.59)	1.28 (1.03,1.6)
quartile 3 vs 4	1.25 (1.04,1.51)	1.17 (0.97,1.42)	1.17 (0.96,1.42)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
quartile 1 vs 4	1.46 (1.2,1.78)	1.22 (1,1.49)	1.26 (0.99,1.6)
quartile 2 vs 4	1.24 (1,1.52)	1.16 (0.95,1.41)	1.18 (0.95,1.46)
quartile 3 vs 4	1.03 (0.85,1.24)	1.01 (0.84,1.21)	1.01 (0.84,1.22)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 42: Adjusted odds of AHA defined hypertension status by quartile of time spent sedentary adjusted for total accelerometer wear time; HCHS/SOL (2008-2011).

	Model 1	Model 2
Hypertensive vs. normotensive		
quartile 1 vs 4	0.65 (0.54,0.79)	0.74 (0.6,0.91)
quartile 2 vs 4	0.74 (0.61,0.89)	0.84 (0.68,1.02)
quartile 3 vs 4	0.72 (0.6,0.87)	0.75 (0.61,0.91)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive		
quartile 1 vs 4	0.82 (0.68,0.99)	0.91 (0.75,1.11)
quartile 2 vs 4	0.79 (0.66,0.95)	0.89 (0.74,1.08)
quartile 3 vs 4	0.81 (0.67,0.99)	0.85 (0.7,1.04)

Model 1: Adjusted for age, sex, center, background and years in the U.S..
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day

Appendix Table 43: Adjusted odds of hypertension status by hypertensive medication use and quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and minutes in brisk walking and faster ambulation (≥100 steps/min); HCHS/SOL (2008-2011).

1-39 steps per minute			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
quartile 1 vs 4	1.21 (1.01,1.47)	1.13 (0.92,1.39)	0.71 (0.47,1.06)
quartile 2 vs 4	1.16 (0.97,1.39)	1.08 (0.89,1.31)	0.78 (0.57,1.06)
quartile 3 vs 4	0.97 (0.82,1.14)	0.96 (0.8,1.14)	0.79 (0.62,1)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
quartile 1 vs 4	1.12 (0.93,1.34)	1.06 (0.87,1.3)	0.93 (0.61,1.41)
quartile 2 vs 4	1.04 (0.86,1.26)	0.99 (0.81,1.2)	0.9 (0.65,1.25)
quartile 3 vs 4	0.98 (0.82,1.17)	0.99 (0.83,1.18)	0.94 (0.74,1.2)
40-99 steps per minute			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
quartile 1 vs 4	1.68 (1.41,2)	1.49 (1.23,1.81)	1.74 (1.29,2.35)
quartile 2 vs 4	1.58 (1.31,1.9)	1.49 (1.23,1.82)	1.68 (1.28,2.2)
quartile 3 vs 4	1.15 (0.96,1.37)	1.17 (0.97,1.41)	1.26 (1.02,1.55)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
quartile 1 vs 4	1.4 (1.19,1.65)	1.3 (1.09,1.55)	1.62 (1.2,2.2)
quartile 2 vs 4	1.27 (1.07,1.51)	1.26 (1.05,1.51)	1.49 (1.15,1.92)
quartile 3 vs 4	1.08 (0.9,1.31)	1.16 (0.96,1.4)	1.29 (1.03,1.61)
100+ steps per minute			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
category 1 vs 4	2 (1.51,2.65)	1.48 (1.11,1.98)	1.4 (1.05,1.87)
category 2 vs 4	1.59 (1.34,1.89)	1.29 (1.08,1.53)	1.24 (1.04,1.49)
category 3 vs 4	1.36 (1.15,1.61)	1.26 (1.06,1.49)	1.23 (1.03,1.46)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
category 1 vs 4	1.63 (1.26,2.11)	1.32 (1,1.73)	1.3 (0.99,1.71)
category 2 vs 4	1.33 (1.12,1.57)	1.16 (0.98,1.38)	1.15 (0.97,1.37)
category 3 vs 4	1.16 (0.98,1.37)	1.12 (0.95,1.32)	1.12 (0.95,1.32)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 44: Adjusted odds of AHA defined hypertension status by minutes spent in at least 10-minute bouts of ≥40 steps/min, ≥70 steps/min,100+ steps/min; HCHS/SOL (2008-2011).

Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
category 1 vs 4	1.57 (1.31,1.88)	1.35 (1.11,1.64)	1.27 (1.02,1.58)
category 2 vs 4	1.42 (1.18,1.71)	1.3 (1.08,1.56)	1.24 (1.02,1.5)
category 3 vs 4	1.21 (1.02,1.43)	1.15 (0.96,1.37)	1.11 (0.93,1.34)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
category 1 vs 4	1.25 (1.04,1.52)	1.14 (0.93,1.39)	1.13 (0.9,1.42)
category 2 vs 4	1.14 (0.95,1.36)	1.09 (0.91,1.3)	1.08 (0.9,1.3)
category 3 vs 4	1.06 (0.9,1.26)	1.04 (0.88,1.23)	1.04 (0.87,1.24)
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
category 1 vs 4	1.54 (1.27,1.87)	1.36 (1.11,1.66)	1.31 (1.06,1.61)
category 2 vs 4	1.28 (1.04,1.58)	1.11 (0.9,1.38)	1.09 (0.88,1.35)
category 3 vs 4	1.33 (1.06,1.66)	1.26 (1,1.58)	1.25 (0.99,1.57)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
category 1 vs 4	1.28 (1.05,1.55)	1.19 (0.97,1.45)	1.17 (0.96,1.44)
category 2 vs 4	1.16 (0.95,1.42)	1.06 (0.87,1.3)	1.05 (0.86,1.29)
category 3 vs 4	1.27 (1.03,1.57)	1.26 (1.02,1.55)	1.25 (1.02,1.54)
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)			
Hypertensive vs. normotensive			
	Model 1	Model 2	Model 3
category 1 vs 4	1.5 (1.23,1.84)	1.29 (1.05,1.59)	1.26 (1.02,1.55)
category 2 vs 4	1.48 (1.15,1.91)	1.36 (1.04,1.77)	1.35 (1.03,1.75)
category 3 vs 4	1.31 (0.98,1.75)	1.25 (0.93,1.69)	1.24 (0.92,1.67)
Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive			
category 1 vs 4	1.29 (1.05,1.58)	1.16 (0.95,1.43)	1.16 (0.94,1.42)
category 2 vs 4	1.28 (1,1.64)	1.2 (0.93,1.54)	1.19 (0.93,1.54)
category 3 vs 4	1.29 (0.99,1.68)	1.23 (0.94,1.6)	1.22 (0.94,1.59)

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use and average accelerometer wear time per day
Model 3: Adjusted for Model 2 + percentage of time spent sedentary

Appendix Table 45: Adjusted odds of AHA defined hypertension status by quartile and category of peak cadence indicators adjusted for total volume of steps; HCHS/SOL (2008-2011).

Peak 30-minute cadence				
	Hypertensive vs. normotensive		*Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive*	
	Model 1	Model 2	Model 1	Model 2
quartile 1 vs 4	1.22 (0.99,1.49)	1.29 (1.05,1.59)	1.25 (1.01,1.54)	1.28 (1.03,1.59)
quartile 2 vs 4	0.99 (0.81,1.21)	1.02 (0.84,1.24)	0.96 (0.78,1.17)	0.97 (0.79,1.18)
quartile 3 vs 4	1.03 (0.84,1.27)	1.05 (0.85,1.29)	1.03 (0.85,1.26)	1.04 (0.86,1.27)
Peak 60-minute cadence				
	Hypertensive vs. normotensive		*Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive*	
	Model 1	Model 2	Model 1	Model 2
quartile 1 vs 4	1.21 (0.99,1.48)	1.29 (1.05,1.57)	1.27 (1.04,1.55)	1.31 (1.07,1.6)
quartile 2 vs 4	1.2 (0.98,1.46)	1.21 (1,1.48)	1.07 (0.88,1.3)	1.07 (0.88,1.31)
quartile 3 vs 4	1.16 (0.96,1.41)	1.16 (0.96,1.41)	1.15 (0.96,1.39)	1.15 (0.96,1.39)
Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)				
	Hypertensive vs. normotensive		*Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive*	
	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	0.98 (0.8,1.2)	1.1 (0.88,1.38)	0.93 (0.76,1.14)	0.97 (0.77,1.21)
category 2 vs 4	0.99 (0.83,1.2)	1.02 (0.85,1.23)	0.87 (0.73,1.04)	0.88 (0.73,1.04)
category 3 vs 4	0.96 (0.78,1.18)	0.93 (0.76,1.15)	0.93 (0.76,1.13)	0.92 (0.75,1.12)
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
	Hypertensive vs. normotensive		*Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive*	
	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	1.01 (0.82,1.26)	1.15 (0.91,1.44)	0.99 (0.81,1.2)	1.03 (0.82,1.29)
category 2 vs 4	1.07 (0.86,1.32)	1.07 (0.86,1.32)	1.04 (0.86,1.26)	1.04 (0.86,1.26)
category 3 vs 4	1.12 (0.91,1.38)	1.07 (0.86,1.32)	0.99 (0.82,1.2)	0.97 (0.8,1.18)
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)				
	Hypertensive vs. normotensive		*Elevated, treated, untreated stage 1& 2 hypertension vs. normotensive*	

	Model 1	Model 2	Model 1	Model 2
category 1 vs 4	0.94 (0.78,1.13)	1.05 (0.86,1.29)	0.96 (0.8,1.15)	1 (0.81,1.23)
category 2 vs 4	1.03 (0.86,1.23)	1.03 (0.87,1.23)	0.98 (0.81,1.18)	0.98 (0.81,1.18)
category 3 vs 4	1.09 (0.91,1.31)	1.03 (0.85,1.25)	1 (0.84,1.18)	0.98 (0.82,1.18)

Model 1: Adjusted for age, sex, center, background, years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use, average accelerometer wear time per day and total step volume

Model 2: Adjusted for Model 1 + percentage of time spent sedentary

Appendix Table 46: Adjusted means of SBP mmHg and DBP mmHg by hypertensive medication use and quartile or category of cadence indicators adjusted for total volume of steps; HCHS/SOL (2008-2011).

Peak 30-minute Cadence				
Hypertension Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
Q1 (>65.85)	132.82 (130.06, 135.58)	133.07 (129.89, 136.26)	76.83 (75.09, 78.57)	77.04 (75.17, 78.92)
Q2 (65.85->74.67)	133.46 (130.48, 136.44)	133.62 (130.43, 136.82)	77.58 (75.91, 79.25)	77.74 (75.94, 79.54)
Q3 (74.67->85.70)	132.71 (129.63, 135.78)	132.99 (129.76, 136.23)	76.39 (74.46, 78.32)	76.64 (74.7, 78.58)
Q4 (85.70+)	132.55 (129.54, 135.55)	132.91 (129.61, 136.2)	76.12 (74.11, 78.13)	76.4 (74.27, 78.53)
p-value	0.95	0.97	0.43	0.52
No Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
Q1 (>65.85)	Model 1	Model 2	Model 1	Model 2
Q2 (65.85->74.67)	122.35 (121.14, 123.56)	122.33 (121.09, 123.56)	72.39 (71.55, 73.24)	72.37 (71.51, 73.23)
Q3 (74.67->85.70)	120.82 (119.65, 121.99)	120.79 (119.56, 122.03)	72.09 (71.21, 72.96)	71.95 (71.06, 72.84)
Q4 (85.70+)	121.01 (119.79, 122.23)	121.01 (119.74, 122.29)	72.08 (71.15, 73.02)	71.96 (71, 72.93)
p-value	120.93 (119.61, 122.24)	120.93 (119.5, 122.36)	72.28 (71.41, 73.15)	72.11 (71.17, 73.05)
Q1 (>65.85)	0.03	0.04	0.85	0.74
Peak 60-minute Cadence				
Hypertension Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
Q1 (>54.37)	133.76 (130.99, 136.54)	134.03 (130.8, 137.26)	77.14 (75.4, 78.89)	77.36 (75.51, 79.22)
Q2 (54.37->61.06)	132.32 (129.43, 135.2)	132.51 (129.44, 135.57)	76.81 (75.15, 78.47)	77.02 (75.19, 78.85)
Q3 (61.06->69.51)	133.55 (130.47, 136.64)	133.77 (130.55, 136.98)	76.99 (75.05, 78.94)	77.22 (75.28, 79.16)
Q4 (69.51+)	131.96 (128.83, 135.08)	132.37 (129, 135.74)	76.12 (74.08, 78.15)	76.45 (74.32, 78.58)
p-value	0.68	0.7	0.79	0.85
No Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
Q1 (>54.37)	122.16 (120.94, 123.38)	122.14 (120.88, 123.39)	72.23 (71.38, 73.08)	72.23 (71.37, 73.09)
Q2 (54.37->61.06)	120.77 (119.65, 121.9)	120.75 (119.57, 121.94)	72.05 (71.17, 72.93)	71.9 (70.98, 72.82)

Q3 (61.06->69.51)	121.52 (120.33, 122.72)	121.53 (120.26, 122.8)	72.5 (71.62, 73.38)	72.35 (71.45, 73.26)
Q4 (69.51+)	120.64 (119.4, 121.87)	120.62 (119.28, 121.96)	72.02 (71.16, 72.88)	71.88 (70.95, 72.81)
p-value	0.02	0.02	0.62	0.56
Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)				
Hypertension Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
Minutes	Model 1	Model 2	Model 1	Model 2
>13.51	135.57 (132.1, 139.04)	136.31 (132.55, 140.07)	78.58 (76.53, 80.63)	79.21 (76.84, 81.59)
13.51->23.76	132.59 (129.64, 135.54)	132.9 (129.76, 136.05)	77.04 (75.31, 78.76)	77.3 (75.5, 79.1)
23.76->32.46	132.42 (129.62, 135.23)	132.18 (129.04, 135.32)	77.06 (75.32, 78.79)	76.94 (75.05, 78.84)
≥32.46	132.35 (129.6, 135.11)	132.11 (128.81, 135.41)	75.68 (74, 77.36)	75.51 (73.62, 77.4)
p-value	0.29	0.17	0.05	0.04
No Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
>13.51	121.59 (120.36, 122.82)	121.55 (120.23, 122.88)	72.12 (71.19, 73.04)	72.18 (71.19, 73.16)
13.51->23.76	120.99 (119.78, 122.19)	121.03 (119.78, 122.27)	72.04 (71.2, 72.88)	71.95 (71.08, 72.82)
23.76->32.46	120.83 (119.69, 121.97)	120.87 (119.67, 122.08)	72.23 (71.45, 73.01)	71.99 (71.16, 72.83)
≥32.46	121.81 (120.61, 123.01)	121.85 (120.56, 123.14)	72.41 (71.52, 73.29)	72.33 (71.39, 73.27)
p-value	0.19	0.22	0.82	0.76
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
Hypertension Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
Minutes	Model 1	Model 2	Model 1	Model 2
>4.90	134.21 (130.57, 137.86)	135.15 (130.92, 139.39)	76.95 (74.89, 79.02)	77.15 (74.76, 79.54)
4.90->9.68	134.44 (131.42, 137.46)	134.58 (131.32, 137.85)	78.04 (76.29, 79.79)	78.19 (76.38, 80)
9.68->14.87	132 (129.5, 134.5)	131.52 (128.62, 134.42)	76.47 (74.81, 78.14)	76.56 (74.68, 78.45)
≥14.87	131.68 (128.72, 134.64)	131.67 (128.5, 134.84)	75.66 (73.79, 77.52)	75.87 (73.89, 77.85)
p-value	0.96	0.15	0.16	0.2
No Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2

>4.90	121.72 (120.5, 122.93)	121.73 (120.41, 123.05)	72.3 (71.38, 73.21)	72.52 (71.52, 73.52)
4.90->9.68	121.29 (120.07, 122.5)	121.31 (120.05, 122.56)	72.13 (71.23, 73.03)	71.95 (71.01, 72.88)
9.68->14.87	121.01 (119.88, 122.14)	120.99 (119.76, 122.22)	72.15 (71.34, 72.95)	71.8 (70.92, 72.67)
≥14.87	121.31 (120.1, 122.53)	121.29 (120, 122.58)	72.3 (71.44, 73.16)	72.2 (71.29, 73.1)
p-value	0.57	0.69	0.25	0.51
Bouts of brisk walking and faster ambulation (≥ 100 steps/min)				
Hypertension Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
Minutes	Model 1	Model 2	Model 1	Model 2
>0.58	134.94 (131.48, 138.4)	136.16 (132.28, 140.04)	77.33 (75.31, 79.35)	77.51 (75.25, 79.78)
0.58->3.22	133.32 (130.09, 136.55)	133.57 (130.11, 137.03)	76.94 (75.2, 78.68)	77.14 (75.28, 79)
3.22->5.75	132.39 (129.83, 134.95)	131.82 (128.54, 135.1)	76.97 (75.22, 78.72)	77.14 (75.15, 79.13)
≥5.75	132.05 (128.88, 135.23)	131.86 (128.48, 135.23)	76.06 (74.14, 77.98)	76.32 (74.24, 78.4)
p-value	0.47	0.25	0.66	0.75
No Medication Use				
	Systolic Blood Pressure (mmHg)		*Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
>0.58	121.45 (120.23, 122.68)	121.35 (120.05, 122.66)	72.1 (71.24, 72.97)	72.31 (71.42, 73.2)
0.58->3.22	121.41 (120.22, 122.61)	121.47 (120.18, 122.75)	72.19 (71.3, 73.09)	72.05 (71.1, 73)
3.22->5.75	121.08 (119.91, 122.25)	121.18 (119.89, 122.47)	72.34 (71.52, 73.15)	71.99 (71.08, 72.9)
≥5.75	121.31 (120.11, 122.52)	121.35 (120.08, 122.61)	72.17 (71.33, 73.01)	72.06 (71.18, 72.94)
p-value	0.88	0.96	0.93	0.91

Model 1: Adjusted for age, sex, center, background, years in the U.S., BMI, education, employment, occupation, income, mobility limitations moderate, mobility limitations climbing stairs, marital status, predicted total energy intake, CESD10, alcohol use, cigarette use, average accelerometer wear time per day and total step volume
Model 2: Adjusted for Model 1 + percentage of time spent sedentary

Appendix Table 47: Adjusted means and mean changes of systolic (mmHg) and diastolic blood pressure (mmHg) by quartile of peak 30 and 60-minute cadence, HCHS/SOL (2008-2017).

Peak 30-minute Cadence				
Mean Change in Systolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
Q1 (<59.68)	1.22 (-0.02, 2.45)	0.98 (-0.73, 2.68)	1.05 (-0.51, 2.6)	1.09 (-0.55, 2.72)
Q2 (59.68->74.45)	1.65 (0.37, 2.93)	1.2 (-0.61, 3)	1.24 (-0.45, 2.92)	1.25 (-0.43, 2.92)
Q3 (74.45->91.13)	2.1 (1.01, 3.19)	1.54 (-0.04, 3.12)	1.6 (0.09, 3.11)	1.59 (0.07, 3.11)
Q4 (91.13+)	1.96 (0.58, 3.35)	1.13 (-0.78, 3.04)	1.22 (-0.45, 2.9)	1.2 (-0.49, 2.9)
<0.01	0.64	0.89	0.9	0.92
Mean Change in Diastolic Blood Pressure (mmHg)				
Q1 (<59.68)	-1.21 (-2.09, -0.33)	-0.84 (-2.03, 0.34)	1.05 (-0.51, 2.6)	-0.83 (-1.93, 0.26)
Q2 (59.68->74.45)	-0.72 (-1.64, 0.2)	-0.62 (-1.89, 0.64)	1.24 (-0.45, 2.92)	-0.79 (-1.92, 0.33)
Q3 (74.45->91.13)	0.22 (-0.63, 1.07)	0.25 (-0.89, 1.39)	1.6 (0.09, 3.11)	-0.05 (-1.11, 1.02)
Q4 (91.13+)	-0.09 (-1.05, 0.88)	-0.29 (-1.59, 1.01)	1.22 (-0.45, 2.9)	-0.64 (-1.81, 0.53)
<0.01	0.03	0.21	0.9	0.47
Peak 60-minute Cadence				
Mean Change in Systolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
Q1 (<46.19)	1.23 (0, 2.46)	0.92 (-0.77, 2.6)	1.05 (-0.51, 2.6)	0.98 (-0.67, 2.63)
Q2 (46.19->59.61)	1.58 (0.3, 2.86)	1.16 (-0.64, 2.96)	1.24 (-0.45, 2.92)	1.2 (-0.46, 2.87)
Q3 (59.61->75.57)	2.07 (1.03, 3.11)	1.52 (-0.09, 3.13)	1.6 (0.09, 3.11)	1.58 (0.05, 3.11)
Q4 (75.57+)	2.05 (0.7, 3.41)	1.27 (-0.58, 3.12)	1.22 (-0.45, 2.9)	1.37 (-0.31, 3.04)
<0.01	0.62	0.89	0.9	0.9
Mean Change in Diastolic Blood Pressure (mmHg)				
Q1 (<46.19)	-1.14 (-1.98, -0.29)	0.92 (-0.77, 2.6)	1.05 (-0.51, 2.6)	-0.81 (-1.9, 0.28)
Q2 (46.19->59.61)	-0.59 (-1.59, 0.41)	1.16 (-0.64, 2.96)	1.24 (-0.45, 2.92)	-0.58 (-1.79, 0.64)
Q3 (59.61->75.57)	-0.06 (-0.87, 0.75)	1.52 (-0.09, 3.13)	1.6 (0.09, 3.11)	-0.35 (-1.4, 0.7)
Q4 (75.57+)	0.01 (-0.92, 0.94)	1.27 (-0.58, 3.12)	1.22 (-0.45, 2.9)	-0.58 (-1.71, 0.56)
Q1 (<46.19)	0.09	0.89	0.9	0.87

Model 1: Adjusted for age, sex, center, background and years in the U.S.

Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, cigarette use, alcohol use, marital status, income, average accelerometer wear time per day and years between visits

Model 3: Adjusted for Model 2 -alcohol use
Model 4: Adjusted for Model 4 + percentage of time spent sedentary

Appendix Table 48: Adjusted mean changes of SBP (mmHg) and SBP (mmHg) by quartile of minutes per day spent sedentary (0 steps/min) HCHS/SOL (2008-2011).

	Mean Change in Systolic Blood Pressure (mmHg)		
	Model 1	Model 2	Model 3
Q1 (>556.87)	1.89 (0.69, 3.09)	1.2 (-0.45, 2.85)	1.23 (-0.52, 2.98)
Q2 (556.87->644.40)	2.2 (1.05, 3.34)	1.53 (0.08, 2.97)	1.53 (-0.05, 3.11)
Q3 (644.40->713.96)	1.21 (-0.09, 2.51)	0.79 (-0.83, 2.41)	0.83 (-1, 2.67)
Q4 (713.96+)	1.61 (0.41, 2.82)	1.19 (-0.38, 2.75)	1.23 (-0.52, 2.97)
<0.01	0.59	0.77	0.79
	Mean Change in Diastolic Blood Pressure (mmHg)		
	Model 1	Model 2	Model 3
Q1 (>556.87)	0.08 (-0.78, 0.94)	0.21 (-0.91, 1.33)	0.1 (-1.11, 1.31)
Q2 (556.87->644.40)	-0.19 (-1.06, 0.67)	-0.05 (-1.12, 1.02)	-0.19 (-1.37, 1)
Q3 (644.40->713.96)	-0.51 (-1.42, 0.39)	-0.29 (-1.38, 0.81)	-0.41 (-1.64, 0.82)
Q4 (75.57+)	-1.09 (-1.93, -0.24)	-0.84 (-1.94, 0.26)	-0.98 (-2.2, 0.24)

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, alcohol use, cigarette use, marital status, income, average accelerometer wear time per day and years between visits
Model 3: Adjusted for Model 2 + alcohol use, cigarette use, CESD10

Appendix Table 49: Adjusted mean changes of systolic (mmHg) and diastolic blood pressure (mmHg) by quartile of minutes per day spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and minutes in brisk walking and faster ambulation (≥100 steps/min) HCHS/SOL (2008-2011).

1-39 steps per minute				
Mean Change in Systolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
Q1 (<161.20)	1.36 (0.14, 2.58)	1.1 (-0.42, 2.62)	1.05 (-0.66, 2.77)	1 (-0.9, 2.89)
Q2 (161.20->213.73)	1.17 (-0.15, 2.48)	0.83 (-0.87, 2.53)	0.79 (-1.04, 2.61)	0.79 (-0.92, 2.49)
Q3 (213.73->274.92)	2.61 (1.4, 3.81)	2.01 (0.42, 3.6)	1.95 (0.21, 3.69)	2.03 (0.43, 3.62)
Q4 (274.92+)	1.9 (0.8, 2.99)	1.21 (-0.34, 2.76)	1.16 (-0.48, 2.8)	1.32 (-0.6, 3.24)
<0.01	0.23	0.43	0.44	0.4
Mean Change in Diastolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
Q1 (<161.20)	-1.23 (-2.06, -0.41)	-1.37 (-2.4, -0.35)	-1.14 (-2.29, 0.02)	-1.47 (-2.79, -0.15)
Q2 (161.20->213.73)	-0.57 (-1.53, 0.39)	-0.64 (-1.79, 0.51)	-0.4 (-1.66, 0.86)	-0.68 (-1.87, 0.52)
Q3 (213.73->274.92)	0.02 (-0.84, 0.89)	-0.23 (-1.36, 0.9)	0.03 (-1.25, 1.31)	-0.21 (-1.35, 0.93)
Q4 (274.92+)	0.17 (-0.68, 1.01)	-0.06 (-1.13, 1.02)	0.18 (-0.99, 1.35)	0.05 (-1.32, 1.41)
<0.01	0.02	0.08	0.07	0.35
40-99 steps per minute				
Mean Change in Systolic Blood Pressure (mmHg)				
	Model 1	Model 4	Model 3	Model 4
Q1 (<24.82)	0.85 (-0.3, 2.01)	0.54 (-0.92, 1.99)	0.49 (-1.11, 2.09)	0.33 (-1.29, 1.95)
Q2 (24.82->40.44)	1.88 (0.54, 3.22)	1.54 (-0.19, 3.27)	1.5 (-0.42, 3.42)	1.45 (-0.28, 3.18)
Q3 (40.44->65.39)	2.31 (1.18, 3.43)	1.77 (0.24, 3.29)	1.69 (0.04, 3.34)	1.79 (0.26, 3.32)
Q4 (65.39+)	1.99 (0.77, 3.21)	1.4 (-0.23, 3.03)	1.34 (-0.41, 3.08)	1.61 (-0.23, 3.46)
p-value	0.17	0.31	0.32	0.3
Mean Change in Diastolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
Q1 (<24.82)	-1.12 (-1.91, -0.34)	-1.37 (-2.4, -0.35)	-0.95 (-2.04, 0.13)	-0.74 (-1.84, 0.36)
Q2 (24.82->40.44)	-0.49 (-1.48, 0.49)	-0.64 (-1.79, 0.51)	-0.33 (-1.68, 1.02)	-0.37 (-1.6, 0.87)
Q3 (40.44->65.39)	0.01 (-0.82, 0.84)	-0.23 (-1.36, 0.9)	-0.04 (-1.31, 1.22)	-0.33 (-1.45, 0.79)
Q4 (65.39+)	-0.1 (-1.02, 0.81)	-0.06 (-1.13, 1.02)	-0.13 (-1.34, 1.07)	-0.81 (-2.05, 0.43)
p-value	0.1	0.31	0.3	0.71

≥100 steps per minute				
Mean Change in Systolic Blood Pressure (mmHg)				
Minutes	Model 1	Model 2	Model 3	Model 4
<0	0.78 (-1.61, 3.17)	0.82 (-1.64, 3.28)	0.71 (-1.86, 3.29)	0.87 (-1.62, 3.36)
0->3.42	1.67 (0.62, 2.72)	1.31 (-0.16, 2.78)	1.26 (-0.34, 2.86)	1.33 (-0.13, 2.79)
3.42->12.14	1.57 (0.36, 2.78)	1.15 (-0.45, 2.75)	1.1 (-0.61, 2.81)	1.16 (-0.44, 2.75)
≥12.14	2.14 (0.97, 3.32)	1.51 (-0.03, 3.05)	1.42 (-0.33, 3.17)	1.49 (-0.05, 3.03)
p-value	0.65	0.92	0.93	0.94
Mean Change in Diastolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
<0	-0.75 (-2.38, 0.88)	-1.37 (-2.4, -0.35)	-0.2 (-2, 1.6)	-0.19 (-1.9, 1.53)
0->3.42	-1.06 (-1.81, -0.31)	-0.64 (-1.79, 0.51)	-0.91 (-1.97, 0.14)	-1.03 (-1.95, -0.1)
3.42->12.14	-0.17 (-1, 0.67)	-0.23 (-1.36, 0.9)	-0.14 (-1.32, 1.04)	-0.32 (-1.4, 0.75)
≥12.14	-0.1 (-0.95, 0.75)	-0.06 (-1.13, 1.02)	-0.24 (-1.47, 0.99)	-0.54 (-1.62, 0.55)
p-value	0.14	0.32	0.31	0.39

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, cigarette use, marital status, income, average accelerometer wear time per day and years between visits
Model 3: Adjusted for Model 2 +alcohol use and income
Model 4: Adjusted for Model 3 + percentage of time spent sedentary

Appendix Table 50: Adjusted mean changes of SBP (mmHg) and DBP (mmHg) by minutes per day spent in at least 10-minute bouts of > 40 steps/min, >70 steps/min and >100 steps/min HCHS/SOL (2008-2017).

Bouts of purposeful steps and faster ambulation (> 40 steps/min)				
Mean Change in Systolic Blood Pressure (mmHg)				
Minutes	Model 1	Model 2	Model 3	Model 4
<0	1.61 (0.34, 2.88)	1.32 (-0.24, 2.88)	1.24 (-0.39, 2.88)	1.39 (-0.27, 3.04)
0->9.65	1.08 (-0.06, 2.22)	0.62 (-0.91, 2.15)	0.53 (-1.16, 2.22)	0.66 (-0.86, 2.18)
9.65->28.33	2.39 (1.18, 3.6)	1.95 (0.33, 3.57)	1.88 (0.1, 3.65)	1.96 (0.34, 3.58)
≥28.33	1.75 (0.52, 2.97)	1.14 (-0.44, 2.71)	1.05 (-0.7, 2.79)	1.08 (-0.56, 2.72)
p-value	0.24	0.23	0.21	0.23
Mean Change in Diastolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
<0	-1.15 (-2.11, -0.19)	-1.14 (-2.22, -0.05)	-0.92 (-2.08, 0.23)	-0.88 (-2.07, 0.3)
0->9.65	-0.62 (-1.44, 0.2)	-0.83 (-1.9, 0.24)	-0.61 (-1.81, 0.59)	-0.69 (-1.76, 0.37)
9.65->28.33	0.12 (-0.74, 0.97)	-0.03 (-1.17, 1.1)	0.18 (-1.08, 1.44)	-0.01 (-1.14, 1.12)
≥28.33	-0.35 (-1.24, 0.54)	-0.62 (-1.65, 0.42)	-0.41 (-1.59, 0.78)	-0.83 (-1.93, 0.28)
p-value	0.11	0.16	0.16	0.22
Bouts of slow to medium steps and faster ambulation (> 70 steps/min)				
Mean Change in Systolic Blood Pressure (mmHg)				
Minutes	Model 1	Model 2	Model 3	Model 4
<0	1.85 (0.92, 2.78)	1.53 (0.15, 2.92)	1.44 (-0.07, 2.94)	1.57 (0.18, 2.96)
0->6.13	0.92 (-0.4, 2.25)	0.52 (-1.1, 2.13)	0.44 (-1.29, 2.16)	0.53 (-1.07, 2.14)
6.13->16.47	2.56 (1.08, 4.04)	2.09 (0.29, 3.89)	2.03 (0.03, 4.04)	2.09 (0.29, 3.89)
≥16.47	1.47 (0.12, 2.81)	0.79 (-0.92, 2.51)	0.68 (-1.18, 2.53)	0.77 (-0.95, 2.5)
p-value	0.21	0.17	0.16	0.17
Mean Change in Diastolic Blood Pressure (mmHg)				
	Model 1	Model 2	Model 3	Model 4
<0	-0.63 (-1.34, 0.08)	-0.7 (-1.68, 0.28)	-0.49 (-1.58, 0.6)	-0.59 (-1.58, 0.41)
0->6.13	-0.74 (-1.67, 0.19)	-0.88 (-1.93, 0.18)	-0.67 (-1.85, 0.51)	-0.82 (-1.87, 0.23)
6.13->16.47	0.3 (-0.7, 1.3)	0.14 (-1.07, 1.36)	0.35 (-0.99, 1.69)	0.13 (-1.08, 1.34)
≥16.47	-0.55 (-1.54, 0.45)	-0.89 (-2.1, 0.31)	-0.69 (-2.04, 0.66)	-0.96 (-2.17, 0.26)
p-value	0.2	0.17	0.16	0.17
Bouts of brisk walking and faster ambulation (> 100 steps/min)				

	Mean Change in Systolic Blood Pressure (mmHg)			
Minutes	Model 1	Model 2	Model 3	Model 4
<0	1.36 (0.5, 2.22)	1.03 (-0.29, 2.36)	0.96 (-0.49, 2.42)	1.05 (-0.27, 2.37)
0->4.54	2.72 (0.7, 4.74)	2.1 (-0.11, 4.32)	2.03 (-0.31, 4.37)	2.11 (-0.1, 4.32)
4.54->11.21	3.05 (1.28, 4.82)	2.44 (0.38, 4.5)	2.33 (0.02, 4.64)	2.45 (0.39, 4.5)
≥11.21	1.07 (-0.42, 2.56)	0.46 (-1.35, 2.27)	0.37 (-1.54, 2.28)	0.45 (-1.36, 2.26)
p-value	0.11	0.16	0.16	0.16
	Mean Change in Diastolic Blood Pressure (mmHg)			
	Model 1	Model 2	Model 2	Model 5
<0	-0.83 (-1.47, -0.19)	-0.88 (-1.76, 0)	-0.67 (-1.68, 0.35)	-0.81 (-1.69, 0.07)
0->4.54	0.08 (-1.22, 1.38)	-0.16 (-1.61, 1.3)	0.06 (-1.51, 1.62)	-0.14 (-1.6, 1.33)
4.54->11.21	0.97 (-0.15, 2.08)	0.73 (-0.58, 2.04)	0.96 (-0.49, 2.4)	0.75 (-0.57, 2.06)
≥11.21	-0.66 (-1.73, 0.41)	-1.04 (-2.28, 0.19)	-0.82 (-2.19, 0.54)	-1.08 (-2.32, 0.16)
p-value	0.01	0.01	0.01	0.02

Model 1: Adjusted for age, sex, center, background and years in the U.S.
Model 2: Adjusted for Model 1 + BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, cigarette use, marital status, average accelerometer wear time per day and years between visits
Model 3: Adjusted for Model 2 + alcohol use and income
Model 4: Adjusted for Model 3 + percentage of time spent sedentary

Appendix Table 51: Adjusted means of changes in blood pressure by hypertension medication use at baseline and cadence indicators adjusted for total volume of steps; HCHS/SOL (2008-2011).

Peak 30-minute Cadence				
Hypertension Medication Use				
	Mean Changes in Systolic Blood Pressure (mmHg)		*Mean Changes in Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
Q1 (>65.85)	0.68 (-0.81, 2.17)	0.65 (-0.85, 2.15)	-0.97 (-1.93, 0)	-1.05 (-2.02, -0.08)
Q2 (65.85->74.67)	1.77 (0.26, 3.29)	1.8 (0.28, 3.31)	-0.63 (-1.73, 0.46)	-0.57 (-1.68, 0.53)
Q3 (74.67->85.70)	1.45 (-0.33, 3.23)	1.49 (-0.29, 3.27)	-0.4 (-1.53, 0.72)	-0.3 (-1.43, 0.83)
Q4 (85.70+)	1.23 (-0.34, 2.8)	1.29 (-0.28, 2.86)	-0.49 (-1.61, 0.63)	-0.32 (-1.44, 0.8)
p-value	0.43	0.4	0.71	0.45
Peak 60-minute Cadence				
Hypertension Medication Use				
	Mean Changes in Systolic Blood Pressure (mmHg)		*Mean Changes in Diastolic Blood Pressure (mmHg)*	
	Model 1	Model 2	Model 1	Model 2
Q1 (>54.37)	0.64 (-0.89, 2.16)	0.59 (-0.93, 2.12)	-1.01 (-1.99, -0.03)	-1.12 (-2.08, -0.15)
Q2 (54.37->61.06)	1.58 (0.09, 3.06)	1.61 (0.13, 3.09)	-0.7 (-1.78, 0.38)	-0.62 (-1.7, 0.47)
Q3 (61.06->69.51)	1.59 (-0.11, 3.28)	1.64 (-0.05, 3.33)	-0.37 (-1.46, 0.73)	-0.24 (-1.32, 0.85)
Q4 (69.51+)	1.29 (-0.28, 2.86)	1.35 (-0.24, 2.93)	-0.43 (-1.55, 0.7)	-0.28 (-1.42, 0.86)
p-value	0.5	0.42	0.61	0.31
Bouts of purposeful steps and faster ambulation (≥ 40 steps/min)				
Hypertension Medication Use				
	Mean Changes in Systolic Blood Pressure (mmHg)		*Mean Changes in Diastolic Blood Pressure (mmHg)*	
Minutes	Model 1	Model 2	Model 1	Model 2
>13.51	1.48 (-0.02, 2.99)	1.5 (0, 3)	-0.2 (-1.27, 0.88)	-0.37 (-1.46, 0.72)
13.51->23.76	1.63 (0.16, 3.11)	1.63 (0.15, 3.12)	-0.11 (-1.18, 0.96)	-0.08 (-1.15, 1)
23.76->32.46	0.7 (-0.93, 2.33)	0.69 (-0.96, 2.33)	-1.45 (-2.5, -0.41)	-1.31 (-2.36, -0.25)
≥32.46	1.23 (-0.49, 2.94)	1.22 (-0.51, 2.95)	-0.76 (-1.93, 0.41)	-0.67 (-1.85, 0.51)
p-value	0.52	0.5	0.01	0.05
Bouts of slow to medium steps and faster ambulation (≥ 70 steps/min)				
Hypertension Medication Use				

	Mean Changes in Systolic Blood Pressure (mmHg)		*Mean Changes in Diastolic Blood Pressure (mmHg)*	
Minutes	Model 1	Model 2	Model 1	Model 2
>4.90	1.56 (0.04, 3.08)	1.57 (-0.02, 3.15)	-0.33 (-1.41, 0.75)	-0.69 (-1.83, 0.45)
4.90->9.68	1.26 (-0.28, 2.81)	1.26 (-0.3, 2.82)	-0.54 (-1.65, 0.57)	-0.45 (-1.57, 0.66)
9.68->14.87	1.1 (-0.48, 2.69)	1.1 (-0.55, 2.75)	-0.89 (-1.93, 0.14)	-0.61 (-1.72, 0.49)
≥14.87	1.21 (-0.5, 2.92)	1.21 (-0.51, 2.92)	-0.67 (-1.82, 0.48)	-0.58 (-1.75, 0.59)
p-value	0.95	0.96	0.78	0.97

Bouts of brisk walking and faster ambulation (≥ 100 steps/min)

Hypertension Medication Use

	Mean Changes in Systolic Blood Pressure (mmHg)		*Mean Changes in Diastolic Blood Pressure (mmHg)*	
Minutes	Model 1	Model 2	Model 1	Model 2
>0.58	1.09 (-0.34, 2.53)	0.87 (-0.6, 2.35)	-0.67 (-1.73, 0.4)	-1.24 (-2.33, -0.15)
0.58->3.22	1.59 (-0.02, 3.19)	1.63 (0, 3.27)	-0.55 (-1.69, 0.59)	-0.42 (-1.56, 0.71)
3.22->5.75	1.26 (-0.44, 2.96)	1.45 (-0.34, 3.24)	-0.74 (-1.75, 0.26)	-0.24 (-1.31, 0.82)
≥5.75	1.09 (-0.51, 2.69)	1.15 (-0.48, 2.77)	-0.53 (-1.66, 0.6)	-0.37 (-1.52, 0.77)
p-value	0.87	0.79	0.97	0.39

Model 1: Adjusted for age, sex, center, background, years in the U.S., BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, alcohol use, cigarette use, marital status, income, average accelerometer wear time per day, years between visits and total step volume
Model 2: Model 1 + percentage of time spent sedentary

Appendix Table 52: Adjusted means of systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertension medication use and graduated step index level, HCHS/SOL (2008-2011).

Hypertension Medication Use	
Mean Systolic Blood Pressure (mmHg)	
Sedentary (<5,000)	133.05 (130.57, 135.53)
Low Activity (5,000-7,499)	133.48 (130.95, 136.01)
Somewhat Active (7,500-9,999)	134.91 (131.65, 138.18)
Active (10,000 -12,499)	131.28 (127.24, 135.32)
Highly Active (>12,500)	131.92 (127.82, 136.03)
p-value	0.58
Mean Diastolic Blood Pressure (mmHg)	
Sedentary (<5,000)	77.35 (75.86, 78.83)
Low Activity (5,000-7,499)	76.69 (75.17, 78.21)
Somewhat Active (7,500-9,999)	77.39 (75.36, 79.41)
Active (10,000 -12,499)	76.13 (73.89, 78.37)
Highly Active (>12,500)	74.53 (72.29, 76.78)
p-value	0.13
No Medication Use	
Mean Systolic Blood Pressure (mmHg)	
Sedentary (<5,000)	121.69 (120.9, 122.49)
Low Activity (5,000-7,499)	121.18 (120.34, 122.02)
Somewhat Active (7,500-9,999)	120.79 (119.87, 121.71)
Active (10,000 -12,499)	120.76 (119.66, 121.86)
Highly Active (>12,500)	121.02 (120.02, 122.02)
p-value	0.45
Mean Diastolic Blood Pressure (mmHg)	
Sedentary (<5,000)	73.69 (72.93, 74.44)
Low Activity (5,000-7,499)	72.73 (72.01, 73.44)
Somewhat Active (7,500-9,999)	72.6 (71.85, 73.34)
Active (10,000 -12,499)	72.28 (71.45, 73.1)
Highly Active (>12,500)	72.28 (71.45, 73.1)
p-value	<0.01

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 53: Adjusted mean change of SBP (mmHg) and DBP (mmHg) by graduated step index level, HCHS/SOL (2008-2017).

	Mean Change in Systolic Blood Pressure (mmHg)
Sedentary (<5,000)	1.15 (-0.07, 2.37)
Low Activity (5,000-7,499)	1.44 (0.19, 2.68)
Somewhat Active (7,500-9,999)	3.04 (1.76, 4.32)
Active (10,000 -12,499)	2.01 (0.64, 3.38)
Highly Active (>12,500)	1.42 (-0.07, 2.92)
p-value	0.13
	Mean Change in Diastolic Blood Pressure (mmHg)
Sedentary (<5,000)	-1.22 (-2.07, -0.38)
Low Activity (5,000-7,499)	-0.69 (-1.6, 0.21)
Somewhat Active (7,500-9,999)	0.56 (-0.4, 1.51)
Active (10,000 -12,499)	0.17 (-1.04, 1.38)
Highly Active (>12,500)	-0.25 (-1.24, 0.75)
p-value	0.02

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 54: Adjusted mean SBP (mmHg) and DBP (mmHg) by baseline hypertensive medication use and quartile of peak cadence indicators, HCHS/SOL (2008-2011).

	Peak 30-minute Cadence	Peak 60-minute Cadence
Hypertension Medication Use		
Mean Systolic Blood Pressure (mmHg)		
Q1	133.14 (130.66, 135.63)	134.08 (131.59, 136.58)
Q2	134.18 (131.35, 137.02)	133.33 (130.68, 135.98)
Q3	133.46 (130.81, 136.11)	133.02 (130.3, 135.75)
Q4	131.43 (128.14, 134.73)	131.51 (128.15, 134.87)
p-value	0.02	0.47
Mean Diastolic Blood Pressure (mmHg)		
Q1	77.52 (76.03, 79.02)	77.91 (76.42, 79.4)
Q2	77.87 (76.15, 79.58)	77.38 (75.79, 78.96)
Q3	75.48 (73.98, 76.98)	75.36 (73.75, 76.97)
Q4	75.58 (73.24, 77.91)	75.58 (73.3, 77.87)
p-value	0.03	0.03
No Medication Use		
Mean Systolic Blood Pressure (mmHg)		
Q1	122.14 (121.32, 122.97)	122.02 (121.17, 122.87)
Q2	120.55 (119.66, 121.44)	121.26 (120.45, 122.08)
Q3	121.2 (120.36, 122.04)	120.67 (119.82, 121.52)
Q4	120.79 (119.91, 121.66)	120.75 (119.87, 121.62)
p-value	0.02	0.07
Mean Diastolic Blood Pressure (mmHg)		
Q1	74.04 (73.28, 74.81)	73.99 (73.21, 74.76)
Q2	72.71 (71.89, 73.53)	72.9 (72.11, 73.69)
Q3	72.77 (72.08, 73.45)	72.6 (71.91, 73.28)
Q4	71.8 (71.14, 72.46)	71.84 (71.15, 72.53)
p-value	<0.0001	<0.0001

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 55: Adjusted mean change in SBP (mmHg) and SBP (mmHg) by quartile of peak cadence indicators, HCHS/SOL (2008-2017).

	Mean Change in Systolic Blood Pressure (mmHg)	
	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	1.24 (0.01, 2.47)	1.25 (0.02, 2.48)
Q2	1.66 (0.39, 2.94)	1.59 (0.32, 2.87)
Q3	2.08 (0.99, 3.17)	2.06 (1.02, 3.09)
Q4	1.95 (0.56, 3.34)	2.03 (0.68, 3.39)
p-value	0.67	0.66
	Mean Change in Diastolic Blood Pressure (mmHg)	
	Peak 30-minute Cadence	Peak 60-minute Cadence
Q1	-1.2 (-2.08, -0.32)	-1.12 (-1.96, -0.28)
Q2	-0.71 (-1.63, 0.2)	-0.58 (-1.58, 0.41)
Q3	0.21 (-0.64, 1.05)	-0.07 (-0.88, 0.74)
Q4	-0.1 (-1.06, 0.87)	0 (-0.94, 0.93)
p-value	0.04	0.11

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 56: Adjusted mean SBP (mmHg) and DBP (mmHg) by baseline hypertensive medication use time spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and brisk walking and faster ambulation (≥ 100 steps/min), HCHS/SOL (2008-2011).

		Hypertension Medication Use		
		Mean Systolic Blood Pressure (mmHg)		
	1-39 steps/min	40-99 steps/min		≥ 100 steps/min
Q1	132.89 (130.26, 135.52)	133 (130.48, 135.52)	Category 1	134.11 (130.9, 137.33)
Q2	132.42 (129.48, 135.36)	134.16 (131.48, 136.85)	Category 2	133.28 (131.04, 135.51)
Q3	134.02 (131.14, 136.9)	132.95 (129.94, 135.97)	Category 3	134.13 (131.4, 136.86)
Q4	133.75 (130.95, 136.56)	132.49 (129.37, 135.61)	Category 4	131.46 (128.58, 134.34)
p-value	0.79	0.75	p-value	0.26
		Mean Diastolic Blood Pressure (mmHg)		
Q1	76.71 (75.01, 78.41)	76.99 (75.4, 78.57)	Category 1	77.61 (75.4, 79.81)
Q2	76.42 (74.62, 78.23)	77.85 (76.3, 79.41)	Category 2	77.32 (75.97, 78.68)
Q3	77.33 (75.55, 79.11)	75.97 (74.04, 77.9)	Category 3	76.74 (75.09, 78.4)
Q4	76.92 (75.21, 78.63)	76.03 (74.38, 77.68)	Category 4	75.75 (73.84, 77.67)
p-value	0.88	0.21	p-value	0.38
		No Medication Use		
		Mean Systolic Blood Pressure (mmHg)		
	1-39 steps/min	40-99 steps/min		≥ 100 steps/min
Q1	120.84 (120.01, 121.68)	121.78 (120.9, 122.66)	Category 1	123.3 (121.53, 125.08)
Q2	121.43 (120.59, 122.27)	121.31 (120.51, 122.11)	Category 2	121.69 (120.94, 122.44)
Q3	121.39 (120.57, 122.2)	120.6 (119.74, 121.46)	Category 3	120.75 (119.97, 121.53)
Q4	121.01 (120.13, 121.89)	120.96 (120.15, 121.77)	Category 4	120.72 (119.88, 121.56)
p-value	0.61	0.18	p-value	0.04
		Mean Diastolic Blood Pressure (mmHg)		
Q1	73.03 (72.28, 73.77)	73.42 (72.69, 74.16)	Category 1	73.45 (72, 74.91)
Q2	72.99 (72.3, 73.68)	73.15 (72.42, 73.87)	Category 2	73.93 (73.25, 74.61)
Q3	72.66 (71.96, 73.36)	72.29 (71.57, 73.02)	Category 3	72.63 (71.95, 73.31)
Q4	72.65 (71.94, 73.37)	72.44 (71.78, 73.09)	Category 4	71.86 (71.23, 72.49)
p-value	0.71	0.02	p-value	<0.001

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 57: Adjusted mean change in SBP (mmHg) and DBP (mmHg) by time spent in incidental or sporadic movement (1-39 steps/min), purposeful steps and faster ambulation (40-99 steps/min) and brisk walking and faster ambulation (≥100 steps/min) HCHS/SOL (2008-2017).

		Mean Change in Systolic Blood Pressure (mmHg)		
	1-39 steps/min	40-99 steps/min		≥ 100 steps/min
Q1	1.41 (0.2, 2.63)	0.88 (-0.28, 2.04)	Category 1	0.81 (-1.56, 3.18)
Q2	1.18 (-0.12, 2.49)	1.89 (0.55, 3.23)	Category 2	1.68 (0.63, 2.73)
Q3	2.6 (1.4, 3.81)	2.31 (1.18, 3.43)	Category 3	1.57 (0.36, 2.78)
Q4	1.82 (0.7, 2.94)	1.96 (0.73, 3.18)	Category 4	2.13 (0.95, 3.31)
p-value	0.25	0.2	p-value	0.67
		Mean Change in Diastolic Blood Pressure (mmHg)		
	1-39 steps/min	40-99 steps/min		≥ 100 steps/min
Q1	-1.21 (-2.04, -0.39)	-1.1 (-1.89, -0.32)	Category 1	-0.73 (-2.34, 0.89)
Q2	-0.57 (-1.52, 0.39)	-0.49 (-1.48, 0.5)	Category 2	-1.06 (-1.8, -0.31)
Q3	0.02 (-0.84, 0.88)	0.01 (-0.82, 0.84)	Category 3	-0.17 (-1, 0.67)
Q4	0.13 (-0.73, 0.99)	-0.13 (-1.06, 0.8)	Category 4	-0.11 (-0.96, 0.75)
p-value	0.04	0.12	p-value	0.15

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 58: Adjusted mean SBP (mmHg) and DBP (mmHg) by baseline hypertensive medication use and at least10-minute bouts of >40 steps/min, ≥70 steps/min and ≥ 100 steps/min, HCHS/SOL (2008-2011).

	≥40 steps/min	≥ 70 steps/min	≥ 100 steps/min
Hypertension Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Category 1	133.08 (130.33, 135.83)	133.14 (130.98, 135.3)	133.65 (131.65, 135.65)
Category 2	134.94 (132.22, 137.67)	135.91 (132.98, 138.85)	133.89 (130.23, 137.55)
Category 3	133.98 (131.61, 136.36)	132.7 (129.76, 135.65)	131.7 (127.81, 135.59)
Category 4	130.44 (127.28, 133.6)	130.28 (127.2, 133.36)	131.25 (127.6, 134.91)
p-value	0.04	0.01	0.46
Mean Diastolic Blood Pressure (mmHg)			
Category 1	78.21 (76.57, 79.85)	77.25 (75.91, 78.6)	77.39 (76.17, 78.61)
Category 2	78.08 (76.47, 79.69)	78.26 (76.55, 79.96)	76.8 (74.26, 79.34)
Category 3	76.45 (74.95, 77.95)	76.17 (74.29, 78.04)	75.5 (73.32, 77.69)
Category 4	74.56 (72.68, 76.44)	74.53 (72.43, 76.63)	74.93 (72.54, 77.32)
p-value	<0.01	0.01	0.09
No Medication Use			
Mean Systolic Blood Pressure (mmHg)			
Category 1	121.28 (120.36, 122.2)	121.61 (120.91, 122.3)	121.31 (120.71, 121.9)
Category 2	121.6 (120.75, 122.44)	120.83 (119.93, 121.74)	121.47 (120.34, 122.61)
Category 3	120.67 (119.79, 121.55)	121.05 (120.1, 122.01)	120.91 (119.78, 122.03)
Category 4	121.23 (120.43, 122.02)	120.78 (119.76, 121.8)	120.55 (119.37, 121.73)
p-value	0.4	0.34	0.53
Mean Diastolic Blood Pressure (mmHg)			
Category 1	73.64 (72.82, 74.47)	73.42 (72.79, 74.06)	73.37 (72.8, 73.93)
Category 2	72.98 (72.22, 73.75)	73.11 (72.34, 73.89)	72.3 (71.37, 73.22)
Category 3	72.67 (71.98, 73.36)	72.53 (71.71, 73.35)	72.04 (71.1, 72.97)
Category 4	72.27 (71.61, 72.93)	71.69 (70.96, 72.42)	71.74 (70.85, 72.63)
p-value	0.02	<0.01	<0.01

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 59: Adjusted mean change in systolic (mmHg) and diastolic blood pressure (mmHg) by time spent in at least 10-minute bouts of >40 steps/min, ≥70 steps/min and ≥ 100 steps/min, HCHS/SOL (2008-2011).

	Mean Change in Systolic Blood Pressure (mmHg)		
	≥40 steps/min	≥ 70 steps/min	≥ 100 steps/min
Category 1	1.64 (0.37, 2.91)	1.86 (0.94, 2.79)	1.37 (0.52, 2.22)
Category 2	1.08 (-0.05, 2.22)	0.92 (-0.41, 2.24)	2.7 (0.68, 4.72)
Category 3	2.38 (1.17, 3.59)	2.54 (1.06, 4.02)	3.04 (1.27, 4.81)
Category 4	1.73 (0.5, 2.96)	1.46 (0.12, 2.81)	1.08 (-0.41, 2.56)
p-value	0.25	0.21	0.12
	Mean Change in Diastolic Blood Pressure (mmHg)		
	≥40 steps/min	≥ 70 steps/min	≥ 100 steps/min
Category 1	-1.13 (-2.09, -0.17)	-0.62 (-1.33, 0.09)	-0.82 (-1.46, -0.19)
Category 2	-0.62 (-1.44, 0.2)	-0.74 (-1.67, 0.19)	0.06 (-1.24, 1.37)
Category 3	0.12 (-0.74, 0.97)	0.28 (-0.72, 1.29)	0.95 (-0.16, 2.07)
Category 4	-0.36 (-1.26, 0.53)	-0.55 (-1.55, 0.45)	-0.65 (-1.72, 0.41)
p-value	0.12	0.22	0.01

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 60: Adjusted mean systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertensive medication use and quartile of time spent sedentary HCHS/SOL (2008-2011).

Hypertension Medication Use	
Mean Systolic Blood Pressure (mmHg)	
Q1	132.14 (129.14, 135.14)
Q2	133.53 (130.79, 136.28)
Q3	133.46 (130.73, 136.19)
Q4	133.23 (130.61, 135.85)
p-value	0.85
Mean Diastolic Blood Pressure (mmHg)	
Q1	76.34 (74.54, 78.13)
Q2	76.28 (74.63, 77.93)
Q3	77.61 (75.97, 79.25)
Q4	77.04 (75.38, 78.69)
p-value	0.53
No Medication Use	
Mean Systolic Blood Pressure (mmHg)	
Q1	121.13 (120.31, 121.95)
Q2	121.09 (120.26, 121.93)
Q3	121.2 (120.37, 122.03)
Q4	121.16 (120.29, 122.03)
p-value	1
Mean Diastolic Blood Pressure (mmHg)	
Q1	72.55 (71.85, 73.25)
Q2	72.71 (72.05, 73.36)
Q3	72.67 (71.95, 73.38)
Q4	73.35 (72.64, 74.07)
p-value	0.19

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 61: Adjusted mean change in systolic (mmHg) and diastolic blood pressure (mmHg) by quartile of time spent sedentary, HCHS/SOL (2008-2011).

	Mean Change in Systolic Blood Pressure (mmHg)
Q1	1.88 (0.68, 3.08)
Q2	2.22 (1.08, 3.37)
Q3	1.23 (-0.06, 2.52)
Q4	1.58 (0.37, 2.79)
p-value	0.59
	Mean Change in Diastolic Blood Pressure (mmHg)
Q1	0.07 (-0.79, 0.93)
Q2	-0.17 (-1.03, 0.69)
Q3	-0.49 (-1.39, 0.4)
Q4	-1.12 (-1.96, -0.27)
p-value	0.14

Adjusted for age, sex, center, background, years in the U.S. and average accelerometer wear time

Appendix Table 62: Adjusted mean systolic (mmHg) and diastolic blood pressure (mmHg) by baseline hypertensive medication use and quartile of time spent sedentary independent of time spent in at least 10-minute bouts of purposeful stepping and faster ambulation HCHS/SOL (2008-2011).

	Hypertension Medication Use	***No Medication Use***
	Mean Systolic Blood Pressure (mmHg)	
Q1	132.58 (129.01, 136.14)	121.53 (120.28, 122.78)
Q2	133.88 (130.47, 137.29)	121.64 (120.37, 122.92)
Q3	133.01 (129.78, 136.23)	121.13 (119.9, 122.36)
Q4	132.88 (129.82, 135.94)	120.97 (119.7, 122.25)
p-value	0.86	0.57
	Mean Diastolic Blood Pressure (mmHg)	
Q1	77.17 (75.19, 79.15)	71.76 (70.83, 72.68)
Q2	76.95 (75.04, 78.86)	72.19 (71.29, 73.1)
Q3	77.65 (75.75, 79.56)	71.88 (71.02, 72.73)
Q4	76.57 (74.61, 78.53)	72.67 (71.78, 73.56)
p-value	0.71	0.12

Adjusted for age, sex, center, background, years in the U.S., education, employment, occupation, income mobility limitation moderate, mobility limitation climbing stairs, marital status, predicted energy intake, alcohol usage, smoking, accelerometer wear time per day and time spent in at least 10-minute bouts of purposeful stepping and faster ambulation

Appendix Table 63: Adjusted mean change in systolic (mmHg) and diastolic blood pressure (mmHg) by quartile of time spent sedentary independent of time spent in at least 10-minute bouts of purposeful steps and faster ambulation, HCHS/SOL (2008-2011).

Mean Change in Systolic Blood Pressure (mmHg)	
Q1	1.32 (-0.47, 3.11)
Q2	1.54 (-0.03, 3.11)
Q3	0.81 (-1.03, 2.66)
Q4	1.17 (-0.62, 2.96)
p-value	0.78
Mean Change in Diastolic Blood Pressure (mmHg)	
Q1	0.22 (-1.07, 1.5)
Q2	-0.17 (-1.35, 1.01)
Q3	-0.43 (-1.67, 0.8)
Q4	-1.06 (-2.32, 0.19)
p-value	0.27

Adjusted for age, sex, center, background and years in the U.S., BMI, education, employment, occupation, mobility limitations moderate, predicted total energy intake, CESD10, alcohol use, cigarette use, marital status, income, average accelerometer wear time per day, years between visits and time spent in 10-minute bouts of purposeful stepping and faster ambulation

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