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Comparison of Accelerometer Cut Points to Estimate Physical Activity in U.S. Adults

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Abstract

The purpose of this study was to (1) describe physical activity prevalence, categorized according to the *2008 Physical Activity Guidelines for Americans (2008 Guidelines)*, using different accelerometer cut points and (2) examine physical activity prevalence patterns by reported cut points across selected characteristics. Cut points from 9 studies were used to estimate physical activity prevalence in a national adult sample (n=6547). Estimates were stratified by validation study activity protocols used to derive cut points–ambulatory (walking/running) and lifestyle activities (e.g., gardening, housework, walking). Results showed that the prevalence of meeting *2008 Guidelines* ranged from 6.3% to 98.3% overall and was lower for cut points derived from ambulatory (median=11.5%, range=6.3%–27.4%) compared to lifestyle (median=77.2%, range=60.6%–98.3%) protocols. Prevalence patterns across protocols differed for age, but were similar for other characteristics. In conclusion, prevalence of meeting *2008 Guidelines* varied widely, indicating choice of cut point impacts prevalence. Generation of future accelerometer cut points may consider developing cut points for demographic subgroups using a variety of lifestyle physical activities.

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1. Introduction

Regular physical activity helps prevent early death and chronic diseases such as coronary heart disease, stroke, type 2 diabetes, depression, and some types of cancer (Ballard-Barbash et al., 2012; US Department of Health and Human Services, 2008b). Because of the importance of physical activity to health, national public health surveillance systems measure and track physical activity for use in planning, implementing, and evaluating public health practice (Galuska & Fulton, 2009). Physical activity levels of the U.S. population are most commonly assessed using a self-report measure, a valuable approach for monitoring and surveillance of physical activity in populations because of its feasibility, efficiency, and cost. Accelerometers, a device-based motion sensor, however, provide a precise measure of body movement (Troiano, Pettee Gabriel, Welk, Owen, & Sternfeld, 2012).

Uniaxial accelerometry, when worn on the hip, is an objective means of measuring vertical acceleration (Kozey, Staudenmayer, Troiano, & Freedson, 2010) and is one method of assessing free-living physical activity (Montoye, Kemper, Saris, & Washburn, 1996). The use of accelerometry for this purpose has become more feasible as accelerometers have become smaller, more reliable, and less expensive (Troiano et al., 2012). Although numerous studies designed to calibrate and validate accelerometers have been conducted, there is no standardized methodology to translate accelerometer output (i.e., counts per unit of time) into an estimate of physical activity (Masse et al., 2005). The most common means of doing so is to translate accelerometer output into measures of MET expenditure that reflect thresholds for specified levels of physical activity. However, as shown in Table 1, nine studies that used Actigraph accelerometer data to estimate participants' level of aerobic activity used radically different cut points to define participation in moderate-intensity activity (cut point range:191–2743) and in vigorous-intensity activity (cut point range: 4945–7526) (Brage, Wedderkopp, Franks, Andersen, & Froberg, 2003; Brooks, Gunn, Withers, Gore, & Plummer, 2005; Freedson, Melanson, & Sirard, 1998; Heil, Higginson, Keller, & Juergens, 2003; Hendelman, Miller, Bagget, Debold, & Freedson, 2000; Leenders, Sherman, Nagaraja, & Kien, 2001; Matthews, 2005; Swartz et al., 2000; Troiano et al., 2008; Yngve, Nilsson, Sjostrom, & Ekelund, 2003).

Previous research has examined differences in physical activity estimates across multiple cut points in both youth and adults (Evenson, Buchner, & Morland, 2012; Loprinzi et al., 2012; Trost, Loprinzi, Moore, & Pfeiffer, 2011). Among youth, when compared to indirect calorimetry, only child-based cut points developed by Evenson and colleagues (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008) exhibited acceptable classification accuracy for sedentary, light, moderate, and vigorous activity levels (Trost et al., 2011). In adults, the prevalence of meeting previous physical activity recommendations (Haskell et al., 2007) showed a wide discrepancy (4.5% to 97.6%) for multiple cut points (Loprinzi et al., 2012). Prevalence estimates using cut points derived with a lifestyle activity protocol (72.1%, 97.6%) were much higher than prevalence estimates using cut points derived with a walking/running activity protocol (4.5% to 36.4%) (Loprinzi et al., 2012). Cut points derived from studies using participation in ambulatory activities (walking or running) only are considerably higher than cut points derived from participation in lifestyle activities which include other activities such as household or gardening activities in addition to walking or running (Matthews, 2008). The physical activity protocol (participation in ambulatory or lifestyle activities) used to develop cut points is important because some lifestyle activities are composed of complex movement patterns that are associated with little vertical acceleration, meaning they exhibit lower counts, but expend energy through contractions of large muscle groups (Matthews, 2005; Swartz et al., 2000).

The impact of using cut points derived from purely ambulatory and lifestyle protocols to estimate physical activity levels based on the *2008 Physical Activity Guidelines for Americans (2008 Guidelines)* for adults is unknown. Furthermore, there is little information regarding demographic patterns for multiple cut points derived from studies using ambulatory and lifestyle protocols. Therefore, we sought to estimate levels of physical activity as defined by different accelerometer cut points and to describe differences in levels of physical activity with cut points developed with ambulatory and lifestyle protocols. We also sought to examine patterns of physical activity prevalence, using different accelerometer cut points, across demographic and anthropometric characteristics and to determine if patterns are similar across study activity protocols.

2. Methods

2.1 Study Sample

We analyzed data from the 2003–2004 and 2005–2006 cycles of the National Health and Nutrition Examination Survey (NHANES), of U.S. children and adults (Centers for Disease Control and Prevention & National Center for Health Statistics, 2003–2004, 2005–2006), which uses a stratified multistage probability sampling design to produce a nationally-representative sample of the civilian non-institutionalized U.S. population. We limited our potential study sample to the 10,637 NHANES respondents aged 18 years or older who participated in both the interview and physical examination components of the survey. The overall response rates among participants who were selected and responded to the examination component of the two survey cycles were 76% in 2003–2004 and 77% in 2005–2006 (http://www.cdc.gov/nchs/nhanes/response_rates_CPS.htm). The Centers for Disease Control and Prevention Ethics Review Board approved the survey protocols, and all adults who participated in the survey provided their informed consent.

2.2 Measures

NHANES participants were classified by sex, age (18–24, 25–44, 45–64, or ≥ 65 years), educational attainment (high school graduate or less, some college or technical school, or college graduate), race/ethnicity (non-Hispanic White, non-Hispanic Black, Mexican American or Other race), and body mass index (BMI) category (underweight/normal weight: BMI < 25.0, overweight: BMI= 25.0–29.9, obese: BMI ≥ 30) (National Heart Lung and Blood Institute, 1998).

Physical activity was assessed with a uniaxial accelerometer (ActiGraph model 7164, LLC, Ft. Walton Beach, FL) that participants wore for 7 days over their right hip on an elasticized belt except when they were sleeping or in contact with water (such as when bathing or swimming) (Troiano et al., 2008). At the end of the 7-day activity assessment period, participants returned their accelerometers by mail, and NHANES personnel downloaded the data and checked to determine whether the calibration of the accelerometer was still within manufacturer's specifications. Accelerometer data were then initially processed using the National Cancer Institute's statistical SAS programming code for aggregating data from the accelerometer (see http://riskfactor.cancer.gov/tools/nhanes_pam/) to determine how long participants wore their accelerometer on each of the 7 days and to estimate the number of minutes they engaged in bouts of physical activity of both moderate- and vigorous-intensity for at least 10 minutes. A valid day was determined as 10 or more hours of wear time or less than 14 hours of non-wear time. Non-wear time was assessed as any time interval with 60 or more minutes of continuous zero counts, allowing for a 1 to 2 minute interruption with counts between 0 and 100 (Troiano et al., 2008).

We then estimated the amount of time participants spent engaged in at least a 10-minute bout of moderate-intensity equivalent physical activity during valid days and categorized them into physical activity categories. This process was repeated for each set of cut points shown in Table 1. Consistent with criteria in the *2008 Guidelines* (US Department of Health and Human Services, 2008a), we defined an activity bout as 10 or more consecutive minutes of at least moderate-intensity activity. Because we were using accelerometer data, we allowed for a 1 to 2 minute interruption of the moderate- or vigorous-intensity criteria. We defined time spent in moderate-intensity equivalent activity as the sum of time spent in bouts of moderate-intensity activity plus twice the time spent in bouts of vigorous-intensity activity (US Department of Health and Human Services, 2008a).

We excluded survey participants who were missing more than 3 days of valid accelerometer data from our analyses. For those missing 1 to 3 days of accelerometer data, we imputed values, using the single imputation expectation-maximization algorithm (Catellier et al., 2005), for the missing days to provide a complete week (7 full days) of physical activity. We then added the daily totals to obtain the total number of minutes participants were engaged in moderate-intensity equivalent physical activity per week. Based on these totals, participants were subsequently classified into one of four physical activity categories corresponding to the *2008 Guidelines*: highly active, sufficiently active, insufficiently active, and inactive. Highly active is defined as >300 minutes of moderate-intensity aerobic activity, >150 minutes of vigorous-intensity aerobic activity, or an equivalent combination of moderate- and vigorous-intensity physical activity per week. Sufficiently active is defined as 150–300 minutes of moderate-intensity aerobic activity, 75–150 minutes of vigorous-intensity aerobic activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity per week. Insufficiently active is defined as some aerobic activity but not enough to meet the highly or sufficiently active definition. Inactive was defined as no moderate-intensity equivalent physical activity for ≥10 minutes (US Department of Health and Human Services, 2008a). We considered participants to have met the *2008 Guidelines*, defined as ≥150 minutes of moderate-intensity equivalent minutes of activity per week, if they were active or highly active.

To address the potential impact of the activities used to develop the MET expenditure cut points, we reviewed activity protocols for each of the validation studies. We considered validation studies that estimated MET expenditure solely on the basis of walking and running to have had an "ambulatory activity protocol" and those that estimated MET expenditure on the basis of other activities in addition to walking and running to have had a "lifestyle activity protocol." These "lifestyle activities" consist of common physical activities that people engage in such as gardening, raking, mowing, vacuuming, sweeping, mopping, playing with children, and loading/unloading boxes.

2.3 Statistical Analyses

We estimated the physical activity prevalence and corresponding 95% confidence intervals for the overall sample and by the following demographic and anthropometric characteristics: age group, sex, race/ethnicity, education level, and BMI category. Median and range estimates were used to summarize physical activity prevalence across activity protocols. In all analyses, we used SUDAAN, version 9.2 (Research Triangle Institute, Research Triangle Park, NC) to account for the stratification, clustering, and weighting used in the complex survey design. Adjusted sample weights for subsamples with four or more valid days were used for all analyses (see http://riskfactor.cancer.gov/tools/nhanes_pam/).

3. Results

3.1 Study Sample

Of 10,637 adults who participated in both the interview and examination components of NHANES during 2003–2006, 9,601 also participated in the accelerometer protocol. Of these, we excluded data from 3,054 participants for the following reasons: accelerometer not calibrated (n=449) or reliable (n=162), no valid days (n=667) or only 1–3 valid days (n=1745), or missing demographic or anthropometric data (n=31). This left us with an analytic sample of 6,547 adults with all required demographic and anthropometric data and 4 or more valid days of accelerometer data (Table 2).

3.2 Physical Activity Prevalence Estimates

The prevalence of the four levels of aerobic activity varied depending on the cut point used and the study protocol (ambulatory or lifestyle activities) in which the cut points were derived (Table 3). Using the ambulatory protocol median, 54.4% of adults were classified as insufficiently active and 35.7% were classified as inactive. In contrast, using the lifestyle protocol median, 20.3% of the adults were categorized as insufficiently active and 2.5% were classified as inactive. The median prevalence of adults classified as highly active was also notably different between the study activity protocols. Only 3.8% of adults were classified as highly active based on the median ambulatory protocol compared to 55.5% adults classified as highly active based on the median lifestyle protocol. The prevalence of the two levels of aerobic activity (meeting or not meeting the *2008 Guidelines*) also varied depending on the cut point used and the study protocol in which the cut points were derived (Table 3). The prevalence of meeting the *2008 Guidelines* was 65% lower for the ambulatory protocol cut points with 11.5% median prevalence for the ambulatory protocol cut points and 77.2% median prevalence for the lifestyle protocol cut points.

When comparing the prevalence of meeting the *2008 Guidelines* by demographic and anthropometric characteristics, the prevalences in all subgroups were notably larger for the lifestyle protocol (Table 4). In ambulatory and lifestyle protocol groups, the patterns of prevalence were similar for sex, race/ethnicity, education, and BMI subgroups. Adults who were men, Mexican Americans, graduated from college, and had a normal BMI had larger prevalences for meeting the *2008 Guidelines* as compared to adults who were women, did not graduate from college, who were not Mexican American, and did not have a normal BMI, regardless of the activity protocol. Prevalence of meeting the *2008 Guidelines* for the ambulatory protocol decreased with age whereas those for the lifestyle protocol increased for the 25–44 year olds and then decreased with increasing age. When comparing the magnitude of the differences in the range of prevalence of meeting the *2008 Guidelines* in subgroups, notable differences were found for females, adults 65 years and older, and obese adults (Table 4). For females, the range was 46.2% for the lifestyle activity protocol compared to 13.7% for the ambulatory activity protocol. A similar difference was found for obese adults where the range was 46.2% for the lifestyle activity protocol cut points compared to 16.4% for the ambulatory activity protocol. The largest difference was found for adults 65 years and older where the range was 60.5% for the lifestyle activity protocol cut points compared to 9.8% for the ambulatory activity protocol.

To further investigate whether the choice of cut points influenced the comparison of prevalence estimates for meeting the *2008 Guidelines* across subgroups, examination of the relative magnitude of differences in prevalence across subgroups were observed for BMI category and education level. The effects for BMI category on prevalence were larger for cut points from studies using ambulatory activity protocols than lifestyle activity protocols. For studies using cut points from ambulatory activities, the prevalence for overweight (11.9%) was two-thirds the prevalence of normal weight (18.1%) and the prevalence for obese (4.9%) was one-third of the prevalence for normal weight. For studies using cut points from lifestyle activities, the relative magnitude of differences in prevalence were less pronounced with similar prevalence estimates for overweight (79.2%) and normal weight (80.0%). The prevalence for obese (71.8%) was slightly less. Similarly, the effects of education on prevalence were larger for cut points from studies using ambulatory activity protocols than lifestyle activity protocols. For studies using cut points from ambulatory activities, the prevalence for college graduates (20.2%) was nearly twice the prevalence of adults who were not college graduates (8.9% for some college and 8.9% for high school or less). The effects of education on prevalence were similar for cut points using lifestyle activities where estimates of 73.4%, 77.8%, and 82.4% for high school graduates or less, some college, and college graduates, respectively, varied slightly. There appears to be a similar pattern for prevalence estimates across sex, age, and race/ethnicity subgroups for ambulatory and lifestyle activities.

4. Discussion

Our findings showed that when using an accelerometer to estimate the percentage of the U.S. adult population meeting the aerobic component of the *2008 Guidelines*, the prevalence varied depending on the choice of cut point. The physical activity prevalences from lifestyle protocol cut points were notably larger than estimates from ambulatory protocol cut points. For example, from 2003 to 2006, between 61% and 98% of adults would be classified as meeting *2008 Guidelines* using lifestyle cut points whereas between 6% and 27% would meet *2008 Guidelines* using ambulatory cut points. This results in a median difference of 65 percentage points, based on the median estimates of 77% and 12% for lifestyle and ambulatory protocol cut points, respectively. While the magnitude of the prevalence of meeting the *2008 Guidelines* is different for ambulatory and lifestyle cut points, the prevalence patterns are similar. For example, both ambulatory and lifestyle cut points show more men than women meet the *2008 Guidelines*.

There also appears to be a similar pattern for prevalence estimates across most demographic and anthropometric subgroups, but not necessarily all subgroups. Although sex, race/ ethnicity, and age groups show similar patterns irrespective of activity protocol, the effects for body mass index and education seem to be much larger for ambulatory activities compared to lifestyle activities. The prevalence estimates for meeting the 2008 Guidelines for some subgroups are at least twice as large as other subgroups (e.g., 18% for normal weight and 5% for obese) when using cut points from ambulatory activities whereas the prevalence estimates are similar across subgroups (e.g., 80% for normal weight and 72% for obese) when using cut points from lifestyle activities.

Although we found no studies whose results were directly comparable with ours, we did find three that addressed how variations in accelerometer cut points affect physical activity estimates, one among youth and adults (Loprinzi et al., 2012), one among children and youth aged 5–15 years (Trost et al., 2011), and one among older adults (Evenson et al., 2012). In the study among youth and adults, using the same NHANES data and some of the same cut points, researchers found that the prevalence of meeting the old recommendations varied significantly, depending on the cut point used (Loprinzi et al., 2012). Similar to our findings, using the same heterogeneous sample of adults (Loprinzi et al., 2012), the prevalence of meeting previous recommendations varied from 5% to 98%. In addition, the prevalence varied from 5% to 36% in studies using an ambulatory protocol and from 72% to 98% in studies using a lifestyle activity protocol. In the study among children and youth (Trost et al., 2011), researchers who compared accelerometer cut points derived from 5 youth-specific equations with indirect calorimetry, a criterion measure, found that the physical activity estimates varied widely depending on the cut points used. Estimates from two of the five cut points underestimated time spent in moderate-to-vigorous intensity physical activity by 39% to 74%. In older adults (≥ 60 years) (Evenson et al., 2012), researchers examined the impact of a set of pre-determined cut points on daily minutes of moderate to vigorous physical activity, using data from the 2003–2006 NHANES examination. Findings showed the patterns of physical activity were generally consistent across age groups, gender and race/ethnicity. For example, prevalence estimates were always lower for women, regardless of the cut point used.

The differences in cut points in the validation studies we examined may be attributed to three factors. The first is the more comprehensive activity profile used in studies that attempted to reflect energy expended in lifestyle activities (US Department of Health and Human Services, 1996), which tend to involve movement patterns with less vertical acceleration and thus produce lower accelerometer readings than ambulatory activities of the same intensity level (Bassett et al., 2000; Matthews, 2005, 2008; Swartz et al., 2000). The second factor contributing to the differences in cut points is the small, disproportionately young, and fairly homogeneous nature of the samples in the studies we examined. Future accelerometer validation studies may benefit from accelerometer cut points derived from samples more representative of the U.S. adult population. The third factor contributing to the variation is the choice of statistical methods used to determine the cut points. In general, the use of accelerometer data to estimate energy expenditure is based on the assumption of a linear relationship between vertical acceleration and energy expenditure. Although this assumption has been shown to be more valid in estimating energy expended in ambulatory activities such as walking and running, it has been shown to be less valid in estimating energy expended in lifestyle activities such as sweeping or raking (Matthews, 2005). Thus, a simple linear association between counts and physical activity intensity may not generalize to all types of physical activities (Crouter & Bassett, 2008; Crouter, Clowers, & Bassett, 2006; Crouter, Horton, & Bassett, 2011; Crouter, Kuffel, Haas, Frongillo, & Bassett, 2010).

This study has at least two limitations. The first limitation is that our findings may have been affected by selection bias inasmuch the distribution of characteristics among participants of our analytic sample (n=6547) may have differed from that among the NHANES participants excluded from analysis (n=3054). However, we found no significant differences between the two groups by sex or BMI and only small (<10%) albeit significant differences by education and race/ethnicity. The largest difference between the two groups was that 18 to 24 year olds accounted for 22% of NHANES participants excluded from our study sample but only 11% of those included in the sample. We could not determine, however, the extent to which physical activity patterns among participants in this age group may have differed from patterns among NHANES participants who were excluded from the study sample. The second limitation is that NHANES data did not include a criterion measure of physical activity energy expenditure (such as doubly labeled water) with which to compare our estimates of energy expenditure.

Although there is no universally-accepted method of measuring physical activity, estimates of physical activity based on accelerometer data offer a number of advantages over estimates based on self-reports of physical activity, including the elimination of recall bias, social desirability bias, and issues related to estimating the duration and frequency of one’s physical activities (Atienza et al., 2011). However, because accelerometers, worn on the hip, measure only vertical acceleration, they fail to account adequately for activities other than walking or running or to indicate the purpose of any physical activity. Physical activity estimates based on accelerometer data, therefore, should not be compared directly with estimates based on self-reports. Because few population-based studies of the relationship between physical activity and health outcomes have used accelerometer-derived measures of physical activity (Bowles, 2012), associations between physical activity and health (US Department of Health and Human Services, 2008b) on which national physical activity guidelines are based have been derived solely from studies that relied on subjects’ self-reports of their physical activity. The extent to which such associations would differ if physical activity estimates were based on accelerometer data is unclear. Furthermore, accelerometer data, like self-reported measures of physical activity, are subject to various sources of measurement error (Nusser et al., 2012). Currently, a study is underway to examine the error in self-reported and accelerometry-derived physical activity with known standards of energy expenditure (Bowles et al., 2012).

5. Conclusion

Our findings indicate that researchers using accelerometer data to estimate physical activity prevalence in a given population need to be aware that their choice of activity level cut points can have a marked effect on their estimates. Depending on the cut point used, physical activity prevalence may be under- or over-estimated by varying degrees. Furthermore, because of the potential bias by body mass index and education level, it may be that there is not a “one size fits all” for defining standard cut points. Generation of future accelerometer cut points may consider developing cut points for demographic subgroups using a variety of lifestyle physical activities.

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Table 1

Description of Actigraph studies and corresponding prediction equations and cut points

Activity Protocol[a] First Author, Publication Year (Method[b])	Sample			Equation for metabolic costs in METs	Cut points for MET values	
	Size (n)	Sex	Ages[c] (years)		Moderate (3 to 6)	Vigorous (≥ 6)
Ambulatory Activities						
Brage, 2003[d]	12	M	23 – 30	2.886 + 0.0007429*counts/min−0.02*VO_2 Study sample VO_2 (=61.6)[EQ1]	1810	5850
				National Health and Nutrition Examination Survey laboratory sample VO_2 (=43.2)[EQ2]	1316	5354
Freedson, 1998	50	M/F	24 ± 4	1.439008 + 0.000795*counts/min	1952	5725
Leenders, 2001	28	M/F	24 ± 4	2.240 + 0.0006*counts/min	1267	6252
Brooks, 2005	72	M/F	35 – 45	2.32 + 0.000389*counts/min[EQ1]	1748	9460
				3.33 + 0.000370*counts/min−0.012*weight[EQ2]	weight-specific	weight-specific
Heil, 2003	58	M/F	28 ± 6	1.551 + 0.000619*counts/min[EQ1]	2341	7187
				−1.833 + 0.00171*counts/min + 1.957*height-0.000631*counts/min*height[EQ2]	height-specific	height-specific
Yngve, 2003	28	M/F	23 ± 3	1.136 + 0.0008249*counts/min[EQ1]	2260	5896
Yngve, 2003	28	M/F	23 ± 3	0.751 + 0.0008198*counts/min[EQ2]	2743	6403
Troiano, 2008[e]	n/a	n/a	n/a	Based on weighted average of cut points	2020	5999
Lifestyle Activities						
Hendelman, 2000	25	M/F	30 – 50	2.922 + 0.000409*counts/min	191	7526
Matthews, 2005	19	M/F	19 – 29	Based on distributional properties resulting from combined information from laboratory and field studies	760	5725
Swartz, 2000	70	M/F	19 – 74	2.608 + 0.0006863*counts/min	574	4945

[a]Activity protocol refers to the type of activities in which the cut points were derived: ambulatory (walking/running only) and lifestyle activities (for example, gardening, raking, vacuuming, and playing with children)

[b]Method is the study-specific cut point

[c]Age distribution from study is either a range (with '−') or the mean and standard deviation (with '± ')

[d]Equation was converted from $VO_2 \cdot kg^{-1}$ to METs by dividing the parameters by 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$

[e]Troiano cut points are a weighted average of cut points from the Brage, Freedson, Leenders, and Yngve studies.

Table 2

Distribution of characteristics among study participants, National Health and Nutrition Examination Survey (NHANES) 2003–2006

Characteristic	n[a]	Percentage	Weighted	
			Percentage	(95%CI)
Sex				
Male	3223	49.2	48.1	(46.6,49.5)
Female	3324	50.8	51.9	(50.5,53.4)
Age Group, y				
18 – 24	859	13.1	11.1	(9.9,12.4)
25 – 44	2003	30.6	39.2	(36.5,41.8)
45 – 64	1936	29.6	33.0	(30.7,35.5)
65 or older	1749	26.7	16.7	(15.1,18.4)
Race/Ethnicity				
Non-Hispanic White	3367	51.4	72.0	(67.3,76.3)
Non-Hispanic Black	1334	20.4	11.5	(8.9,14.8)
Mexican American	1403	21.4	7.9	(5.9,10.5)
Other	443	6.8	8.6	(7.2,10.2)
Education Level				
High school graduate or less	3431	52.4	41.8	(39.3,44.4)
Some college/technical school	1846	28.2	32.4	(30.5,34.3)
College graduate	1270	19.4	25.8	(22.9,28.9)
Body Mass Index (BMI)[b] Category				
Underweight/Normal	2177	33.3	35.0	(33.1,37.0)
Overweight	2290	35.0	33.7	(31.8,35.7)
Obese	2080	31.8	31.3	(29.1,33.5)

[a]Unweighted sample size

[b]Underweight/normal, overweight, and obese classifications are on the basis of body mass index, which is weight (kg) / height (m)^2. Underweight/normal: < 25.0; overweight: 25.0–29.9; and obese: ≥ 30.0

Abbreviations: confidence interval (CI)

Table 3

Accelerometer-derived prevalence (%) of U.S. adults meeting the *2008 Physical Activity Guidelines for Americans*[a] *(2008 Guidelines)*, National Health and Nutrition Examination Survey 2003–2006

Activity Protocol[b] Method[c]	Physical Activity Level								Met *2008 Guidelines*	
	Inactive[a]		Insufficiently Active[a]		Sufficiently Active[a]		Highly Active[a]		(Highly or Sufficiently Active)[a]	
	%	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**
Ambulatory Activities										
Brage,[EQ1]	29.1	(27.1, 31.1)	57.9	(56.1, 59.7)	8.9	(7.8, 10.0)	4.1	(3.2, 5.0)	13.0	(11.4, 14.6)
Brage,[EQ2]	16.8	(15.6, 17.9)	57.7	(55.9, 59.6)	15.6	(14.2, 17)	9.9	(8.6, 11.2)	25.5	(23.5, 27.4)
Freedson	32.3	(30.3, 34.3)	56.3	(54.6, 58.0)	7.8	(6.8, 8.7)	3.6	(2.8, 4.3)	11.4	(9.9, 12.8)
Leenders	16.3	(15.1, 17.5)	56.3	(54.3, 58.4)	16.9	(15.5, 18.3)	10.5	(9.1, 11.9)	27.4	(25.4, 29.3)
Brooks,[EQ1]	28.3	(26.4, 30.3)	58.2	(56.4, 60.1)	9.9	(8.8, 11.0)	3.5	(2.7, 4.3)	13.4	(11.9, 15.0)
Brooks,[EQ2]	50.5	(47.3, 53.7)	39.2	(36.9, 41.6)	6.2	(5.1, 7.4)	4.0	(3.3, 4.7)	10.3	(8.8, 11.7)
Heil,[EQ1]	41.3	(39.0, 43.6)	50.8	(49.0, 52.7)	6.0	(5.2, 6.9)	1.8	(1.3, 2.4)	7.9	(6.7, 9.0)
Heil,[EQ2]	55.0	(52.5, 57.6)	33.4	(31.6, 35.2)	6.4	(5.5, 7.2)	5.2	(4.4, 6.1)	11.6	(10.3, 12.9)
Yngve,[EQ1]	39.0	(36.8, 41.2)	52.4	(50.6, 54.2)	6.0	(5.2, 6.8)	2.6	(1.9, 3.2)	8.6	(7.5, 9.7)
Yngve,[EQ2]	48.2	(45.8, 50.6)	45.5	(43.6, 47.4)	4.7	(4.1, 5.3)	1.6	(1.1, 2.1)	6.3	(5.4, 7.2)
Troiano[e]	34.2	(32.1, 36.2)	55.1	(53.4, 56.8)	7.6	(6.7, 8.6)	3.1	(2.4, 3.8)	10.7	(9.4, 12.1)
Median %		*35.7*		*54.4*		*7.1*		*3.8*		*11.5*
(Min-Max)		*(16.3–55.0)*		*(33.4–58.2)*		*(4.7–16.9)*		*(1.6–10.5)*		*(6.3–27.4)*
Lifestyle Activities										
Hendelman	0.1	(0.0, 0.1)	1.7	(1.4, 1.9)	2.4	(2.0, 2.7)	95.9	(95.4, 96.5)	98.3	(98.0, 98.6)
Matthews	5.1	(4.3, 5.8)	34.3	(32.5, 36.1)	24.1	(22.2, 26.1)	36.5	(34.4, 38.6)	60.6	(58.7, 62.6)
Swartz	2.5	(2.1, 3.0)	20.3	(18.9, 21.8)	21.6	(19.9, 23.4)	55.5	(53.4, 57.6)	77.2	(75.5, 78.8)
Median %		*2.5*		*20.3*		*21.6*		*55.5*		*77.2*
(Min-Max)		*(0.1–5.1)*		*(1.7–34.3)*		*(2.4–24.1)*		*(36.5–95.9)*		*(60.6–98.3)*

[a]Only the aerobic component of the *2008 PAG* is assessed; Highly active is defined as >300 minutes of moderate-intensity aerobic activity, >150 minutes of vigorous-intensity aerobic activity, or an equivalent combination of moderate- and vigorous-intensity physical activity per week. Sufficiently active is defined as 150–300 minutes of moderate-intensity aerobic activity, 75–150 minutes of vigorous-intensity aerobic activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity per week. Insufficiently active is defined as some aerobic activity but not enough to meet the highly or sufficiently active definition. Inactive was defined as no moderate- or vigorous-intensity aerobic activity for ≥10 minutes.

[b]Activity protocol refers to the type of activities in which the cut points were derived: ambulatory (walking/running only) and lifestyle activities (for example, gardening, raking, vacuuming, and playing with children)

[c]Method is the study-specific cut point

[d]Instances where prevalence estimates for 'Sufficiently Active' plus 'Highly Active' are not equal to 'Met *2008 Guidelines*' are due to rounding error

[e]Troiano cut points are a weighted average of cut points from the Brage, Freedson, Leenders, and Yngve studies, thus the Troiano estimates are not included in the median estimates

Abbreviations: Confidence interval (CI); equation (EQ), minimum (Min), maximum (Max)

Table 4

Median and Range of prevalence estimates of meeting the *2008 Physical Activity Guidelines for Americans*[a] by activity protocol[b], method[c], and sample characteristics, National Health and Nutrition Examination Survey 2003–2006

Characteristic	Ambulatory Activities			Lifestyle Activities		
	Median %[d]	Minimum	Maximum	Median %[d]	Minimum	Maximum
Overall	11.5	6.3	27.4	77.2	60.6	98.3
Gender						
Male	13.2	6.9	36.0	83.8	70.2	98.5
Female	10.3	5.7	19.4	71.0	51.8	98.1
Age Group						
18 – 24	16.9	9.4	35.4	83.6	67.9	99.6
25 – 44	12.8	6.8	33.4	87.2	70.6	100.0
45 – 64	10.7	6.1	24.7	78.9	61.1	99.1
65 or older	6.8	3.4	13.2	46.0	31.4	91.9
Race/Ethnicity						
Non-Hispanic White	12.0	7.1	27.3	76.6	60.1	98.2
Non-Hispanic Black	9.9	4.1	23.5	75.1	55.7	97.6
Mexican American	12.9	4.4	34.2	84.6	70.5	99.6
Other	11.8	3.7	27.4	77.8	62.4	99.0
Education Level						
High school graduate or less	8.9	3.3	25.7	73.4	58.0	97.5
Some college/technical school	9.0	4.8	24.1	77.8	60.3	98.7
College graduate	20.2	12.9	34.1	82.4	65.3	99.1
Body Mass Index (BMI) Category[e]						
Underweight/Normal	18.1	9.7	33.4	80.0	65.4	98.1
Overweight	11.9	6.8	29.6	79.2	63.8	98.7
Obese	4.9	1.9	18.3	71.8	51.9	98.1

[a]Only the aerobic component of the *2008 Physical Activity Guidelines for Americans* are assessed

[b]Activity protocol refers to the type of study in which the cut points were derived: ambulatory (walking/running only) and lifestyle activities (for example, gardening, raking, vacuuming, and playing with children)

[c] Method is the study-specific cut point

[d] % Median of the prevalence estimates for meeting the *2008 Physical Activity Guidelines for Americans*

[e] Underweight/normal, overweight, and obese classifications are on the basis of body mass index, which is weight (kg) / height (m)^2. Underweight/normal: < 25.0; overweight: 25.0–29.9; and obese: ≥ 30.0