

The Patterns of Physical Activity and Sedentary Behavior outside of a College Physical Activity Course

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Objectives: We investigated the patterns of physical activity (PA) and sedentary behavior (SB) outside of a college weight training course. **Methods:** We recruited university undergraduate students (N = 225) enrolled in a weight training course. The variables included bouts of moderate-to-vigorous intensity physical activity (PA), total sedentary time, and compliance with PA guidelines. **Results:** More than half of the participants did not meet the recommended aerobic PA guidelines outside of the weight training class. Gender discrepancy exists in the patterns of PA and SB. No differences in the variables were found between PA and non-PA students. **Conclusions:** Despite a participation in physical activity course, additional physical activity outside of the class is necessary to achieve physical activity guidelines.

Key words: strength training; college health; physical activity; sedentary behavior; health behavior
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Although research has emphasized the various health benefits of physical activity¹ and the possible adverse health outcomes of sedentary behaviors,² a lack of physical activity and prolonged sitting time among college students are still primary public health concerns. For decades, physical inactivity has been identified as one of the national priority health-risk behaviors in college and university populations.³ According to a 2013 report from the American College Health Association, 53.8% of college and university students in the United States (US) did not engage in sufficient daily aerobic physical activity for health as specified in physical activity guidelines.⁴

Physical education (PE) (eg, physical activity course [PAC]) has been used as an important avenue in school settings from elementary school through college to deliver conceptual information about physical activity and health and to increase actual physical activity participation.⁵⁻⁷ However,

compared to other school settings, only a few studies have shown varying degrees of success of college PE to increase physical activity.^{8,9} As a result of this fractured literature, the Guide to Community Preventive Services Task Force requires additional research to determine the effectiveness of college PE in increasing physical activity and fitness.¹⁰ In addition, instead of a mandatory PAC, many colleges and universities offer a variety of elective PACs providing students with a choice that may cause unbalanced participation in only preferred activities such as weight training or jogging.¹¹ Thus, it is important to understand the patterns of physical activity and sedentary behaviors among college students enrolled in a PAC for developing effective PACs that help students achieve recommended physical activity levels.

To provide scientific information to help individuals improve their health through relevant physical activity, the US Department of Health

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and Human Services released the *2008 Physical Activity Guidelines for Americans* that include guidelines for aerobic and muscle-strengthening activities. To achieve health benefits for adults, the guideline recommends at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical activity each week, or a corresponding combination thereof in bouts of at least 10 minutes. In addition, muscle-strengthening activities, using all major muscle groups, are recommended at least 2 days a week for additional health benefits that are not found through aerobic activities.¹ However, a selected course among a variety of physical activity courses may not be able to provide all required amounts or types of activities for health. For example, participating in a weight training course helps students meet the muscle-strengthening guideline, but extra participation in aerobic activity outside of the class may still be needed for substantial health benefits. In addition, it is possible that the amount of activity in which students participate during class may be compensated by less regular activity time outside of the class.¹²

An effective college PAC not only may help students increase participation in physical activity during the class, but also influence students' long-term health behaviors that affect the rest of their lives.¹³ In addition, the federal physical activity guidelines provide science-based physical activity guidance to help people improve and maintain their health. Thus, incorporating the physical activity guidelines into a college PAC may be a solution to increase the effectiveness of college PACs on helping college students achieve recommended physical activity levels and to provide activity-specific recommendations (eg, relevant intensity or amount of activity in a selected PAC) that may be used as an individually preferred activity guideline. However, little is known about the patterns of physical activity and sedentary behaviors performed within and outside of a PAC among university students in relation to the physical activity guidelines. This is crucial because it will be the first essential step to provide an idea of potential improvement for developing the abovementioned programs. Therefore, the purpose of this study was to investigate college students' patterns of physical activity and sedentary behaviors outside of a physical activity course.

METHODS

Participants and Protocol

Two-hundred twenty-five university students who voluntarily registered in a 16-week weight training course were recruited at a large urban university in the southern US. All participants were undergraduate students representing various academic disciplines on campus. Sixteen weight training classes were offered for a one-hour course credit and designed to have the students perform a full-body weight training workout primarily focusing on increasing muscular strength using a "Periodization" program (ie, training in cycle of increasing intensity and decreasing volume). All students in the classes followed the same program under the instructor's supervision with allowance for choosing their own moderate- and vigorous-intensity weights for lifting based on their abilities. Participants met twice per week for 90 minutes at a scheduled time (eg, every hour from 9am through 3pm on Monday and Wednesday, or Tuesday and Thursday). During the first 6 weeks, the classes began with 30-minute lectures focusing on program principles, proper techniques with demonstrations, safety rules, exercise physiology, and nutrition and weight management in relation to resistance training, followed by the Periodization program. The class participation satisfied the recommended level of muscle-strengthening activity guideline.

Following informed consent, participants were provided a triaxial accelerometer (ActiGraph GT3X+; Pensacola, FL) with written and in-person instructions and were asked to wear the device on their right hip for 7 consecutive days, during all waking hours of the day. For supporting objective data for physical activity and sedentary times, participants were asked to complete self-administered questionnaires for leisure time physical activity and sitting time on the day of device return. The participants were asked to ignore the activities performed in the weight training classes to complete the questionnaires.

To compare with the patterns of physical activity and sitting times of university students who were not enrolled in any PACs, additional students (N = 153) who had same conditions as the PAC group (eg, undergraduates representing various academic disciplines) but no experience of taking a PAC in college were recruited as a control group. All stu-

dents in the control group were asked to complete an informed consent and aforementioned questionnaires to assess physical activity and sitting times. Accelerometers were not used for the control group.

Instruments

ActiGraph GT3X+ accelerometer. Times spent in physical activity and sedentary behaviors of students in a weight training course were objectively measured using the ActiGraph GT3X+ accelerometer (Pensacola, FL). Downloaded data from the device were screened for wear time using a validated method requiring a minimum of 10 hours of wear time per day for at least 4 of 7 days,¹² and a 1-second epoch was used to report the data. Device non-wear time was defined as 60 consecutive minutes of 0 counts with allowance for 1-2 minutes of detected counts between 0 and 100. Wear time was estimated by subtracting non-wear time from 24 hours.¹² Freedson et al's cut-point¹⁴ was used to estimate times spent in sedentary behaviors (<100 counts per minute) and light- (100-1951 counts per minute), moderate- (1952-5724 counts per minute) and vigorous- (≥ 5725 counts per minute) intensity physical activities. Sedentary time was determined as the amount of time accumulated below 100 counts per minute during detected wear time. Bouted moderate to vigorous physical activity was also calculated using a method reported by Troiano et al¹² and defined as a minimum of 10 consecutive minutes above a cut-point of 1952 counts per minute, with allowance for 1-2-minute drop-times below the cut-point. Lastly, a sedentary break was defined as an interruption in sedentary time with the counts of 100 or above per minute.¹⁵ The cut-point of meeting the physical activity guidelines was determined as achieving or exceeding at least 150 minutes a week of bouts moderate to vigorous intensity physical activity.¹

Past-week Modifiable Activity Questionnaire. A self-administered past-week Modifiable Activity Questionnaire (SMAQ) was used to assess leisure time physical activities over the past 7 days for both groups. The SMAQ included 38 common leisure physical activities among this population (eg, weight lifting, swimming, football, basketball). Leisure time physical activity was estimated by weighting any reported activities (in hours/week)

by estimated metabolic equivalent (MET) of that activity¹⁶ and then by summing for all performed activities. The estimate for total leisure physical activity was expressed as MET·hours per week (MET·hours/week).¹⁷ The threshold for meeting or non-meeting physical activity guidelines was 7.5 MET·hours/week for the estimates derived from this questionnaire.¹⁸

Multi-context Sitting Time Questionnaire (MSTQ). An additional questionnaire (MSTQ) was used to measure sitting time across domains and contexts on a typical weekdays and weekends. Because the MSTQ was developed to apply to both professionals and students, it was modified to use for only college students. Adequate convergent validity ($r = .34 - .61$) and strong test-retest reliability ($r > .70$) have been described previously.¹⁹

Data Analysis

All variables were tested for normality first with a Shapiro-Wilk test. Descriptive statistics were computed for all demographic variables and relevant variables presented as frequency, mean, median, standard deviation, percentage and inter-quartile range. Because all estimates from the accelerometer were not normally distributed, medians and inter-quartile ranges (IQR) were reported for summary statistics. To compare statistical differences in time estimates (eg, times of physical activity and sedentary behaviors) and summary variables from questionnaires between men and women and PAC and non-PAC students, Mann-Whitney U tests were conducted. In addition, Friedman tests were conducted for testing differences in physical activity and sedentary times between weekdays and weekends and across times of day (eg, morning, early afternoon, and late afternoon). All estimates of physical activity and sedentary behaviors were adjusted for class time and device wear time. All statistical analyses were conducted using IBM SPSS 21 for Windows (Armonk, NY).

RESULTS

Demographic characteristics and the estimates derived from accelerometers for PAC students are presented in Table 1. Participants included 116 men and 109 women with mean ages (\pm SD) of 20.6 (± 2.0) and 20.2 (± 1.5) years, respectively. Generally, men and women were evenly distrib-

Table 1
Demographic Characteristics and Accelerometer-derived
Summary Estimates for Sedentary Time and Physical Activity

Variable	Men (N = 116)		Women (N = 109)	
	N, Mean or Median	%, SD, or IQR	N, Mean or Median	%, SD, or IQR
Age	20.6	2.0	20.2	1.5
College Years				
1	4	3.4	6	5.5
2	39	33.6	44	40.4
3	38	32.8	30	27.5
4	35	30.2	29	26.6
Ethnicity				
White	35	30.2	46	42.2
African American	11	9.5	12	11.0
Hispanic	34	29.3	32	29.4
Asian	36	31.0	19	17.4
Total wear time	749.1	637.7, 906.6	770.6	639.6, 961.5
Total Sedentary Time (m/d)	527.7	452.5, 616.1	550.2	441.0, 656.4
Bouted Moderate to Vigorous Physical Activity during WT classes (m/d)	0	0, 5.7	0	0, 6.0
Bouted Moderate to Vigorous Physical Activity outside of classes (m/d)	20.7	12.3, 34.3	20.0	12.9, 33.4
Met aerobic activity guidelines	56	48.3	50	45.9
Met muscle-strengthening guidelines	109	94.0	105	96.3
Met both guidelines	53	45.7	49	44.9

Note.

N = number of participants, SD = standard deviation, IQR = inter-quartile range

uted among categories of college years and ethnicity except for relatively low numbers of first-year (3.4% and 5.5%, respectively) and African-American (9.5% and 11.0%, respectively) students. The small proportion of African-American students in the current study was similar to the proportion (7.2%) at the university.

The average daily device wear times were 749.1 minutes/day (IQR 637.7-906.6) and 770.6 minutes/day (IQR 639.6-961.5) for men and women, respectively. The median minutes of bouts moderate to vigorous intensity physical activity performed during the weight training classes were 0 min/day (IQR 0-5.7 and 0-6.0, respectively) for both men and women. In general, men and women did not differ significantly in estimates of the

behaviors performed outside of class with respect to sedentary time, bouts moderate to vigorous intensity physical activity, and prevalence estimates of meeting guidelines. In brief, women had slightly greater sedentary time (550.2 minutes/day [IQR 441.0-656.4]) than men (527.7 minutes/day [IQR 452.5-616.1]) outside of the class. Medians of bouts moderate to vigorous intensity physical activity performed outside of the class were 20.7 minutes/day (IQR 12.3-34.3) for men and 20.0 minutes/day (IQR 12.9-33.4) for women. Furthermore, less than half of the participants in both male and female students met aerobic physical activity guidelines (48.3% for men and 45.9% for women) and lower percentages of participants (45.7% for men and 44.9% for women) were found when

Table 2
Summary Estimates of Sedentary Time, Bouted Moderate-to-Vigorous Intensity Physical Activity, and Accumulated PA by Class Days, Non-class Days, and Weekends

Variable	Men (N = 116)			Women (N = 109)		
	Class Weekdays	Non-class Weekdays	Weekends	Class Weekdays	Non-class Weekdays	Weekends
Sedentary Time^a (min/d)	565.0 ^b [481.7, 646.6]	549.5 ^b [473.9, 656.6]	527.2 [427.1, 619.9]	575.0 ^b [468.9, 692.1]	553.5 ^b [508.0, 655.4]	513.8 [456.6, 612.5]
Bouted MVPA^a (min/d)	31.6 ^{b,c} [13.2, 52.0]	25.0 ^b [12.0, 43.0]	6.6 [0, 26.8]	29.1 ^b [18.2, 50.1]	27.0 ^b [12.5, 41.1]	0 [0, 21.4]
Accumulated PA						
Light ^a (min/d)	63.0 ^{c,d} [49.4, 81.8]	56.3 [45.7, 73.9]	61.5 [40.9, 81.6]	53.6 [44.6, 65.2]	54.4 [45.2, 66.4]	55.0 [44.5, 75.2]
Moderate ^a (min/d)	77.5 ^{b,c} [60.8, 96.1]	65.9 ^b [53.9, 81.9]	45.9 ^d [31.5, 64.3]	70.2 ^{b,c} [55.1, 89.0]	61.7 ^b [52.8, 78.1]	37.9 [23.9, 55.6]
Vigorous ^a (min/d)	6.8 ^{b,c,d} [3.9, 15.6]	5.7 ^b [2.9, 11.4]	4.5 ^d [2.0, 8.5]	5.3 ^{b,c} [2.9, 11.6]	4.5 ^b [2.2, 7.4]	2.7 [1.7, 6.5]

Note.

N = number of participants, MVPA = moderate to vigorous intensity physical activity, PA = physical activity
 Values are medians (inter-quartile range) or means (standard deviation)

a = indicates Non-parametric variables

b = Significantly different from Weekends (p < .05)

c = Significantly different from Non-class Weekdays (p < .05)

d = Significantly different from Women (p < .05)

considering both aerobic and muscle-strengthening activity guidelines.

The median minutes of sedentary behaviors and physical activity are presented averaged across all class weekdays, non-class weekdays, and weekends by sex in Table 2. Men and women had significantly fewer minutes of sedentary behaviors (p = .026 vs ≤ .001 for men and women, respectively), bouts moderate to vigorous intensity physical activity (p ≤ .001 vs ≤ .001), and accumulated moderate- (p ≤ .001 vs ≤ .001) and vigorous-intensity (p = .015 vs .002) physical activities on weekends compared with weekdays. Some significant differences were also found between class and non-class weekdays. Men had a significantly higher amount of moderate-to-vigorous intensity physical activity outside of class on class days compared to non-class days (p = .03). In addition, the minutes of accumulated light- (p = .012 vs .63 for men and women, respectively), moderate- (p ≤ .001 vs = .002), and vigorous-intensity (p = .002 vs .035) physical activities were higher on class days than non-class days

in both men and women, except for light-intensity activity in women (p = .63). Lastly, men had significantly higher light- and vigorous-intensity activities than women on class days (63.0 vs 53.6 minutes/day, p = .007 and 6.8 vs 5.3 minutes/day, p = .041, respectively).

Identical estimates of sedentary behaviors and physical activity, but adjusted for total device wear time, are presented in Table 3. After adjusting for total wear time, both men and women showed significantly higher amounts of sedentary time on class days than non-class days (p ≤ .001 vs ≤ .001 for men and women, respectively) and on weekdays than weekends (p = .015 vs ≤ .001). In addition, women's sedentary time (71.8% [IQR 65.4-76.5]) was significantly higher than men's (67.2% [IQR 59.8-73.5]) on class days (p ≤ .001). When comparing the values of bouts moderate to vigorous intensity physical activity, men had a significantly greater amount of minutes on class days than non-class days (3.7 vs 2.8%, p = .001, respectively) whereas the opposite pattern was shown that sig-

Table 3
Summary Estimates of Sedentary Time, Bouted Moderate-to-Vigorous Intensity Physical Activity, and Accumulated PA by Class Days, Non-class Days, and Weekends Adjusted for Total Device Wear Times

Variable	Men (N = 116)			Women (N = 109)		
	Class Weekdays	Non-Class Weekdays	Weekends	Class Weekdays	Non-Class Weekdays	Weekends
Sedentary Time^a (%)	67.2 ^{b,c,d} [59.8, 73.5]	62.8 [56.7, 77.7]	60.9 [54.5, 69.9]	71.8 ^{b,c} [65.4, 76.5]	66.4 ^b [60.6, 70.2]	63.8 [56.8, 70.9]
Bouted MVPA^a (%)	3.7 ^{b,c} [1.3, 6.6]	2.8 ^b [1.3, 4.8]	0.4 [0, 3.1]	3.1 ^{b,c} [1.9, 5.9]	3.3 ^b [1.5, 4.8]	0 [0, 2.4]
Accumulated PA						
Light ^a (%)	6.9 ^{b,c} [5.1, 8.7]	6.5 ^b [4.9, 8.2]	7.4 [5.1, 9.2]	5.8 ^b [4.8, 7.2]	6.1 ^b [5.0, 7.2]	6.7 [5.5, 8.5]
Moderate ^a (%)	8.6 ^{b,c} [6.8, 11.0]	7.5 ^b [6.0, 9.1]	5.5 [3.4, 7.6]	8.1 ^{b,c} [6.0, 10.1]	6.9 ^b [5.8, 8.7]	4.5 [2.6, 6.8]
Vigorous ^a (%)	0.6 ^{b,c,d} [0.4, 1.7]	0.6 ^d [0.5, 1.2]	0.5 ^d [0.2, 0.9]	0.5 ^{b,c} [0.3, 1.4]	0.5 ^b [0.2, 0.8]	0.3 [0.1, 0.7]

Note.

N = number of participants, MVPA = moderate to vigorous intensity physical activity, PA = physical activity
 Values are medians (inter-quartile range) or means (standard deviation)

a = indicates Non-parametric variables

b = Significantly different from Weekends ($p < .05$)

c = Significantly different from Non-class Weekdays ($p < .05$)

d = Significantly different from Women ($p < .05$)

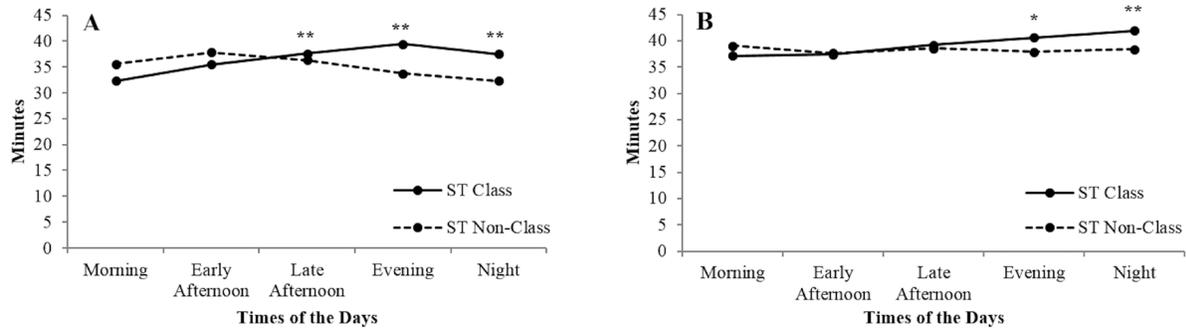
nificantly fewer minutes of moderate-to-vigorous intensity physical activity was found on class days than non-class days in women (3.1 vs 3.3%, $p \leq .001$, respectively). The amounts of moderate-to-vigorous intensity physical activity were significantly higher on weekdays than weekends for both sexes ($p \leq .001$). In regards to accumulated physical activity, the results were generally similar to unadjusted estimates, except for significantly higher accumulated light-intensity activities on weekends compared with weekdays in both men ($p = .024$) and women ($p = .004$).

Figure 1 shows the time-specific patterns of sedentary times. In general, on non-class days, the average minutes of sedentary times remained constant throughout the day in both men and women. However, on the days of class, both men and women tended to have fewer minutes of sedentary times, but not significantly different, outside of the classes during the morning and early afternoon compared with normal days (eg, non-class days), and the crossover between class days and non-class days occurred

around the time-point of late afternoon. Sedentary times on the class days were significantly higher in the late afternoon, evening, and night (except for late afternoon for women) compared to those on the non-class days for both sexes ($p < .01$).

No significant differences in demographic characteristics were found between PAC and non-PAC students (Table 4). Self-reported total leisure time physical activity among PAC students (28.7 MET h/w [IQR 12.9-46.6]) was not significantly different from the time in non-PAC students (25.3 MET h/w [IQR 11.8-43.3]) ($p = .58$). The prevalence of students meeting the aerobic activity guidelines was not also significantly different between the 2 groups (68.9% vs 66.0%). However, a large difference in percentages of students meeting muscle-strengthening activity guidelines was found between PAC and non-PAC students (95.1% vs 49.0%, respectively), which, in turn, resulted in a large difference in the prevalence of students meeting both aerobic and muscle-strengthening activity guidelines between PAC and non-PAC students (66.7% vs 38.5%, re-

Figure 1
(A) Time-specific Sedentary Times in Men on Class and Non-class Days
(B) Sedentary Times in Women



Note.

* indicates significantly different in sedentary times from non-class days ($p < .05$).

** indicates significantly different in sedentary times from non-class days ($p < .01$).

Morning indicates an averaged means of sedentary time from 9am to 11:59am, from 12pm to 2:59pm for early afternoon, from 3pm to 5:59pm for late afternoon, from 6pm to 8:59pm for evening, and from 9pm to 11pm for night.

spectively). With respect to sitting times, there were no significant differences in sitting times on both weekdays and weekends between the 2 groups (720 minutes/day vs 745 minutes/day on weekdays, $p = .38$ and 640.0 vs 672.5 minutes/day on weekends, $p = .41$ respectively).

DISCUSSION

We investigated the overall patterns of physical activity and sedentary behaviors among university students who enrolled in a PAC (ie, weight training) and the comparisons of the behaviors with non-PAC registered students in relation to the *2008 Physical Activity Guidelines for Americans*. Results suggest several significant differences in university students' physical activity and sedentary time between class days and non-class days as well as weekdays and weekends. Further, in terms of overall physical activity and sedentary behaviors outside of a PAC, it seems that the students require additional physical activity and effort to avoid sedentary behaviors for health benefits.

In our study, a weight training course was selected among the various physical activity courses for the following reasons: (1) weight training is one of the most preferred exercises (eg, weight training and

jogging) among college students;¹¹ (2) resistance training has been emphasized as a key element to a well-rounded physical activity program for overall health and function;²⁰ and (3) weight training class is one of the most commonly offered programs at many colleges and universities.²¹

Given that a lack of bouts moderate-to-vigorous intensity physical activity was performed in the weight training class, the overall estimates of moderate-to-vigorous intensity physical activity outside of the class suggest that more than half of the participants (ie, 51.7% for men and 54.1% for women) enrolled in a PAC still did not meet the aerobic physical activity guidelines. These results are consistent with results estimated from the national college population in 2013 (49.3% for men and 56.0% for women).⁴ In addition, participants' amounts of time spent in sedentary behaviors outside of the class are higher than the amounts of the normal US adult population at the same age (ages 20-29 years) (eg, 8.8 vs 7.3 hours/day for men and 9.2 v. 7.7 hours/day for women).²² Our results suggest that a PAC seems to have no further effects on promoting physical activity and reducing sedentary time beyond the class time and further support the assertions of other PE-based interventions that it is required for students to be encouraged to partici-

Table 4
Demographic Characteristics and Self-reported Sitting and Physical Activity (PA) Status Compared with the Control Group

Variables	PAC Students (N = 225)		Non-PAC Students (N = 153)	
	N, Mean or Median	%, SD or IQR	N, Mean or Median	%, SD or IQR
Age	20.4	1.8	20.6	1.9
Sex				
Men	116	51.6	81	52.9
Women	109	48.4	72	47.1
College Years				
1	10	4.5	18	11.8
2	83	36.9	52	34.0
3	68	30.2	43	28.1
4	64	28.4	40	26.1
Ethnicity				
White	81	36.0	59	38.6
African American	23	10.2	13	8.5
Hispanic	66	29.3	44	28.7
Asian	55	24.5	37	24.2
PA status				
Total Leisure PA (MET·hour/week)	28.7	12.9, 46.6	25.3	11.8, 43.3
2008 PA Guidelines for Americans				
Met aerobic activity guidelines (≥ 7.5 MET hour/week)	155	68.9	101	66.0
Met muscle-strengthening guidelines (≥ 2 times per week)	214	95.1	75	49.0
Met both guidelines	150	66.7	59	38.5
Sitting status				
Sitting on weekdays (min/day)	720.0	545.0, 855.0	745.0	600.0, 900.0
Sitting on weekends	640.0	510.0, 780.0	672.5	515.0, 892.5

Note.

N = number of participants, SD = standard deviation, IQR = inter-quartile range

pate in additional physical activity outside of a PAC to achieve recommended physical activity levels.⁷

The findings from the comparison with non-PAC students in this study also suggest the aforementioned lack of effect of PAC. For example, participants enrolled in a PAC showed no significant differences in self-reported amounts of leisure time physical activity, sitting times, and the prevalence of students meeting aerobic activity guidelines outside of the class compared with non-PAC students. However, in terms of compliance of the physical activity guidelines, our study demonstrates an apparent effect

of a weight training course on helping students meet muscle-strengthening activity guidelines, which, in turn, led to an increase in the prevalence of students meeting both aerobic and muscle-strengthening activity guidelines. For instance, participating in a weight training course resulted in substantial differences in the prevalence of students meeting both guidelines compared to not participating (66.7% vs 38.5%) in this study. These findings highlight the idea that a PAC may not be able to provide all of the required activities to meet the guidelines. Thus, integrating the physical activity guidelines into col-

lege PAC may be a potential solution to provide sufficient activities for improving health.

Day-specific investigations of physical activity and sedentary time in our study may provide insight into the patterns of the behaviors among university students. Because the estimates of physical activity and sedentary time are contingent upon device wear time (ie, more wear time higher absolute estimates), adjusting for wear time may provide more stable estimates of the behaviors.²³ The adjusted results of the current study suggest that women were more sedentary and less active on the days when they have a physical activity class compared to days of not having a class, whereas men were more active and sedentary on class days than non-class days. In fact, similar results were found from other research that individuals who exercised were about 30% less active overall on the same days compared to days they do not exercise.²⁴ The “activitystat” hypothesis, meaning the central control of physical activity based on a certain point of overall energy expenditure, could be a possible explanation for the results of more sedentary and less activity on class days.²⁵ Given that an individual’s daily physical activity levels are controlled by the brain rather than by the environment, to maintain an individual’s set point of total daily energy expenditure,²⁵ more physical activity participation during the physical activity class can be compensated by less activity at another. As male students are more likely to participate in physical activity long enough to work up a sweat than female students,²⁶ men in the current study may have a pattern of exercising on specific days in a week instead of participating in physical activity throughout the week. Moreover, both men and women were more active and more sedentary on weekdays than weekends. This finding is consistent with other previous research suggesting that different intervention strategies may be required to promote physical activity in college students.²⁷

The findings of time-specific changes in sedentary time in our study revealed different patterns of the behavior on the days of PAC compared to non-PAC days, which, in turn, could explain how the day-specific differences in sedentary time occurred. Specifically, unlike the patterns of sedentary time on non-PAC days which remained constant throughout the day, relatively lower sedentary time occurred in the morning and early afternoon (ie, corresponding to the period of physical activity classes) and

gradually increased during the rest of the day. This finding may strengthen the argument that regular exercisers may make less effort to be active beyond their scheduled exercise time.²⁴ Thus, health educators or physical activity instructors should consider the prevalence of students’ physical activity and sedentary behaviors outside of classes, and additional participation in physical activity after PAC should be encouraged for health benefits.

The strengths of this study included a relatively large sample size of college undergraduates using objective measurement. In addition, several specific data analyses based on times and days may provide a better understanding about the patterns of physical activity and sedentary behaviors. Lastly, including non-PAC students as a control group may strengthen our argument.

Despite the aforementioned strengths, several important limitations should be considered. First, we used a convenience sample of university students enrolled in a weight training course. This may limit to generalize the findings to other diverse populations or other universities. In addition, the data were obtained from the students in a weight training course only. The participants may not be representative of all college PAC students. Thus, the findings may not be generalized to college students in other PACs such as those in a jogging class. Second, objective measurement was not used for the control group to reduce participant burden. Because comparison of the group difference was not the main purpose of our study, validated questionnaires can provide sufficient information about leisure time physical activity and sitting time for this study. Third, our study includes the nature of the cross-sectional study design which precludes causal inferences between the variables. Lastly, to analyze time-specific sedentary time on PA class and non-class days, participants (N = 154) were only used who had full accelerometry data between 9am to 11pm for 5 weekdays. The findings may differ when including all participants. However, the sample size was still sufficient to identify the research question, and the findings should be acceptable.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Our results indicate that more than half of university students enrolled in a weight training course

did not achieve the recommended aerobic physical activity levels, and their amounts of time spent in physical activity and sedentary behaviors beyond their class times did not differ from those who were not involved in any PACs. Both men and women had higher amounts of sedentary time on days when they had a weight training class compared to days they did not have the class. These results reflect the increased sedentary time that occurs after class time. As our findings suggest that a physical activity course may be unable to provide sufficient recommended physical activity levels to achieve health benefits, incorporating adequate amount of physical activity levels into the college students' lifestyle may be facilitated by including the physical activity guidelines in the PAC curricular developed by instructor, department, or college (eg, encouraging students to participate in additional physical activity outside of PAC through quality intramural sports programs). In addition, a sex discrepancy was found in the patterns of moderate-to-vigorous intensity physical activity between class and non-class days. Men were more active on the class days than non-class days, whereas women exhibited the opposite pattern. It may be relevant to provide individualized or course-specific programs to maximize their effects for increasing the prevalence of persons meeting the guidelines. Future study investigating other PACs also will help to clarify this topic.

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Human Subjects Approval Statement

The Institutional Review Board of the University of Texas at Austin approved the study protocol (2013-08-0011).

Conflict of Interest Disclosure Statement

All authors of this article declare they have no conflicts of interest.

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