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Longitudinal changes in anthropometry and body composition in university freshmen

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Abstract

Objective—Investigate predictors of weight gain in college freshmen.

Study Design—A longitudinal cohort study followed a representative sample of freshmen (N = 264) from 8/2011 to 6/2012.

Methods—Repeated measurements of anthropometry, dual-energy X-ray absorptiometry (DXA), physical activity, and diet were collected. We investigated predictors of 9-month weight gain using regression models.

Results—172 participants completed follow-up: 75% gained >0.5 kg. Mean weight change was +2.3 kg (*SD* 3.2) and +2.0 kg (*SD* 3.2) and mean adiposity change was +1.3% (*SD* 1.6) and +0.7% (*SD* 2.2) in men and women, respectively. In participants gaining >0.5 kg, weight increased 5.6% and body fat increased 1.6%. Anthropometric change in men occurred in the first semester, while women increased in both semesters. Leaner DXA-defined body composition at baseline was consistently associated with greater weight gain (p-values 0.029–0.049).

Conclusions—Freshman weight gain is common and reflects increased adiposity. Leaner body composition at the beginning of college predicted greater weight gain in men and women during the first year of college.

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Conflict of interest disclosure

The authors have no conflicts of interest to report. The authors confirm that the research presented in this article met the ethical guidelines, including adherence to the legal requirements, of the United States and received approval from the Institutional Review Board of Cornell University.

Authorship

P.A.C., K.C.H., and K.A.G. designed the study, carried out the study, and managed and analyzed the data; K.C.H. and P.A.C. drafted the manuscript, and all authors edited the manuscript.

Keywords

Freshman weight; body composition; adiposity; college weight gain; cohort study

Introduction

For many of the ~3 million U.S. high school graduates who enroll in college directly after high school,[1] the first year is a transition period of increasing autonomy. The phenomenon of freshman weight gain, first noted in the mid-1980s by Hovell et al.,[2] occurs in about 75% of first year students, regardless of attendance at a public or private institution.[3,4] A meta-analysis[5] of 24 studies (pooled N = 3,401) reported average weight change of +1.75 kg (95% CI: 1.73–1.78 kg) during freshman year. Mean weight gain during four years of college is approximately 3 kg,[6, 7] and although studies report a 2- to 3-fold greater weight gain in men,[8,9] there is inconsistent evidence for sex differences.[4,10,11] Freshman weight gain has been associated with dietary intake, initial weight,[12] psychological stress,[5] snacking habits,[13] physical inactivity,[14,15] alcohol consumption[16] and residence on campus.[17] Many studies draw limited conclusions due to single sex samples,[18,19] short study duration, and/or small sample size.[16]

First-year weight gain is predictive of weight gain over all years of college[6] and of the adult trajectory,[8,20] contributing to long-term risk of overweight and obesity and associated co-morbidities, including metabolic syndrome.[21,22] Furthermore, weight gain in young people with a normal body mass index (BMI) has been associated with changes in risk-related metabolic biomarkers.[23] Even in the context of a normal BMI, excess adiposity increases health risks[23,24] and is associated with a higher prevalence of dyslipidemia, hypertension, metabolic syndrome, and type two diabetes.[25,26] In both adolescents and adults, a higher waist circumference has been associated with a 5.5- to 16.5-fold increased odds of metabolic syndrome.[27] Despite an understanding that excess adipose tissue is the key determinant of adverse outcomes,[27] the majority of published studies of weight gain does not consider body composition change.

Current Behavioral Risk Factor Surveillance System (BRFSS) data indicate 43% of the U.S. adults aged 18–24 years are overweight or obese.[28] It is important to prevent excessive weight and adiposity gain during the transition from home to college,[29] and there is a need for research that extends beyond the first semester, uses valid and reliable body composition assessment techniques such as dual-energy X-ray absorptiometry (DXA), examines sex differences, and investigates differences between freshmen who gain weight and those who do not. We addressed these knowledge gaps by studying the association of baseline body composition, anthropometry and behaviors related to energy balance with subsequent changes in anthropometry and body composition in a random sample of college freshmen followed for one academic year.

Methods

Study design and participants

We conducted a prospective cohort study of university freshmen at a largely residential university in the northeastern U.S. Students ≥18 years of age in the class of 2015 were eligible. 1001 students were randomly selected and invited via email for study participation prior to arrival on campus; approximately 500 students accessed the electronic materials describing the study, and 264 enrolled in the study. Baseline data collection included questionnaires (within 1 month prior to arrival on campus), and assessments of anthropometry (within first 3 days on campus), and body composition via DXA (within first month). Follow-up visits included anthropometric assessments at the end of first semester (mean 14.1 weeks from baseline [*SD* 1.1]) and at the end of the academic year (mean 34.8 weeks from baseline [*SD* 1.5]). The initial sample was 50% female and the distribution by country of origin (domestic vs. international) and college of matriculation was representative of the incoming class of 2015. Written informed consent was obtained from all participants, and the study was approved by the Cornell University Institutional Review Board.

Questionnaire data

Web-based self-administered questionnaires were used to collect the information on usual diet (Diet History Questionnaire, DHQII[30]; baseline and end of year) and physical activity (Global Physical Activity Questionnaire (GPAQ)[31]; baseline, mid-year, and end of year). The DHQII is a valid instrument[30] for assessing the usual dietary intake, and includes 134 food and beverage items. The GPAQ is a validated physical activity questionnaire[31,32] comprised of 16 questions on the intensity, duration, and frequency of physical activity (PA) in a recent typical week. To obtain a composite metric of daily activity, a metabolic equivalent (MET) value[33] of PA was assigned to each intensity level. MET is a unit of relative energy expenditure (amount of energy expended for activity is divided by the amount of energy expended at rest): 1 MET corresponds to energy expenditure at rest, 4–6.9 METs corresponds to moderately intense PA, and ≥7 METs corresponds to vigorous activity. MET hours/day were calculated from the number of hours/week in activities at each intensity level. Sedentary time was ascertained by self-report of the typical amount of time per day spent sitting or reclining, excluding time asleep.

Dining hall data

University policy requires all freshmen to enroll in a meal plan and dining hall access requires each student's ID card to be 'swiped' through an electronic card reader. We computed the average number of card swipes/day for each participant for the fall and spring semesters and used total card swipes/semester as a measure of meals consumed.

Physical measurements

Anthropometrists measured weight, height, and waist and hip circumferences within the first 3 days on campus, at mid-year, and at the end of the academic year. Before each data collection, anthropometrists completed interactive training sessions and were evaluated for accurate, reliable technique using standardized, calibrated instruments. Participants wore

minimal, light clothing and, anthropometrists took two repeated measurements of height (stadiometer; Shorr Productions, Olney, MD) and weight (digital scale; Seca, Chino, CA). Three repeated measurements of waist and hip circumference were taken using a steel measuring tape (Lufkin, Apex, NC), and values were averaged for analysis.

Whole body DXA scans (QDR4500, total body fat percent precision 1%[34]; Hologic Inc.) were completed in the first and last months of the academic year, yielding estimates of total body fat percent (BF%), truncal fat percent (TF%), and fat mass index (FMI, the ratio of fat mass [kg] to height [m^2]).

Statistical analysis

To assess the similarity of this sample to the U.S. population of young adults, we applied publicly available statistical programs (Centers for Disease Control and Prevention[35]) to generate z-scores for BMI-for-age, height-for-age, and weight-for-age. We used logistic and linear regression methods to investigate baseline factors associated with weight gain for categorical and continuous weight change, respectively. In logistic models, weight gain was defined as an increase in body weight >0.5 kg over the academic year; the 'no weight gain' group experienced either weight loss or <0.5 kg weight gain. Fully adjusted statistical models included sex, baseline anthropometry, total BF%, diet (energy intake and total fat), and energy expenditure (PA and sedentary time).

Using SAS (Statistical Analysis System) 9.4, we evaluated differences in participant characteristics with a threshold of statistical significance ($p < 0.05$) using the chi-square test and Student's *t*-test (two-sided); when underlying statistical assumptions were not met, non-parametric tests were used.

Results

Of the 264 participants enrolled in the study, 9% ($N = 23$) completed only online forms prior to arrival on campus, 26% ($N = 69$) completed only the baseline visit or only a mid-year visit, and 65% ($N = 172$) had complete follow-up, with measurements and questionnaire data at baseline and at the end of the academic year. Participants with complete follow-up comprise the main analytical group. Although women were slightly more likely to complete the final visit, the baseline characteristics were similar between those who started the study and those who completed follow-up (Table 1). The 92 participants with incomplete follow-up included 60% men (versus 45% in the analytical group), and had slightly higher baseline weight and adiposity (Appendix Table A.1). Participant feedback indicated attrition was mainly due to busy student schedules. Mean percentiles computed from sex-specific z-scores for weight-for-age, BMI-for-age, and height-for-age were 51.9%, 48.3%, and 52.9%, respectively, indicating the sample was anthropometrically similar to the U.S. reference data.

The average weight gain over the academic year was 2.1 kg (*SD* 3.0); men and women gained 2.3 (*SD* 3.2) and 2.0 kg (*SD* 2.9), respectively. DXA estimated adiposity change (BF %) was 1.0% (*SD* 1.9); men and women increased 1.3% (*SD* 1.6) and 0.7% (*SD* 2.2), respectively. 75% of the sample ($N = 129$) gained >0.5 kg and 43 participants did not gain weight (19 men; 24 women). Among nongainers, 27 (63%; 13 men, 14 women) lost >0.5 kg

and 16 maintained stable weight (within +/−0.5 kg of baseline weight) over the academic year; the latter group experienced small negative and/or no change in the anthropometric measurements.

On average, students who gained weight over the academic year experienced a 5.6% increase in weight, a 3 cm increase in waist circumference, a 1.1-unit increase in BMI, and a 0.6-unit increase in FMI. 89% of participants who gained weight increased in adiposity (BF %) and the increase in adiposity accounted for about half of the weight gain.

The participants who gained ≥0.5 kg had, on average, lower starting values for waist circumference ($p = 0.029$), BMI ($p = 0.033$), and FMI ($p = 0.049$) compared to those who did not gain weight (Table 2). At study baseline, students with subsequent weight gain had lower percentiles of BMI-for-age (43.3 vs. 53.5; $p = 0.03$) and weight-for-age (47.4 vs. 56.5; $p = 0.07$), but did not differ significantly on height-for-age at baseline (52.1 vs. 51.4; $p = 0.93$) compared to the students who did not gain weight. There was little difference between weight change groups in their daily exercise, sedentary time, and dietary intake at study baseline. Self-reported mean alcohol intake was negligible at <2% of energy intake in all groups at baseline and end of the year.

Sex-specific changes in body composition and energy expenditure

During the first semester, among individuals who gained weight, men gained approximately 1 kg more weight ($p = 0.019$) and increased about 1 cm more in waist circumference ($p = 0.044$) compared to women (Table 3). Anthropometric changes over the academic year were similar by sex among those who gained weight, but women increased more in hip circumference ($p = 0.027$). In participants who did not gain weight, first semester and academic year anthropometric changes were negligible for both sexes.

Men who gained weight reported a *decrease* in PA and a concomitant increase in sedentary time over the academic year, whereas women who gained weight reported an *increase* in PA ($p = 0.037$; Table 3) and no change in sedentary time. Participants reported lower energy intake at the end of the study, regardless of weight gain status. Paradoxically, the decrease in energy intake was 1.5- to 2.5-fold greater among participants who gained weight (versus no weight gain group). There was no association of the daily frequency of dining hall meals (swipes/day) with weight gain (dichotomous variable gain/no gain) in either 1st or 2nd semester or with weight change (continuous variable, kg change over full study period). In contrast, the cumulative total of dining hall meals (total swipes: mean = 246; $SD = 77$) was positively associated with changes in weight, BMI, and waist circumference over the year. A one standard deviation higher value of ‘total swipes’ was associated with +0.6 kg weight change ($p = 0.0314$), +0.2 kg/m^2 BMI change ($p = 0.0447$), and +0.5 cm waist circumference change ($p = 0.0436$), after adjusting for sex and baseline anthropometry (data not shown).

Baseline characteristics and weight gain

In regression models lower BMI, FMI, waist circumference, BF%, and TF% at baseline were statistically significantly associated with greater odds of gaining weight over the first year of college (Table 4). For example, a one-unit lower BMI at baseline was associated with

an 11% greater odds of gaining weight in freshman year [odds ratio (OR) 0.89; 95% CI 0.80, 0.99]. When models were adjusted for sex, associations were similar for baseline BMI and waist circumference and stronger in magnitude for body composition indicators. We tested the interaction of each variable with sex and detected a statistically significant interaction between sex and PA ($P_{interaction} = 0.041$); among women, a one-unit *greater* MET·hr/d PA at study baseline was associated with a 10% greater odds of gaining weight, but there was no such association in men.

The findings were similar in regression models with the continuous outcome of weight gain (kg) (Table 5). Leaner body composition at baseline was associated with greater weight gain over the year; baseline waist circumference ($p = 0.038$), BF% ($p = 0.009$), and TF% ($p = 0.024$) were all inversely and statistically significantly associated with weight gain. The sex x PA interaction was statistically significant in the fully adjusted model ($p = 0.049$). Thus, among women only, a one-unit *greater* MET·hr/d of baseline PA was associated with 0.11 kg increase in weight over the year; there was no association in men.

Comment

This study investigated the association of baseline body composition, anthropometry, and behaviors related to energy balance with changes in anthropometry and body composition during the first year of college. Leaner body composition at the start of college, estimated by DXA, was associated with greater odds and magnitude of weight gain. We found a statistically significant interaction between sex and baseline PA such that women who subsequently gained weight reported *higher* baseline PA; in men there was no PA-weight gain association. Among participants gaining weight, men increased in anthropometric indicators primarily in the first semester whereas female participants increased in both semesters.

Nine prior longitudinal studies that evaluated sex differences in weight change in the first year of college reported mixed findings. In four studies of the first year of college men gained more weight than women,[3,16,36,37] while the remaining five studies showed no difference by sex[3,4,10–12]; three studies reported greater weight gain in men over the first semester.[9,16,38] Our findings indicate study duration may contribute to the inconsistencies in past reports, and this is supported by a positive correlation between study duration and weight gain [$r = 0.40$, $p < 0.01$ in $N = 3,309$].[5] Ultimately, we found little difference in the absolute amount of weight gain by sex over the full academic year, which is consistent with one prior study.[16]

The association of baseline adiposity and subsequent weight gain is inconsistent in prior studies. Among six studies addressing this question, two[29,39] reported a positive association of baseline BMI with weight gain, one[40] reported no association, two[9,41] reported an inverse association, and one[16] reported an inverse association using DXA estimated BF%. We found an inverse association using DXA estimated BF%, consistent with the one prior study (of 29 participants) that also used DXA.[16] DXA reliably provides accurate estimates of adiposity in young adults.[42] Past inconsistencies may be explained in part by differences in the methods used to assess adiposity, or by the use of statistical approaches that fail to account for

regression to the mean. The present study, in contrast, used models that account for regression to the mean (outcome is change, starting level is adjusted as a covariate), thus regression to the mean is not likely to explain the findings.

Our study shows that both male and female participants who gained weight also increased in adiposity. The one prior study that used DXA to assess longitudinal body composition changes in first year students reported BF increases in men only.[16] A study of freshmen, which used bioelectrical impedance to estimate body composition, reported a BF% increase of 2.2% (*SD* 2.7) and 1.8% (*SD* 3.2) in men and women, respectively,[43] similar to our findings. A similar study of first year students conducted at multiple universities in the UK (*N* = 250)[12] reported small but significant gains in weight (0.8 kg, *SD* 2.1) and adiposity (fat mass increased 0.9 kg, *SD* 1.9), measured via bioelectrical impedance, after the first three months of the first term, but no significant increases in weight or adiposity over the year. Continued research to characterize young adult weight and adiposity trajectories is warranted to inform targeted strategies to reduce the risk of unhealthy weight gain.

Overall, 75% of the participants gained weight, which is similar to prior reports of college-based studies.[3,4] The sample was similar to contemporary population medians for weight-, BMI- and height-for-age z-scores.[35] Furthermore, recent national data on age- and sex-specific anthropometric trajectories[28] show the median expected weight gain for 18-year-olds over an academic year is 1.1 kg and 0.7 kg for men and women, respectively. In this study, men and women who gained weight increased 3.6 kg and 3.2 kg, respectively, well in excess of expected trajectories. Virtually all students who gained weight had an increase in BF% measured by DXA, with adipose gain accounting for about two-thirds of total weight gain, similar to the past reports in this age group.[37] In summary, we observed weight gain consisting mainly of adipose gain, and the magnitude of weight gain was greater than that which would be expected from maturation.

Our findings did not support an association of energy and/or macronutrient intake with body habitus change. Indeed, all participants reported a decrease in kcal/day over the academic year, with the greatest decrease reported by participants who gained weight. These findings may reflect selective under-reporting of intake, problems in reporting in the context of institutional dining, and/or a true effort by students experiencing weight gain to control weight. The frequency of eating in a dining hall was <2 meals/day in all subgroups, and no information on other food sources was available, limiting a full analysis of dietary intake. Although the average dining hall visits per day did not predict weight gain, the total count of meals consumed in the all-you-care-to-eat dining facilities was significantly positively associated with changes in weight, BMI, and waist circumference over the year.

Limitations

We acknowledge several limitations including the lack of data on race/ethnicity. The study sample is assumed to be representative of the incoming class of 2015 where 20.1% self-identify as under-represented minorities. Although data on family socioeconomic status (SES) indicators were not available, SES is unlikely to confound the associations because all freshmen live and eat in the same environment and purchase of a meal plan is required. Also,

while this sample was anthropometrically similar to national reference data, the findings may not be generalizable to all U.S. freshmen given differences in campus-specific demographic characteristics and/or other factors relevant to weight change.

Participants lost to follow-up tended to be male, and had higher starting weight, BMI, and waist circumference compared to the sample with complete follow-up. If all participants who dropped out went on to gain weight then the trend for gainers to be leaner at baseline would be attenuated, but we cannot assess the degree to which this possible selection bias affects the findings.

This study has important strengths including the repeated measurements of body composition by DXA and anthropometry, large sample size, and the focus on within-person body composition change in subgroups defined by sex and weight gain status.

In our analyses we distinguished participants who gained weight during the first year of college and those who did not, using the threshold of weight change >0.5 kg to classify status. Prior research[5] defined weight gain as any positive change in weight; however, the threshold in this investigation was set to exceed the measurement error of the scale used in this study. Although this is expected to improve the classification of true weight gain, we addressed potential misclassification by modeling continuous and categorical weight outcomes, which produced concordant results.

Conclusion

First year students followed prospectively from the summer prior to college through the end of the academic year, measured with DXA and anthropometry, gained an average of 2 kg, 75% gained weight, and those gaining weight experienced a 5.6% increase in weight and a 1.6% increase in BF. Weight gain reflected gain in adiposity, as confirmed by DXA findings. In women only, higher self-reported PA at the beginning of the year was associated with greater weight gain, and in both sexes leaner body composition at the beginning of the year was associated with greater weight gain in both categorical and continuous models. Further research investigating the relation of adiposity change to cardiometabolic risk in normal weight individuals is needed to explore the physiologic consequences of body composition changes in this age group.

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Appendix. LONGITUDINAL CHANGES IN ANTHROPOMETRY AND BODY COMPOSITION IN UNIVERSITY FRESHMEN

Table A1

Baseline characteristics of the participants with incomplete follow-up compared to the participants with complete follow-up.

Characteristic	Participants with incomplete follow-up $N = 92$		Participants with complete follow-up $N = 172$		p-Value*
Gender (% female)	40.2		54.7		**0.025**
Nationality (% non-U.S.)	7.6		7.0		0.850
	Mean	**SD**	**Mean**	**SD**	
Age (years)	18.1	0.3	18.1	0.2	0.546
Weight (kg)	66.8	13.2	62.7	11.6	**0.018**
Body mass index (kg/m^2)	22.6	3.1	21.7	3.0	**0.011**
Waist circumference (cm)	74.9	8.9	72.4	7.9	**0.016**
Hip circumference (cm)	97.3	7.3	95.5	7.3	0.074
Total body fat (%)	22.2	7.8	20.9	7.3	0.308
Fat mass index (kg/m^2)	5.2	2.8	4.7	2.1	0.229
Total physical activity (MET·hr/d)‡	11.4	13.9	9.8	9.3	0.879
Sedentary time (hr/d)	5.8	2.8	6.6	2.9	0.079
Usual energy intake (kcal/d)	1925	760	2081	784	0.210
Carbohydrate (% total kcal)‡	49.4	7.3	48.7	7.5	0.443
Protein (% total kcal)‡	16.1	2.8	16.2	3.2	0.856
Fat (% total kcal)‡	31.6	6.1	32.7	6.4	0.282

Note.

*Statistical significance was from a two-sample Student's *t*-test for variables meeting the underlying assumptions of the test, otherwise, statistical significance was from the Wilcoxon Signed Rank non-parametric test ($p < 0.05$ **bolded**).

‡Mean percent of energy from alcohol consumption <1% in both groups; macronutrient total does not sum to 100% due to rounding.

Table 1

Baseline participant characteristics by completeness of participation.

Baseline characteristics	All participants $N = 264$*		Participants with follow-up $N = 172$†	
Sex (% female)	49.6		54.7	
Nationality (% non-U.S.)	7.2		7.0	
	Mean	***SD***	**Mean**	***SD***
Age (years)	18.1	0.3	18.1	0.2
Weight (kg)	63.9	12.2	62.7	11.6
BMI (kg/m^2)	22.0	3.1	21.7	3.0
WC (cm)	73.1	8.3	72.4	7.9
HC (cm)	96.0	7.3	95.5	7.3
Total BF (%)	21.2	7.4	20.9	7.3
FMI ($kg_{adipose}/m^2$)	4.8	2.2	4.7	2.1
Total PA (MET·hr/d)	10.2	10.9	9.8	9.3
Sedentary time (hr/d)	6.3	2.9	6.6	2.9
Usual energy intake (kcal/d)	2034	778	2081	784
Carbohydrate (% energy)‡	48.9	7.4	48.7	7.5
Protein (% energy)‡	16.2	3.1	16.2	3.2
Fat (% energy)‡	32.4	6.4	32.7	6.4

Note. Abbreviations: BMI, body mass index; WC, waist circumference; HC, hip circumference; BF, body fat; FMI, fat mass index; PA, physical activity.

*Sample size varies slightly by variable due to missing data; $N > 235$ except for energy intake ($N = 196$).

†Sample size at final follow-up varies slightly by variable due to missing data; $N > 163$, except for energy intake ($N = 137$).

‡Macronutrient total does not sum to 100% due to rounding.

Table 2

Baseline characteristics of participants with follow-up ($N = 172$), stratified by weight gain over the academic year (>0.5 kg vs. no weight gain)[*].

Baseline characteristics	Weight gain $N = 129$		No weight gain $N = 43$		p-Value[†]
Sex (% female)	54.3		55.8		0.860
Nationality (% non-U.S.)	9.3		0		**0.038**
	Mean	***SD***	**Mean**	***SD***	
Age (years)	18.1	0.3	18.0	0.2	0.565
Weight (kg)	61.9	11.6	65.0	11.4	0.107
Height (cm)	169.5	9.6	169.4	9.0	0.961
BMI (kg/m^2)	21.4	2.8	22.6	3.5	**0.033**
WC (cm)	71.6	7.3	74.8	9.1	**0.029**
HC (cm)	95.0	7.3	96.9	7.3	0.130
Total BF (%)	20.2	7.0	22.9	8.1	0.066
Truncal body fat (%)	16.6	6.9	19.5	8.2	0.072
Lean body mass (%)	79.8	7.0	77.1	8.1	0.066
FMI ($kg_{adipose}/m^2$)	4.5	1.9	5.4	2.5	**0.049**
Total PA (MET·hr/d)	10.4	9.7	7.8	7.8	0.169
Sedentary time (hr/d)	6.7	2.9	6.1	3.1	0.228
Usual energy intake (kcal/d)	2093	853	2042	516	0.773
Carbohydrate (% energy)	49.2	7.5	46.9	7.1	0.180
Protein (% energy)	16.0	3.2	16.7	3.0	0.275
Fat (% energy)	32.3	6.5	33.9	6.2	0.203

Note.

[*] Sample size varied slightly by variable due to missing data; $N > 122$ for weight gain group and $N > 39$ for comparison group for all variables except for dietary intake variables ($N = 106$ and 31, respectively).

[†] Statistical significance of difference based on two-sample t-test for variables meeting underlying assumptions; otherwise, statistical significance based on Wilcoxon Signed Rank nonparametric test ($p < 0.05$ **bolded**).

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Table 3

Sex-specific change in body composition and energy expenditure, during first semester and academic year; mean change in each characteristic and the corresponding standard deviation are shown by sex within weight change groups.

	Participants gaining >0.5 kg†			No weight gain†	
	Men *N* = 59	Women *N* = 70		Men *N* = 19	Women *N* = 24
First semester change*	**Mean (*SD*)**	**Mean (*SD*)**	***p*-Value‡**	**Mean (*SD*)**	**Mean (*SD*)**
Anthropometry					
Weight (kg)	3.4 (2.5)	2.4 (1.9)	**0.019**	0.2 (1.8)	−0.5 (1.9)
Weight (% change)	5.2 (3.8)	4.4 (3.5)	0.264	0.4 (2.6)	−0.6 (3.1)
Height (cm)	0.0 (0.6)	0.2 (0.5)	**0.010**	−0.1 (0.5)	0.2 (0.6)
BMI (kg/m^2)	1.1 (0.8)	0.9 (0.7)	0.090	0.1 (0.6)	−0.2 (0.8)
WC (cm)	3.4 (3.2)	2.4 (2.5)	**0.044**	0.7 (2.2)	−0.1 (2.0)
HC (cm)	1.8 (3.4)	2.4 (2.6)	0.337	0.1 (3.7)	−0.7 (2.7)
Energy expenditure					
Total PA (MET·hr/day)	0.1 (8.4)	2.3 (11.8)	0.057	−2.3 (10.4)	6.7 (11.3)
Sedentary time (hr/day)	0.4 (3.9)	0.4 (3.1)	0.954	0.1 (4.2)	1.5 (3.6)
Academic year change*					
Anthropometry					
Weight (kg)	3.6 (2.2)	3.2 (2.0)	0.361	−1.7 (2.2)	−1.6 (2.0)
Weight (% change)	5.5 (3.4)	5.6 (3.3)	0.701	−2.3 (3.0)	−2.6 (3.0)
Height (cm)	0.3 (0.7)	0.5 (0.6)	0.092	0.3 (0.7)	0.4 (0.5)
BMI (kg/m^2)	1.1 (0.7)	1.1 (0.7)	0.976	−0.6 (0.8)	−0.7 (0.8)
WC (cm)	2.9 (2.2)	3.1 (2.4)	0.700	−0.8 (2.9)	−0.9 (2.8)
HC (cm)	1.5 (2.4)	2.6 (3.0)	**0.027**	−1.5 (3.5)	−2.1 (2.6)
Body composition					
Total BF (%)	1.8 (1.2)	1.5 (1.8)	0.327	−0.3 (1.5)	−1.4 (1.6)
Truncal body fat (%)	2.0 (1.3)	1.7 (2.3)	0.255	−0.3 (1.5)	−1.8 (1.9)
Lean body mass (%)	−1.8 (1.2)	−1.5 (1.8)	0.327	0.3 (1.5)	1.4 (1.6)
FMI ($kg_{adipose}/m^2$)	0.5 (0.4)	0.6 (0.6)	0.683	−0.2 (0.4)	−0.5 (0.5)
Energy expenditure					

	Participants gaining >0.5 kg†			No weight gain†	
	Men *N* = 59	Women *N* = 70		Men *N* = 19	Women *N* = 24
First semester change*	**Mean (*SD*)**	**Mean (*SD*)**	***p*-Value‡**	**Mean (*SD*)**	**Mean (*SD*)**
Total PA (MET·hr/day)	−2.3 (8.8)	1.5 (14.2)	**0.037**	−1.0 (13.1)	6.1 (7.9)
Sedentary time (hr/day)	1.2 (3.0)	0.2 (3.5)	0.138	0.8 (3.2)	1.7 (3.8)
Diet					
Energy intake (kcal/day)	−484 (1040)	−363 (873)	0.264	−204 (764)	−131 (566)
Carbohydrate (% energy)	−0.1 (9.0)	−0.1 (6.9)	0.714	1.7 (5.4)	−1.5 (4.6)
Protein (% energy)	−0.7 (4.1)	−0.7 (2.9)	0.499	−1.2 (2.1)	−0.4 (3.4)
Fat (% energy)	−0.2 (5.4)	0.3 (6.6)	0.403	−1.4 (3.7)	1.4 (4.2)
Dining hall frequency (swipes/day)§	−0.1 (0.3)	−0.1 (0.2)	0.911	−0.2 (0.4)	−0.1 (0.2)

Note.

*First semester change is the difference between the measurement at the end of first semester and baseline (mean 14.07 weeks [*SD* 1.09]); academic year change is the difference between the measurement at the end of spring semester and the baseline (mean 34.8 weeks [*SD* 1.48]).

†*N* varies slightly by variable: FFQ-derived diet composition variables had the lowest response rate (men *N* = 28, women *N* = 40).

‡Statistical significance of sex difference based on two-sample t-test for variables meeting the underlying assumptions of the test, otherwise, significance based on Wilcoxon Signed Rank nonparametric test ($p < 0.05$ **bolded**).

§The difference between the average count of card swipes per day in the spring semester and that of fall semester.

Table 4

Logistic regression models estimating the relation of baseline characteristics to risk of weight gain over the first year of college (dichotomous outcome defined as gaining >0.5 kg vs. no gain).

Baseline characteristics	Model I, unadjusted*		Model II, sex adjusted†		Model III, fully adjusted§	
Anthropometry	**Odds ratio**	**95% CI**	**Odds ratio**	**95% CI**	**Odds ratio**	**95% CI**
BMI (kg/m^2)	**0.89**‡	**0.80, 0.99**	**0.89**	**0.80, 0.99**	0.96	0.75, 1.22
WC (cm)	**0.95**	**0.91, 0.99**	**0.95**	**0.90, 0.99**	0.88	0.78, 1.00
HC (cm)	0.97	0.92, 1.01	0.97	0.92, 1.01	1.01	0.87, 1.18
Body composition						
Total BF (%)	0.95	0.91, 1.0	**0.91**	**0.84, 0.97**	0.89	0.80, 1.00
Truncal body fat (%)	0.95	0.91, 1.0	**0.93**	**0.88, 0.98**	0.94	0.86, 1.02
FMI ($kg_{adipose}/m^2$)	**0.83**	**0.71, 0.98**	**0.78**	**0.65, 0.95**	0.79	0.57, 1.09
Energy expenditure						
Total PA (MET·hr/d)	1.04	0.99, 1.08	Men: 0.99‡	0.93, 1.05	Men: 0.96‡	0.88, 1.04
			Women: 1.10‡	**1.01, 1.19**	Women: **1.10**‡	**1.00, 1.21**
Sedentary time (hr/d)	1.07	0.95, 1.21	1.07	0.95, 1.21	1.12	0.95, 1.32

Note.

*No variables other than the single variable listed were included in unadjusted model.

†Model was adjusted for sex, and sex by 'variable' interaction was tested and included if statistically significant.

‡The *p*-value for estimates shown in bold was <0.05; the sex by PA interaction $p = 0.0409$, thus model estimates shown are sex-specific.

§Models for anthropometry and body composition variables were adjusted for sex, baseline weight, baseline diet (energy intake, total fat [% energy]), and energy expenditure (PA, sex by PA interaction, and sedentary time).

Table 5

Regression models estimating the association of baseline characteristics with subsequent weight gain (continuous outcome, kg) over one academic year.

	Model I, adjusted for sex *			Model II, fully adjusted†		
Baseline characteristics	***β***	**95% CI**	***p*-value**	***β***	**95% CI**	***p*-value**
Anthropometry						
Weight (kg)	−0.02	−0.06, 0.03	0.494	0.02	−0.04, 0.08	0.537
BMI (kg/m^2)	−0.07	−0.22, 0.08	0.379	0.03	−0.30, 0.36	0.854
WC (cm)	**−0.07**	**−0.13, −0.00**	**0.038**‡	**−0.21**	**−0.36, −0.06**	**0.007**
HC (cm)	−0.03	−0.09, 0.04	0.425	0.03	−0.20, 0.25	0.833
Body composition						
Total BF (%)	**−0.12**	**−0.21, −0.03**	**0.009**	**−0.17**	**−0.30, −0.04**	**0.013**
Truncal body fat (%)	**−0.09**	**−0.17, −0.01**	**0.024**	**−0.11**	**−0.22, −0.00**	**0.050**
FMI ($kg_{adipose}/m^2$)	−0.26	−0.51, 0.00	0.054	−0.35	−0.76, 0.07	0.107
Energy expenditure						
Total PA (MET·hr/d)‡	Men: 0.14	−0.78, 1.06	0.769	Men: −0.03	−0.13, 0.08	0.601
	Women: −0.14	−1.06, 0.78	0.769	Women: **0.11**	0.01, 0.20	**0.026**
Sedentary time (hr/d)	0.008	−0.15, 0.17	0.922	0.05	−0.14, 0.24	0.603

Note.

*Model I for each variable, in separate models, adjusted for sex; sex by physical activity (PA) interaction was tested, but only included if statistically significant.

†Models for anthropometry and body composition variables were adjusted for sex, baseline weight, baseline diet (energy intake, total fat [% energy]), and energy expenditure (PA, sex by PA interaction, and sedentary time).

‡*p*-values <0.05 and associated parameters are in bold, and in model I the *p*-value for the sex by PA interaction = 0.8510; in model II, *p*-value for interaction = 0.0486, interaction beta coefficient = −0.135 (men 1; women 0), and thus both models shown accounting for sex interaction.