Ambulatory Physical Activity Patterns of College Students

Timothy K. Behrens and Mary K. Dinger

ABSTRACT

The purpose of this study was to describe the ambulatory physical activity of a sample of college students. A descriptive, cross-sectional study was conducted in which students (N = 441; males: n = 204, age = 20.20 ± 1.99, BMI = 25.19 ± 4 kg/m^2; females: n = 237, age = 19.92 ± 1.64, BMI = 22.91 ± 3.2 kg/m^2) wore an accelerometer, with cycle mode enabled, during all waking hours for 7 consecutive days. The independent variables were day of the week and gender. The dependent variable was steps per day. Two-factor ANOVA, an independent t-test, and chi-squares were calculated. Results indicated that students averaged 11,473.87 ± 2,978.62 steps per day for the week. They were most active on weekdays, and less active on weekends. Mean steps per week, weekday, and weekend did not differ by gender. Further, the majority of the students (67.4%) were exceeding the 10,000 steps per day recommendation. These results can be useful to health educators and researchers seeking a description of ambulatory physical activity in college students.

INTRODUCTION

The moderate physical activity recommendation was released in 1995 by the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) as a joint position stand regarding the amount of physical activity (PA) necessary for health benefits.[1] Some of these health benefits include reduced risk of cardiovascular disease, colon cancer, breast cancer, type 2 diabetes, and obesity.[2] The CDC/ACSM recommendation calls for Americans to accumulate at least 30 minutes of moderate-intensity physical activity (MPA) on most, if not all, days of the week.[1] In addition, another PA recommendation by Hatano and colleagues[3] suggested that health benefits can be derived from the accumulation of 10,000 steps per day. The latter recommendation has found widespread acceptance in the popular media and has been widely promoted by the lay press.[4-6]

Unfortunately, most Americans are not meeting the CDC/ACSM recommendation. Surveillance data indicate that approximately 67% of adults do not engage in enough leisure-time PA to attain health benefits.[7] In young adults the percentage (57.5%) is only slightly improved,[7] and while many think that college students are much more active than the majority of Americans, 43% of college students do not engage in enough PA to improve their health status.[8] This statistic is particularly disconcerting because the sharpest decline in PA participation occurs during late adolescence and early adulthood.[9]

The majority of PA surveillance data have been collected with self-reported questionnaires, which have been associated with considerable sources of error such as a dependence on recall and a lack of precision to the activity being recalled,[10] the general overestimation of self-reported physical activity,[11] and discrepant correlations with varying intensities of physical activity.[10,11] Conversely, directly assessing PA with motion detectors can yield a more accurate description of ambulatory PA, which accounts

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for the great majority of all PA.[12, 13]

With regards to those meeting the popular 10,000 steps per day recommendation, the literature is fragmented at best. Current evidence suggests that the accumulation of 10,000 steps per day is indicative of an active individual most likely meeting the CDC/ACSM recommendation.[14] However, to date, only a few large-scale studies have examined steps per day in different populations.[15-17] Therefore, it is difficult to ascertain whether individuals in different populations are accumulating enough steps per day for health-related benefits. To our knowledge, there has been only one preliminary investigation of ambulatory (step) patterns in the college population,[18] and it is unknown whether the PA patterns reported in that study are representative of a larger group of students. Therefore, the purpose of this study was to examine the ambulatory PA patterns of a large sample of college students.

METHODS

Participant Recruitment

Following approval by the institutional review board, undergraduate college students were recruited to participate in the study. The researchers used a variety of recruiting methods. Potential participants were recruited through announcements to large general education classes, flyers posted in high traffic areas around campus, advertisements placed in the student newspaper and website, and an informational table at the student union. In order to be eligible to participate in the study, students had to be 18–30 years old, enrolled in at least 12 academic hours, and could not be members of an intercollegiate athletic team due to the imposed PA of team members in their athletic pursuits. Eligible students who were interested in participating in the study were instructed to contact the researchers via telephone or email to schedule an appointment.

Research Design

A cross-sectional, descriptive study was conducted. The independent variables were day of the week and gender. The dependent variable was number of steps per day. According to Baumgartner, Strong, and Hensley,[19] 377 subjects were needed to represent the undergraduate student population of approximately 20,000 (90% confidence, alpha = 0.05).

Instrument

The Manufacturing Technology Incorporated Actigraph Monitor Model 7164 (Ft. Walton Beach, FL) (Actigraph) is the accelerometer that was used to determine the number of steps that subjects accumulated throughout the day. The Actigraph is a single axis accelerometer that measures and records accelerations ranging in magnitude from 0.05 to 2 Gs. The Actigraph measures 2 x 1.6 x 0.6 inches and weighs 1.5 ounces.[20] The Actigraph is initialized and downloaded using a reader interface that is connected to a serial port of a computer. The Actigraphs used in this study were calibrated by the manufacturer prior to the start of this study.

The validity of the Actigraph monitor has been well documented with Actigraph counts significantly correlated with energy expenditure[21, 22] and relative oxygen consumption[21, 22] during ambulatory activity. Additionally, research has indicated that the Actigraph accelerometer has acceptable reliability[23] (ICC = 0.80), and that when the device is worn for seven consecutive days PA and physical inactivity patterns can be provided with 90% reliability.[24]

When the cycle mode is activated, the Actigraph counts the number of cycles in the acceleration signal over a user-specified time period. When the Actigraph is worn at the waist, cycle counts approximate the number of steps taken during the time interval.[20] In recent studies,[25, 26] researchers found that cycle counts were highly representative of actual ambulatory PA and suggested that the Actigraph be used as the criterion measure when assessing steps per day.

Procedures

After participants completed the informed consent and the PAR-Q,[27] weight and height were assessed using a physician's balance-beam scale and stadiometer. Each participant was fitted with a cotton belt that fit closely around his/her waist. The belts were used to attach the Actigraph (which was in the pouch available from the manufacturer) to the body, so that the Actigraph could be worn under clothing and fit snugly against the skin. Subjects were instructed to keep the Actigraph in the pouch and to make sure that the pouch was oriented properly (Velcro® flap pointed downward and away from the body) when putting on the Actigraph each morning. Participants were told to wear the Actigraph monitor over their right hip during all waking hours for seven consecutive days, except when showering, bathing, or swimming. Participants were instructed to remove the Actigraph when going to bed at night. In addition, participants were given a log sheet to record what time they put on and removed the Actigraph each day.

At the end of the seven days, participants returned their Actigraphs and log sheets. All participants who completed the study received a report that included information about their daily caloric expenditure in PA, and one student each semester was randomly chosen to receive $50. Data were collected in 14 different cohorts, ranging in size from 12 to 45 students, between September 13, 2002 and April 23, 2003.

Data Reduction

One-minute cycle periods were used in this study. Steps per minute were summed across 60 minutes to obtain total steps per hour for each day. The number of hours during each 24-hour period with total steps per hour greater than zero was determined. The researchers decided *a priori* that subjects must have worn the Actigraph for at least 12 hours per day (75% coverage for 16 waking hours), on at least five of the seven days (standard interpretation of the MPA recommendation[28]) in order to be included in the analyses.

Five hundred thirteen (513) students initially participated in the study. Three of the students decided not to complete the study and returned their Actigraphs before

the end of the week. In addition, the researchers excluded data from 10 subjects due to battery failure. This resulted in a sample of 500 students. After applying the *a priori* data inclusion criteria (≥ 12 hours on ≥ 5 days), 441 subjects (88%) remained in the sample. These participants wore the Actigraph 6.56 ± 0.67 days for 15.86 ± 1.29 hours per day.

Data Analysis

Descriptive statistics were calculated for the demographic and step variables. Analysis of variance (ANOVA) was used to examine the difference in steps per day by cohort. There was a significant difference in steps per day among the 14 cohorts ($F[3, 437]=7.04$, $p=.0001$); therefore, cohort was included as a factor in further statistical analyses. A two-factor ANOVA was conducted to test for differences in the number of steps by day of the week and for gender differences in steps.

Student-Newman-Keuls *post hoc* tests were used to examine significant differences. To decrease the risk of type I error, Bonferroni's method was employed to determine the appropriate alpha level given that multiple comparisons were being made.[29] Six comparisons of steps per day were conducted; therefore, an alpha level of 0.007 (.05/6 = 0.007) was used to test for significant differences. Data are presented as means ± standard deviations.

RESULTS

Subjects

During the fall 2002 semester there were 19,584 full-time undergraduate students enrolled at the university. The final sample consisted of 441 students (age: 20.05 ± 1.82 years; BMI 23.97 ± 3.79 kg/m^2). The students in the study were representative of the university student population with regards to gender ($\chi^2=0.44$, $df=1$, $p=0.51$) and ethnicity ($\chi^2=1.67$, $df=5$, $p=0.89$; Table 1). Males (age: 20.20 ± 1.99; BMI: 25.19 ± 4 kg/m^2) did not differ significantly from females (age: 19.92 ± 1.64; BMI: 22.91 ± 3.2 kg/m^2) in age ($F[1, 433] = 2.95$, $p > 0.08$), but had higher BMI's than females ($F[1, 433] = 21.06$, $p < 0.0001$).

Table 1. Representativeness of Sample to University Population.

Characteristic	University Population N=19,584 n (%)	Sample n=441 n (%)
Gender		
Female	9,603 (49%)	237 (53.7%)
Male	9,981 (51%)	204 (46.3%)
Ethnicity		
Caucasian	14,424 (73.6%)	339 (76.8%)
African-American	1,208 (6.2%)	33 (7.5%)
Hispanic	745 (3.8%)	12 (2.7%)
Asian	1,048 (5.4%)	28 (6.4%)
Native American	1,449 (7.4%)	17 (3.9%)
Other	710 (3.6%)	12 (2.7%)

Note. There were no significant differences in gender ($p = 0.50$) or ethnicity ($p = 0.89$) between the population and the sample.

Daily Steps

On average, students accumulated 11,473.87 ± 2,978.62 steps per day during the week. The highest number of steps were accrued on Friday with 12,325.09 ± 4,612.85 steps and the lowest number of steps occurred on Sunday with 9,108 ± 4,600.15 steps. There was a significant difference in the number of accumulated daily steps by day of the week ($F[6, 2867]=25.64$, $p<0.0001$) with Student-Newman-Keuls *post hoc* comparisons indicating that most weekdays (Monday–Friday) were different from the weekends (Saturday and Sunday; Figure 1). Therefore, the data were split into steps by weekday and weekend. A subsequent t-test revealed that students accrued more steps on the weekdays than the weekends ($t=8.41$, $df=1$, $p=0.0001$; Figure 2).

Steps by Gender

When comparing the PA patterns between the genders, there was not a difference in mean steps per day for the week ($F[1, 433] = 0.52$, $p = 0.47$). Further, there was not a significant difference in steps by weekday ($F[1, 433] = 0.76$, $p = 0.38$) or steps by weekend ($F[1, 427] = 0.16$, $p = 0.69$; Figure 2).

10,000 Steps per Day Recommendation

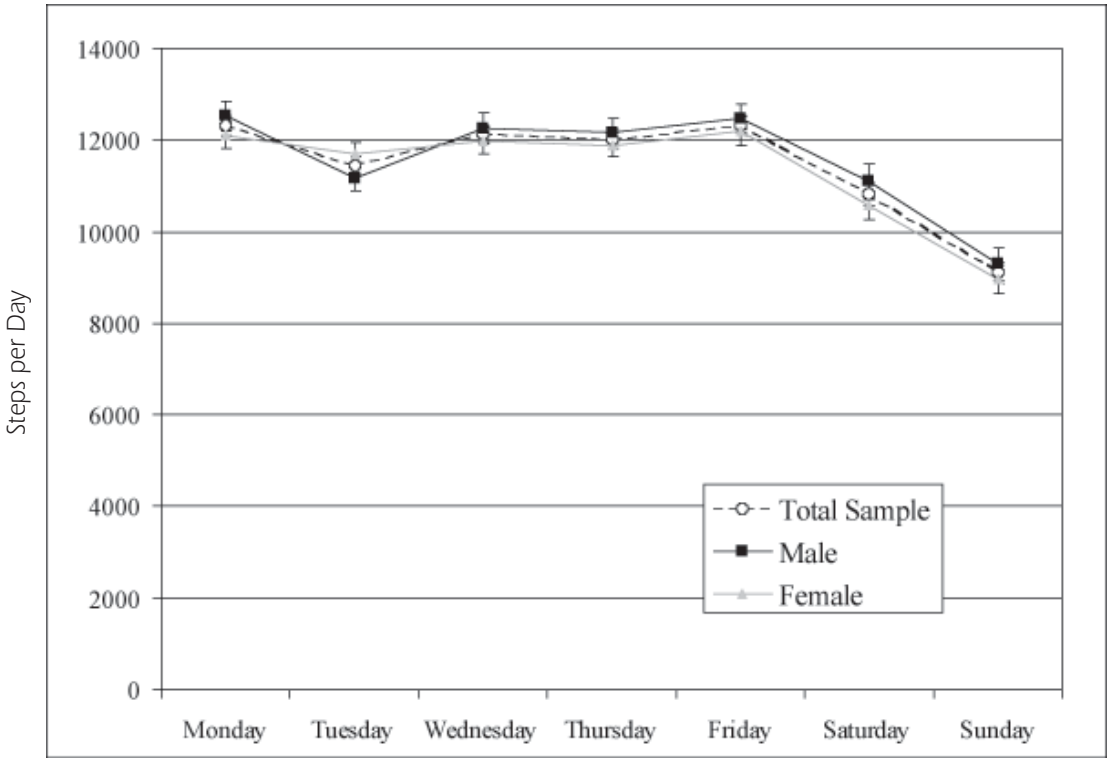
Examining the data for those meeting and not meeting the 10,000 steps per day recommendation revealed that 297 students (67.35%) were accumulating ≥ 10,000 steps per day. Moreover, there was not a significant difference between genders in the accumulation of 10,000 steps per day ($\chi^2 = 0.88$, $df = 1$, $p = 0.35$), with 65.4% of females and 69.6% of males accumulating ≥ 10,000 steps per day.

DISCUSSION

To our knowledge, this is the first large-scale study to examine the daily step patterns of college students. Our results indicate that these college students accumulated 11,473.87 ± 2,978.62 steps per day and were more active on weekdays than on the weekends. Moreover, the majority of the students in this study (67.35%) accumulated ≥10,000 steps per day. Further, there were no significant differences in the daily step patterns of males and females, suggesting that total ambulatory PA does not differ between the genders.

Our findings are similar to previous research conducted among college students regarding PA step patterns. In a preliminary study investigating step patterns of a small group of college students (n = 31), researchers reported that college students averaged 9,932.27 ± 2,680.71 steps per day and that

Figure 1. Mean Steps per Day by Day of the Week



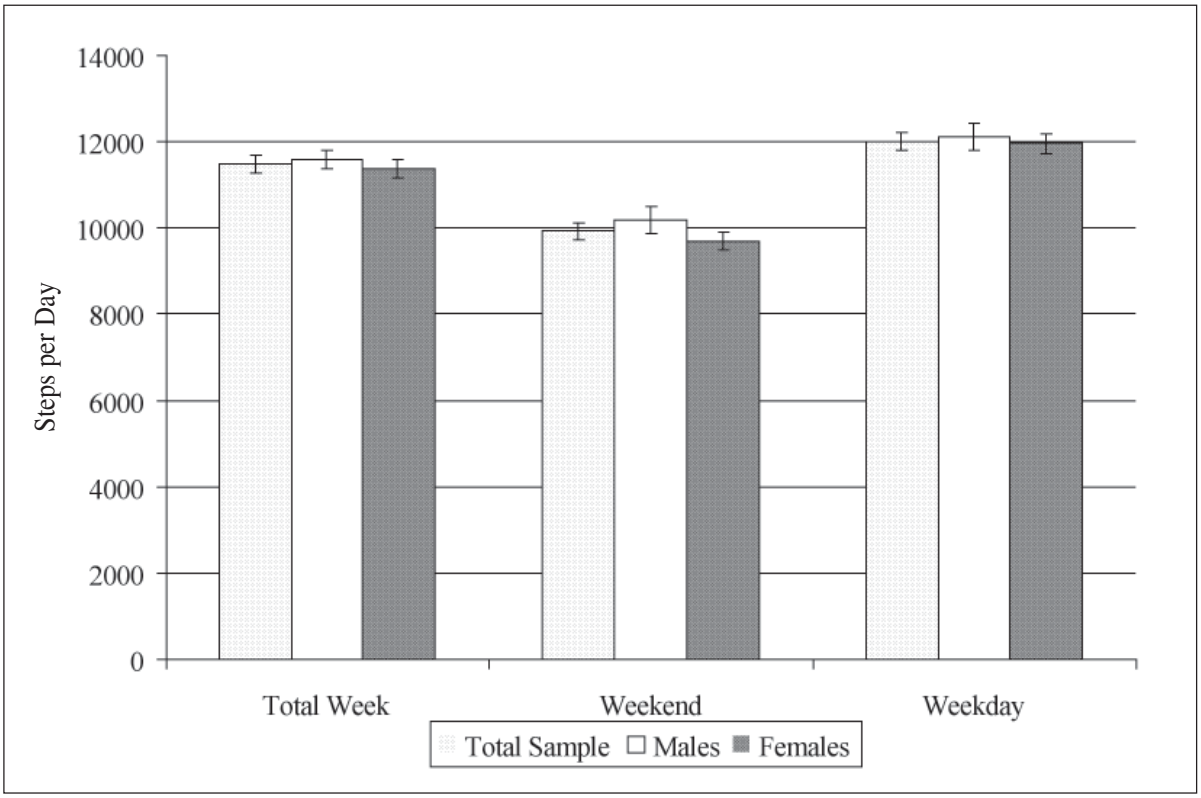
there were no significant differences between males and females in the amount of steps per day.[18] In the current study, we used Actigraph accelerometers, which are more sensitive to incremental movements[25, 26] than the Yamax pedometers used in the aforementioned study.[18] However, Le Masurier and colleagues[26] reported that the Yamax pedometer used by in the previous study monitoring college students[18] records steps within 1% of the steps monitored by the Actigraph, and as previously noted, they suggested that the Actigraph be used as a criterion measure when assessing steps.[26] Since there is concordance between the two instruments, the results of the current study suggest that, in larger samples, the actual number of accrued steps may be more than previously reported in college students.

Examining the differences in PA by day of the week, Matthews and colleagues[24] monitored 122 healthy adults (18–79 years of age) with an Actigraph accelerometer for 21 consecutive days. Although they reported PA as accelerometer counts, and not as steps per day, they found that participants in their study were most active on Saturdays, and that in general, PA levels were higher on weekends than on weekdays. Conversely, the students in our study were most active on weekdays, with Sundays being the most physically inactive day of the week. A possible reason for the discrepancy between the studies could be attributed to the ambulatory PA of college students walking across campus. It is plausible that on weekdays these students may have walked more in the process of traveling from class to class around campus than a typical adult would in a day-to-day situation. Therefore, the steps per day values found in this population are higher during the week than that of a different population where another type of transportation is primary to ambulatory activities. Another possible reason for this discrepancy could be due to the difference in step data versus count data.

In a recent large-scale study examining steps per day in community-dwelling adults in the southeastern United States,[17] researchers found that the participants (male: N=76, age = 48.4 ± 16.3 years; female: N=133, age=47.4 ± 17.5 years) accumulated significantly more steps during the week (6,355 ± 3,975 steps per day) than on the weekend (5,445 ± 3,648 steps per day). Although the students in our study were more active on the weekdays (12,004 ± 146 steps per day) and weekend (9,923 ± 200 steps per day) than the participants in the study by Tudor-Locke et al.,[17] the findings of our study are similar to theirs with regards to weekly ambulatory PA patterns.

Moreover, the results of our study are consistent with a review of previously published studies indicating that healthy young adults can be expected to accumulate between 7,000 and 13,000 steps per day.[30] However, it is interesting to note that

Figure 2. Mean Steps for the Week, Weekdays (Monday–Friday), and Weekend (Saturday & Sunday)



Tudor-Locke & Myers[30] suggested that steps, based on their review, should be fewer for females than males. Similarly, national surveillance data assessing leisure-time PA in young adults suggests that males are more active than females.[8, 31] In contrast, our findings indicate that there is not a gender difference in ambulatory PA. Possible reasons for this discrepancy could be due to males and females attending similar classes on campus and the ability of the Actigraph to more accurately assess ambulatory PA than questionnaires commonly used to collect national PA surveillance data.

The students that participated in the present study were all from the same university, with similar ages (18–30 years; mean age: 20.03 ± 1.82 years), and are from a more localized geographical area than the other large-scale studies reviewed by Tudor-Locke & Myers.[30] Therefore, their PA patterns are more likely to be similar between the genders than those reviewed by Tudor-Locke and Myers.[30] Further, most national surveillance questionnaires assess PA during leisure time,[8, 31] while the Actigraph measures actual bodily movement and therefore captures all ambulatory PA throughout the day. Hence, it is plausible that when all domains of PA are considered (i.e., leisure-time, occupational, transportation, home/garden work and family care), there may not be a gender difference in ambulatory PA. This is a unique finding of this study and future research should examine total ambulatory PA for gender differences.

In most studies conducted to determine the number of daily steps necessary to obtain health benefits (i.e., the accumulation of 30 minutes of MPA that meets with the CDC/ACSM recommendation), the steps per day range has fallen between 9,000 and 11,000 accumulated steps throughout the day.[32-36] Although the purpose of this study was not to determine whether college students were meeting the CDC/ACSM recommendation, the steps per day values of these college students suggest that the majority of these college students were meeting the CDC/ACSM recommendation, as determined from previous research.[32, 34, 36, 37]

This study has implications for both researchers and practitioners in health education. First, because this study represents the first large-scale descriptive study of ambulatory PA patterns in college students, more large-scale studies in different geographical areas are needed to confirm the findings. In particular, researchers should examine step per day patterns, the association that has been observed between the weekend and weekday physical activity patterns, and gender differences observed when assessing accumulated steps per day in college students.

Second, future studies should attempt to

assess the actual intensity and duration of ambulatory PA in order to receive health benefits. Research has demonstrated that health benefits are conveyed when PA is accumulated in bouts ≥10 minutes.[38, 39] In a study exploring this issue, Le Masurier and colleagues examined 35 women who had accumulated ≥10,000 steps per day.[32] They found that when the women accumulated ≥10,000 steps per day, they also accrued approximately 62 minutes of MPA. However, when only bouts of ≥ 10 minutes were examined, the minutes of MPA leading to health benefits dropped to approximately 30 minutes, even though the women had all accumulated ≥ 10,000 steps per day.[32] The findings of Le Masurier and colleagues[32] may indicate that although the majority of students in this study accumulated ≥ 10,000 steps per day, they may not be receiving the health benefits associated with MPA.

Lastly, with current research indicating that poor diet and a lack of PA are the second leading cause of death in the United States,[40] physical inactivity is an important public health issue. It is therefore incumbent upon health educators to increase their PA knowledge. This study can help to equip practitioners by adding to the empirical knowledge base regarding PA patterns among college students. Practitioners should advocate for more education about PA, and innovative ways of increasing PA. Advocacy that encourages environmental changes such as walking paths, college campuses and the surrounding communities that are "closed" to vehicular traffic, and encouraging university and community organizations to promote ambulatory PA such as walking and other moderate activities are areas for health education practitioners to make an impact.

The study population and the geographic area of this study are limitations that could influence the generalizability of our findings. These college students were between the ages of 18 and 30, and from the same university campus. Although this may be viewed as a shortcoming, we argue that this campus is similar in terms of walkability to most mid- to large-sized university campuses in the central region of the United States. Additionally, although these students were representative of the university population with regards to gender and ethnicity, the participants in this study were volunteers who were willing to participate in the study for an entire week. Volunteers for a PA study may be more active than the average student. If so, this would be a threat to the external validity of the findings.

To our knowledge, this cross-sectional descriptive study is the first to examine steps per day in a large group of college students. Our findings indicate that these students were accumulating 11,473.87 ± 2,978.62 steps per day, surpassing the popular 10,000 steps per day recommendation, and were more active on weekdays than on weekends. Further, a unique finding of this study was that there were no differences between males and females in total ambulatory activity. Future research should examine step patterns in large representative groups of college students in other geographical areas to determine the efficacy of our findings—particularly the relationship between gender and total ambulatory activity, and weekday and weekend PA patterns. In addition, future research should attempt to describe the relationship between health benefits derived from PA and total accumulated steps per day, as well as gather qualitative information to understand why students' ambulatory PA patterns may vary.

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