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Sedentary behavior and physical activity of young adult university students

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Abstract

Movement and non-movement behaviors include sleep, sedentary behavior (SB) and physical activity (PA). While young adults are generally perceived as healthy, the level and relationship of SB and PA in college-age students has not been greatly explored. The purpose of this study was to objectively measure the levels of SB and PA in 18–20 year-old university students, record their self-reported extracurricular activities, and explore the relationship of all these with body mass index (BMI) and waist circumference (WC). Male ($n = 48$) and female ($n = 46$) students participated in this cross-sectional study. Hierarchical multiple regression analyses were used to examine time spent in SB, moderate to vigorous physical activity (MVPA), number of self-reported sedentary extracurricular activities, and their relation to the dependent variables of BMI and WC. In correlation analyses, SB ($p < .001$) and MVPA ($p = .017$) both were negatively associated with BMI, and “other” race or ethnicity (African American, Hispanic, mixed; $p = .013$) and number of self-reported sedentary extracurricular activities ($p = .006$) were positively associated with BMI. In the WC regression model, SB ($p = .018$) was negatively associated and number of self-reported sedentary extracurricular activities ($p = .006$) was positively associated with WC. University students may be both highly active and highly sedentary. Future researchers should consider targeting interventions to reduce SB in addition to improving PA.

Keywords

college or university; physical activity; sedentary behavior; young adults

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CONFLICT OF INTEREST
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1 | INTRODUCTION

In research on daily activity, behaviors can be categorized in three areas: sleep, sedentary behavior (SB), and physical activity (PA) (see Figure 1). While there is abundant research on PA and sleep, the third area, SB, is a relatively new, yet rapidly expanding, area of health research with its own role in health. Each day it is possible to accumulate the recommended minimum amount of moderate-to-vigorous PA (MVPA) through daily exercise routines, yet still be highly sedentary, such as during long hours of school or work. According to the Sedentary Behavior Research Network (Tremblay et al., 2017), SB is defined as any non-sleep behavior that uses minimal energy expenditure (≤1.5 metabolic equivalents [METs]) and is done in a seated, reclined, or lying posture, a definition that is supported in other literature (Jago, Fox, Page, Brockman, & Thompson, 2010; Olds, Maher, Ridley, & Kittel, 2010; Spittaels et al., 2012).

SB is increasing across the globe. For example, Chinese youth have recently more than doubled the amount of time spent in SB (Zhang, Seo, Kolbe, Middlestadt, & Zhao, 2012). The cost of SB is substantial. The worldwide cost of health care due to effects of SB was estimated at $150 billion in 2013 (Ding et al., 2016). SB also has costs of early morbidity and death (AHA, 2011) and decreased health-related quality of life (Guallar-Castillón et al., 2014). National and international organizations such as the American Academy of Pediatrics (2001), American Heart Association (2011), Centers for Disease Control and Prevention (2013), Institute of Medicine (2011), and World Health Organization (2010) recognize the deleterious effects of SB across the lifespan. In a number of studies in diverse populations, including young adults, researchers have identified the independent relationship of SB to acute and chronic problems, such as cardiovascular disease, metabolic syndrome, colorectal cancer, and early mortality (Ekelund et al., 2016; Gibbs, Hergenroeder, Katzmarzyk, Lee, & Jakicic, 2015; Owen, Healy, Matthews, & Dunstan, 2010). The global rise in SB among youth and young adults is associated with increases in acute and chronic morbidities. Some have even speculated that the current generation may have a shorter life expectancy than their parents (AHA, 2011; Fontaine, Redden, Wang, Westfall, & Allison, 2003) and that reducing SB could increase life expectancy in the US by 2 years (Katzmarzyk & Lee, 2012).

Despite these associations, little is known about SB patterns in university students. This age group has the largest increase in SB and the greatest decrease in MVPA over the last few decades, compared to all other age cohorts (Nelson, Story, Larson, Neumark-Sztainer, & Lytle, 2008). The purpose of this study was to objectively measure the levels of SB and PA in 18–20-year-old university students and to pilot an open-ended self-report measure of the number and type of self-reported extracurricular activities. These variables were analyzed to examine their relationship to body mass index (BMI) and waist circumference (WC).

2 | METHODS

2.1 | Participants

After obtaining institutional review board approval, recruitment was advertised using university emails, fliers, electronic newsletters, and word of mouth. Eligible participants for the study were English-speaking male and female university students, ages 18–20 years.

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Age range was chosen to reflect the unique developmental stage of “emerging adulthood” (Nelson et al., 2008), while reducing the likelihood of alcohol consumption in those aged 21 years and older as a confounder of caloric intake.

During recruitment, a screening process was done to verify eligibility. Participants could not have any injury or condition such that the ability to walk was compromised and were excluded if they answered “yes“ to any of the questions from the standardized Physical Activity Readiness Questionnaire, which screened out participants with cardiovascular, neurological, orthopedic, or other conditions that are potentially worsened by exercise (Thomas, Reading, & Shephard, 1992).

2.2 | Power analysis

Three sources helped guide estimation of the appropriate sample size for the study: 1) previous similar research; 2) general statistical principles; and 3) the nQuery (Statistical Solutions, Ltd., Los Angeles, CA) power analysis program. Sample sizes in similar research ranged from 77 (Downs, Van Hoomissen, Lafrenz, & Julka, 2013) to 168 (Raynor & Jankowiak, 2010). General consensus on principles of statistics suggest multiple regression analyses should have 10–15 participants per independent variable (Harrell, 2001). The program nQuery estimated a minimum of 59–65 subjects was needed to achieve 80% power with an effect size of .25 for multiple regression. In total, 101 participants were recruited for the study.

2.3 | MEASURES

2.3.1 Demographics and extracurricular activities.—The demographic questionnaire contained five questions, on gender, age, number of semesters in school, ethnicity, and extracurricular activities. This last question was phrased, “What are your extracurricular activities? (ex: running, weight-lifting, video gaming, reading, etc.)”

2.3.2 Accelerometry and GT3X+ validity.—Accelerometers have been used to objectively measure activity since the 1990s. Accelerometers quantify body movement and direction from electric signals and store this information using a unitless measurement called “counts.” Several times each second, an accelerometer measures the magnitude of counts in the x-, y-, and z-axes of the body’s position in space. The counts are aggregated in the post-collection phase, such as into 1-min intervals.

Well-established standardized cutoffs determine the level of intensity of body movement. For example, body movement of less than 150 counts per minute is sedentary, whereas 6,000 counts or more per minute is vigorous physical activity (Peterson, Sirard, Kulbok, DeBoer, & Erickson, 2015; Troiano et al., 2008). For this study, a low-frequency extension setting was used to ensure that the accelerometer would capture even the slightest sedentary-level movements without inadvertently classifying that time as the device being off.

The GT3X+ accelerometer used in this study is a small device weighing 19 g (ActiGraph, 2015) and has been successfully used in studies with university students (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006). Participant completion and usable data for this device exceeds 90% in most studies of youth (Blair et al., 2007; Carr & Mahar,

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2012; Hänggi, Phillips, & Rowlands, 2013; Metcalf et al., 2011; Steele, van Sluijs, Cassidy, Griffin, & Ekelund, 2009). Support for the validity of the ActiGraph GT3X+ is abundant (de Vries et al., 2006; Hänggi et al., 2013; Kaminsky & Ozemek, 2012; Santos-Lozano et al., 2012; Yang & Hsu, 2010). Missing data have been noted to range from 0–3% (de Vries et al., 2006). GT3X+ accuracy ranges between 80% and 100% for SB in laboratory conditions (Carr & Mahar, 2012; Peterson et al., 2015; Sasaki, John, & Freedson, 2011) and in free-living conditions (Kaminsky & Ozemek, 2012; Santos-Lozano et al., 2012). The device construct validity is high ($r = .39$ to .90; de Vries et al., 2006) with agreement between accelerometer-derived SB and direct observation between 80% and 98% (Carr & Mahar, 2012; Hänggi et al., 2013). The ActiGraph GT3X+ has a higher validity in comparison to other accelerometer devices (de Vries et al., 2006) and is the accelerometer of choice for the U.S. National Health and Nutrition Examination Survey (NHANES).

2.4 | PROCEDURES

Participants met with the researcher in a private area of an exercise physiology research laboratory for 15 min at the beginning of the study to complete informed consent. Once consented, participants were assigned a code number. They then completed a demographic form and listed extracurricular activities following the open-ended prompt: “What are your extracurricular activities? (ex. running, weight-lifting, video gaming, reading, etc.)”.

Participants’ weight, height, and WC were taken in duplicate and averaged. Weight was assessed to the nearest 0.1 pound using a digital scale (Seca Scale Robusta 813, Birmingham, UK). Height was recorded to the nearest 0.1 cm using a stadiometer (Shorr Height Measuring Board, Olney, MD). WC was measured using a measuring tape (Lifetime Measuring Tape, Prym-Dritz Corp, Spartanburg, SC) placed directly onto the skin at the level of the iliac crest, just below the umbilicus, and recorded to the nearest 0.5 cm.

The participants were then fitted with an ActiGraph GT3X+ accelerometer placed around the waist at the right hip with an elastic band and buckle. They received instructions about wearing the device for 1 week and removing it for sleep and when the device might get wet, such as showering and swimming. During recruitment, and again when meeting with the researcher, participants were specifically asked to maintain their daily routine and to not change their PA or SB habits.

They then returned for 15 min again exactly 1 week later to return the device. Incentive for participation in the study included a $20 gift card for those with at least 10 hr of valid accelerometry data on at least 3 weekday days and at least 1 weekend day (40-hr minimum total).

2.5 | Data analysis

Responses to the extracurricular activities question were designated as either SB or PA according to the Compendium of Physical Activities and scored in METs, according to the threshold of ≤1.5 METs for SB and all else as PA (Ainsworth et al., 2011).

Accelerometry data were collected at 30 Hz (30 data points gathered per second) and then aggregated during the post-collection processing stage in 1-min intervals. Periods of >60

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min of accelerometer count values of 0 were considered time when the GT3X+ was not worn (non-wear time) or sleep (Troiano et al., 2008). After removal of these data points, days with at least 10 hr of valid accelerometer data were retained for further processing (Matthews et al., 2008).

Count values obtained from the device were categorized by intensity level by applying the thresholds used for the NHANES accelerometer data with adjustment of the sedentary level to fit recent evidence specific for the device (sedentary <150 counts/min; light, 150–2,019 counts/min; moderate, 2,020–5,998 counts/min; vigorous, >5,999 counts/min; Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011; Peterson et al., 2015; Troiano et al., 2008).

BMI was calculated from height and weight data. The International Obesity Task Force (IOTF) has identified the standard of BMI ≥25 as overweight and ≥30 as obese at age 18.0 years based on data from nationally representative samples in six countries (Cole & Lobstein, 2012). Although the Centers for Disease Control and Prevention and the World Health Organization have created BMI percentiles for age and gender up to age 19.9 years, the IOTF standard was followed to use adult classifications of BMI because all participants were at least 18 years old and to enable meaningful comparisons with the 20 year-old participants. Although BMI uses both overweight and obese cutoffs, WC commonly uses only a cutoff for obesity. Waist circumference threshold values for obesity were ≥102 cm for males and ≥88 cm for females (World Health Organization, 2008).

Data were managed and statistical analyses performed using SPSS 22.0 (IBM Corp., Chicago, IL). Descriptive statistics were used to summarize demographic and accelerometry data. When computing the hierarchical multiple regression models, all statistical assumptions were met. Race was categorized in three groups: Caucasian, Asian, and Other (African American, Hispanic, and mixed). Caucasians were the referent group in the multiple regression analyses. Asians constituted a separate group because they were present in sufficient numbers. Hierarchical multiple regression was completed using demographic variables, the number of self-reported sedentary extracurricular activities reported on the questionnaire, and objectively measured activity level as independent variables to predict BMI and WC. Statistical analyses used two-tailed testing of *p*-values with an alpha of .05.

3 | RESULTS

Of the 101 participants who consented to participate in the study, 94 (93.1%) had enough valid accelerometer data to be used for analysis. Of the seven participants who had insufficient data, four lacked at least one valid weekend day of 10 hr or more, two lacked both weekday and weekend days of valid data, and one became ill and could not complete the study.

Demographic characteristics of the 94 participants appear in Table 1. The sample of 46 females and 48 males was nearly evenly divided between 18, 19, and 20 year-old students in their first 3 years of college and were mainly in Caucasian and Asian racial categories. The

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number of students who were overweight or obese according to BMI and WC using standard adult cutoffs is shown in Table 2.

The mean accelerometer wear time per day was 14.5 (SD = 1.3) hr. As measured objectively by the ActiGraph GT3X+, average time per day spent in SB was 10.0 (SD = 1.2) hr, light PA 3.35 (SD = 0.7) hr, and MVPA 1.1 (SD = 0.5) hr. Average daily percentage of time spent in SB, light PA, and MVPA was 68.9 (SD = 5.0), 23.2 (SD = 4.4), and 7.9 (SD = 3.1) percent, respectively. Participants self-reported an average of 4.2 (SD = 1.6) extracurricular activities. Of these activities, an average of 1.7 (SD = 1.0) were sedentary and 2.5 (SD = 1.4) were active. The most common SBs were screen time behaviors (video gaming, television, computers, movies), reading, and writing. The most common active behaviors were sports, student clubs, and volunteering.

The overall hierarchical multiple regression model was statistically significant and explained 32.6% of the variance in BMI (see Table 3). In the final block of the regression model, when gender, age, race, and average daily percent of time spent in MVPA were controlled, average daily percentage of time spent in SB and number of self-reported sedentary extracurricular activities were added to the model and uniquely explained 18.8% of the variance in BMI, which was statistically significant.

When all variables were included in the model with BMI as the dependent variable, the following were individually significant: 1) race comparison of Other to Caucasian; 2) average daily percentage of time spent in MVPA; 3) average daily percentage of time spent in SB; and 4) number of self-reported sedentary extracurricular activities. Gender, age, and the race comparison of Asian to Caucasian were non-significant. When participants were Other race, BMI increased by 2.321 points. As self-reported sedentary extracurricular activities increased by 1, BMI increased by .930 points. As average daily percentage of time spent in MVPA increased by 1%, BMI decreased by .308 points. When average daily percentage of time spent in SB increased by 1%, BMI decreased by .289 points.

Using WC as the dependent variable, the overall model with all variables was statistically significant and explained 17.5% of the variance (see Table 4). In the final model controlling for gender, age, race, and average daily percentage of time spent in MVPA, the average daily percentage of time spent in SB and number of self-reported sedentary extracurricular activities uniquely explained 8.9% of the variance in WC, which was statistically significant. When all variables were included in the model for WC, average daily percentage of time spent in SB was the only individually statistically significant variable. With all other variables controlled, as average daily percentage of time spent in SB increased by 1%, WC decreased by 0.479 cm.

4 | DISCUSSION

The relationship between SB, PA, and BMI and WC is multi-faceted. This study contributes another dimension of understanding of SB in young adult university students, an under-explored population. Although there are few recent studies objectively measuring SB habits among this emerging adulthood group, the results that university students are both highly

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active and highly sedentary are in line with findings from another study (Fountaine, Liguori, Mozumdar, & Schuna, 2011).

Perhaps the most interesting finding was the lack of evidence to support a relationship between higher amounts of sedentary time and increased BMI or WC. In fact, an inverse relationship between average daily percentage of time spent in SB and both BMI and WC was the only statistically significant factor common to both regression models. These findings, however, should not be taken to mean that SB does not negatively affect the university student. Several reasons may account for this seemingly paradoxical result. This may be related to the fact that the participants also had high amounts of MVPA, which has been shown to attenuate some of the effects of SB time (Ekelund et al., 2016). In some populations, individuals who are highly active and participate in sports also have more sedentary time (Jago, Anderson, Baranowski, & Watson, 2005). Additionally, there is evidence to suggest that most individuals fall into one of only a few dominant behavior and activity level categories. For example, in one study, most participants fit into one of three groups: high SB with high PA, low SB with high PA, and moderate SB with low PA (Jago et al., 2010). In another similar study including both children and adults, more than one-third of the adolescent and adult participants were categorized with disproportionately highly SB and yet still met recommended daily PA guidelines (Spittaels et al., 2012).

These results reinforce the concept that within certain populations, individuals with high amounts of PA may also demonstrate excessive SB. The participants in this research averaged a high amount (1.1 hr) of MVPA every day. This is similar to findings by Raynor and Jankowiak (2010) though three times as much as Downs et al. (2013). Neither of these groups explored SB. In the present study, participants also averaged a high amount (10 hr) of sedentary time per day, putting them in a high PA/high SB group (Jago et al., 2010). Although Ekelund et al. (2016) found that sufficient levels of MVPA can reduce all-cause mortality associated with SB, further exploration is needed on other factors such as disease morbidity and health-related quality of life.

Clearly, many other factors play important roles in BMI and WC. Dietary intake cannot be ruled out as a factor influencing the results of this study. Evidence in young adults indicates that excessive time spent in watching television and videos is associated with poor dietary choices, while more time completing homework and reading is associated with more healthy eating behaviors (Utter, Neumark-Sztainer, Jeffery, & Story, 2003). Because this sample was from a university community with the reputation for competitive academics, perhaps these students represented those who make healthy food choices and maintain a healthy weight. Or, to the contrary, perhaps some of the students had insufficient caloric intake, resulting in lower BMI and WC. Because the focus of this research was to analyze measures of SB and PA, nutrition was not a component in this study, and therefore, the nutritional status of these participants is not known. However, given the balance between energy in (diet) and energy out (behavior and activity level), nutrition always has some role in BMI and WC.

An interesting finding in this study was the significance of the open-ended question that was piloted regarding the number self-reported extracurricular activities. The higher the number of self-reported sedentary habits, the higher was the BMI. This self-report therefore may potentially be an indicator of current or future negative health outcomes as measured by BMI and WC. Similar results have been found in other studies using diaries. For example, in one study of university students, individuals who had stronger sedentary habits reported being more sedentary via diaries compared to their peers (Conroy, Maher, Elavsky, Hyde, & Doerksen, 2013). In a study of Australian adults, self-report of television viewing was linked to undiagnosed glucose dysregulation and metabolic syndrome (Owens et al., 2010). Although cell phone usage was not directly mentioned as an extracurricular activity in this study, increased phone usage in college students has indicated a pattern of making more SB choices and was inversely related to cardiorespiratory fitness (Lepp, Barkley, Sanders, Rebold, & Gates, 2013).

Despite the fact that there are good physical objective measures of SB such as accelerometry, self-report of sedentary extracurricular activities may have a place for identifying relationships between behaviors, activity level, and BMI and WC. Because this open-ended question was a statistically significant predictor in this study, it was an important and successful first step in identifying another measure of behavior that is rapid and simple. Additional research is needed to determine whether the number and type of responses to, "What are your extracurricular activities?" are valid and reliable when considering the impact of SB and PA.

Based on results from this study, efforts that focus solely on increasing PA habits in university students might not be successful because this group already meets national PA guideline standards. Furthermore, additional research indicates that efforts to specifically reduce SB, such as targeted reduction in screen time such as television-viewing, may have a greater impact on increasing PA than targeting PA alone (Epstein et al., 2006; Robinson, 1999). In fact, interventions that only focus on reducing SB are as effective at improving BMI as combined SB, PA, and diet interventions (Liao, Liao, Durand, & Dunton, 2014).

Maintaining healthy habits, including reducing SB and improving PA, is essential, even in the otherwise fit person. For example, in one recent study, even persons who were normally physically active begin to have impaired glucose management within a matter of days of adopting a sedentary lifestyle (Mikus et al., 2012). In recognition of these findings, the US National Heart, Lung, and Blood Institute and National Institute on Aging noted that SB is distinct from PA and encouraged SB-specific interventions (Manini et al., 2015).

5 | LIMITATIONS

Although this study supports and adds to the current body of SB literature, there were some limitations. The convenience sampling and self-selection process of the participants inherently brings issues of sampling bias. Students who are sedentary might not be interested in participating in a "daily activity of college students study," as it might be perceived that their sedentary lifestyle is less desirable for research. Also, during the recruitment process, females, first-year university students, and Asians were strong referrers to friends and colleagues. Recruitment of the other groups had to be escalated to try to boost participant numbers and diversity. Because social networking and friendship groups play an important role in an individual's choice to be active or sedentary, the referrals from

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the participants themselves may have influenced the sample in the direction of those who were already highly active and highly sedentary while maintaining a lower BMI and WC (Macdonald-Wallis, Jago, & Sterne, 2012; Sawka, McCormack, Nettel-Aguirre, Hawe, & Doyle-Baker, 2013).

Also, nutrition was not measured and constitutes the “energy in” portion of the energy balance equation. Additional factors, such as work status or means of transportation to school, were not measured and could alter the overall sedentary or active profile of an individual. Finally, study participants were not asked if they were currently trying to lose weight, which may have affected their choices regarding both SB and MVPA.

6 | CONCLUSION

The results of this study highlight the uniqueness of the university student population as it pertains to PA and SB habits. Populations with high amounts of daily MVPA may also have high amounts of SB. Average daily percent of time spent in SB and MVPA, as well as number of self-reported extracurricular sedentary habits, play a role in describing the BMI and WC of young adult university students. In looking toward future research, understanding and seeking interventions for university students that target reducing SB and establishing healthy habits may afford the greatest potential benefit by providing a foundation for a lifetime of positive behaviors that maximizes physical wellness. Current trends to use personal devices, smartphones, and activity trackers to measure SB, PA, nutrition, sleep, and other lifestyle factors provide innovative opportunities for researchers and health care providers to educate clients and intervene in new ways to promote healthy lifestyles.

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REFERENCES

ActiGraph. (2015, November). GT3x+ and wGT3X+ device manual. ActiGraph, LLC. Retrieved from http://actigraphcorp.com/wp-content/uploads/2015/11/GT3X-wGT3X-Device-Manual-110315.pdf

AHA. (2011). Understanding childhood obesity: 2011 statistical sourcebook. American Heart Association. Retrieved from http://www.heart.org/idc/groups/heart-public/@wcm/@fc/documents/downloadable/ucm_428180.pdf

Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, … Leon AS (2011). 2011 compendium of physical activities: A second update of codes and MET values. Medicine and Science in Sports and Exercise, 43, 1575–1581. 10.1249/MSS.0b013e31821ece12 [PubMed: 21681120]

American Academy of Pediatrics. (2001). Children, adolescents, and television. Pediatrics, 107, 423–426. 10.1542/peds.107.2.423 [PubMed: 11158483]

Blair NJ, Thompson JMD, Black PN, Becroft DMO, Clark PM, Han DY, … Mitchell EA (2007). Risk factors for obesity in 7-year-old European children: The Auckland birthweight collaborative study. Archives of Disease in Childhood, 92, 866–871. 10.1136/adc.2007.116855 [PubMed: 17855436]

Carr LJ, & Mahar MT (2012). Accuracy of intensity and inclinometer output of three activity monitors for identification of sedentary behavior and light-intensity activity. Journal of Obesity, 2012, 1–9. 10.1155/2012/460271

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CDC. (2013, January). Healthy weight: It's not a diet, it's a lifestyle! Retrieved from http://apps.nccd.cdc.gov/dnpabmi/Calculator.aspx?CalculatorType=Metric

Cole TJ, & Lobstein T (2012). Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatric Obesity, 7, 284–294. 10.1111/j.2047-6310.2012.00064.x [PubMed: 22715120]

Conroy DE, Maher JP, Elavsky S, Hyde AL, & Doerksen SE (2013). Sedentary behavior as a daily process regulated by habits and intentions. Health Psychology, 32, 1149–1157. 10.1037/a0031629 [PubMed: 23477579]

de Vries SI, Bakker I, Hopman-Rock M, Hirasing RA, & van Mechelen W (2006). Clinimetric review of motion sensors in children and adolescents. Journal of Clinical Epidemiology, 59, 670–680. 10.1016/j.jclinepi.2005.11.020 [PubMed: 16765269]

Ding D, Lawson KD, Kolbe-Alexander TL, Finkelstein EA, Katzmarzyk PT, van Mechelen W, & Pratt M (2016). The economic burden of physical inactivity: A global analysis of major non-communicable diseases. The Lancet, 388, 1311–1324. 10.1016/S0140-6736(16)30383-X

Downs A, Van Hoomissen J, Lafrenz A, & Julka DL (2013). Accelerometer-measured versus self-reported physical activity in college students: Implications for research and practice. Journal of American College Health, 62, 204–212. 10.1080/07448481.2013.877018

Ekelund U, Steene-Johannessen J, Brown WJ, Fagerland MW, Owen N, Powell KE, … Lee I-M (2016). Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. The Lancet, 388, 1302–1310. 10.1016/S0140-6736(16)30370-1

Epstein LH, Raja S, Gold SS, Paluch RA, Pak Y, & Roemmich JN (2006). Reducing sedentary behavior. Psychological Science, 17, 654–659. 10.1111/j.1467-9280.2006.01761.x [PubMed: 16913945]

Fontaine KR, Redden DT, Wang C, Westfall AO, & Allison DB (2003). Years of life lost due to obesity. Journal of the American Medical Association, 289, 187–193. 10.1001/jama.289.2.187 [PubMed: 12517229]

Fountaine CJ, Liguori GA, Mozumdar A, & Schuna JM Jr. (2011). Physical activity and screen time sedentary behaviors in college students. International Journal of Exercise Science, 4(2), 3.

Gibbs BB, Hergenroeder AL, Katzmarzyk PT, Lee I-M, & Jakicic JM (2015). Definition, measurement, and health risks associated with sedentary behavior. Medicine and Science in Sports and Exercise, 47, 1295–1300. 10.1249/MSS0000000000000517 [PubMed: 25222816]

Guallar-Castillón P, Bayán-Bravo A, León-Muñoz LM, Balboa-Castillo T, López-García E, Gutierrez-Fisac JL, & Rodríguez-Artalejo F (2014) The association of major patterns of physical activity, sedentary behavior and sleep with health-related quality of life: A cohort study. Preventive Medicine, 67, 248–254. 10.1016/j.ypmed.2014.08.015 [PubMed: 25138382]

Hänggi JM, Phillips LRS, & Rowlands AV (2013) Validation of the GT3X ActiGraph in children and comparison with the GT1M ActiGraph. Journal of Science and Medicine in Sport / Sports Medicine Australia, 16(1), 40–44. 10.1016/j.jsams.2012.05.012

Harrell FE (2001). Chapter 4: Multivariate modeling strategies. Regression modeling strategies: With applications to linear models, logistic regression, and survival analysis. (1st ed., pp. 53–86) New York: Springer-Verlag.

Institute of Medicine. (2011). Early childhood obesity prevention policies: Goals, recommendations, and potential actions. Retrieved from http://www.iom.edu/~/media/Files/Report%20Files/2011/Early-Childhood-Obesity-Prevention-Policies/Young%20Child%20Obesity%202011%20Recommendations.pdf

Jago R, Anderson CB, Baranowski T, & Watson K (2005). Adolescent patterns of physical activity: Differences by gender, day, and time of day. American Journal of Preventive Medicine, 28, 447–452. 10.1016/j.amepre.2005.02.007 [PubMed: 15894148]

Jago R, Fox KR, Page AS, Brockman R, & Thompson JL (2010). Physical activity and sedentary behaviour typologies of 10–11 year olds. International Journal of Behavioral Nutrition and Physical Activity, 7, 59. 10.1186/1479-5868-7-59 [PubMed: 20663226]

Author Manuscript

Kaminsky LA, & Ozemek C (2012). A comparison of the Actigraph GT1M and GT3X accelerometers under standardized and free-living conditions. Physiological Measurement, 33, 1869–1876. 10.1088/0967-3334/33/11/1869 [PubMed: 23111061]

Katzmarzyk PT, & Lee I-M (2012). Sedentary behaviour and life expectancy in the USA: A cause-deleted life table analysis. BMJ Open, 2(4), e000828. 10.1136/bmjopen-2012-000828

Kozey-Keadle S, Libertine A, Lyden K, Staudenmayer J, & Freedson PS (2011). Validation of wearable monitors for assessing sedentary behavior. Medicine and Science in Sports and Exercise, 43, 1561–1567. 10.1249/MSS.0b013e31820ce174 [PubMed: 21233777]

Lepp A, Barkley JE, Sanders GJ, Rebold M, & Gates P (2013). The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. International Journal of Behavioral Nutrition and Physical Activity, 10, 79. 10.1186/1479-5868-10-79 [PubMed: 23800133]

Liao Y, Liao J, Durand CP, & Dunton GF (2014). Which type of sedentary behavior intervention is more effective at reducing body mass index in children? A meta-analytic review. Obesity Reviews, 15, 159–168. 10.1111/obr.12112

Macdonald-Wallis K, Jago R, & Sterne JAC (2012). Social network analysis of childhood and youth physical activity: A systematic review. American Journal of Preventive Medicine, 43, 636–642. 10.1016/j.amepre.2012.08.021 [PubMed: 23159259]

Manini TM, Carr LJ, King AC, Marshall S, Robinson TN, & Rejeski WJ (2015). Interventions to reduce sedentary behavior. Medicine and Science in Sports and Exercise, 47, 1306–1310. 10.1249/MSS0000000000000519 [PubMed: 25222818]

Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, & Troiano RP (2008). Amount of time spent in sedentary behaviors in the United States, 2003–2004. American Journal of Epidemiology, 167, 875–881. 10.1093/aje/kwm390 [PubMed: 18303006]

Metcalf BS, Hosking J, Jeffery AN, Voss LD, Henley W, & Wilkin TJ (2011). Fatness leads to inactivity, but inactivity does not lead to fatness: A longitudinal study in children (EarlyBird 45). Archives of Disease in Childhood, 96, 942–947. 10.1136/adc.2009.175927 [PubMed: 20573741]

Mikus CR, Oberlin DJ, Libla JL, Taylor AM, Booth W, & Thyfault JP (2012). Lowering physical activity impairs glycemic control in healthy volunteers. Medicine and Science in Sports and Exercise, 44, 225–231. 10.1249/MSS.0b013e31822ac0c0 [PubMed: 21716152]

Nelson MC, Story M, Larson NI, Neumark-Sztainer D, & Lytle LA (2008). Emerging adulthood and college-aged youth: An overlooked age for weight-related behavior change. Obesity, 16, 2205–2211. 10.1038/oby.2008.365 [PubMed: 18719665]

Olds TS, Maher CA, Ridley K, & Kittel DM (2010). Descriptive epidemiology of screen and non-screen sedentary time in adolescents: A cross sectional study. International Journal of Behavioral Nutrition and Physical Activity, 7, 92–100. 10.1186/1479-5868-7-92 [PubMed: 21194427]

Owen N, Healy GN, Matthews CE, & Dunstan DW (2010). Too much sitting: The population-health science of sedentary behavior. Exercise and Sport Sciences Reviews, 38(3), 105–113. 10.1097/JES.0b013e3181e373a2 [PubMed: 20577058]

Owens JF, Buysse DJ, Hall M, Kamarck TW, Lee L, Strollo PJ, … Matthews KA (2010). Napping, nighttime sleep, and cardiovascular risk factors in mid-life adults. Journal of Clinical Sleep Medicine, 6, 330–335. [PubMed: 20726280]

Peterson NE, Sirard JR, Kulbok 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. 10.1002/nur.21694 [PubMed: 26444969]

Raynor DA, & Jankowiak NM (2010). Accelerometry-determined adherence to the 2008 physical activity guidelines for Americans among college students. American Journal of Health Education, 41, 353–362. 10.1080/19325037.2010.10599164

Robinson TN (1999). Reducing children’s television viewing to prevent obesity: A randomized controlled trial. Journal of the American Medical Association, 282, 1561–1567. 10.1001/jama.282.16.1561 [PubMed: 10546696]

Santos-Lozano A, Torres-Luque G, Marín P, Ruiz J, Lucia A, & Garatachea N (2012). Intermonitor variability of GT3X accelerometer. International Journal of Sports Medicine, 33, 994–999. 10.1055/s-0032-1312580 [PubMed: 22791617]

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Sasaki JE, John D, & Freedson PS (2011). Validation and comparison of ActiGraph activity monitors. Journal of Science and Medicine in Sport, 14, 411–416. 10.1016/j.jsams.2011.04.003 [PubMed: 21616714]

Sawka KJ, McCormack GR, Nettel-Aguirre A, Hawe P, & Doyle-Baker PK (2013). Friendship networks and physical activity and sedentary behavior among youth: A systematized review. International Journal of Behavioral Nutrition and Physical Activity, 10, 130–138. 10.1186/1479-5868-10-130 [PubMed: 24289113]

Spittaels H, Cauwenberghe EV, Verbestel V, Meester FD, Dyck DV, Verloigne M, … Bourdeaudhuij ID (2012). Objectively measured sedentary time and physical activity time across the lifespan: A cross-sectional study in four age groups. International Journal of Behavioral Nutrition and Physical Activity, 9, 149–160. 10.1186/1479-5868-9-149 [PubMed: 23249449]

Steele RM, van Sluijs EM, Cassidy A, Griffin SJ, & Ekelund U (2009). Targeting sedentary time or moderate- and vigorous-intensity activity: Independent relations with adiposity in a population-based sample of 10-y-old British children. The American Journal of Clinical Nutrition, 90, 1185–1192. 10.3945/ajcn.2009.28153 [PubMed: 19776141]

Thomas S, Reading J, & Shephard RJ (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Canadian Journal of Sport Sciences, 17, 338–345. [PubMed: 1330274]

Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, … and on behalf of SBRN Terminology Consensus Project Participants. (2017). Sedentary Behavior Research Network (SBRN)—Terminology consensus project process and outcome. International Journal of Behavioral Nutrition and Physical Activity, 14, 75–91. 10.1186/s12966-017-0525-8 [PubMed: 28599680]

Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, & McDowell M (2008). Physical activity in the United States measured by accelerometer. Medicine and Science in Sports and Exercise, 40, 181–188. 10.1249/mss.0b013e31815a51b3 [PubMed: 18091006]

Utter J, Neumark-Sztainer D, Jeffery R, & Story M (2003). Couch potatoes or French fries: Are sedentary behaviors associated with body mass index, physical activity, and dietary behaviors among adolescents? Journal of the American Dietetic Association, 103, 1298–1305. 10.1016/S0002-8223(03)01079-4 [PubMed: 14520247]

World Health Organization. (2008). Waist circumference and waist-hip ratio. Report of a WHO expert consultation. Geneva: World Health Organization. Retrieved from whqlibdoc.who.int/publications/2011/9789241501491eng.pdf

World Health Organization. (2010). Global strategy on diet, physical activity and health. Retrieved from http://apps.who.int/gb/ebwha/pdf_files/WHA57/A57_R17-en.pdf

Yang C-C, & Hsu Y-L. (2010). A review of accelerometry-based wearable motion detectors for physical activity monitoring. Sensors, 10, 7772–7788. 10.3390/s100807772 [PubMed: 22163626]

Zhang J, Seo D-C, Kolbe L, Middlestadt S, & Zhao W (2012). Associated trends in sedentary behavior and BMI among Chinese school children and adolescents in seven diverse Chinese provinces. International Journal of Behavioral Medicine, 19, 342–350. 10.1007/s12529-011-9177-2 [PubMed: 21748473]

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FIGURE 1.

Conceptual model of movement-based terminology. From Tremblay et al. (2017).

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TABLE 1

Demographic characteristics of sample and description of variables

Characteristic	***n***	**%**	***M* (SD)**
Gender			
Male	48	51.1	
Female	46	48.9	
Age (years)			
18	30	31.9	
19	30	31.9	
20	34	36.2	
Race			
Asian	37	39.4	
Caucasian	40	42.6	
Other	16	16.9	
No response	1	1.1	
College year			
1st year	29	30.1	
2nd year	31	33.0	
3rd year	32	34.0	
4th year	2	2.1	
Body mass index (kg/m^2)			
Male			23.3 (2.7)
Female			24.4 (4.2)
Waist circumference (cm)			
Male			85.3 (7.4)
Female			88.7 (9.6)
Sedentary hehavior (hr/day)			10.0 (1.2)
MVPA (hr/day)			1.1 (.5)

MVPA = moderate-to-vigorous physical activity.

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TABLE 2

Percentage of sample overweight or obese based on BMI and WC

	n	%
BMI		
Male	13	13.8
Female	15	16.0
WC		
Male	16	17.0
Female	4	4.3

BMI = body mass index (kg/m^2), WC = waist circumference (cm). Unlike BMI, WC commonly uses a cutoff for obesity only, so this table reflects overweight and obesity combined.

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TABLE 3

Factors associated with BMI in hierarchical multiple regression

	R^2	R^2 change	*F* change	*p*	*b*	*p*
Block 1	.130	.130	3.333	.014		
Gender: Female vs. Male					0.828	.252
Age					0.493	.262
Race: Asian vs. Caucasian					0.359	.648
Race: Other vs. Caucasian					3.027	.003
Block 2	.138	.008	0.773	.021		
Gender: Female vs. Male					0.730	.319
Age					0.367	.428
Race: Asian vs. Caucasian					0.250	.753
Race: Other vs. Caucasian					2.834	.007
Ave. daily % MVPA					−0.111	.382
Block 3	.326	.188	11.995	<.001		
Gender: Female vs. Male					0.927	.159
Age					0.680	.109
Race: Asian vs. Caucasian					0.160	.822
Race: Other vs. Caucasian					2.321	.013
Average daily % MVPA					−0.308	.017
Average daily % SB					−0.289	<.001
Number of SBs listed					0.930	.006

BMI = body mass index, MVPA = moderate-to-vigorous physical activity, SB = sedentary behavior.

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TABLE 4

Factors associated with WC in hierarchical multiple regression

	R^2	R^2 change	*F* change	*p*	*b*	*p*
Block 1	.085	.085	2.068	.092		
Gender: Female vs. Male					2.762	.130
Age					0.675	.541
Race: Asian vs. Caucasian					−1.544	.435
Race: Other vs. Caucasian					3.862	.127
Block 2	.085	.000	0.035	.157		
Gender: Female vs. Male					2.709	.145
Age					0.607	.603
Race: Asian vs. Caucasian					−1.603	.426
Race: Other vs. Caucasian					3.758	.149
Ave. daily % MVPA					−0.060	.851
Block 3	.175	.089	4.644	.018		
Gender: Female vs. Male					3.045	.089
Age					1.143	.318
Race: Asian vs. Caucasian					−1.758	.365
Race: Other vs. Caucasian					2.894	.250
Average daily % MVPA					−0.386	.265
Average daily % SB					−0.479	.018
Number of SBs listed					1.620	.074

MVPA = moderate-to-vigorous physical activity, SB = sedentary behavior, WC = waist circumference.