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Comparison of Self-Reported and Objectively Measured Sedentary Behavior and Physical Activity in Undergraduate Students

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Abstract

OBJECTIVE—To investigate differences between estimates of sedentary behavior and physical activity (PA) from the International Physical Activity Questionnaire (IPAQ) and accelerometry in undergraduate students.

PARTICIPANTS—91 students participated in the study.

METHODS—Sedentary behavior and PA were objectively measured by an accelerometer for 7 days and then self-reported with the IPAQ. Partial correlations were used to assess associations among PA variables and participant characteristics between the methods. Agreement was assessed via the Bland-Altman method.

RESULTS—Correlation coefficients between self-reported and objectively measured PA ranged from 0.21 to 0.38 ($p \leq 0.05$ for all). A higher proportion of students were classified as meeting PA guidelines via self-report compared to objective measurements. Bland-Altman plots revealed acceptable agreement between methods, however, bias was evident for all PA intensities. Sex and lean body mass impacted these differences.

CONCLUSIONS—Researchers should exercise caution when interpreting PA assessed via the IPAQ in undergraduate students.

Keywords

physical activity; accelerometer; bland-altman method; self-report; sitting

Physical activity (PA) is associated with numerous health benefits and a decreased risk of morbidity and mortality (Physical Activity and Cardiovascular Health, 1996; U.S Department of Health and Human Services, 2008). Many lasting health behaviors including PA patterns are developed during the transition from adolescence to early adulthood (Calfas et al., 2000; U.S Department of Health and Human Services, 2014). This transition from

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high school to college often represents the first time young adults live on their own, with freedom to develop new routines and establish health-related behaviors. Increases in sedentary behavior and decreases in PA often occur alongside this transition, with PA declining as students progress through college (Bray & Born, 2004; Deforche, Van Dyck, Deliens, & De Bourdeaudhuij, 2015; Kwan, Cairney, Faulkner, & Pullenayegum, 2012; Small, Bailey-Davis, Morgan, & Maggs, 2013). To this end, the 2016 National College Health Assessment II indicated that less than half (47%) of undergraduate students self-reported meeting the physical activity guidelines of 150 minutes per week of moderate-to-vigorous physical activity (MVPA) (American College Health Association, 2016).

A great deal of research uses self-report methods to estimate PA levels. A variety of well-researched instruments designed to quantify PA levels exist that can be administered with little cost and provide an opportunity to gather data on large samples of participants (Hallal et al., 2012). These instruments are easy to use and are quick to complete. The International Physical Activity Questionnaire (IPAQ) has been used extensively to assess sedentary behavior and PA via self-report. Available as both a long and short form, the IPAQ was developed to assess population levels of PA across countries (Craig et al., 2003; Dyrstad, Hansen, Home, & Anderssen, 2014; Hallal et al., 2012; Ottevaere et al., 2011). Although widely accepted, numerous studies have reported low to moderate associations between the IPAQ and objective measures of PA via accelerometers, which may differ based on the population being studied (Boon, Hamlin, Steel, & Ross, 2010; Craig et al., 2003; Dyrstad et al., 2014; Lee, Macfarlane, Lam, & Stewart, 2011; Ottevaere et al., 2011). The latest models of objective PA monitoring devices now have the ability to measure acceleration on three axes, where they previously only used one axis. Additionally, updated algorithms and cut-points for classifying PA intensity with accelerometers have greatly improved activity monitoring. This calls into question the validity and reliability of the IPAQ (Lee et al., 2011). To date, few studies have assessed the ability of the IPAQ to produce acceptable estimates of sedentary behavior and PA compared to an objective measure (i.e., accelerometer) in an undergraduate student population (Dinger, Behrens, & Han, 2006; Downs, Van Hoomissen, Lanfrenz, & Julka, 2014). Previous studies have demonstrated intraclass correlation coefficients of 0.52–0.89 indicating moderate to strong test-retest reliability for the IPAQ in college students (Dinger et al., 2006; Murphy et al., 2017), however, validity assessments have relied mostly on correlations between variables to draw conclusions on the agreement between methods (Dinger et al., 2006; Downs et al., 2014). While correlations quantify the strength of a relationship between variables, they do not assess the degree to which methods agree with one another, which is an important property to assess in methods that attempt to quantify the same measure (Giavarina, 2015).

Previous research has found that various factors can bias how an individual reports behavior, often leading to significant overestimation of desirable behaviors such as PA. Although previous research has provided minimal evidence that PA over-reporting is associated with social desirability in college students, other factors such as sex, athletic identity, and level of cardiorespiratory fitness may play a role (Dinger et al., 2006; Downs et al., 2014; Motl, McAuley, & DiStefano, 2005; Tomaz, Lambert, Karpul, & Kolbe-Alexander, 2016; Wolin, Heil, & Askew, 2008). Regardless of the cause of bias, self-report estimates of sedentary behavior and PA may lead to inaccurate generalizations about college students' activity levels, which is problematic considering the sharpest decline in PA appears to occur during the time period of late adolescence and early adulthood (Small et al., 2013). Therefore, it is important for self-report questionnaires to accurately distinguish physically active from inactive individuals of this demographic. The purpose of this study was to compare self-reported (IPAQ) and objectively measured (triaxial accelerometer) levels of sedentary behavior and PA in undergraduate students with the use of multiple statistical approaches. A secondary purpose was to identify whether participant characteristics such as sex, body composition, and cardiorespiratory fitness influenced differences between self-reported and objectively measured PA in this sample, as previous studies have identified that these factors may introduce bias (Dinger et al., 2006; Dyrstad et al., 2014; Gu, Key, & Reeves, 2018; Hagstromer, Ainsworth, Oja, & Sjostrom, 2010; Tomaz et al., 2014; Wolin et al., 2008). We hypothesized that students would under-estimate sedentary behavior and over-estimate PA when quantified via the IPAQ compared to accelerometry.

METHODS

In this cross-sectional study, data were collected during two visits spaced approximately one week apart. Before the first visit to the laboratory, participants were instructed to avoid strenuous activity for at least 24 h and refrain from caffeine and large meals for at least 2 h. During the first visit, consent, demographic information, and anthropometric measurements were obtained. Peak oxygen consumption (VO_2 peak) was measured via incremental treadmill test to exhaustion. Participants were given an accelerometer and instructed to wear the accelerometer on their right hip during all waking hours for the next 7 days, only removing the device for night-time sleep and water-based activities. Previous research has demonstrated no meaningful differences in total activity counts or vector magnitude activity counts in this model of accelerometer when worn on the contralateral hip (Aadland & Ylvisaker, 2015), so the right hip was chosen for consistency. Participants concurrently documented activities they performed over the 7 days in an activity log (Figure 1). After the 7 days of accelerometer wear, participants returned to the laboratory for a body composition assessment and were asked to self-report their physical activity and time spent sitting over the past 7 days with the short form of the IPAQ. All participants included in this analysis had at least 6 valid days of accelerometer wear that consisted of at least 10 waking hours of data, in addition to a complete set of IPAQ data. Written informed consent was obtained from all participants prior to testing. The study was approved by the University's Institutional Review Board.

Participants

A convenience sample of 91 undergraduate students aged 18–25 years old were recruited to take part in the study. Exclusion criteria included being enrolled in college ≥ 6 years, age > 25 years, collegiate athlete, diagnosed cardiometabolic or pulmonary disease, currently pregnant or breastfeeding, or any injury limiting PA. All participants completed a pre-screening questionnaire and health history questionnaire to determine eligibility to participate.

Participant characteristics are shown in Table 1. The mean age was 20.4 years and 60% of participants were women. The level of cardiorespiratory fitness of this sample of students was high overall, with approximately 85% falling above the 50^{th} percentile based on age and sex (Kaminsky, Arena, & Myers, 2015). On average, participants were normal weight, with a mean body mass index (BMI) of 23.9 kg·m^{-2}. The majority of participants (76%) were non-smokers and over half lived off campus (56%).

Anthropometric Data

Height was measured to the nearest 0.1 cm as the average of two measurements with a stadiometer (Seca 220, Hamburg, Germany). Body mass was measured with a calibrated electric scale to the nearest 0.1 kg (Seca 220, Hamburg, Germany). BMI was computed as body mass divided by height squared. Body volume was measured via air displacement plethysmography with the BOD POD® in the morning within an hour of waking, after a 12 h overnight fast. Participants were instructed to avoid exercise prior to the measurement. Before each measurement, the system was calibrated according to the manufacturer’s instructions. A minimum of two consecutive body volume measurements were taken while participants were seated and relaxed in the chamber, wearing a tight fitting swimsuit and swim cap. Body density was calculated using body mass and body volume measures, accounting for measured thoracic gas volume, and converted to percent body fat with the Siri (general population) or Schutte (African American) equation.

Oxygen Consumption (VO_2 peak)

To assess cardiorespiratory fitness, participants completed a maximal incremental exercise test on a motorized treadmill (Trackmaster, Newton, KS). After a 2 minute warm up at 5.6 km/h (0% incline), participants self-selected a “comfortably hard” jogging pace that stayed constant for the duration of the test. After selecting a pace, elevations in treadmill gradient occurred at a rate of 1% every minute. All participants received verbal encouragement and the test was terminated upon volitional exhaustion. Data for VO_2 and related gas exchange measures were obtained via indirect calorimetry with a TrueOne 2400 Metabolic Measurement System (Parvo Medics, Inc., Salt Lake City, UT). Before each test, the metabolic system was calibrated according to the manufacturer’s recommendations. Heart rate was continuously measured using a heart rate monitor and receiver integrated with the metabolic cart (Polar Electro, Inc., Woodbury, NY). For analyses of oxygen consumption, data were processed using a 15 breath-moving average (Robergs, Dwyer, & Astorino, 2010). The highest average value within one minute of test termination was defined as VO_2 peak.

Questionnaire

Self-reported PA over the past 7 days was obtained with the short form of the IPAQ. The IPAQ asks questions about PA performed in bouts of at least 10 minutes or more, specifically, walking, moderate, and vigorous activities. A description of how to distinguish these activities from one another is provided in each question, in addition to common examples of each activity. Each question is assigned an average metabolic equivalent (MET) that was derived by calculating an average of the METs required for different activities within the designated intensity. For example, the question regarding vigorous PA states “vigorous activities refer to activities that take hard physical effort and make you breathe much harder than normal". Examples of vigorous activities are provided and include heavy lifting, digging, aerobics, or fast bicycling. The average absolute intensity representing these vigorous activities is 8 METs (IPAQ Group, 2005). Similarly, the absolute intensity representing moderate PA is 4 METs (IPAQ Group, 2005). To assess sitting time, one question asks about the amount of time spent sitting or lying while doing various activities or watching television on a typical weekday. Total daily PA in minutes per day was calculated by multiplying the amount of time spent in each activity by the amount of days the activity was performed throughout the last 7 days and dividing the amount by 7. All participants provided valid responses for the IPAQ questions regarding moderate, vigorous, and sitting activities. Two participants checked "don't know" for the amount of walking they performed on a typical day; however, were still included in the analysis.

Participants were classified as meeting or not meeting the PA guidelines for each method. For the IPAQ, participants were classified as meeting the physical activity guidelines if they self-reported participating in at least 150 minutes per week of MVPA. For the accelerometer, participants accumulating a minimum of 150 minutes per week of MVPA in bouts of 10 minutes or more (with allowance of interruptions of 1–2 min) were categorized as meeting the PA guidelines.

Objective PA Measurement

The ActiGraph GT3X+ (ActiGraph, LLC, Pensacola, FL) was used to objectively assess sedentary behaviors and PA levels. The test–retest reliability of the ActiGraph accelerometer has been previously assessed in adults and results showed intra-class correlation coefficients of 0.70–0.90 (Sirard, Forsyth, Oakes, & Schmitz, 2011). Participants with at least 6 days (4 week days and 2 weekend days) of at least 10 h of daily recordings were included in the analysis. Data were collected at 30 Hz, converted to 60 s epochs and processed using ActiLife 6.3.1 software (ActiGraph, LLC, Pensacola, FL). Non-wear time was defined as intervals of at least 90 minutes of consecutive zero counts with allowance of a 2 minute interval of counts greater than zero with the up/downstream 30 minute consecutive zero counts window (Choi, Zhowen, Matthews, & Buchowski, 2011).

During the first visit, participants were instructed on proper placement and use of the accelerometer. Participants were instructed to wear the accelerometer on the anterior axillary line of the right hip during all waking hours for 7 days and to maintain normal activity patterns. Participants were also given an activity log and were instructed to record structured daily activities and times when the accelerometer was removed (Figure 1).

The cut-points used were based on data derived and validated from this model of accelerometer, specifically in young adults. The cut-points reflect the use of information obtained from all three axes of measurement of the accelerometer (vertical, antero-posterior, medio-lateral) and body position, in the form of the vector magnitude (Peterson et al., 2015; Sasaki, John, & Freedson, 2011). Sedentary time was defined as all activities <150 counts/minute (Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011; Peterson et al., 2015). Light-intensity physical activity (LPA) was defined as 150 to 2689 counts/minute. Moderate-intensity physical activity (MPA) was defined as 3.00–5.99 METs corresponding with 2690 to 6166 counts/minute, and vigorous-intensity physical activity (VPA) was defined as ≥6.00 METs corresponding with ≥6167 counts/minute (Sasaki et al., 2011).

Statistical Analysis

Descriptive statistics for variables are presented as a percentage or mean ± SD. Assumptions were checked with visual inspection of normality and residual plots for all dependent variables. Two extreme outliers existed for self-report variables and were removed to avoid compromising inferences of tests (Giavarina, 2015). A square root transformation was applied to non-normally distributed variables and then re-checked for normality. A McNemar's test for dependent samples was used to compare the proportion of participants classified as meeting the PA guidelines or not meeting the PA guidelines between the IPAQ and accelerometer. Partial correlations were used to measure the associations among the variables from the two methods, while controlling for the covariates age, sex, and accelerometer wear time.

The degree of agreement between the two methods was assessed using the Bland-Altman technique (Altman & Bland, 1986), stratified by sex. The 95% limits of agreement were determined by calculating two standard deviations of the mean difference between the methods and 95% confidence intervals (CI) were constructed around the limits of agreement (Altman & Bland, 1986; Giavarina, 2015). To statistically assess this, paired t-tests were utilized to assess differences between self-reported and objectively measured PA variables for the entire sample.

To assess for biases that may contribute to differences between self-reported and objectively measured PA and sedentary behavior, partial correlations, independent t-tests, and analysis of covariance (ANCOVA) were utilized. Independent t-tests were used to compare self-reported PA variables between men and women, whereas, ANCOVAs with accelerometer wear time as a covariate were used to compare objectively measured PA variables between men and women. Partial correlations controlling for age and sex were used to assess the associations among body composition (BMI, fat mass, fat free mass, and body fat percentage) and cardiorespiratory fitness with self-reported PA. Another ANCOVA was then utilized to assess differences between sex on each outcome variable representing the discrepancy between self-reported and objectively measured PA (calculated by subtracting objectively measured PA from self-reported PA). Any participant characteristic variable with a significant correlation was then added to the ANCOVA model to understand if it contributed to the discrepancy between self-reported and objectively measured PA. A p value of less than 0.05 was regarded as statistical significance. Statistical analyses were performed in SPSS Version 24 (IBM Corporation, Armonk, NY) and Bland-Altman plots were created in MedCalc (MedCalc Software, Belgium).

RESULTS

Descriptive Data for the IPAQ and Accelerometer

The descriptive data for the IPAQ and the accelerometer are shown in Table 2. All participants wore the accelerometer for at least 10 hours per day and the average number of days worn was 7.0 ± 0.2 d. The number of students classified as meeting the PA guidelines via the IPAQ compared to the accelerometer was significantly different ($p<0.001$). Approximately 78% of the participants met the PA guidelines when self-reported via the IPAQ, while only 54.4% were classified as meeting the PA guidelines when objectively measured by the accelerometer.

Partial Correlations Among IPAQ and Accelerometer Variables

The associations among the variables for the IPAQ and accelerometer, while controlling for age, sex, and total accelerometer wear time, are displayed in Table 3. IPAQ sitting time was positively associated with objectively measured sedentary time (r=0.26, $p=0.02$) and negatively associated with objectively measured LPA (r=−0.24, $p=0.03$). IPAQ walking time was negatively associated with objectively measured sedentary time (r=−0.30, $p=0.006$) and positively associated with objectively measured LPA (r=0.28, $p=0.01$) and steps (r=0.26, $p=0.02$). IPAQ MPA was positively associated with objectively measured steps (r=0.24, $p=0.03$), MPA (r=0.27, $p=0.01$) and total MVPA (r=0.24, $p=0.03$), but not MVPA bouts (r=0.21, $p=0.05$). IPAQ VPA was positively associated with objectively measured steps (r=0.27, $p=0.01$), VPA (r=0.31, $p=0.004$), total MVPA (r=0.28, $p=0.01$), and MVPA bouts (r=0.22, $p=0.04$). MVPA calculated from the IPAQ was positively associated with objectively measured total MVPA (r=0.37, $p<0.001$) and MVPA bouts (r=0.28, $p=0.01$). All IPAQ physical activity variables, but not sitting time, were associated with total accelerometer vector magnitude and accelerometer counts per minute (Table 3, $p<0.05$).

Agreement Between IPAQ and Accelerometer Methods

Bland-Altman plots highlighted the agreement between two methods and revealed that the mean difference between the IPAQ and objectively measured MPA and VPA was −38, 95% CI [−43.6, −32.3] and 21, 95% CI [14.8, 27.2] minutes·day^{-1}, respectively (Figs. 2 and 3), indicating students tended to under-report MPA and over-report VPA when using the IPAQ. For MVPA in bouts of at least 10 minutes (Fig. 4), the mean difference between methods equated to 26, 95% CI [17.2, 34.0] minutes·day^{-1}. Using paired t-tests to statistically compare methods, self-reported minutes per day of VPA and MVPA were significantly higher than objectively measured VPA and MVPA ($p<0.001$ for both), whereas self-reported sitting time and MPA were significantly lower than objectively measured sedentary behavior and MPA ($p<0.001$ for both).

Influence of Participant Characteristics

There were no differences between men and women for self-reported sitting, walking, and MPA or objectively-measured sedentary, LPA, MPA, VPA, total MVPA, and MVPA bouts ($p>0.05$, Table 2). There were significant differences between men and women for self-reported VPA and MVPA ($p<0.001$), with men self-reporting more VPA and MVPA compared to women.

To assess the associations among body composition, cardiorespiratory fitness, and self-reported PA, partial correlations controlling for age and sex were performed. VO_2peak was associated with IPAQ sitting time ($r=-0.23$, $p=0.04$), IPAQ VPA ($r=0.39$, $p<0.001$), and IPAQ calculated MVPA ($r=0.37$, $p=0.002$), respectively. Body fat percentage, BMI, and fat mass were not associated with any IPAQ variable (*p*>0.05); however, lean mass was positively associated with IPAQ VPA (*r*=0.25, *p*=0.02) and MVPA (*r*=0.27, *p*=0.01).

VO_2peak and lean mass were added to the ANCOVA models to assess the discrepancy between self-reported and accelerometry-derived MVPA bouts between men and women. After adding lean mass as a covariate there was no longer a statistically significant difference between sex (*p*>0.05). Lean body mass was a statistically significant covariate (*p*=0.003) indicating it influenced the discrepancy between self-reported and objectively measured PA. VO_2peak was not a significant covariate when added to the model (*p*>0.05), and sex differences remained significant with VO_2 peak in the model.

DISCUSSION

The major findings of this study were that a large amount of bias existed between sedentary time and PA levels when assessed by self-report and accelerometer methods in college students, with sex and lean body mass influencing self-reported PA. Notably, agreement between the two methods was borderline acceptable in this sample of college students, with Bland-Altman plots providing evidence of both fixed and proportional bias. On average, students significantly over-reported MVPA by 25.6 minutes per day, under-reported sedentary time by approximately 134 minutes per day and approximately 25% of students were misclassified as meeting PA guidelines via self-report when compared to an objective measure. However, our findings that a higher level of self-reported MVPA was related to a higher level of objectively measured MVPA and fitness level, and that self-reported MPA and VPA were distinguishable from one another indicate the IPAQ shows some desirable qualities of a PA questionnaire in a college student sample.

For all IPAQ variables, we found low-to-moderate associations (*r*=0.21 to *r*=0.38) with objective measurements. The findings from our study are consistent with the majority of studies reporting associations of similar magnitude via Pearson or Spearman correlation coefficients with a variety of different sample demographics (Boon et al., 2010; Craig et al., 2003; Dinger et al., 2006; Downs et al., 2014; Dyrstad et al., 2014; Lee et al., 2011; Wolin et al., 2008). Our data showed an association between self-reported walking and accelerometer measured steps, and that self-reported MPA and VPA were associated only with their objectively measured counterparts (i.e., self-reported MPA was not associated with objectively measured VPA) which is different than previous studies and may relate to the choice of cut-points (Dinger et al., 2006; Downs et al., 2014; Dyrstad et al., 2014). We used cut-points based off vector magnitude data, which takes into account acceleration from all three axes as well as body position, where previous studies used cut-points only corresponding with acceleration measurements from the vertical axis (Dinger et al., 2006; Downs et al., 2014; Dyrstad et al., 2014). Our findings indicate that in college students, the IPAQ questions regarding MPA and VPA may be able to discriminate between these two types of PA. Additionally, other studies have reported negligible to low associations of IPAQ calculated MVPA with objectively measured MVPA and activity counts (Dinger et al., 2006; Downs et al., 2014). Our study found these variables to have moderate associations, providing evidence that self-reported MVPA and objectively measured MVPA are distinctly related to each other. All of these associations coincide with desirable qualities of a PA questionnaire.

Our results that students over-report MVPA are similar to that of two studies comparing PA between the IPAQ and accelerometry in college students, which indicated students over-reported MVPA via the IPAQ by 46.2 and 66.9 minutes per day, respectively (Dinger et al., 2006; Downs et al., 2014). The Bland-Altman analysis in the present study showed acceptable agreement between the two methods, with approximately 95% of data points falling between the limits of agreement except for VPA. The 95% limits of agreement were constructed according to Bland and Altman's recommendation that 95% of the data points should fall within ±2 standard deviations of the mean difference (Altman & Bland, 1986). This recommendation quantifies bias and a range of agreement across two measures analytically, yet does not necessarily provide practical or clinical information on whether the agreement interval is too wide or narrow to be considered useful (Giavarina, 2015). Bland-Altman analyses are most practical when limits of maximal expected differences are based upon criteria set forth by the researchers and experts to quantify how much bias between methods is acceptable for drawing conclusions (Giavarina, 2015). The present study and most studies that use the Bland-Altman analysis to compare self-report PA to objectively measured PA report extremely wide limits of agreement (Boon et al., 2010; Dyrstad et al., 2014; Ottavaere et al., 2011; Tomaz et al., 2016; Wolin et al., 2006). Additionally, many studies use varying units when evaluating the agreement between methods of self-report and objectively measured PA (Boon et al., 2010; Dyrstad et al., 2014; Ottevaere et al., 2011; Tomaz et al., 2016; Wolin et al., 2008), which can make comparisons between studies difficult and overall inferences misleading. For example, the calculated limits of agreement in the present study resulted in a discrepancy of at least 50 minutes per day between the two methods. This discrepancy is so large that it is not a surprise that many individuals are misclassified as meeting the PA guidelines when using self-report. It should be an important priority for PA researchers to agree upon an acceptable range of bias between techniques that assess PA to establish standards and consistency among studies.

The Bland-Altman analysis also revealed proportional bias between the two methods for both VPA and MVPA. As the mean of the methods increased, so did the difference between self-reported PA and objectively measured PA (Figs. 3 and 4). Therefore, the discrepancy between the methods was larger for more physically active individuals, which could indicate people with higher activity levels are either more susceptible to over-reporting their activity or the accelerometer is not as valid for evaluating PA levels of highly active individuals (Dyrstad et al., 2014; Tomaz et al., 2016).

The studies comparing the IPAQ questionnaire to an objective measure of PA in college students have not reported data on sedentary time (Dinger et al., 2006; Downs et al., 2014). Our study revealed students under-reported their sedentary time by approximately 134 minutes per day via the IPAQ compared to an objective measure. Similarly, Dyrstad et al. (2014) reported sedentary time was under-reported by 131 minutes per day in a large sample of Norwegian adults aged 20–82 years. Chastin, Culhane, and Dall (2014) compared a direct measure of sitting time (inclinometer) to the IPAQ sitting questions and found individuals under-reported sitting time anywhere from 2.2 to 4.6 hours per day along with low correlations and poor agreement between the two methods. These findings are concerning and indicate using one question for assessing sedentary time may not be accurate.

We found a large proportion of our sample (24%) was misclassified as meeting PA guidelines via the IPAQ compared to an objective measure. Downs et al. (2014) also reported the IPAQ classified approximately 33% more first-year college students as meeting the PA guidelines compared to an accelerometer. Epidemiological studies involving college students, such as the data collected via the National Center for Education Statistics, typically rely on self-report estimates to quantify activity levels, which may be misleading because objective estimates appear to be considerably different (American College Health Association, 2016). Interestingly, there was less discrepancy between the IPAQ and accelerometer methods when comparing the estimates using total minutes of MVPA accumulated rather than MVPA occurring in bouts of 10 minutes or more. The two methods differed by 17 minutes per day in the present study, with students under-reporting total MVPA. One study also found a similar discrepancy between the methods, 8.7 minutes per day on average, when comparing total accelerometer derived MVPA to MVPA calculated via the IPAQ in college students (Dinger et al., 2006). Although the IPAQ only asks about PA performed in bouts of 10 minutes or more, it appears that the extent to which students report their MVPA corresponds better with objectively measured total MVPA accumulated on a typical day. In fact, when inspecting all data captured by the accelerometer in the present study, MVPA equated to an average of 71.8 minutes per day, similar to Dinger et al. (2006), who reported an average of 73.5 minutes per day of total MVPA in college students.

Although there was no difference in the amount of time spent in bouts of MVPA between men and women, both over-reported MVPA on the IPAQ. Men over-reported their MVPA by almost twice the amount captured by the accelerometer. This was influenced by a very high amount of self-reported VPA by the men. Similarly, Dinger et al. (2006) found college-aged men reported significantly more VPA with the IPAQ compared to college-aged women, although accelerometer measured VPA was not different between men and women. Larger studies have also reported this discrepancy in men of varying ages (Dyrstad et al., 2014; Hagstromer et al., 2010; Wolin et al., 2008). The majority of men in the present study had a high VO_2 peak and low body fat percentage, which may have contributed to this discrepancy. Had we recruited a greater amount of individuals with lower VO_2 peak and higher body composition, we may have had different results. Our results indicated VO_2 peak and lean body mass were associated with self-reported PA. When including lean body mass as a covariate, the difference between men and women for self-report and objectively measured PA was no longer significant. This result indicates body composition may influence how young individuals self-report activity levels. A recent study found that individuals who fell above the 50th percentile for cardiorespiratory fitness for their age and sex tended to over-report VPA with the global physical activity questionnaire (GPAQ) to a larger extent compared to individuals below the 50th percentile (Tomaz et al., 2016). This corresponded with a weaker level of agreement for VPA between the GPAQ and accelerometry in individuals with higher levels of fitness, which the authors suggest could be due to difficulty distinguishing MPA from VPA (Tomaz et al., 2016). Although our study showed VO_2 peak was related to self-reported VPA, MVPA, and inversely related to sitting time it did not appear to be an important covariate as there were still significant differences between men and women even when VO_2 peak was included in the model. These results demonstrate that higher self-reported PA is related to cardiorespiratory fitness, not necessarily more bias in self-report, another property desirable of a PA questionnaire. In contrast, Downs et al. (2014) found neither body composition nor estimated VO_2max to be associated with IPAQ MVPA in first-year college students. Downs et al. (2014) utilized the YMCA submaximal cycle ergometer test to estimate VO_2 max, which may have contributed to the lack of association between self-reported MVPA and VO_2 max. The role of body composition variables and other physical qualities for influencing self-report PA warrants further investigation.

Limitations

The present study was not without limitations. To truly examine the properties of the IPAQ in college students, a larger sample size is necessary. The undergraduate students who participated in our study were recruited as a convenience sample, with almost half of the students reporting their major field of study as health-related. Thus, limiting the generalizability of the results. The average student in our sample also had an above average cardiorespiratory fitness level, met PA guidelines, and fell within the normal range for BMI, which may not be representative of the entire college student population. This also limits our ability to draw conclusions on whether body composition or fitness influence how students perceive and self-report levels of PA.

Although we used an objective measurement of sedentary time to compare with self-reported sitting time on the IPAQ, these may not be comparable because questionnaires and accelerometers are distinct methods. Accelerometers classify all minutes below the specified count threshold as sedentary behaviors and the IPAQ only asks about behaviors performed in a sitting or lying position. The IPAQ also asks for an individual to report sitting activities performed on a typical weekday, which does not account for weekend sedentary activities where the accelerometer data was collected over 7 days including both week and weekend days.

While we utilized updated cut-points based off regression equations developed from a sample of young adults, which accounted for acceleration measurements of three axes, previous research has reported that there are limitations with this approach (Sasaki et al., 2011). Machine learning methods for analyzing accelerometer data have been shown to be an effective approach for distinguishing between different PA intensities; however, they are complex. The use of cut-points, although not ideal, is an easy way to quantify PA behavior that has been demonstrated to be effective and widely used by researchers. The classification of PA intensity with accelerometer data is dependent on the cut-points used, indicating it is important to utilize cut-points derived specifically from the population being studied (Strath, Bassett Jr., & Swartz, 2003; Wanner et al., 2016). To our knowledge, the cut-points developed by Sasaki et al. (2011) are the only validated cut-points that include data from the vector magnitude of all three axes of measurement. Vector magnitude data, in theory, accounts for more information within each data point when compared to single axis data (Howe, Staudenmayer, & Freedson, 2009). The use of vector magnitude also takes into account body position, whereas the vertical axis does not. While additional research is necessary to more accurately define thresholds for each PA intensity, there are data to support that the use of vector magnitude improves validity in the classification of sedentary behavior and other PA intensities (Evenson et al., 2015; Peterson et al., 2015; Pfister et al., 2017; Santos-Losano et al., 2013). Similarly, some research indicates utilizing vector magnitude may be helpful for decreasing measurement error (Evenson et al., 2015). Although these cut-points were ultimately based on a small sample size and four treadmill speeds, other widely used cut-points were developed in a similar manner (Freedson, Melanson, & Sirard, 1998). While this is a limitation, previous research has demonstrated that adding specific lifestyle activities to a prediction model does not significantly improve accuracy of the prediction (Crouter, Churilla, & Bassett, 2006).

Conclusions

The present study shows a large discrepancy exists between self-report PA as estimated via the IPAQ and PA objectively measured with an accelerometer in a sample of undergraduate students. This resulted in a large percentage of undergraduate students being misclassified as meeting PA guidelines by the IPAQ when compared to an accelerometer. In general, agreement between the methods was borderline acceptable and mostly weak associations existed between self-report and objectively measured PA variables. However, the IPAQ questions provided evidence for having the ability to discriminate between capturing MPA and VPA. Additionally, self-reported estimates of MVPA were more accurate when comparing the total amount of MVPA accumulated throughout the day rather than MVPA accumulated in 10 minute bouts obtained by the accelerometer. Men tended to over-report PA to a greater extent than women, and lean body mass appeared to influence this difference. It is suggested that PA researchers devise standards for acceptable ranges of bias between methods for assessing PA so self-report questionnaires have greater practical utility.

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REFERENCES

1. Aadland E & Ylvisåker E (2015), Reliability of the ActiGraph GT3X+ accelerometer in adults under free living conditions. PLoS One, 10, e0134606. doi: 10.1371/journal.pone.0134606. [PubMed: 26274586]
2. Altman DG, & Bland JM (1986). Statistical methods for assessing agreement between two methods of clinical measurement. Lancet, 8476, 307–10. doi: 10.1016/S0140-6736(86)90837-8
3. American College Health Association. (2016). American College Health Association-National College Health Assessment II: Reference group executive summary spring 2016 executive summary [internet]. Retrieved from: http://www.acha-ncha.org/docs/ncha-ii%20spring%202016%20us%20reference%20group%20executive%20summary.pdf.
4. Boon RM, Hamlin MJ, Steel GD, & Ross JJ (2010). Validation of the New Zealand Physical Activity Questionnaire (NZPAQ-LF) and the International Physical Activity Questionnaire (IPAQ-LF) with accelerometry. British Journal of Sports Medicine, 44, 741–746. doi: 10.1136/bjsm.2008.052167. [PubMed: 18981036]

5. Bray SR, & Born HA (2004). Transition to university and vigorous physical activity: implications for health and psychological well-being. Journal of American College Health, 52(4), 181–188. doi: 10.3200/JACH.52.4.181-188. [PubMed: 15018429]
6. Calfas KJ, Sallis JF, Nichols JF, Sarkin JA, Johnson MF, Caparosa S, Thompson S, … Alcaraz JE (2000). Project GRAD: two-year outcomes of a randomized controlled physical activity intervention among young adults. American Journal of Preventative Medicine, 18(1), 28–37. doi: 10.1016/S0749-3797(99)00117-8.
7. Chastin SF, Culhane B, & Dall PM (2014). Comparison of self-reported measure of sitting time (IPAQ) with objective measurement (activPAL). Physiological Measurement, 35(11), 2319–2328. doi: 10.1088/0967-3334/35/11/2319. [PubMed: 25341050]
8. Choi L, Zhouwen L, Matthews CE, & Buchowski MS (2011). Validation of accelerometer wear and non wear time classification algorithm. Medicine & Science in Sports & Exercise, 43(2), 357–364. doi: 10.1249/MSS.0b013e3181ed61a3. [PubMed: 20581716]
9. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, … Oja P (2003). International Physical Activity Questionnaire: 12-country reliability and validity. Medicine & Science in Sports & Exercise, 35(8), 1381–1395. doi: 10.1249/01.MSS.0000078924.61453.FB. [PubMed: 12900694]
10. Crouter SE, Churilla JR, & Bassett DR Jr. (2008). Estimating energy expenditure using accelerometers. European Journal of Applied Physiology, 98, 601–612. doi: 10.1007/s00421-006-0307-5.
11. Deforche B, Van Dyck D, Deliens T, & De Bourdeaudhuij I (2015). Changes in weight, physical activity, sedentary behaviour and dietary intake during the transition to higher education: a prospective study. International Journal of Behavioral Nutrition & Physical Activity, 12(1), 16. doi: 10.1186/s12966-015-0173-9. [PubMed: 25881147]
12. Dinger MK, Behrens TK, & Han JL (2006). Validity and reliability of the International Physical Activity Questionnaire in college students. American Journal of Health Education, 37(6), 337–343. doi: 10.1080/19325037.2006.10598924.
13. Downs A, Van Hoomissen J, Lanfrenz A, & Julka DL (2014). Accelerometer-measured versus self-reported physical activity in college students: implications for research and practice. Journal of American College Health, 62(3), 204–212. doi: 10.1080/07448481.2013.877018. [PubMed: 24377672]
14. Dyrstad SM, Hansen BH, Holme IM, & Anderssen SA (2014). Comparison of self-reported versus accelerometer-measured physical activity. Medicine & Science in Sports & Exercise, 46(1), 99–106. doi: 10.1249/MSS.0b013e3182a0595f. [PubMed: 23793232]
15. Freedson PS, Melanson E, & Sirard J (1998). Calibration of the Computer Science Applications, Inc. accelerometer. Medicine & Science in Sports & Exercise, 30(5), 777–781. [PubMed: 9588623]
16. Giavarina D Understanding Bland Altman analysis. Biochemical Medicine (Zagreb), 25(2), 141–51. doi: 10.11613/BM.2015.015.
17. Guo W, Key TJ, & Reeves GK (2019). Accelerometer compared with questionnaire measures of physical activity in relation to body size and composition: a large cross-sectional analysis of UK Biobank. BMJ Open, 9(1), e024206. doi: 10.1136/bmjopen-2018-024206.
18. Hagstromer M, Ainsworth BE, Oja P, & Sjostrom M (2010). Comparison of a subjective and an objective measure of physical activity in a population sample. Journal of Physical Activity & Health, 7(4), 541–550. [PubMed: 20683097]
19. Hallal PC, Anderson LB, Bull FC, Guthold R, Haskell W, & Ekelund U (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet, 380(9838), 247–257. doi: 10.1016/S0140-6736(12)60646-1. [PubMed: 22818937]
20. Howe CA, Staudenmayer JW, & Freedson PS (2009). Accelerometer prediction of energy expenditure: vector magnitude versus vertical axis. Medicine & Science in Sports & Exercise, 41, 2199–2206. doi: 10.1249/MSS.0b013e3181aa3a0e. [PubMed: 19915498]
21. IPAQ Group (2005). Guidelines for data processing and analysis of the International Physical Activity Questionnaire. http://www.ipaq.ki.se.

22. Kaminsky LA, Arena R, & Myers J (2015). Reference standards for cardiorespiratory fitness measured with cardiopulmonary exercise testing: data from the Fitness Registry and the Importance of Exercise National Database. Mayo Clinic Proceedings, 90(11), 1515–1523. doi: 10.1016/j.mayocp.2015.07.026. [PubMed: 26455884]
23. Kozey-Keadle S, Libertine A, Lyden K, Staudenmayer J, & Freedson PS (2011). Validation of wearable monitors for assessing sedentary behavior. Medicine & Science in Sports & Exercise, 43(8), 1561–1567. doi: 10.1249/MSS.0b013e31820ce174. [PubMed: 21233777]
24. Kwan MY, Cairney J, Faulkner GE, & Pullenayegum EE (2012). Physical activity and other health-risk behaviors during the transition into early adulthood. American Journal of Preventative Medicine, 42(1), 14–20. doi: 10.1016/j.amepre.2011.08.026.
25. Lee PH, Macfarlane DJ, Lam TH, & Stewart SM (2011). Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. International Journal of Behavioral Nutrition & Physical Activity, 8(1):115. doi: 10.1186/1479-5868-8-115. [PubMed: 22018588]
26. Motl RW, McAuley E, & DiStefano C (2005). Is social desirability associated with self-reported physical activity? Preventative Medicine, 40, 735–739. doi: 10.1016/j.ypmed.2004.09.016.
27. Murphy JJ, Murphy MH, MacDonncha C, Murphy N, Nevill AM, & Woods CB (2017). Validity and reliability of three self-report instruments for assessing attainment of physical activity guidelines in university students. Measurement in Physical Education & Exercise Science, 21(3), 134–141. doi: 10.1080/1091367X.2017.1297711.
28. Ottevaere C, Huybrechts I, De Bourdeaudhuij I, Sjostrom M, Ruiz JR, Ortega FB, Hagstromer M, … De Henauw S (2011). Comparison of the IPAQ-A and Actigraph in relation to VO_2max among European adolescents: the HELENA study. Journal of Science & Medicine in Sport, 14(4), 317–324. doi: 10.1016/j.jsams.2011.02.008. [PubMed: 21444243]
29. Peterson NE, Sirard JR, Kulbox PA, DeBoer MD, & Erickson JM (2015). Validation of accelerometer thresholds and inclinometry for measurement of sedentary behavior in young adult university students. Research in Nursing & Health, 38, 492–499. doi: 10.1002/nur.21694. [PubMed: 26444969]
30. Pfister T, Matthews CE, Wang Q, Kopciuk KA, Courneya K, & Friedenreich C (2017). Comparison of two accelerometers for measuring physical activity and sedentary behavior. BMJ Open Sport & Exercise Medicine, 3, e000227. doi: 10.1136/bmjsem-2017-000227.
31. Physical activity and cardiovascular health. (1996). NIH consensus development panel on physical activity and cardiovascular health. Journal of the American Medical Association, 276(3), 241–246. doi: 10.1001/jama.1996.03540030075036. [PubMed: 8667571]
32. Robergs RA, Dwyer D, & Astorino T (2010). Recommendations for improved data processing from expired gas analysis indirect calorimetry. Sports Medicine, 40(2), 95–111. doi: 10.2165/11319670-000000000-00000. [PubMed: 20092364]
33. Santos-Lozano A, Santin-Medeiros F, Cardon G, Torres-Luque R, Bailon R, Bergmeir C, Ruiz JR, …, Garatachea N (2013). Actigraph GT3X: Validation and determination of physical activity intensity cut points. International Journal of Sports Medicine, 34(11), 975–982. doi: 10.1055/s-0033-1337945. [PubMed: 23700330]
34. Sasaki JE, John D, & Freedson PS (2011). Validation and comparison of ActiGraph activity monitors. Journal of Science & Medicine in Sport, 14(5), 411–416. doi: 10.1016/j.jsams.2011.04.003. [PubMed: 21616714]
35. Sirard JR, Forsyth A, Oakes JM, & Schmitz KH (2011). Accelerometer test-retest reliability by data-processing algorithms: results from the twin cities walking study. Journal of Physical Activity & Health, 8(5), 668–674. [PubMed: 21734312]
36. Small M, Bailey-Davis L, Morgan N, & Maggs J (2013). Changes in eating and physical activity behaviors across seven semesters of college: living on or off campus matters. Health Education & Behavior, 40(4), 435–441. doi: 10.1177/1090198112467801. [PubMed: 23232092]
37. Strath SJ, Bassett DR Jr., Swartz AM (2003). Comparison of MTI accelerometer cut-points for predicting time spent in physical activity. International Journal of Sports Medicine, 24, 298–303. doi: 10.1055/s-2003-39504. [PubMed: 12784173]

38. Tomaz SA, Lambert EV, Karpul D, & Kolbe-Alexander TL (2016). Cardiovascular fitness is associated with bias between self-reported and objectively measured physical activity. European Journal of Sport Science, 16(1), 149–157. doi: 10.1080/17461391.2014.987323. [PubMed: 25537282]

39. U.S. Department of Health and Human Services. (2008). 2008 Physical Activity Guidelines for Americans [internet]. Retrieved from: http://health.gov/paguidelines/pdf/paguide.pdf.

40. U.S. Department of Health and Human Services. (2014). Healthy People 2020: National health promotion and disease prevention objectives [internet]. Retrieved from: https://www.healthypeople.gov/2020/topics-objectives/topic/physical-activity.

41. Wanner M, Probst-Hensch N, Kriemler S, Meier F, Autenrieth C, & Martin BW (2016). Validity of the long international physical activity questionnaire: influence of age and language region. Preventative Medicine Reports, 3, 250–256. doi: 10.1016/j.pmedr.2016.03.003.

42. Wolin KY, Heil D, & Askew S (2008). Validation of the International Physical Activity Questionnaire-Short Form among blacks. Journal of Physical Activity & Health, 5(5), 746–60. [PubMed: 18820348]

ID Date						DAY 1						Wake Time: AM/PM Sleep time: AM/PM	
		Code						Code				Accelerometer Removal	
	Time	:00	:15	:30	:45		Time	:00	:15	:30	:45	Time	Activity
AM	12 midnt					PM	12 noon					On:	
	1:00						1:00					Off:	
	2:00						2:00					On:	
	3:00						3:00					Off:	
	4:00						4:00					On:	
	5:00						5:00					Off:	
	6:00						6:00					On:	
	7:00						7:00					Off:	
	8:00						8:00					On:	
	9:00						9:00					Off:	
	10:00						10:00					On:	
	11:00						11:00					Off:	
Comments:							*Other activities not listed:*						
Structured Exercise (type, duration, time of day):													

FIGURE 1.

Example of the accelerometer log book. Participants filled in activities for each 15 minute block for each day with the use of letters or numbers that corresponded with specific activities.

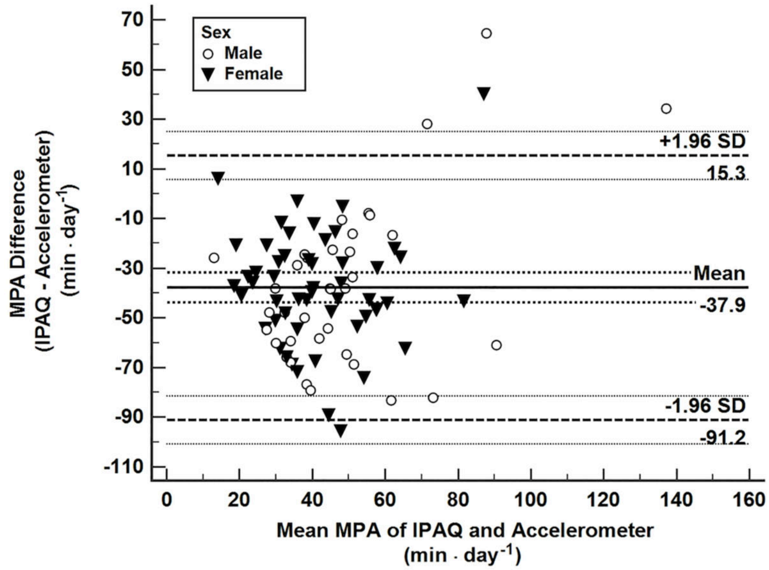

FIGURE 2.

Bland-Altman plot for minutes per day of MPA assessed by the IPAQ and accelerometer defined as 2690–6166 cpm (n=91). The mean difference, limits of agreement (dashed), and 95% confidence intervals for the mean and limits of agreement (dotted) are plotted.

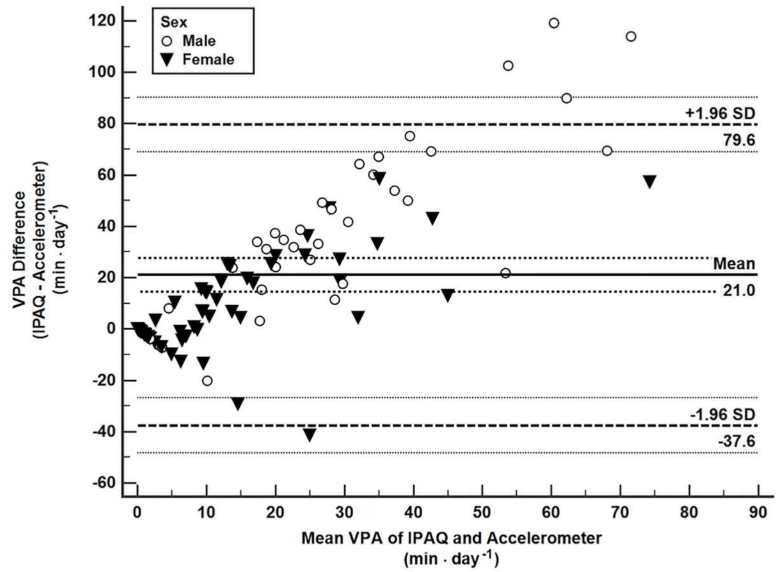

FIGURE 3.

Bland-Altman plot for minutes per day of VPA assessed by the IPAQ and accelerometer defined as >6166 cpm (n=91). The mean difference, limits of agreement (dashed), and 95% confidence intervals for the mean and limits of agreement (dotted) are plotted.

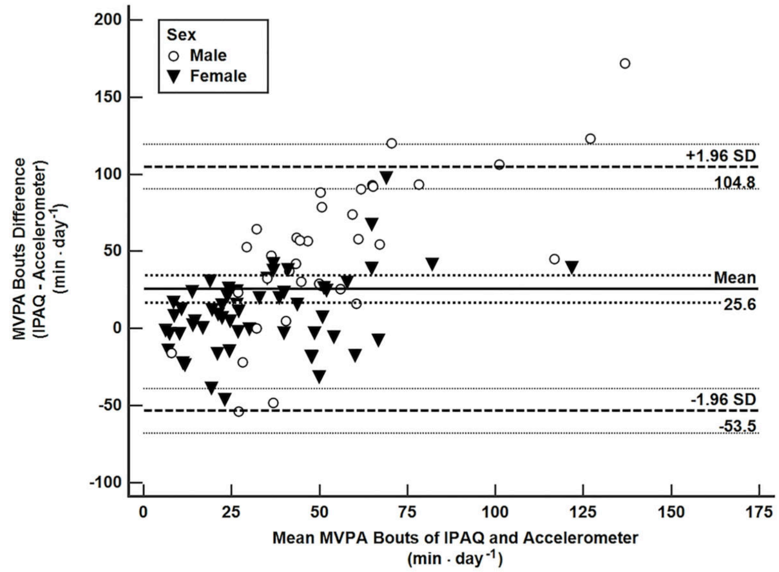

FIGURE 4.

Bland-Altman plot for minutes per day of MVPA in bouts of at least 10 minutes assessed by the IPAQ and accelerometer defined as >6166 cpm (n=91). The mean difference, limits of agreement (dashed), and 95% confidence intervals for the mean and limits of agreement (dotted) are plotted.

TABLE 1.

Characteristics of participants (n = 91).

Variable	Men	Women	All
Sex, *n* (%)	36 (39.6)	55 (60.4)	91 (100)
Age, yr	20.6 ± 1.6	20.3 ± 1.2	20.4 ± 1.3
Ethnicity, *n* (%)			
Non-Hispanic white	29 (31.9)	45 (49.5)	74 (81.3)
Hispanic	3 (3.3)	6 (6.6)	9 (9.9)
African American	2 (2.2)	0 (0)	2 (2.2)
Asian	2 (2.2)	4 (4.4)	6 (6.6)
Class Standing, *n* (%)			
Freshman	11 (12.1)	12 (13.2)	23 (25.3)
Sophomore	5 (5.5)	14 (15.4)	19 (20.9)
Junior	10 (11)	12 (13.2)	22 (24.2)
Senior	10 (11)	17 (18.7)	28 (29.7)
Weight, kg	77.8 ± 10.5	65.5 ± 9.9	70.4 ± 11.8
Height, cm	177.7 ± 7.7	167.4 ± 7.0	171.5 ± 8.8
BMI, $kg \cdot m^{-2}$	24.6 ± 2.7	23.4 ± 3.0	23.9 ± 2.9
Body Fat (%)	13.8 ± 5.3	27.1 ± 6.3	21.8 ± 8.8
$\dot{V}O_2$peak, $ml \cdot kg^{-1} \cdot min^{-1}$	53.1 ± 5.8	42.8 ± 5.1	46.9 ± 7.4
Smoker, *n* (%)	11 (12.1)	11 (12.1)	22 (24.2)
Living on Campus, *n* (%)	16 (17.6)	24 (26.4)	40 (44)

BMI, body mass index; VO_2peak, peak oxygen consumption; Data are presented as mean ± SD or *n* (%).

TABLE 2.

Descriptive physical activity data from objective and self-reported measures. Data are presented as mean ± SD (*n* = 91).

Variable	Men (n = 36)	Women (n = 55)	All (n = 91)
Objective PA measurements[a]			
Wear time ($hr \cdot d^{-1}$)	15.4 ± 1.5	15.7 ± 0.9	15.6 ± 1.2
Steps (per day)	9591.2 ± 2453.1	9745.5 ± 2586.2	9684.5 ± 2521.7
Sedentary ($min \cdot d^{-1}$)	488.5 ± 92.4	522.0 ± 80.3	508.7 ± 86.4
Light intensity ($min \cdot d^{-1}$)	361.4 ± 62.1	350.0 ± 72.8	354.5 ± 68.6
Moderate intensity ($min \cdot d^{-1}$)	67.5 ± 20.2	59.8 ± 18.9	62.9 ± 19.7
Vigorous intensity ($min \cdot d^{-1}$)	9.1 ± 9.5	8.9 ± 10.8	9.0 ± 10.2
Total MVPA ($min \cdot d^{-1}$)	76.6 ± 22.3	68.7 ± 25.2	71.8 ± 24.3
MVPA 10+ min bouts ($min \cdot d^{-1}$)	29.6 ± 19.8	29.0 ± 20.7	29.2 ± 22.1
Self-reported variables[b]			
Sitting ($min \cdot d^{-1}$)	368.5 ± 116.7	378.7 ± 164.7	374.7 ± 146.9
Walking ($min \cdot d^{-1}$)[c]	82.8 ± 91.0	92.9 ± 105.1	88.8 ± 99.2
Moderate ($min \cdot d^{-1}$)	30.0 ± 33.5	21.6 ± 19.7	24.9 ± 26.2
Vigorous ($min \cdot d^{-1}$)	48.8 ± 34.3	17.6 ± 21.7[*]	29.9 ± 31.2
MVPA ($min \cdot d^{-1}$)	78.8 ± 48.4	39.2 ± 29.8[*]	54.8 ± 42.7

MVPA, moderate to vigorous physical activity

[a]Assessed by ActiGraph GT3X+ accelerometer, analyzed in 60 s epochs

[b]Self-reported PA from the IPAQ-SF

[c]For IPAQ walking, n = 89

[*]Statistically significant difference compared to men, $p < 0.001$

TABLE 3.

Partial correlation coefficients between objective and self-repored measures of physical activity (n = 91).

Objective Variables	Sitting (min·d^{-1})	Walking^{ab} (min·d^{-1})	Moderate^{ab} (min·d^{-1})	Vigorous^{a} (min·d^{-1})	MVPA^{a} (min·d^{-1})
Sedentary (min·d^{-1})	0.26 *	−0.31 **	−0.18	−0.05	−0.20
Light (min·d^{-1})	−0.24 *	0.28 **	0.10	−0.05	0.08
Moderate (min·d^{-1})	−0.05	0.19	0.27 *	0.18	0.32 **
Vigorous (min·d^{-1})^{b}	−0.13	0.04	−0.07	0.31 **	0.25 *
Steps (steps·d^{-1})	−0.17	0.26 *	0.24 *	0.27 *	0.32 **
Total MVPA (min·d^{-1})	−0.10	0.14	0.24 *	0.28 **	0.37 ***
MVPA bouts (min·d^{-1})	−0.09	−0.02	0.21	0.22 *	0.28 **
Total vector magnitude	−0.20	0.26 *	0.28 **	0.26 *	0.38 ***
Total activity (cpm)	−0.21	0.27 *	0.28 *	0.27 *	0.38 ***

MVPA, moderate to vigorous physical activity; cpm, counts per minute

[a] Square root transformed variable

[b] For IPAQ walking correlations, n = 89

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Partial correlations control for sex, age, and accelerometer wear time.