

Tracking 30-Day Physical Activity Behavior with Wearable Fitness Trackers in College-Aged Adults

Original Research

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Abstract

Introduction: Consumer grade, wrist-worn wearable fitness trackers (WFT) are commonly worn on a daily basis by college-aged adults. Objectively assessing college-aged adults physical activity throughout a 30-day period has not been well documented to accurately assess physical activity behavior.

Methods: Fifteen college-aged participants (male n=7 and female n=9), completed the 30-day tracking assessment while wearing a wrist-worn WFT. The WFT was worn on the non-dominant hand, per manufacture guidelines and was to only be removed to charge the battery, at night during sleeping hours.

Results: Throughout the 30 days, males accumulated more steps, expended more calories, and traveled a greater distance than their female counterparts, $p < 0.005$ for all. There were no main effects for step counts, daily caloric expenditure and daily total distance for days of the week ($p \geq 0.128$ for all). However, there was a significant sex by day of the week interaction for daily steps ($p = 0.005$), but not total calories or total distance ($p \geq 0.096$).

Conclusions: Males were more active and expended more calories than females throughout 30 days of monitoring. However, the day of the week did not significantly alter physical activity and caloric expenditure.

Key Words: daily activity, step counts, caloric expenditure

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Introduction

Wearable fitness trackers (WFT) have advanced throughout the last decade to more accurately track health and fitness metrics. Smart watches that serve as fitness trackers are tools used to track and record health habits, such as physical activity, sleep patterns, daily step counts as well as caloric expenditure¹⁻³. Tracking physical activity behavior has been found to help improve health behavior by improving health consciousness and awareness⁴. However, less is known if WFT can alter physical activity behavior, especially in a college-aged population. Prior to understanding if WFTs can alter physical activity behavior in a college-aged population, more data and information is needed to objectively assess, free-living physical activity to create a well-established baseline model at this emerging

adulthood stage of life.

The term “emerging adulthood” is defined as the college-aged years that ranges from 18-25 years old⁵. This period from high school to college and then throughout the college years are times of behavioral transitions, many of which can negatively affect long-term health^{6,7}. As college students, transition away from a more controlled environment while living at home with their parents, they have greater autonomy for daily behaviors, including positive and negative



health behaviors. Negative health behaviors are prevalent in college-aged adults and include problematic weight gain^{7,8}, high stress levels^{9,10}, physical inactivity¹¹ and low levels of quality sleep¹² among others. To address the physical inactivity aspect of negative health behaviors, detailed research is needed to investigate and objectively quantify physical activity in college-aged adults to better understand day-to-day behavior¹¹.

Several studies have found differences in physical activity between male and female college-aged adults^{11,13,14}. More specifically, males between the ages of 20-29 have been found to average nearly 18 minutes more moderate daily activity than their female counterparts¹¹. Interestingly, research also shows that college-aged adults tend to be extremely active or sedentary¹⁵. Not only are males more involved in physical activity but they tend to spend more time on electronics such as watching television and excessive seated cell phone activities as well^{5,16,17}. It has been found that college-aged adults seem to be the most active for activities such as sports or other leisure physical activities¹⁸. However, research is less clear if the college-aged adults alter physical activity behavior based on the day of the week⁹.

Therefore, the purpose of the study was to assess physical activity behavior with wearable fitness trackers for 30 days in college-aged males and females to understand physical activity patterns in a free-living environment. Objectively quantified physical activity research is sparse in college-aged adult populations and the results are limited due to gaps in methodologies as most research tracked physical activity for seven days^{11,19}. Previous studies have utilized self-reported physical activity surveys¹⁸ while others have monitored physical activity with a WFTs or accelerometers (e.g., Fitbit or hip-worn accelerometer)^{1,2,19,20}, however, only steps per day or activity counts per day with accelerometers are typically reported in these studies. Currently, to our knowledge, there is no research to quantify daily physical activity and caloric expenditure with a validated WFT for 30 consecutive days.

Scientific Methods

Participants came to the human performance laboratory and provided informed consent. Once participants provided informed consent, each participant reported their age and sex, then height and weight were measured via a stadiometer and balance beam scale, respectively. A participant was prohibited from participation based on a contraindication to physical activity. The methods for the study were approved by the university Institutional Review Board.

Once initial baseline measurements were recorded, participants were fitted with a validated, wrist-worn wearable fitness tracking device (Polar m430, Polar Electro, 2018) that measured physical activity in steps per day, daily total distance and caloric expenditure²¹. Daily total distance was estimated from the steps per day and not based on global positioning system (GPS) tracking due to ineffectiveness of GPS tracking indoors. After each participant was fitted for a device, trained research personnel assisted the participant to set up their personal profile on the wearable device manufacturer's cell phone application and cloud-based content management software (Polar Flow App, Polar Global). Syncing a wearable device to participant's cell phone was required to allow the daily data from the wearable device to be automatically uploaded to the manufacturers content management software for future data downloads. Each participant was instructed how to utilize the device to record and view daily metrics recorded for the study.

The wrist-worn wearable fitness tracker device required some recharging time. Therefore, all participants were instructed to recharge the device during down times when seated, or sleeping. Participants were instructed to wear the devices for 30 consecutive days. Throughout the 30 days, the wearable fitness tracker recorded daily physical activity metrics such as steps per day, distance, and total calories. After the 30-day monitoring period, participants were required to return the device within three days. At that time, trained research personnel ensured all data was downloaded and the device was reset to delete all identifiable information about the participant. Participants were compensated, \$50 for their participation in the study.

Statistical Analysis

Descriptive statistics (means and standard deviations) were calculated for physical characteristics and the dependent variables (daily steps, daily caloric expenditure and total distance). Distance, while similar to steps, was used to illustrate physical activity that can be applied outside of wearable devices, if need be. Independent samples t-tests were used to examine differences between sex (male, female) for physical characteristics (age, height, weight) and for overall daily steps, daily caloric expenditure and daily distance throughout the 30 day period. Sex was the between subjects variable and days of the week were the within subjects variables. Multiple mixed-effects models were used to analyze the relationship between the dependent variables (daily steps, daily caloric expenditure and daily distance) and the time variant (days of the week) and time invariant (sex) factors and interactions between these terms. Mixed-effects models were necessary due to the multiple observations and interdependence of the observations within the participants^{22,23}.



All statistics were analyzed using IBM SPSS 27.0 (Version 27.0, IBM Inc., Armonk, NY). The criterion for statistical significance was set a priori at $p \leq 0.05$.

Results

Physical Characteristics

Physical characteristics including age, height, and weight, were calculated and compared. Males were significantly taller and weighed more than females in the study ($p \leq 0.005$ for all, (Table 1).

Table 1. Physical characteristics for females and males.

	Female (n = 9)	Male (n = 7)
Age (years)	20.7 $\pm$ 0.7	21.3 $\pm$ 0.8
Height (cm)	169.9 $\pm$ 6.1	180.6 $\pm$ 4.3*
Weight (kg)	63.3 $\pm$ 8.7	84.3 $\pm$ 16.0*

Data are means $\pm$ SD

*Significant difference between sexes, $p < 0.005$ for all

Analysis by Sex

Daily steps, total calories, and total distance for each day were calculated and compared. Males accumulated significantly more daily steps, expended more calories, and traveled a total distance than females in the study ($p < 0.001$ for all, (Table 2).

Table 2. Calories, steps and distance throughout the 30-day time span by sex.

	Female (n = 9)	Male (n = 7)
Total Calories	2,363 $\pm$ 668	2,938 $\pm$ 454*
Steps (daily steps)	12,248 $\pm$ 5784	14,425 $\pm$ 6450*
Distance (miles)	4.4 $\pm$ 2.2	6.2 $\pm$ 3.0*

Data are means $\pm$ SD

*Significant difference between sexes, $p < 0.001$ for all

Analysis by Days of the Week

There were no significant main effects of days of the week for daily steps, total calories, and total distance, $p \geq 0.128$ for all, (Table 3).

Analysis by Sex and Days of the Week

There was a significant sex by day interaction for daily steps, $p = 0.005$ (Table 4). Post hoc analysis revealed that males, relative to females, only accumulated more steps on the weekends (i.e., Saturday and Sunday). There were no significant interactions or main effects for days of the week for total calories and total distance ($p \geq 0.096$ for all).

**Table 3.** Calories, steps and distance for each day throughout the 30-day time for all participants.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Total Calories	2,542 ± 622	2,620 ± 675	2,522 ± 669	2,526 ± 603	2,658 ± 697	2,733 ± 695	2,429 ± 625
Steps (daily steps)	12,645 ± 5,954	13,756 ± 5,971	12,476 ± 5,748	12,642 ± 5,540	13,471 ± 6,533	14,723 ± 6,653	11,546 ± 6,161
Distance (miles)	5.01 ± 2.48	5.35 ± 2.29	5.01 ± 3.25	4.74 ± 2.20	5.31 ± 3.01	5.44 ± 2.68	4.39 ± 2.51

Data are means ± SD. No significant differences or main effects, $p \geq 0.128$ for all

Table 4. Calories, steps and distance for each day by sex throughout the 30-day time for all participants.

	Monday		Tuesday		Wednesday		Thursday	
	Female	Male	Female	Male	Female	Male	Female	Male
Total Calories	2,254 ± 589	2,980 ± 365	2,350 ± 637	3,049 ± 493	2,307 ± 636	2,930 ± 538	2,463 ± 701	2,635 ± 369
Steps (daily steps)	10,648 ± 4,339	15,684 ± 6,837	12,694 ± 5,272	15,436 ± 6,711	11,522 ± 5,024	14,284 ± 6,691	13,881 ± 6,036	10,502 ± 3,804
Distance (miles)	3.9 ± 1.6	6.6 ± 2.8	4.5 ± 1.7	6.6 ± 2.6	4.2 ± 2.1	6.5 ± 4.4	4.7 ± 2.1	4.8 ± 2.4

Data are means ± SD. There were significant sex by day interaction for daily steps, $p = 0.005$.

Table 4. Continued

	Friday		Saturday		Sunday	
	Female	Male	Female	Male	Female	Male
Total Calories	2,489 ± 730	2,966 ± 516	2,528 ± 744	3,077 ± 432	2,113 ± 555	2,919 ± 357
Steps (daily steps)	13,059 ± 5,985	14,220 ± 7,518	13,821 ± 7,010	16,239 ± 5,847	9,675 ± 5,430	14,437 ± 6,219
Distance (miles)	4.7 ± 2.4	6.4 ± 3.6	5.0 ± 2.7	6.2 ± 2.4	3.4 ± 2.0	5.9 ± 2.5

Data are means ± SD



Discussion

The primary findings of the study indicate college-aged adults accumulated 33% more steps, an average 13,336 for daily steps, than the traditionally recommended 10,000 daily steps²⁴. Furthermore, males were 17.8% more active and expended 24.4% more calories than females throughout a 30-day time period in which the monitoring took place. In the present study the individuals wore a Polar m430 and used the manufacturer's cell phone app to track physical activity, likely resulting in slightly different actual counts than previous reports that used different WFT technology. As the devices have become more consistent and reliable²⁵ consumers may find more confidence in their physical activity and the information from WFT. The validity and reliability of the Polar m430 WFT has been studied against other WFT and research-based accelerometers^{25,26}. When compared to the waist and chest worn research-based accelerometers, the Polar m430 can be trusted to show close to valid results for energy expenditure only^{25,26}. When tracking other PA measurements, research suggests that the Polar m430 should not replace research-based accelerometers, but can be used as a source to compare PA overtime^{25,26}. One factor to consider for the differences in measurements may be the location of accelerometer. Depending on what activity PA is being measured during can impact which body part is being more active, ultimately increase or decrease tracking. While past studies have used different WFT or accelerometers, it is not advisable to provide direct comparisons of wearable data such as daily steps from one device manufacturer to another²⁶. Regardless of different devices utilized in previous research, past findings align with the current study highlighting how physical activity and energy expenditure is different between sexes, but not different based on days of the week^{11,13}.

The importance of increasing physical activity is well understood and Jayedi, Gohari, & Bidar²⁷ suggests daily increases in step counts may be associated with a decreased risk of death in adults later in life. While greater steps counts may be associated with decreased risk for death, the previous self-reported data, found physical activity and confidence to be active appears to be different based on the sex of emerging adults¹⁴. In more recent research on college-aged adults, utilizing WFT, have identified that male students engage in significantly more moderate to vigorous activity when compared to age-matched females¹⁴. A study by Keating et al.¹¹ did determine that male college-aged adults participated in more vigorous exercise than female college-aged adults while others showed no significant differences among males and females. One of the studies that found conflicting information used an extensive self-report questionnaire that focused only a few questions on physical activity measures²⁷. The other conflicting study was done using a waist worn pedometer and self-logging steps daily²⁸. The current study did find a difference in physical activity between males and females. The utilization of a more modern waist worn fitness tracker that directly counted and reported steps to an app may account for some of the differences found between sex. Another explanation for the difference between male and female physical activity could be the level of comfort in recreation centers²⁹. Wilson et al.²⁹ identified differences between sex and physical activity behaviors as females reported lower comfort using weight training areas, a perceived lack of skill to engage in weight training, and increased self-consciousness when exercising in the campus recreation centers. While physical activity can take place in locations outside of campus recreation centers, these facilities on college campuses play a pivotal role in increasing physical activity behavior, especially in places with extreme hot and cold temperatures and other adverse weather climates.

While the research objectively measured physical activity in college-aged adults during a 30-day span of time, the study is not without limitations. First, a larger sample of college-aged adults is needed to better identify if other factors can account for variations in physical activity behavior. Factors, such as age, weight status, athlete, non-athlete, exercise experience, and various levels of self-efficacy for physical activity and peer influence physical activity behavior^{16,17,30}. Regardless of the participant sample size ($n=15$), each participant recorded 30 days of activity, therefore resulting in 450 data points for each dependent variable, which is a robust sample. Another limitation to the findings is likely due to the inability of the data to be sorted based on weight status due to the limited participant sample of college-aged adults. Research should aim to assess how various weight status' individuals, sex, and fitness level can influence daily activity levels. A multifactorial approach is needed to better understand physical activity behavior and identify potential ways to intervene when aiming to promote healthy lifestyles, specifically increasing physical activity. Lastly, the time of year (i.e., temperature and weather) and the geographic location of students can influence the results when making large scale generalizations. The data was collected during the 2nd half of the fall semester at a Midwestern suburban campus. A warmer climate and or warmer months may likely alter physical behavior differently.

Results of the current study indicated that college-aged male participants significantly accumulated more daily steps, expended more daily calories, and traveled a greater daily distance when compared to college-aged female participants. The analysis on sex and day of the week revealed that male participants significantly accumulated more steps than

female participants only on the weekends. While the study assessed physical activity behavior, negative health behaviors such as binge drinking and poor nutrition were not studied and are prevalent for emerging adults as they gain more autonomy³¹ which could influence physical activity behavior. More research is warranted on the impact physical activity has on reducing those negative health behaviors. Therefore, encouraging the importance of physical activity should happen early and often during an emerging adults time at a college or university. Additionally, female students should be targeted for physical activity recommendations as they had significantly lower daily steps, expended less calories, and less total daily distance than their male counterparts.

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