Moreno et al. Journal of Interaction Science 2013, 1:4
http://www.journalofinteractionscience.com/content/1/1/4

Journal of Interaction Science
a SpringerOpen Journal

RESEARCH Open Access

Associations between internet use and fitness among college students: an experience sampling approach

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Abstract

Objective: Almost a third of college students are obese, placing them at risk for adult obesity and its complications. Internet use may be one factor contributing to college student obesity. The purpose of this study was to examine associations of college student internet use with physical activity and fitness.

Methods: Older adolescents between 18 and 23 years were recruited from a large university. Using experience sampling method, participants received 6 randomly-timed text message surveys for 7 days. Survey questions assessed whether they were currently online, for how long and current online activities. Participants also completed the International Physical Activity questionnaire and reported their body mass index. Multivariate models assessed the association of internet use with physical activity and fitness.

Results: Among 189 participants, the mean age was 18.9 (SD = 0.9), 58.8% were female and most were Caucasian (90.5%). Greater internet use was associated with fewer days per week of vigorous intensity exercise ($p < 0.001$). Participants who spent less than 1 hour/day online reported a mean of 3.2 days per week of vigorous intensity exercise (SD = 2.0), those with 3 or more hours online daily reported 1.4 (SD = 2.1). Those who reported internet activities focused on academics reported increased days of vigorous intensity exercise compared to those who reported internet activity focused on social networking sites ($p < 0.001$).

Conclusions: There were no significant associations between internet use time and BMI. Findings suggest that both online time and particular online activities may be associated with decreased vigorous physical activity. Future efforts should consider reframing internet use guidelines for this population around both time and activities.

Introduction

While college students are largely considered a healthy population, approximately 31% are overweight or obese [1]. Many adolescents who are obese during college remain obese as adults [2]. New onset obesity is also a concern because college is a period in which many older adolescents often have poor diets and are physically inactive [3-5]. Current recommendations for college student physical activity include 75 minutes per week of vigorous intensity aerobic activity [6].

One factor contributing towards college student obesity may be internet use. Initial investigations of associations between internet use and fitness have largely focused on younger adolescent populations and have shown inconsistent findings. Previous work has illustrated that decreased physical activity is associated with more time spent on the internet [7,8]. Higher levels of media exposure in general have been associated with less time doing vigorous physical activity [9]. Conversely, another study found little relationship between time spent on the internet and fitness [10].

College students have nearly ubiquitous internet access, the vast majority of students use a social networking site, and nearly half own smartphones that allow internet access [11-13]. College students have been described as the most highly connected population, as their use of nearly every technological tool is highest among all populations [14]. Students engage in a variety of online activities, including email, academic work and social

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networking sites. It has been suggested that the time college students spend using the internet may impact their physical fitness by replacing time spent on exercise. However, some types of internet use, such as academic work, could potentially increase efficiency and lead to more time for exercise. Further understanding of how internet use may impact physical activity in this population could influence health promotion guidelines for college students.

The purpose of this study was to determine college students' internet use and internet activities, and relate these to physical activity and fitness. Towards this goal, we used a novel, technology-based method for capturing Internet use intensity and activities of experience sampling method (ESM).

Methods

Setting and subjects

This study included college students from a large state university. Potential participants were recruited from a large Department of Communication class that is a requirement for several majors and a general education requirement for many departments. Inclusion criteria required students to be current undergraduates between the ages of 18 and 23 years. This study received approval from the university's Institutional Review Board.

Recruitment

Students were initially recruited to participate in a brief online health survey for extra credit in the communications class. Students in this class were given several extra credit options during the semester and could participate in up to five of these assignments. Over three-quarters of students in the class pursued at least one extra credit assignment during the semester. Among these five extra credit options, one was an online health survey that included measures of fitness and physical activity. From a classroom of 375 students, 273 participants (72.8%) completed the online survey for extra credit. We recruited all students who completed this online survey to the experience sampling method (ESM) portion of the study using email and phone calls. Inclusion criteria for this portion of the study required the student to have a cell phone with texting ability. Recent data from this university suggested that over 75% of students owned such a phone [15].

Experience sampling method

Assessing total daily internet use is challenging because of the multiple ways in which this media can be accessed, such as through smartphones, tablets and laptops, which may lead to overestimation of internet use time [16]. Experience Sampling Methodology, also called ecological momentary assessment is a method of data collection that maximizes the use of technology for measuring technology. Researchers can send electronic prompts, such as text messages, which are responded to by participants with data illustrating their current activities, actions or feelings. ESM involves multiple assessments over time that focus on an individual's current or very recent behaviors; this method is particularly effective for behaviors that occur intermittently [17-19].

This study applied ESM using short message service (SMS) text messages sent to and received from participants' cell phones. To develop the ESM program we worked with an application developer who designed and programmed an SMS survey tool web application. The survey tool was paired with a commercial communication application (Twilio, http://www.twilio.com/) designed to securely send and receive high volumes of incoming and outgoing scheduled SMS messages. Text message survey responses were recorded by the secure SMS survey tool database.

ESM procedure

Participants were randomly assigned to one of three separate 7-day ESM campaigns conducted throughout the semester. Throughout the 7-day ESM campaign each participant received a total of 43 text messages. The SMS program delivered text message surveys 6 times a day between 6:00 am and 1:00 am. One of the seven days was randomly chosen to incorporate a seventh text message survey sent overnight between the hours of 1:00 am and 6:00 am. Each day the SMS program generated a randomized schedule for each individual subject that distributed the daily text messages across six time windows of 3–4 hours, with a minimum of 20 minutes between text messages. For example, the first text message was sent within the time window of 6:00 am to 9:00 am, the second was sent during the window of 9:00 am and 12:00 pm. A return text message was considered valid data so long as it was received before the subsequent text message had been sent. If it was not received by that time, it was considered a missed response. Participants who completed the ESM portion of the study received a $10 incentive; students who responded to 75% or more text message surveys received an additional $50.

Internet use measurement

To measure daily internet use and activities with ESM, the text message surveys included three questions. The first question was, "Are you currently online?" Answer options to the first question were Y for yes and N for no. The second question was, "If so, for how many minutes have you been online?" For this second question, participants were instructed to numerically enter the number of minutes they had been online. The third question was, "What are you currently doing online?" For the

third question, participants entered all applicable options from a predetermined list included as follows:

List of internet activities
- A =academic work or homework
- B =browsing online such as shopping or reading news
- C =chatting online
- D =downloading files
- E =email
- F =Facebook or other social networking sites (SNSs) such as Twitter
- G =gaming
- H =Hulu, Pandora or other music or video streaming sites

The list was developed through a review of the existing literature on older adolescent internet use [20-22] and was piloted on a separate sample of students to ensure comprehensiveness. During pre-study testing, pilot participants reported that the online activity list was both memorable and easy to use.

The three questions appeared in a single text message as: 1) Are you currently online? 2) If so, how many minutes have you been online? 3) What are you doing online? Thus, an example of a response text was "y45ace" to indicate the participant was online for 45 minutes doing academic work, chatting and email. If the participant was not online at the time the text was received, the text response was "n."

Physical activity and fitness measurement

As part of the online survey, the International Physical Activity Questionnaire assessed physical activity over the past seven days [23]. This instrument assesses vigorous physical activities, moderate physical activities, time spent walking and time spent sitting. For each type of these four types of physical activity the average minutes of activity per day were reported. BMI was calculated by asking for self-reported weight in pounds and height in feet and inches. This instrument has been shown to have good criterion validity and reliability among college students [24].

Analysis

The purpose of this study was to determine college students' internet use and internet activities, and relate these to physical activity and fitness.

Internet use categorization

Based on their average daily time spent on internet use, participants were categorized as *low* users (< 1 hour per day), *moderate* users (1–2 hours per day), *moderately high* users (>2–3 hours per day), and *high* users (> 3 hours per day). Internet use groups were defined with respect to the calculated interquartile range, as well as clinical guidelines for adolescent Internet use and trends within the literature [25,14]. The full analysis of internet use time is described elsewhere [26].

Physical activity categorization

Using data from the International Physical Activity scale, physical activity was calculated for each of the four activity types in two ways, days per week and daily minutes. The physical activity measures (daily minutes spent on the various activities) were not normally distributed, so the outcome measures were log-transformed for conducting comparisons between groups.

Associations of internet use time with physical activity and fitness

In this section we describe analyses to assess associations between total time spent on the internet and measures of physical activity and BMI. An initial bivariate analysis related the internet use group (low, moderate, moderately high, high) to the two measures of physical activity (days per week and daily minutes) for the four activity types. A multivariate model examined associations of internet use with the number of days per week reported for each of the four physical activities. Models were adjusted for gender and race. A negative binomial generalized linear model was used to examine the association between internet use groups and the number of days per week reported for each of the physical activities. A linear contrast was used to evaluate whether there was a linear trend in the number of days of reported physical activity across the internet use groups.

To determine associations between internet use groups and BMI, an analysis of covariance (ANCOVA) model was used to compare BMI across the four Internet use groups. Gender and race (white versus non-white) were included as covariates.

Associations between internet use activities and physical activity

In this section we describe analyses to assess associations between specific internet use activities reported by participants using ESM and reported physical activity. In order to determine whether specific internet use activities were associated with physical activity days per week, we used a generalized linear mixed effects model with subject specific random effects and an autorergressive correlation structure to evaluate the association between physical activity and the probability of being engaged in each internet activity (academic, SNS, browsing, chatting, e-mail, gaming, streaming or downloading) while being online.

All P values were 2-sided, and $P < .05$ was used to indicate statistical significance. Statistical analyses were

performed using SAS software version 9.2 (SAS Institute, Cary, NC).

Results

Participants

All students who completed the survey in class were invited to participate in the ESM phase of the study, and from this population, 193 (71%) were enrolled. A total of 3 participants did not respond to any text message surveys during the ESM phase and were dropped from all analyses as non-responders. Among 190 participants who provided data, 189 (99%) completed our goal of 75% of texts completed. Overall, 93.2% (95% CI: 91.8%–94.5%) of text messages were responded to with viable data. The mean age of participants was 18.9 (SD = 0.9) years and 58.8% were female. The majority of participants were white (90.5%). Please see Table 1 for descriptive information.

College students' daily internet use measured by ESM

Participants received a total of 43 text message surveys over 7 days. Responses indicated that 28.1% (95% CI [26.5%, 29.8%]) of all measured time points the participant was currently on the internet. The median time spent engaging in internet use reported for each individual text query was 30 minutes (IQR 20–60).

Our three analysis strategies led to the following three results. First, the total unadjusted amount of daily internet use time reported on ESM data had a median of 66 minutes (IQR 30–135). Second, using multilevel modeling, the predicted average total amount of daily time spent on the internet was 56 minutes, 95% CI [51, 62]. Third, when we examined the probability that participants would respond to the text survey reporting that they were currently online, we found the average daily amount of time spent on the internet was 55.6 minutes (range 20–102 minutes).

Table 1 Demographic information

N = 190	Study sample mean (SD)/ N (%)
Age	18.9 (1.0)
Gender	
Males	79 (41.6)
Females	111 (58.4)
Ethnicity	
Caucasian/White	172 (90.5)
Hispanic/Latino	6 (3.2)
Asian/Asian American	5 (2.6)
African American	2 (1.0)
Native American/Alaskan Native	0 (0.0)
Multi-racial	5 (2.6)

Low internet users comprised 44.8% of the study population, moderate internet users made up 35.8%, moderately high internet users were 10.5% and high internet users were 8.9% of the study population. Further data regarding students' daily internet use is reported elsewhere.

Among the high internet use group, the three most common activities were SNS use, email and browsing. This was in contrast to the other three internet use groups, among whom the top three internet use activities were academics, SNS use and browsing.

College students' physical activity and BMI

Students' reported vigorous intensity exercise for an average of 2.9 (SD = 2.0) days out of 7, with a daily mean of 39.4 minutes (SD = 29.0). For moderate intensity exercise, the average was 3.1 (SD = 2.1) days out of 7, with a daily mean of 34.5 minutes (SD = 25.3). Students averaged 6.7 days per week walking (SD = 0.9), with a daily mean of 60.4 minutes (SD = 45.7). The mean number of daily hours spent sitting was 6.6 (SD = 3.1). Students' mean BMI was 22.7 (SD = 3.0), the median BMI was 22.3 (range = 16.4-40.2).

Associations of internet time with physical activity and fitness

Both the number of days per week and the number of minutes per day of vigorous physical activity were significantly associated with internet use. Participants who were categorized as *low internet users* reported a mean number of 3.2 (SD = 2.0) days of vigorous intensity exercise, while those who were *moderate internet users* the mean number of days was 2.9 (SD = 2.0). Mean number of days of vigorous physical activity declined to 2.7 (SD = 2.2) for the *moderately high internet users*, and to 1.4 (SD = 2.1) for the *high internet use* group ($p = 0.003$). Analogously, a significant negative trend in the number of minutes per day spent on vigorous intensity exercise was observed with increasing internet use. The results of this analysis are summarized in Table 2. Internet use was not significantly associated with physical activity types of sitting, walking, or moderate intensity exercise, nor with BMI.

Associations between internet activities and physical activity

Specific internet activities interacted with the internet use groups to predict physical activity. Students who demonstrated high levels of internet use focused on social networking sites were less likely to report vigorous physical activity 3 days a week ($p < 0.001$). Conversely, students who demonstrated high levels of internet use focused on academic tasks were more likely to report vigorous physical activity 3 or more days per week ($p = 0.001$) (Figure 1).

Table 2 Comparison of physical fitness measures between internet use groups

	Internet use groups				
	<1 hours (n = 85)	1-2 hours (n = 68)	2-3 hours (n = 20)	3+ hours (n = 17)	
Fitness variables	*Low internet use*	*Moderate internet use*	*Moderately high internet use*	*High internet use*	**p-value**
Sitting					
Days per week reported					0.978
M (SD)	7.0 (0.1)	6.8 (0.9)	7.0 (0.0)	6.9 (0.3)	
Daily hours					0.701
M (SD)	6.4 (3.0)	6.5 (2.6)	7.2 (3.9)	7.5 (4.1)	
Walking					
Days per week reported					0.943
M (SD)	6.6 (1.2)	6.8 (0.6)	6.9 (0.2)	6.6 (0.9)	
Daily minutes					0.080
M (SD)	51.1 (27.0)	62.6 (39.2)	70.8 (70.8)	87.9 (96.9)	
Moderate intensity exercise					
Days per week reported					0.722
M (SD)	3.4 (2.0)	3.1 (2.0)	3.0 (2.1)	2.9 (2.8)	
Daily minutes					0.056
M (SD)	35.8 (25.7)	31.8 (23.0)	38.8 (22.8)	34.4 (35.3)	
Vigorous intensity exercise					
Days per week reported					0.003
M (SD)	3.2 (2.0)	2.9 (2.0)	2.7 (2.2)	1.4 (2.1)	
Daily minutes					0.008
M (SD)		40.3 (26.8)	38.0 (28.2)	20.9 (24.1)	

Discussion

Study findings illustrate a significant negative association of high internet use with both the number of days per week and daily minutes of vigorous physical activity. Our findings are consistent with previous work that suggested high levels of media exposure were associated with lower vigorous physical activity. One possible explanation for these findings is that vigorous exercise often requires planning or organization efforts that could be forestalled by excess time on the internet. These results are significant given that vigorous physical activity is associated with decreased risk of cardiovascular disease, even compared to exercise such as walking [27].

Our findings suggest that it is not just the amount of internet use that impacts fitness behaviors, but how the internet is used. Specifically, students whose high internet use featured frequent social networking site activities were less likely to report vigorous physical activity 3 days a week. Conversely, students whose high levels of internet use focused on academic tasks were more likely to report vigorous physical activity 3 or more days per week. Perhaps students who have goal-oriented internet use towards academic tasks are also better able to plan and achieve their physical activity goals. Alternatively, higher use of social networking sites may be an activity that uses time that would have been spent towards other activities such as fitness. Further work is needed to understand these relationships.

We did not find a significant relationship between internet use and time spent sitting, walking or moderately exercising. The lack of association found with walking or moderate intensity exercise could be related to limited variability in these measures due to the transportation habits of the college population, as many students either walk or bike on campus. While this is reassuring in the current study context, it raises questions about whether students will be able to maintain high rates of walking or moderate intensity exercise after college. The benefits of exercising through walking on biking on campus may be lost once these students transition into lives that involve commuting to work by car, yet their internet use patterns may continue for decades. This raises additional concerns about the potential impact of internet use once the protective effects of walking or biking decrease after college.

Our study is limited in that we only examined students from one class at a single university. In order to maximize generalizability, we selected a large class that draws from multiple majors and is a general education requirement for several academic programs. The demographic characteristics of our sample were consistent with that of the university, and the mean BMI of participants in

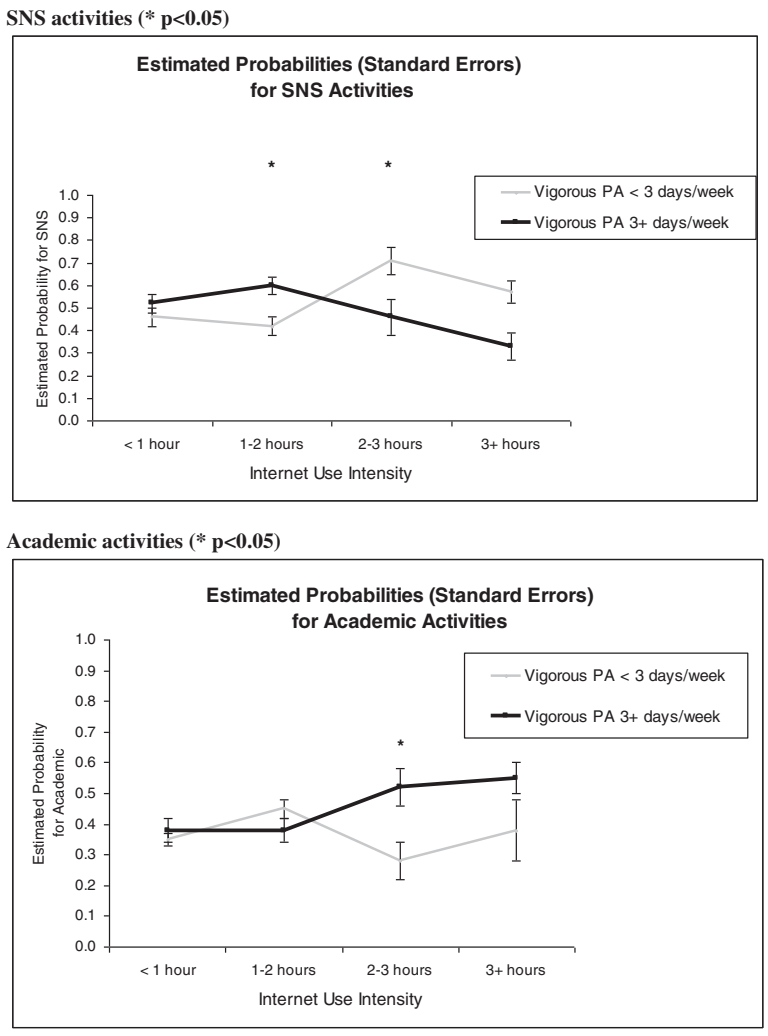

Figure 1 Association between vigorous physical activity (PA) and internet use intensity for two online activities: SNS and academics. Association between vigorous physical activity (PA) and internet use intensity for academic activities while being online (* $p < 0.05$).

our study was similar to that found in previous work [24]. Findings are also limited as the initial approach of providing extra credit to participants for completion of the online survey may have biased our study sample; however, over three-quarters of the class participated in at least one extra credit opportunity. Self-selection in completing a survey of physical activity and BMI may have biased our study sample; those who were less active may have been less likely to participate. This could be a contributing reason for the lack of association between BMI and internet use. While our study did not show impact on BMI, physical activity is likely an upstream determinant of BMI. For many of our participants, we may not yet have seen impact of their BMI but they have evidence of decreased vigorous activity. Further, future studies focused on populations of students who are already overweight or at risk are needed to further understand this relationship among an at-risk population. Also, future studies could consider adding an objective physical activity measure, such as a pedometer, towards a more comprehensive fitness measurement. Future studies could also consider investigating other factors that may have impacted student physical activity, such as distance between home and campus.

Despite these limitations, our study has important implications. Further consideration of guidelines for appropriate internet use may be beneficial for college students. The American Academy of Pediatrics (AAP) internet use guidelines for adolescents recommend two hours a day of recreational internet use; however these recommendations may be better suited to younger teens. Our study illustrates that among college students, internet use that exceeds 3 hours a day was associated with decreased

vigorous exercise. Further, high levels of recreational internet use, such as on SNS, were more likely to be associated with infrequent vigorous physical activity compared to internet use for academic purposes. This may provide evidence towards developing specific recommendations for internet use and activities among this age group. A prior study found that an intervention to reduce television viewing was found to lower BMI among adolescents [3].

Finally, it is worth considering whether there are ways to link college students' internet use with encouragement towards fitness efforts. Our study found that use of SNS was associated with decreased likelihood of vigorous exercise 3 days per week. It is possible that university health service efforts could place prompts within social media platforms to encourage exercise among high internet users. Previous work suggests that incorporation of technology into fitness interventions in this population may be both feasible and effective [28].

Conclusion

Study findings illustrate a significant negative association of high internet use with both the number of days per week and daily minutes of vigorous physical activity. Almost 10% of participants in our study met criteria as high internet users, these participants may be at higher risk of obesity and its complications if their internet use behaviors persist. Our findings suggest that particular internet use activities interacted with internet use to predict lower physical activity patterns. These findings have implications for shaping internet use recommendations for this population.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MAM, MD, MSEd, MPH: Conceptualized and designed the study, supervised analysis, drafted the manuscript. LJ, MPH: Contributed to study design, supervised data collection, participated in analysis, edited the manuscript. RK, BS: Participated in recruitment and data collection, contributed to analysis, contributed to manuscript. JE, PhD: Led analysis, edited manuscript. NG: Participated in drafting and editing manuscript. AED: Participated in data collection and manuscript editing. HNY, PhD: Participated in analysis and manuscript editing. EDC, MD, PhD: Participated in analysis and manuscript editing. DAC, MD, MPH: Participated in conceptualizing the study as well as manuscript drafting and editing. All authors read and approved the final manuscript.

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Received: 5 April 2013 Accepted: 9 July 2013
Published: 9 August 2013

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doi:10.1186/2194-0827-1-4
Cite this article as: Moreno *et al.*: Associations between internet use and fitness among college students: an experience sampling approach. *Journal of Interaction Science* 2013 **1**:4.