

Developmental Psychology

Binge Eating and Health Behaviors During Times of High and Low Stress Among First-year University Students

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The current study examined the influence of physical activity and sleep on binge eating during times of typically higher- and lower-stress over the academic year ($n=394$, $M_{age}=18.6$). First-year undergraduate students completed surveys of physical activity, sleep, and binge eating behaviors across four waves spanning the academic year. Results of multilevel models revealed relatively stable binge eating scores across the academic year. We found no robust associations between physical activity or sleep and binge eating during times of high and low stress. Small effects in this study, consistent with other non-clinical samples, highlight that eating behaviors are resistant to change.

Binge eating disorder (BED) is the most prevalent and chronic eating disorder among 15- to 24-year-olds in Canada and the United States (Hudson et al., 2007; National Eating Disorder Association, 2021), forecasting future psychosocial problems such as social isolation and depression (Mason & Heron, 2016). Peak rates occur between the ages of 18 and 20 (McVey, 2014) and in high numbers on university campuses (Lipson & Sonnevill, 2017; Tylka & Subich, 2002). In a sample of U.S. college students 13.5% of women and 3.6% of men reported disordered eating behaviors and attitudes, such as loss of control while eating, and eating until physically uncomfortable (Eisenberg et al., 2011). Among women in first-year university, vulnerability to eating problems and difficulties associated with the transition to university increases the likelihood of students reporting binge eating symptoms (Barker & Galambos, 2007). Physical activity and good quality sleep are associated with fewer binge eating symptoms (Blanchet et al., 2018; Quick et al., 2016), but most university students' physical activity and sleep habits are inadequate (Hardcastle et al., 2015). Sleep and physical activity may mitigate binge eating behaviors in students who are particularly vulnerable to disordered eating and poor health during the transition to university, but it might be difficult to maintain health behaviors that protect against binge eating behaviors during more intensive times of the academic year. However, longitudinal research examining such associations is lacking. In a longitudinal study, we test whether binge eating is associated with physical activity and sleep in first-year un-

dergraduates, and whether these associations strengthen or weaken across the academic year.

Binge eating and health during the transition to university

Binge eating is generally defined as a loss of control while objectively overeating to a point of physical discomfort and emotional distress (Hilbert et al., 2011; National Eating Disorder Association, 2021; Sysko et al., 2012). It is a response directed toward managing difficult emotions and regulating stress (McManus & Waller, 1995), such as during key developmental transitions. Clinical and subclinical binge eating behaviors are associated with poor psychosocial outcomes such as anxiety and depressive symptoms (Kessler et al., 2013), social impairment (Kessler et al., 2014), and weight and shape concerns (Wilfley et al., 2003). First-year university students, facing a confluence of developmental milestones, may be at particularly high risk for binge eating behaviors. Their stressors include forming new social groups, taking on financial responsibilities (e.g., paying tuition, rent, groceries), new academic demands, and for some students, balancing work and school (Joo et al., 2008; Murphy & Archer, 1996). For example, students who report high stress before an exam are more likely to consume larger amounts of food on exam days (Costarelli & Patsai, 2012; Macht et al., 2005). Binge eating appears to be an effective maladaptive coping mechanism for dealing with unpleasant emotional states (Berg et al., 2017; Mason et al., 2021). Daily health behaviors may serve to lessen

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binge eating behaviors as an outlet for managing negative affect and stress in university students. However, general physical health tends to decline in first-year university; unhealthy eating, poor sleep, and physical inactivity are common in undergraduate populations (Calamidas & Crowell, 2018; Papaconstantinou et al., 2020; Wilson et al., 2020). When under stress, people deviate from healthy routines such as adequate sleep and physical activity (O'Connor & Conner, 2011; Torres & Nowson, 2007). For first-year students not accustomed to the academic demands of university, declines in physical health at stressful times of the academic year may contribute to elevated rates of binge eating behaviors.

Sleep and binge eating

Half of university students do not meet sleep recommendations for overall health and well-being (i.e., 7-9 hours per night; Papaconstantinou et al., 2020), leading to reduced physical and mental health (Lund et al., 2010). A multi-national study found that post-secondary students who experienced a decline in sleep quality in college were at higher risk for engaging in disordered eating behaviors (Du et al., 2021). One explanation for this is that a lack of quality sleep impacts metabolic hormones that regulate hunger and satiety cues which can lead to increased energy intake (Chaput et al., 2007; Taheri et al., 2004). Poor sleep also tends to occur in tandem with high stress (Doolin et al., 2018), and thus may be more likely at the end of a semester when workloads are higher and stressors peak. Whether the association between sleep quantity and quality and binge eating behaviors is stronger at these times of the academic year is an open question.

Physical activity and binge eating

Like most of the general population, university students do not meet daily recommendations of 150 minutes of moderate to vigorous physical activity per week (Biddle et al., 2019; *ParticipACTION Report Card on Physical Activity for Adults*, 2021; Román-Mata et al., 2020). Nearly two thirds of undergraduate students in one study were inactive (Papaconstantinou et al., 2020), and declines in physical activity that occur in the transition from high school to university persist across students' degree programs (Wilson et al., 2020). Physical activity has been identified as a possible mechanism for improving binge eating behaviors because of its impact on mood, cravings, and mental health (Beaulieu et al., 2016; Drenowatz et al., 2017; Mochovitch et al., 2016). Indeed, students who engage in more physical activity report experiencing lower stress (VanKim & Nelson, 2013), and exercise-related reductions in stress may help to reduce binge eating behaviors that are often a response to negative affect. Physical activity may be especially beneficial in reducing binge eating at the end of semesters, when students face higher-intensity academic demands such as term papers and final exams.

The Current Study

In sum, there is evidence that physical activity and sleep are related to binge eating but whether there are protective advantages to maintaining these health behaviors during times of the academic year that are typically higher stress is unclear. Our goals are to measure variation in binge eating behaviors across the first year of university, to test whether sleep and physical activity are associated with binge eating, and to test whether these associations are stronger or weaker at times of the year that are typically higher- and lower- stress. We expect that (1) binge eating behaviors will be worse in late November and March (ends of semester) compared to September and January (starts of semester); (2) students getting more physical activity and sleep will engage in the fewest binge eating behaviors overall, as well as during the more challenging end-of-semester periods of the academic year, and; (3) exercising and sleeping more and better than usual will be associated with fewer binge eating symptoms, and that these associations will be stronger at the ends of each semester. Preregistered research questions and analysis plans are available at <https://osf.io/fk7pc>.

Method

Participants and Procedure

Data for the current study were drawn from a longitudinal study tracking success and well-being in first-year university students during the transition to university. Students were recruited during orientation week in September 2019. Recruiters handed out postcards and candy around campus, inviting students to complete an online eligibility survey. Eligible students were in their first year of any post-secondary education, studying full-time, and under 20 years old.

Eligible students who provided contact information were invited to complete an intake survey for which they received a \$10 amazon.ca gift code and were entered into a draw to win a \$100 amazon.ca gift code. The final sample comprised 510 students, an 85% participation rate among those who were screened as eligible respondents. We invited 481 students who consented to be re-contacted to complete follow-up surveys in November 2019, and January and March 2020. Students were offered a \$10 gift code for each follow-up survey they completed and an additional \$10 bonus for those who completed all four surveys. To improve retention, students were offered a \$20 gift code for the March 2020 survey. The sample for the current study is a subset of these participants ($n=394$) who responded negatively to three past-year household food security screening questions. Only students who responded "never" to questions such as "we worried whether our food would run out before we got money to buy more" were subsequently shown questions about binge eating behaviors.¹ Retention for this subsample was high with 80% of the subsample participating in November ($n=315$), 74% in January ($n=293$), and 80% in March ($n=314$).

Measures

Demographic variables

Sociodemographic characteristics were assessed at intake including age, international student status, first generation student status (i.e., anyone who declared being the first person in their family to go to university or first in family except for a sibling), race/ethnicity, current living situation (with parents, on campus in residence, or off-campus), university-educated parents (whether at least one parent has a university degree), and combined parent income (ranged from 1 [less than \$5,000] to 12 [\$200,000 or greater]). Gender was also queried but due to survey error this was not collected during the intake survey, resulting in missing gender identities for 14.5% of participants in the present study subsample ($n=57$). For data retention within our analyses, we coded participants based on high correspondence between their first name and genders assigned to baby names in the province of Ontario from 1999-2003 (birth years consistent with the age range for this sample). Names that were not associated with a single gender at least 95% of the time were coded as “Neither/unknown”. This procedure is documented in Howard, Carnrite, and Barker (2022). We were able to assign 48 participants Male or Female codes for data retention purposes, and 9 participants were coded as unknown. We do not presume that all assigned codes match each person’s gender identity, and we took this approach only as a strategy to preserve the data in the analyses. Sample descriptive statistics only reflect self-declared gender identities.

Binge eating

Binge eating behaviors were assessed using the binge eating subscale of the *Minnesota Eating Behavior Survey* (von Ranson et al., 2005). Participants responded to 7 statements about their eating behaviors (e.g., “I eat lots and lots of food and feel like I can’t stop”) using a 5-point scale ranging from 1 (*never*) to 5 (*always*). The purpose of this measure is to capture the behaviors and attitudes associated with binge eating behaviors – not to diagnose BED. This scale has acceptable internal consistency (Cronbach’s $\alpha = .78$) and has demonstrated good convergent validity with other disordered eating scales (e.g., Eating Disorder Inventory; von Ranson et al., 2005). Prior to analyses, we verified the factor structure of this subscale using exploratory factor analysis (EFA) at each time point. Results supported a unidimensional structure with high factor loadings at all follow-up time points (results in Supplement 2, <https://osf.io/7bajk/>). At baseline there was adequate support for a single-factor structure and some indication of a two-factor structure that relied on two items about solitary binge eating that cross-loaded on both factors. Taking

all EFA results into consideration, unidimensionality was supported and items were averaged to form mean scores of binge eating behaviors at each assessment point. Higher scores reflect more frequent binge eating behaviors (McDonald’s Omega ranged from 0.86 to 0.91 across time points).

Physical activity

Moderate and vigorous physical activity were measured using two self-report items assessing frequency in a typical week (e.g., “...on how many days do you do vigorous physical activities for at least 10 minutes at a time?”). *Moderate* activities were described as those that “take moderate physical effort and make you breathe somewhat harder than normal (like a brisk walk or bike ride)”. *Vigorous* physical activities were described as those that “take hard physical effort and make you breathe much harder than normal (like jogging or cross-country skiing)”. Items were modified from the *International Physical Activity Questionnaire* (Craig et al., 2003), a scale validated against accelerometer data and showing acceptable reliability (intraclass correlation coefficients ranging from 0.71 to 0.89; Dinger et al., 2006). Participants could report frequencies of between zero and seven times per week. Moderate and vigorous physical activity were retained as separate variables.

Sleep

Participants were asked to estimate “on a typical night, how many hours of *actual sleep* do you get? This may be different from the number of hours you spend in bed.” This text response question permitted numeric entries between 0 and 24 and is adapted from a question on the Pittsburgh Sleep Quality Index (Buysse et al., 1989). Sleep quality during the past two weeks was measured with a single item (e.g., “During the past two weeks, how would you rate your sleep quality overall?”). Participants indicated their level of sleep quality using a four-point scale from 1 (*Very bad*) to 4 (*Very good*). Single-item test-retest reliability ranged from 0.65 to 0.84 during scale development.

Coding for Time

We created three effects codes to isolate mean differences at times during the semester that are typically lower- and higher-stress. One code contrasted the two semesters (Fall=-1 vs. Winter=1) and two codes contrasted the beginning versus end of each semester (September=-0.5 vs. November=0.5, else=0; and January=-0.5 vs. March=0.5, else=0). Effects coding strategies are described in Cohen, Cohen, West, & Aiken (2003, pp. 320–322).

1 We recognize that binge eating behaviors also affect people who cannot afford food. The study from which these data were drawn required decisions to ensure manageable-length surveys with modest respondent burden and high engagement. One such decision was to limit questions about binge eating to the more homogeneous subset of students not experiencing food insecurity.

Analysis Plan

We used multilevel linear modeling of repeated measures nested within persons to test whether physical activity (PA) and sleep were associated with binge eating behaviors during the first year of university, and to test whether these associations differed at times of high and low stress. Models adjusted for demographic covariates and tested within- and between-person effects of physical activity and sleep. Sleep and physical activity were included in models as person-mean centered time-varying predictors (within-person effects; Enders & Tofghi, 2007) and person means (between-person effects). Within-person effects tested whether *higher than usual* physical activity is associated with more or less binge eating; whether *more than usual* sleep is associated with more or less binge eating; and whether these associations vary over time (interactions with codes for time). Between-person effects tested whether students who generally engaged in more physical activity and slept more tended to engage in more or less binge eating, and whether these general effects varied over time (tested as interactions with codes for time). We corrected for multiple comparisons with the Benjamini-Hochberg False Discovery Rate procedure. Analysis plans for this study were preregistered (<https://osf.io/fk7pc>). Deviations from our preregistered protocol were minimal and are noted in text.

Missing data handling

We examined differences in cases with complete versus incomplete data for relevant baseline measures. In our subsample, 93.9% completed the binge eating measure at least once over the school year ($n=370$), and 63.5% completed the binge eating measure at all four waves ($n=250$; $n=47$ completed 3 waves, $n=31$ completed 2 waves, and $n=42$ completed one wave). Complete versus incomplete cases did not differ on baseline demographics or key variables for the baseline, January, and March time points. At the late November follow-up, younger participants were more likely to be missing. Overall, findings support the *missing at random* (MAR) assumption and we used full information maximum likelihood estimation in all models.

Results

Means, standard deviations, sample sizes and percentages are reported for demographic and key variables in [Table 1](#). The sample was gender balanced (54.3% Female [$n=183$]; 45.4% Male [$n=153$]; 0.3% Neither or other gender [$n=1$]; $n=57$ missing gender information) and ethnically diverse: 5.1% self-identified as Black, 2.5% as Indigenous (First Nations, Métis, or Inuit), 2.5% as Latinx, 10.4% as Southeast Asian, 13.5% as South Asian, 4.8% as West Asian/Middle Eastern, 53.0% White, 0.8% as other, and 7.4% as

multiple ethnicities. Ages ranged from 16.4 to 19.9 ($M=18.60$, $SD=0.48$). Average combined parent income was \$124,749,² close to median two-earner family income reported in the province of Ontario (Munger et al., 2016) and 72.1% had at least one parent who was university educated. 55.6% of students lived in residence ($n=219$), 36.3% lived at home ($n=143$), and 8.1% lived off-campus away from parents ($n=32$). 7.1% of students self-identified as international students, and 19% as first-generation students. A table with correlations and summary statistics for key variables is available on our OSF project page (<https://osf.io/7bajk/>).

Hypothesis 1: Changes in binge eating across semesters

Our first hypothesis was partially supported. Binge eating increased from September to the end of first semester, indicating that binge eating behaviors are significantly worse at the end of the Fall semester compared to the beginning ($B=0.09$, $SE=0.04$, $CI_{95\%} = 0.01, 0.16$, $p=0.02$). This association remained significant with covariates in the model ($B=0.08$, $SE=0.04$, $CI_{95\%} 0.01, 0.16$, $p=0.03$). There was no significant difference in binge eating behaviors during the Winter semester nor generally between Fall and Winter semesters ($B=-0.06$, $SE=0.04$, $CI_{95\%} -0.14, 0.02$, $p>0.05$; $B=-0.02$, $SE=0.01$, $CI_{95\%} -0.05, 0.01$, $p>0.05$). On average, binge eating increased by 0.12 points from September to November ([Figure 1](#)). Although statistically significant, this rate of change is likely not meaningful. To illustrate, consider that a person who reports “never” on all seven binge eating symptoms will have a mean score of 1. A person who reports “never” on 6/7 items and reports “rarely” on 1/7 items will have a mean score of 1.14. This difference of 0.14 between our two hypothetical respondents is the *minimum possible change* that we can measure with this scale, and it is greater than our model-estimated difference of 0.12 from the beginning to end of the Fall semester.

Hypothesis 2: Between-person effects of physical activity and sleep

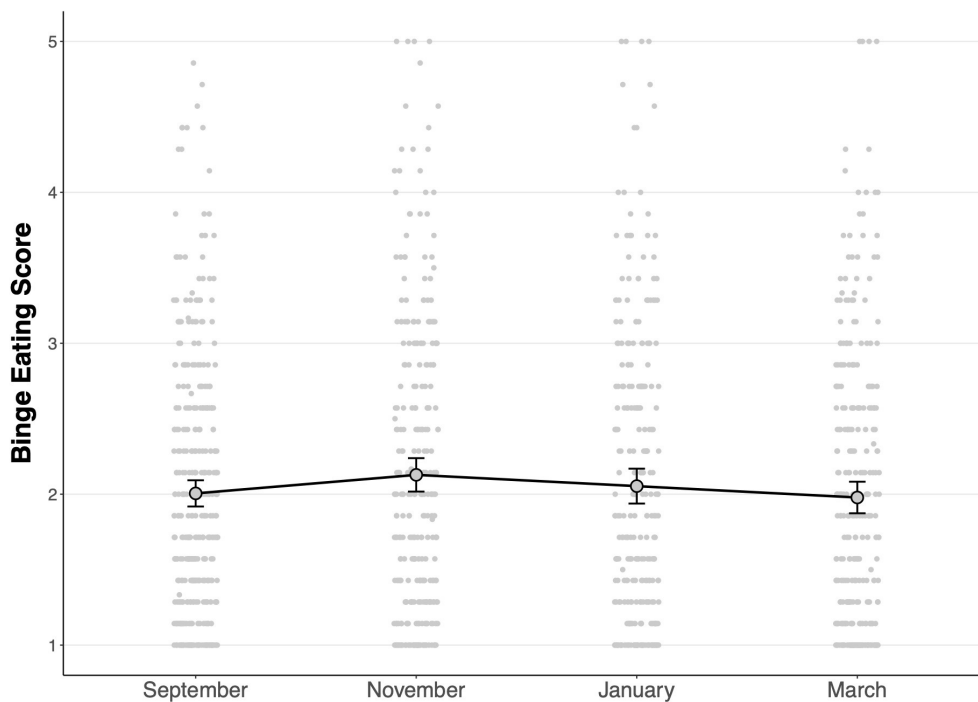
[Table 2](#) shows between-and within-person effects of physical activity and sleep on binge eating behaviors over the academic year. Our second hypothesis was not supported. After controlling for covariates, students getting more physical activity and sleep compared to other students (between-person), did not report engaging in fewer binge eating behaviors in general, nor during the more challenging end-of-semester periods of the academic year. None of the time interactions with between-person vigorous physical activity, moderate physical activity, sleep, or sleep quality were significant so these were not retained in final models (see Supplement 1; <https://osf.io/7bajk/>).

2 Extrapolated estimate from $M=8.99$ on our 12-point income scale. See Howard et al., 2020.

Table 1. Means, Standard Deviations (SD), and valid responses (n) for continuous variables

	September M (SD)	Late November M (SD)	January M (SD)	March M (SD)
Binge Eating	2.01 (0.84)	2.13 (0.97)	2.05 (0.98)	1.98 (0.93)
Vigorous PA (days/wk)	2.26 (2.11)	1.60 (1.89)	1.93 (1.92)	2.04 (1.96)
Moderate PA (days/wk)	4.18 (2.13)	3.55 (2.16)	3.72 (2.14)	3.17 (2.22)
Hours of Sleep	7.03 (1.04)	6.48 (1.32)	6.70 (1.36)	7.24 (1.40)
Sleep Quality	2.80 (0.67)	2.57 (0.72)	2.65 (0.70)	2.76 (0.70)
<i>n</i>	364-372	299-311	279-289	303-309

n=sample size range across measures for each time point; PA=physical activity.

**Figure 1. Means and confidence intervals for each time point with raw data**

Binge eating scores between-persons were highly similar no matter the number of days of moderate or vigorous physical activity that students reported. To illustrate, [Figure 2](#) shows that across every level of moderate and vigorous physical activity, students' binge eating behaviors were similarly distributed, with the most frequent scores appearing on the low end of the scale (e.g., binge eating=1). There is a slight bimodal trend with moderate binge eating scores (e.g., binge eating=3) being frequent as well. Overall, few people endorsed binge eating behaviors on a regular basis, and this pattern was consistent across the academic year.

Hypothesis 3: Within-person effects of physical activity and sleep

Our third hypothesis was not supported: engaging in more physical activity and sleep than usual was not associated with fewer binge eating symptoms (see [Table 2](#)). The effect of within-person moderate physical activity was no longer significant after correction for multiple testing using the Benjamini-Hochberg False Discovery Rate procedure

(Benjamini & Hochberg, 1995). Results did not differ based on time of measurement during Fall or Winter semesters.

Exploratory Analyses: Gender interactions

Given the literature on gender differences in binge eating and health behaviors, we examined interactions of hours of sleep, sleep quality, and moderate and vigorous activity with gender (Dawson et al., 2007; Galland et al., 2017; Janse van Rensburg & Surujlal, 2013). These interactions were exploratory in nature and were not part of our pre-registered analysis plan (see Supplement 2, <https://osf.io/7bajk/>, for a brief summary of measurement invariance testing conducted between male and female respondents on the binge eating scale). As shown in [Table 3](#), there were no significant interactions between sleep variables, and moderate physical activity and gender. We detected significant interactions for between- and within-person vigorous physical activity and gender. This model was repeated coding all missing gender identities as "unknown", and the in-

Table 2. Multilevel Models of the impact of Vigorous and Moderate activity, Hours of sleep and sleep Quality on Binge eating

	Without Covariates		With Covariates	
	Est (SE)	95% CI	Est (SE)	95% CI
Vigorous Physical Activity Model				
Intercept	2.03 (0.04)**	1.94, 2.11	2.29 (0.21)**	1.89, 2.70
Vigorous PA _{BP}	-0.07 (0.02)**	-0.13, -0.03	-0.05 (0.03)	-0.10, 0.002
Vigorous PA _{WP}	-0.02 (0.01)	-0.04, 0.003	-0.02 (0.01)	-0.04, 0.01
Fall semester	0.07 (0.04)	-0.005, 0.15	0.08 (0.04)	-0.003, 0.15
Winter semester	-0.05 (0.04)	-0.13, 0.03	-0.06 (0.04)	-0.14, 0.02
Fall vs Winter	-0.02 (0.01)	-0.05, 0.01	-0.02 (0.01)	-0.05, 0.01
Moderate Physical Activity Model				
Intercept	2.02 (0.04)**	1.94, 2.11	2.31 (0.21)**	1.90, 2.71
Moderate PA _{BP}	-0.04 (0.03)	-0.09, 0.01	-0.02(0.03)	-0.07, 0.03
Moderate PA _{WP}	-0.02 (0.01)*	-0.04, -0.01	-0.02 (0.01)†	-0.04, -0.003
Fall semester	0.07 (0.04)	-0.01, 0.14	0.07 (0.04)	-0.01, 0.15
Winter semester	-0.06 (0.04)	-0.14, 0.02	-0.07 (0.04)	-0.16, 0.01
Fall vs Winter	-0.03 (0.01)	-0.05, 0.001	-0.02 (0.01)	-0.05, 0.004
Hours of Sleep and Sleep Quality Model				
Intercept	2.02 (0.04)**	1.94, 2.11	2.35 (0.21)**	1.94, 2.75
Hours Sleep _{BP}	0.02 (0.05)	-0.08, 0.12	0.04 (0.05)	-0.06, 0.14
Hours Sleep _{WP}	-0.02 (0.02)	-0.06, 0.02	-0.02 (0.02)	-0.06, 0.02
Sleep Quality _{BP}	-0.21 (0.10)*	-0.41, -0.02	-0.17 (0.10)	-0.36, 0.03
Sleep Quality _{WP}	-0.02 (0.03)	-0.07, 0.04	-0.03 (0.03)	-0.09, 0.04
Fall semester	0.07 (0.04)	-0.01, 0.14	0.07 (0.04)	-0.01, 0.15
Winter semester	-0.03 (0.04)	-0.11, 0.05	-0.04 (0.04)	-0.12, 0.04
Fall vs Winter	-0.02 (0.01)	-0.05, 0.01	-0.02 (0.01)	-0.05, 0.01

**p<.01 *p<.05; p† not significant after Benjamini-Hochberg correction;

Note. The model with covariates includes participant age, international student status, first-generation student status, male gender, and neither/unknown gender, ethnicity, if at least one parent is university educated, combined parent income, and living situation. Significant covariates of higher binge eating symptoms included identifying as female or neither/unknown, identifying as South-East Asian, having parents with higher combined income. n=370-372 for models without covariates; n=343-345 for models with covariates; Subscripts: BP=between-person effect; WP=within-person effect; PA=Physical Activity.

teraction with gender and between-persons vigorous activity was no longer significant (p=0.06). Probing the interactions, we found that women who engaged in *more vigorous physical activity on average* reported fewer binge eating behaviors (B=-0.11, SE=0.04, CI_{95%} -0.19, -0.03, p=0.007). There was no significant between-persons effect of vigorous physical activity for men. However, within-person, men who engaged in *higher than usual vigorous physical activity* reported fewer binge eating behaviors (B=-0.04, SE=0.02, CI_{95%} -0.08, -0.01, p=0.01). Participating in more vigorous physical activity than usual was not associated with binge eating behaviors in women.

For the largest effect of between-person vigorous physical activity on binge eating in women, we used an equivalence testing approach (Lakens et al., 2018) to visualize the size of the effect. In Figure 3, the rightmost vertical reference line is placed at zero. The dotted reference lines represent effects equal to the *minimum possible* difference measurable on the binge eating instrument (defined earlier as 0.14 units) and the size of a *reduction in one full symptom* (i.e., changing endorsement of one symptom from “always” to “never”). Figure 3 shows that the confidence interval for

Table 3. Results of Final model for the effect of Vigorous Physical Activity on Binge eating behaviors

	Est (SE)	95% CI
Intercept	2.32 (0.21)*	1.91, 2.72
Fall semester	0.08 (0.04)	-0.002, 0.16
Winter semester	-0.06 (0.04)	-0.14, 0.02
Fall vs Winter	-0.02 (0.01)	-0.05, 0.01
Vigorous PA _{BP}	-0.11 (0.04)**	-0.18, -0.03
Vigorous PA _{WP}	0.01 (0.02)	-0.03, 0.05
Vigorous _{BP} x Gender	0.11 (0.05)*	0.01, 0.21
Vigorous _{WP} x Gender	-0.05 (0.03)*	-0.11, -0.004

**p<.01 *p<.05;

Note. The model covariates include participant age, international student status, first-generation student status, male gender, and neither/unknown gender, ethnicity, if at least one parent is university educated, combined parent income, and living situation. Significant covariates of higher binge eating symptoms included identifying as female or neither/unknown gender, and having parents with higher combined income; PA=Physical Activity.

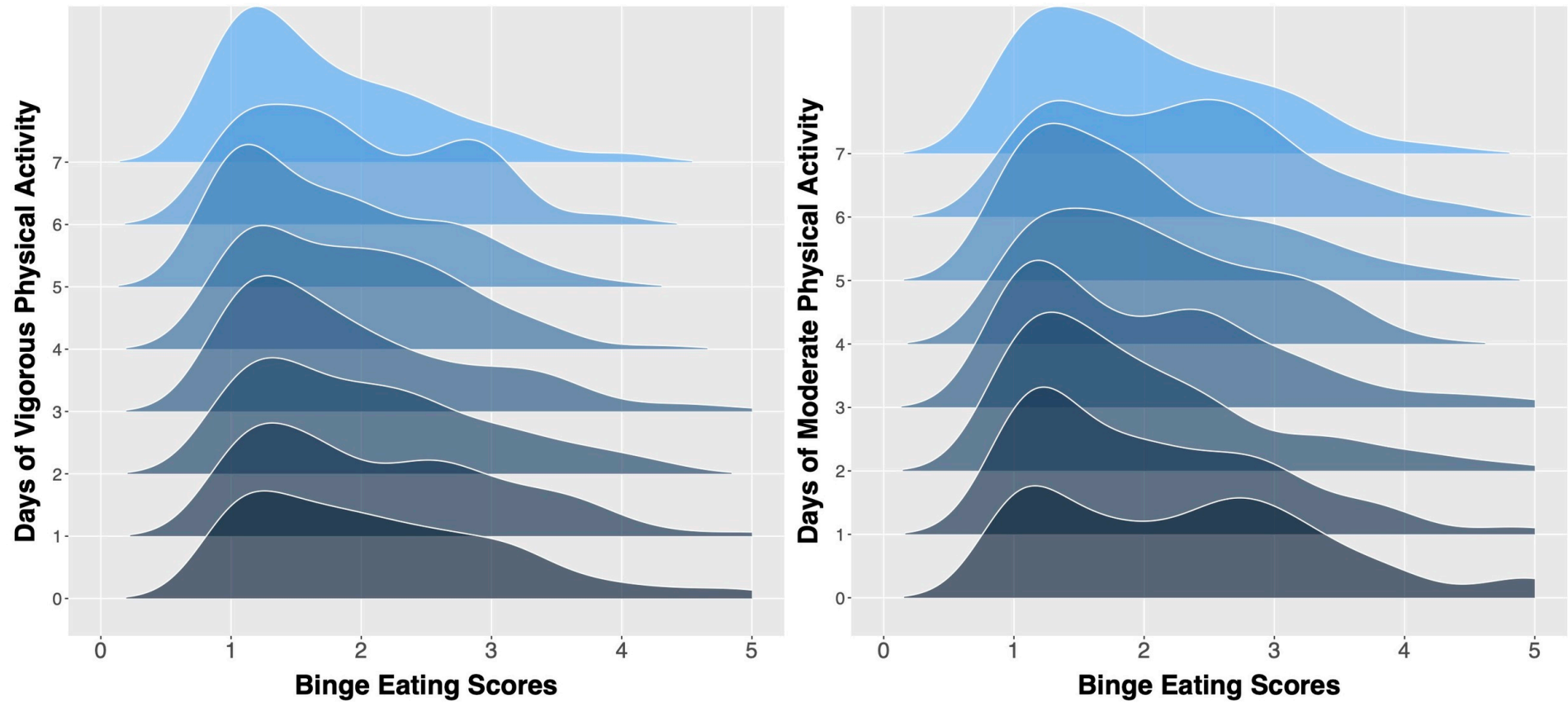


Figure 2. Density distributions of binge eating scores at each number of days of vigorous (Panel A) and moderate (Panel B) physical activity

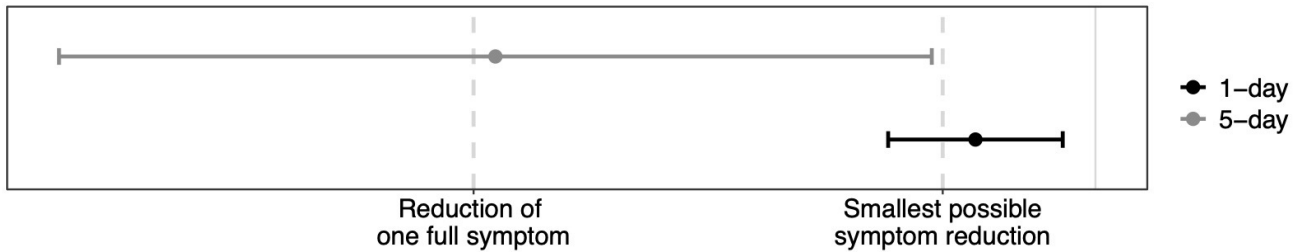


Figure 3. Equivalence test for the between-person effect of vigorous activity on binge eating for participants coded as Female

a one-day change in vigorous physical activity does not cross zero (indicating that this effect is significantly different from zero) and contains the estimate of the minimum possible difference. A one-day increase in vigorous physical activity is thus associated with a reduction in binge eating among women consistent with the minimum possible difference on this scale. Scaling up the estimated effect, [Figure 3](#) also shows that the confidence interval for a five-day increase in vigorous physical activity contains the effect size for a single full symptom reduction, but the interval is wide and uncertainty high.

Discussion

This study examined the association between physical health behaviors and binge eating across the first year of university, focusing on times of the year that are typically higher versus lower stress. The trajectory of binge eating over the academic year (see [Figure 1](#)) was consistent with mental health measures of depression and anxiety that tend to increase during the first semester of university then stabilize or decline by the end of the first year (Barker et al., 2018; Duffy et al., 2020; Howard et al., 2022; Knoesen & Naudé, 2018). However, binge eating increased by just 0.12 units from the beginning to the end of the first semester, an effect size consistent with the smallest possible difference in mean scores on this measure (0.14). The increase in binge eating behaviors we observed was likely not meaningful, suggesting that symptoms were relatively stable across the academic year, similar to other evidence showing that binge eating behaviors develop between adolescence and early adulthood and remain relatively consistent into adulthood (Goldschmidt et al., 2016). Participants may have reached a point of relative stability in their binge eating behaviors by the start of university. Binge eating behaviors in community samples have been associated with significant distress and impairment (Mitchison et al., 2017), and the current study found that these behaviors appear to be stable and established by early adulthood. It is important that prevention strategies for disordered eating behaviors target adolescents with continuity of care into adulthood to reduce the development and maintenance of binge eating behaviors into adulthood.

Lack of evidence for robust associations between physical activity and binge eating

Students who engaged in physical activity more often on average did not report fewer binge eating behaviors. This finding appears to contradict past research linking greater physical activity to fewer binge eating behaviors (Blanchet et al., 2018). However, a closer inspection of the literature shows inconsistencies in the associations between physical activity and binge eating. One study of young adults found that moderate physical activity was associated with binge eating but vigorous physical activity was not (Martinez-Avila et al., 2020). Another study of adults with higher average weight did not find a significant association between binge eating and moderate or vigorous physical activity (Barber et al., 2018). Research on physical activity and binge eating may be more heterogeneous than we expected, especially in community samples. Average rates for moderate and vigorous physical activity in our sample were consistent with past research, and variability in physical activity over the school year is consistent with research showing that physical activity decreases at the end of Fall semester, increases slightly at the beginning of the second semester, and remains steady thereafter (Han et al., 2008; Small et al., 2013).

Many significant effects of physical activity on binge eating reported in prior research are small, whether in clinical, community, or convenience samples. In one university student sample, achieving a small- to medium-sized reduction in binge eating required an additional 9 hours of physical activity per week (Deboer et al., 2012). Likewise, a study of people with binge eating disorder (BED) found that people who spent an average of 50 extra minutes per day on vigorous physical activity reported one less overeating symptom (Smith et al., 2022; average daily physical activity in this sample was 5–6 minutes). Instances of statistically significant results that neglect to mention trivially small effect sizes contribute to impressions of a history of strong links between physical activity and binge eating. In fact, the null effects obtained in the present study are similar in size and direction to previously published findings that did achieve statistical significance.

More meaningful effects of physical activity on binge eating behaviors are present in *intervention* studies for people with BED. In one study, a cognitive behavioral therapy (CBT) plus physical activity condition saw a reduction in

weekly binge eating days from 4.4 days/week to less than 1 day/week at 4-, 10-, and 16-month follow-ups while a CBT-only condition saw a reduction in weekly binge eating days from 4.7 days/week to 2 days/week at follow-ups (Pendleton et al., 2002). Stronger effects of physical activity on binge eating in clinical samples are likely due to demanding interventions that require participants who are largely inactive to engage in exercise at least three times per week (Levine et al., 1996; McIver et al., 2009; Pendleton et al., 2002). Given that a high percentage of people with BED are sedentary, engaging in any level of physical activity would likely benefit their mental health and in turn, disordered eating behaviors. In contrast, a study of a community sample of emerging adults found that there were no significant differences in binge eating scores between control, moderate physical activity, and vigorous physical activity intervention groups (Martinez-Avila et al., 2020). Our exploratory analysis similarly showed that an *extra* five days of physical activity per week was associated with a one-symptom reduction in binge eating among women. Our lack of significant effects could be partly explained by having a moderately active student sample reporting mostly mild binge eating symptoms. Physical activity effects may be easier to detect in clinical samples of people with BED for whom few to no people are scoring at the floor of a symptom measure. However, effect sizes in clinical samples of people with BED also tend to be small (Kerrigan et al., 2019; Smith et al., 2022). Regardless, if physical activity interventions are only effective for those with binge eating disorder or severe symptoms, physical activity may not be a malleable target for improving subclinical binge eating behaviors in student populations.

Sleep may not be a key contributor to binge eating behaviors

Sleep quality and hours of sleep per night were not associated with binge eating behaviors over the school year. A large body of evidence indicates that fewer hours and lower quality sleep in university students is associated with poorer physical and mental health (Lund et al., 2010; Suardiaz-Muro et al., 2020). The link between sleep and binge eating, however, is less robust and lacks longitudinal evidence. Cross-sectional findings suggest that poor sleep quality is associated with more binge eating behaviors (Fusco et al., 2020; Trace et al., 2012), while evidence from randomized controlled trials shows that sleep deprivation does not increase the likelihood of binge eating (Cerolini et al., 2018). One explanation for this discrepancy is that sleep and binge eating are more strongly associated in people with higher average weight regardless of binge eating status (Tzischinsky & Latzer, 2006). People with higher average weight are more likely to have obstructive sleep apnea which is associated with sleep deprivation and fragmented sleep (Khan et al., 2013) that is further associated with increased levels of ghrelin, the “hunger hormone”. Another explanation for our lack of significant effects could be due to our use of a single item to examine sleep quality which tends to be a more consistent indicator of binge eating behaviors. Consequently, the association between sleep and

binge eating may only be visible in clinical samples whose BMIs are typically in the highest categories and less likely to be present in a non-disordered student sample.

Study Limitations

Findings from this study are limited to retrospective reports across four two-week periods during the academic year and may not have captured instances of binge eating for students who engage in these behaviors transiently. Ecological momentary assessment research has found that specific pre- and post-binge eating feelings and behaviors are evident immediately before or after an episode (Smith et al., 2021), although these changes may be due to person-level changes. Studies we identified that separately examined between and within person effects of sleep and physical activity on binge eating behaviors yielded similar-sized effects to the present study and only between-person effects were statistically significant (Manasse et al., 2022; Smith et al., 2022). Findings from other studies not attending to levels of effect may be capturing largely person-level associations that are confounded by other factors—offering another explanation for why our study yielded different conclusions. For example, given the strong link between mental health and binge eating (Forcier et al., 2006; Keating et al., 2019), it is possible that the effect of physical activity on binge eating might reflect general improvements in mental health and consequent reductions in binge eating. In line with other cross-sectional work that has found similarly small effects, the time scale of the present study might have been insufficient to capture these time-specific links. For students, stress is likely highest during exams in December and April, and measures taken during the days or hours surrounding stressful events may be needed to detect effects.

Another limitation is that our measure of physical activity is a single-item measure that lacks reliability and validity evidence and does not ask about compensatory physical activity behaviors, and our exploratory gender analyses hint that this may be an important future direction: we found a small within-person effect of physical activity on binge eating showing that when men, but not women, engaged in higher than usual vigorous physical activity, they reported fewer binge eating behaviors. For men, the relationship between physical activity and binge eating may be more complex. There is evidence that men with eating disorders engage in both compensatory (e.g., make up for previous binge, reduce/maintain weight or shape) and non-compensatory physical activity (e.g., enjoyment, improve mental health; Lampe et al., 2021) which have been associated with more and less binge eating, respectively (Boyd et al., 2007; Kerrigan et al., 2019). Women may give a wider variety of reasons for compensatory physical activity compared to men. For example, some research shows that compensatory behavior (exercising to compensate for high levels of food intake) is related to binge eating behaviors (Martin et al., 2020). However, another study of mostly women (89%) across the binge eating spectrum found that the most reported reason for exercising was to control weight or shape, whereas the least endorsed reason was so

that they could eat more later (Lampe et al., 2021). Potentially greater variability in reasons for women's compensatory physical activity might explain the null (within-person) finding for women in the current study. Given the links between compensatory physical activity, and eating pathology (Kerrigan et al., 2019; Martin et al., 2020), including a variable to capture this association would have allowed for a more detailed look at how and if the motivations for physical activity are key drivers of binge eating behaviors above and beyond engagement in physical activity.

Finally, we reiterate our design decision not to administer binge eating questions to students experiencing food insecurity. The goal of the larger study from which these data were drawn was to examine numerous markers of well-being during the transition to university and did not consider the binge eating-like characteristics of food insecurity (e.g., overconsumption when access to food increases, and dietary restriction when access to food is low). Yet, food insecurity has been associated with binge eating and weight in other samples (Becker et al., 2017; Rasmusson et al., 2019). Not including people experiencing food insecurity in our sample is an important omission in the present study that limits generalizability.

Conclusion

In sum, results of the current study show that binge eating behaviors are stable across the first year of university. Physical activity and sleep behaviors do not appear strongly associated with binge eating behaviors during the school year, whether during typically low- or high-stress time periods. Our findings highlight that eating behaviors are difficult to change. More general population research testing the role of motivations for physical health in binge eating behaviors is needed to inform public health recommendations and better understand the nuanced role of physical activity in influencing eating pathology.

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Authorship Contributions

ML developed the study goals, drafted the paper, performed data analysis and interpretation. ALH collected the data and provided critical revisions. All authors contributed to study design and approved the final version of the paper for submission.

Competing Interests

The Authors declare that there is no conflict of interest. ALH is a senior editor at Collabra: Psychology. She was not involved in the review process of this article.

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Data Accessibility Statement

We have made the data available to reviewers on our OSF page. Readers are able to request access to the data via OSF [<https://osf.io/tey2x/>]. After requesting access to the data, you will be added as a "reader" to the OSF page and be able to download a copy of the data. Due to confidentiality language in the consent forms for this study, we are unable to post a fully public copy of the data.

Analysis scripts, data dictionary, correlation table, and supplemental material can be found on this paper's project page on the OSF study page [<https://osf.io/7bajk/>].

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