International Journal of Nutrition and Food Sciences
2018; 7(2): 39-46
http://www.sciencepublishinggroup.com/j/ijnfs
doi: 10.11648/j.ijnfs.20180702.11
ISSN: 2327-2694 (Print); ISSN: 2327-2716 (Online)

Frequency of Vending Machine Usage as a Predictor of Weight Status Among College Students

Morgan Faulk Sowers[1], Sarah Colby[1, *], Wenjun Zhou[2], Agricola Odoi[3], Elizabeth Anderson Steeves[1], Katie Kavanagh[1]

[1]Department of Nutrition, University of Tennessee, Knoxville, USA

[2]Department of Business Analytics and Statistics, University of Tennessee, Knoxville, USA

[3]Department of Biomedical and Diagnostic Sciences, University of Tennessee, Knoxville, USA

Email address:
mfaulk@vols.utk.edu (M. F. Sowers), scolby1@utk.edu (S. Colby), wzhou4@utk.edu (W. Zhou), aodoi@utk.edu (A. Odoi), eander24@utk.edu (E. A. Steeves), kkavanag@utk.edu (K. Kavanagh)

[*]Corresponding author

To cite this article:
Morgan Faulk Sowers, Sarah Colby, Wenjun Zhou, Agricola Odoi, Elizabeth Anderson Steeves, Katie Kavanagh. Frequency of Vending Machine Usage as a Predictor of Weight Status Among College Students. *International Journal of Nutrition and Food Sciences*. Vol. 7, No. 2, 2018, pp. 39-46. doi: 10.11648/j.ijnfs.20180702.11

Received: December 30, 2017; **Accepted**: January 25, 2018; **Published**: February 12, 2018

Abstract: *Background:* College students have identified frequent unhealthy snacking from vending machines as influencing their dietary intake and weight status. However, research on associations between vending usage and weight status is lacking. *Objectives:* 1.) Compare college students' demographic characteristics by frequency of vending machine usage (FVU) and body mass index (BMI). 2.) Determine associations between FVU and BMI levels among college students. *Methods:* Using a cross-sectional study design, a convenience sample of college students (n=110) completed an online survey providing demographics, height and weight, and FVU – categorized as "none" (never or rarely), "low" (less than once per month, or "high" (once per month or more). Demographics were analyzed using descriptive statistics with comparisons by FVU and BMI levels. Associations between FVU and BMI levels, alone and controlling for sex and race/ethnicity, were tested using a proportional odds logistic model. *Results:* The majority of participants were in the lowest FVU (50%) and normal BMI (56%; M=24.2 kg/m^2) levels. BMI was significantly different by FVU levels (p=.012). Logistic regression indicated the highest FVU category was associated with a 4.6 times greater odds of being overweight or obese (p=0.001). *Conclusion:* This study described a significant relationship between higher levels of FVU and higher levels of BMI among college students. This formative evidence can inform future vending interventions in this population.

Keywords: Vending Machine Usage, Weight Status, College Students

1. Introduction

College students experience a newfound freedom of choice associated with the college lifestyle, including in dietary choices. [1, 2] Unfortunately, this freedom often translates into the development of unhealthy eating patterns, excessive energy intake, and undesired weight gain. [2-5] Currently, 35.1 percent of college students in the United States are overweight or obese, [6] which can lead to an increased risk of developing serious health conditions such as type 2 diabetes, heart disease, stroke, and certain types of cancer. [7] Furthermore, obesity prevalence in the college-aged individuals has increased more than any age group, and has more than doubled in the past 30 years. [8]

One dietary habit identified by college students as potentially influencing their weight status is frequent snacking. [9] Approximately 47 percent of the variance in weight gain among college students has been attributed to the frequency or amount of snacks consumed. [4] Furthermore, the number of snacks consumed per day and frequency of snack purchases away from home per week has been significantly associated with unhealthy dietary behaviors related to the development of an overweight or obese weight status. [10, 11]

Another aspect of the college lifestyle that influences dietary habits and weight of students is the campus food environment. [12] Purchasing foods on campus has been strongly associated with poor dietary habits, weight gain, and unhealthy weight statuses among college students, largely due to the unhealthy nature of items offered. [12-14] This holds true for vending machines on campus, where over half of college students report purchasing snack foods at least once per week, [15, 16] and majority of vending items are high in calories, sugar, fat, and saturated fat and low in fiber. [16, 17] Vending machine customers recognize the unhealthy nature of vending machines, often identifying these machines as being a source of junk food or contributing to their weight gain. [18, 19] While availability of healthy items is important, consumers' choice of vending machine item may also play a role. Current research regarding the relationship between vending item choice and BMI in college students is inconclusive, with one study reporting no significant differences between item choice and BMI, [16] while another study only found a significant difference in BMI when participants purchased a chocolate bar item vs. another item ($p<0.05$). [20] Additionally, one study found that even when higher proportions of healthy vending items are available, college students choose the most unhealthy options the majority (59%) of the time. [15] However, the impact of vending item choice is mitigated by the fact that studies have shown the majority (approximately 93%) of all vending items are similarly categorized as unhealthy at the study university and other universities around the U.S. [21-23]

While evidence of college students' unhealthy vending item choices suggest more frequent snacking from campus vending machines might be related to higher weight statuses among college students, [4, 20] more research is needed to test and confirm this hypothesis. Though vending machines might be an ideal place for interventions in this population, [24] there is currently limited research available to inform these interventions. To our knowledge, the only other study that has investigated the relationship between frequency of vending machine usage and weight status was performed by Park and Papadaki and found no significant differences in BMI between groups of college students categorized as vending users and non-vending users. [16] Therefore, more evidence suggesting a relationship between frequency of vending usage and weight status is needed before introducing interventions with campus vending machines as a strategy to improve the diet and weight status of college students. [24]

Defining the target population prior to an intervention can improve the intervention's direction to better meet the needs of targeted individuals. [25] Specifically, more information is needed to describe demographic characteristics of college students who purchase items from campus vending machines at different frequency levels, especially related to differences in weight status. [15, 16]

Although, differences in BMI and snacking behaviors by sex and race/ethnicity have been observed in this population [26-30] there have been no studies that have assessed the association between FVU and BMI while also accounting for demographic characteristics. Therefore, the objectives of this study were to describe and compare demographic characteristics of a sample of college students by frequency of vending usage (FVU) and current weight status, measured using body mass index (BMI) and to determine the association between FVU levels and BMI levels, while controlling for sex and race/ethnicity. Based on limited previous research, it was hypothesized that participants with the highest FVU levels would have significantly higher odds of being overweight or obese compared to individuals with the lowest or mid FVU, when controlling for sex and race/ethnicity. [4, 20] The findings of this study will provide evidence to support the need for vending interventions while also gathering information to inform these interventions.

2. Methods

2.1. Study Design and Setting

This cross-sectional study was conducted in January 2017 at a university in the southeastern U.S.

2.2. Participants

The study population included a sub-sample of students (n=270) who previously participated in a larger research project and agreed to participate in future research. The convenience sample was originally recruited for the larger research project using orientation tabling events, e-mail listservs, verbal classroom announcements, and postcards. As part of their participation in the prior study students took an online screener to determine eligibility. Eligibility requirements, based on needs of the larger study, were students at the study university who were first-year students in the 2015-2016 academic year and over the age of 18. To be eligible students also had to have less than optimal fruit and vegetable intake, and met one additional criteria (a first generation college student, of minority status, from a low-income household, or had a parent who was overweight or obese). While the goal number of participants was 105, determined using *a priori* power analysis for logistic regression, [31] all 270 students were invited to participate in the study.

2.3. Data Collection

All 270 students were contacted by e-mail and asked to complete a short online survey using Qualtrics software. [32] They had 14 days from when the e-mailed link was sent to complete the survey. Reminder e-mails were sent on day 7 and 13 to students who had not yet completed the survey. The survey took approximately 10 minutes to complete and participants received a $10 gift card incentive after completion.

2.4. Variables and Data Preprocessing

The online survey asked participants multiple-choice questions regarding their demographics and FVU.

Demographics included the dichotomous variable of sex; continuous variables of age, height, and weight; and categorical variables of race/ethnicity and academic class. FVU was measured by asking participants how often they purchase snack items from vending machines on campus, using a 6-point ordinal scale adapted from a previous vending usage study in this population. [15] Participants who never or rarely used vending machines were categorized in the "lowest" level, participants who used vending machines less than once per month in the "mid" level, and participants who used vending machines once per month or more in the "highest" level. Weight status was determined by utilizing self-reported height and weight to calculate the continuous variable of BMI. [33] The BMI values were also categorized into the ordinal levels of underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), overweight (25 – 29.9 kg/m^2) or obese (>30 kg/m^2). [33]

For meaningful statistical comparisons and logistic regression, most of the categorical variables were re-coded by collapsing the variables into dichotomous variables to account for the expected small sample sizes in the minority categorical levels. Race/ethnicity was recoded into a dichotomous variable that included "white" and "non-white," with "non-white" combining all other race/ethnicities identified, including black, Hispanic, Asian, and other. Since the sample recruited included a majority of freshmen participants, the sophomore, junior, and senior categories were combined into an "upperclassmen" category. The BMI levels were collapsed into a simplified three-level categorical variable by combining the underweight and normal participants to create the "not overweight/obese" category, with the other two categories of "overweight" and "obese" being retained as originally categorized.

2.5. Statistical Methods

2.5.1. Descriptive Characteristics

Summary statistics, including means and standard deviations for continuous variables and frequencies and percentages for nominal and categorical variables, were calculated overall, by the three FVU levels ("lowest," "mid," and "high"), and by the three BMI levels ("not overweight/obese," "overweight," and "obese"). Before statistical comparisons were completed, the variables were analyzed for normality and small cell sizes. The continuous variables of age and BMI were both considered to have a non-normal distribution according to the Shapiro-Wilk test (p <.001). [34] Therefore, median and interquartile ranges were used to provide descriptive statistics and a Kruskal-Wallis test was used to compare the average values for these variables between the three FVU and BMI levels. In addition, due to low cells counts, Fisher's exact test was used to compare the nominal and categorical variables between the FVU and BMI levels. Statistical significance was determined using a critical value of $p<0.05$. Data analyses for descriptive statistics were completed using SPSS, version 23.0. [35]

2.5.2. Logistic Regression

The choice of variables for consideration for statistical model was based on the in Figure 1, representing FVU and demographics as potential predictors of weight status in the college student population. A double-headed arrow between FVU and demographics denotes an expected correlation, but not necessarily a causal relationship.

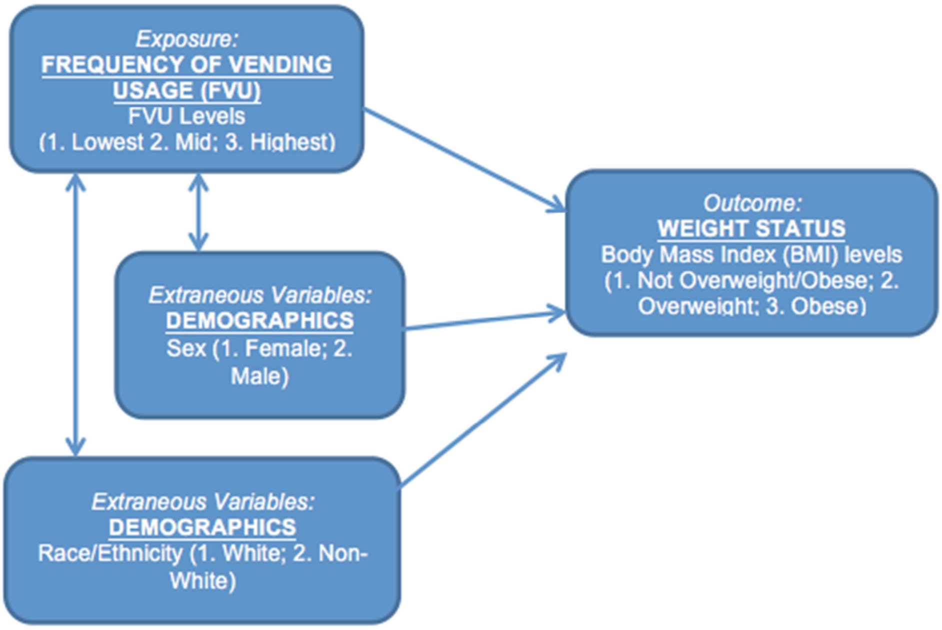

Figure 1. *Conceptual Model Representing Predictors of Weight Status Among College Students.*

A proportional odds logistic regression model was used to determine the association between the ordinal dependent variable of BMI level and independent variable of FVU level. Both a simple model, with only the independent and dependent variables, and a multivariable model, that also included sex and race/ethnicity as potential confounding variables, were fitted to the data. The assumption of proportional odds for each variable was tested using a Wald test of parallel lines assumption.

Potential confounding by sex and race/ethnicity was assessed by comparing the change in parameter estimate of the variables in the model with and without the suspected confounding variable. A 20% change in the estimate of any of the variables already in the model was considered to be indicative of a confounder that was then retained in the model. [34] All two-way interaction terms were assessed for statistical significance and those significant at an $\alpha \leq 0.05$ were retained in the final model.

Odds ratio and 95% confidence intervals were computed for all variables retained in the final model. The critical values used for all significance tests was $p<0.05$. Data analysis for logistic regression were performed using Stata version 13.1. [36]

2.6. Ethical Statement

The Institutional Review Board at the study university approved all procedures prior to data collection. Before participation, all participants read and agreed to an approved informed consent. All data collected were de-identified before analysis.

3. Results

3.1. Descriptive Characteristics

A total of 110 participants completed the survey. Summary statistics for participants' demographic characteristics overall as well as by FVU levels and by BMI levels can be found in Table 1. The majority of participants were female (81%), white (81%), freshmen (69%), with a median age of 18 (IQR=18-19). The majority of participants also had a BMI categorized in the normal level (56%). The median continuous BMI for all participants was 23.2 (IQR=21.3-26.6) kg/m^2, which was also categorized in the upper end of the normal level. [33] Approximately half of the participants were in the lowest FVU level with the remaining participants in the mid (22%) and highest (21%) FVU levels.

Table 1. *Description and Comparison of Demographic Characteristics of College Student Participants Overall, by Frequency of Vending Usage (FVU) Levels and by Body Mass Index (BMI) Levels.*

	TOTAL	**Frequency of Vending Usage (FVU)**				**Body Mass Index (BMI)**			
	(n=110)	**Lowest (n=54)**	**Mid (n=24)**	**Highest (n=32)**		**Not Overweight/Obese (n=69)**	**Over-weight (n=29)**	**Obese (*n*=12)**	
	Median (IQR)	*Median (IQR)*			p^a	*Median (IQR)*			p^a
Age (years)	18.0 (18-19)	18.5 (18-19)	18 (18-19)	18 (18-19)	*.737*	19 (18-19)	18 (18-19)	18 (18-19)	*.228*
	n	*n (%)*			p^b	*n (%)*			p^b
Sex					*.192*				*.931*
Male	20	7 (35)	4 (20)	9 (45)		12 (60)	6 (30)	2 (10)	
Female	90	47 (52)	20 (22)	23 (26)		57 (63)	23 (26)	10 (11)	
Race/Ethnicity					*.597*[c]				*.265*[c]
White	89	45 (51)	20 (23)	24 (27)		59 (66)	21 (24)	9 (10)	
Black	11	4 (36)	2 (18)	5 (46)		2 (18)	6 (55)	3 (27)	
Hispanic	7	2 (29)	2 (29)	3 (43)		6 (86)	1 (33)	0	
Other	3	3 (100)	0	0		2 (67)	1 (33)	0	
Academic Class					*.894*[d]				*.223*[d]
Freshman	76	38 (50)	17 (22)	21 (28)		46 (61)	19 (25)	11 (14)	
Sophomore	23	9 (39)	5 (22)	9 (39)		15 (65)	8 (35)	0	
Junior	8	6 (75)	1 (13)	1 (13)		5 (63)	2 (25)	1 (12)	
Senior	2	1 (33)	0	1 (33)		2 (100)	0	0	
Graduate	1	0	1 (33)	0		1 (100)	0	0	

[*]significant at $p < 0.05$
[a]Kruskal-Wallis test used due to non-normal distribution with continuous variables
[b]Fisher's exact test used due to cell counts less than 5 in at least one cell.
[c]Race/ethnicity combined into "white" and "non-white" (black, Hispanic, and other) variables for fisher's exact test.
[d]Academic class combined into "freshman" and "upperclassman" for fisher's exact test.

Table 1 shows there were no statistically significant differences in any of the demographics by FVU or BMI levels. However, as shown in Table 2, statistical comparisons of BMI by FVU levels found a significant difference in the continuous BMI (p=.007) and the three BMI levels (p=0.012) between the three FVU levels. Specifically, the highest FVU level had the highest average continuous BMI (26.4 ± 5.2 kg/m^2), categorized within the overweight level, and highest proportion of overweight/obese BMI levels (59%).

Table 2. *Description and Comparison of Body Mass Index (BMI) by Frequency of Vending Usage (FVU) levels Among College Student Participants.*

	Frequency of Vending Usage (FVU)			
	Lowest (n=54)	**Mid (n=24)**	**Highest (n=32)**	
	Median (IQR)			p^a
BMI (kg/m^2)	22.7 (20.5-25.2)	22.7 (21.5-26.2)	25.8 (22.2-30.0)	*.007**

	Frequency of Vending Usage (FVU)			
	Lowest (n=54)	**Mid (n=24)**	**Highest (n=32)**	
	n (%)			p^b
BMI Level				*.012**
Not Overweight/Obese	39 (57%)	17 (25%)	13 (19%)	
Overweight	13 (45%)	5 (17%)	11 (38%)	
Obese	2 (17%)	2 (17%)	8 (67%)	

[a]Kruskal-Wallis test used due to non-normal distribution with continuous variables.
[b]Fisher's exact test used due to cell counts less than 5 in at least one cell.

Though not significant, some interesting findings can be drawn from the descriptive results provided for the FVU and BMI levels. More males were in the highest FVU level (45%) while more females were in the lowest FVU level (52%) than other levels, but the majority of both males (60%) and females (63%) were in the non-overweight/obese BMI category. The majority of white participants were in the lowest FVU level (51%) and the non-overweight/obese BMI category (66%), while the non-white participants were almost evenly split between the lowest (43%) and highest (38%) FVU categories and the non-overweight/obese (48%) and either overweight or obese (52%) BMI categories. The majority of both freshman and upperclassmen were in in the lowest FVU category (55%; 47%) and the non-overweight/obese BMI category (61%; 68%).

3.2. Logistic Regression

The final sample size for logistic regression was 109 after exclusion of one participants with missing data due to the choice of "choose not to answer" for the race/ethnicity variable. The non-overweight/obese BMI category was used as the base category for comparison. The reference categories of the independent variables in the model were the lowest FVU level, female sex, and white race/ethnicity. The Wald test of parallel line assumptions indicated none of the variables violated the proportional odds assumption (p=.342).

The model results indicate that none of the demographic variables contributed significantly to the model and neither were they important confounders and so both of them were removed from the final model. There were no statistically significant interaction terms and so none were included in the final model (Table 3).

Table 3. *Proportional Odds Logistic Regression Models for FVU levels Predicting BMI Levels (n=108).*

Predictor	*OR*	*95% CI*	*p*
Mid FVU	1.23	.43, 3.59	.693
Highest FVU	4.46	1.78, 11.18	.001

Note: Mid FVU = < 1 time per month; Highest FVU = 1 time per month or more.

There was a significant association between FVU and BMI level. However, only the highest FVU level had a statistically significant association with the overweight or obese BMI levels in the final model (OR=4.46; p=0.001). Specifically, participants in the highest FVU were 4.46 times more likely to have a BMI in the overweight or obese levels, rather than the non-overweight level, compared to participants in the lowest or mid FVU levels.

4. Discussion

The purpose of this study was to describe the characteristics of vending users by frequency as well as provide evidence for FVU as a predictor of weight status, while considering potential demographic factors. The descriptive statistics provided an idea of the characteristics of college students who use vending machines with different frequencies. The biggest strength of this study was that it was the first to investigate the association between FVU levels and BMI levels, alone and while also controlling for specific demographic factors, in a college population. However, the novelty of this type of research makes it difficult to compare the results to prior research findings, limiting the potential confirmation for validity of the findings.

The first important finding from descriptive analysis was that the sample of students in this study used vending machines less frequently than previous reports of college students. This study sample consisting of approximately 50% vending users and 50% non-vending users was consistent with previous studies in this population; [16, 20] However, only 29% of participants in this study purchased items from vending machines at least once per month compared to 84% (n=294) of participants with this frequency in a similar study of college students. [15] This discrepancy might be due to the differences in sample size and demographic characteristics, with the previously mentioned study including 478 participants, 85% of which were students, with approximately half being female and race/ethnicity or academic year not measured, compared to our sample of 110 college students with a large majority being female, white, and freshmen. [15] In addition, it is unclear whether food availability or health policies differed on these campuses, which have been shown to influence vending machine usage. [16, 21, 37] Future research with a larger sample, additional data collection, and multiple campuses should be conducted to determine if there is an overall decline in vending usage in this population or if the differences are due to other extraneous factors. [38]

Statistical comparisons of the demographic characteristics found no significant differences in FVU or BMI on many of the measured variables. Consistent with other studies, we found no differences in age or sex with FVU. [15, 16] However, this study further contributes to the comparison of demographic characteristics by FVU by also reporting no significant differences in race/ethnicity or academic class.

However, there were significant differences in both the continuous BMI and dichotomous BMI levels between the different FVU levels. The significant differences in BMI between the FVU levels, with the highest FVU level having the highest BMI levels, contradict the previously mentioned findings from Park and Papadaki, which suggested there were no significant differences in BMI between groups of college students categorized as vending users and non-vending users. [16] However, the previous study used a higher frequency to define vending users, set at more than once per week compared to our highest FVU level being once per month or more, and was conducted in a different country and population, making comparison of results difficult. [16] These conflicting results suggest more consistent research is needed to confirm or refute this association.

The discovered differences between weight indicators and FVU levels supported the study hypothesis tested and confirmed with the proportional odds logistic model. Specifically, participants with the highest FVU level, or those that used vending machines once a month or more, had a significant, 4.5 times greater odds of being overweight or obese rather than normal weight, compared to participants with lowest or mid FVU. However, this does not prove a causal relationship between vending machine usage and weight status; instead, FVU may be a proxy for other overall dietary patterns not measured in this study. While there is little evidence to support the finding of weight specifically being related to vending usage, one previous study found individuals in the obese BMI group consumed snacks at a higher frequently than individuals in the normal BMI group ($p<0.05$). [39] Another interesting finding from this study was using vending machines at a mid level, or less than once per month, did not significantly impact the odds of having a higher weight status. Overall, these findings support the use of specifying frequency when categorizing and comparing vending usage among college students.

Another particular strength of this study was the inclusion and testing of demographic variables in the conceptual and logistic model. Their lack of significant contribution to the logistic model indicated these variables may not be predictors or confounders that need to be controlled when determining associations between FVU and BMI. However, while not significant, the results may still provide insight into trends in the associations between sex and race/ethnicity and FVU or BMI. Though a higher proportion of males were categorized in the highest FVU level, associated with higher odds of being overweight/obese according to the logistic regression, neither males nor females were more likely to be overweight/obese in the statistical comparisons. Consistent with the logistic regression results of this study providing roughly equal odds of males and females for being overweight or obese compared to normal weight when controlling for FVU and race/ethnicity, current research in this population has provided conflicting results regarding which sex is more likely to be overweight or obese overall [26, 27] or consume more snacks per day. [29, 39] We also found that a higher proportion of non-white participants were in the highest FVU level and overweight/obese BMI level compared to white participants, though these findings are limited due to the small sample sizes in the non-white group and lack of statistical significance. However, previous studies have also indicated similar results, with non-white adults having a significantly higher obesity prevalence ($p < 0.01$)[28] and consuming significantly more snacks away from home ($p<0.01$) compared to white adults. [30] These findings were supported with the logistic model in this study indicating non-white participants having 67% higher odds of being overweight or obese compared to normal weight than white participants, when controlling for FVU and sex. However, these interpretations of sex and race/ethnicity are limited due to the lack of significance with comparisons or logistic regression in this study.

4.1. Limitations

While this study provided novel information to expand upon evidence regarding vending usage in this population, potential limitations should be taken into consideration when interpreting the results. First, the cross-sectional study design only identifies associations rather than causal relationships. Only gathering data at one time point also leads to a lack understanding regarding changes over time or variances during different time points. Furthermore, the convenience sample commonly used in this and other cross-sectional studies could reduce external validity of the results. Specifically, the majority of participants being female, white, and freshman students may decrease representativeness of the sample and generalizability of results. The eligibility requirements for participation in the larger study from which the sample was taken, identifying participants “at risk” for weight gain may have also biased the results and reduced generalizability. Additionally, differences in the sample sizes within each level, with more participants in the lowest FVU and not overweight/obese BMI levels, may have reduced the ability to detect differences in these groups. A final limitation is that the sample was from a single university, with it being unclear whether food environment characteristics specific to this university may have influenced participants purchasing and consumption patterns in a way that is not consistent with other settings. [12, 24] Despite these limitations, this study was not intended to be a valid representation of all vending users, but rather an exploratory formative research investigation of associations that can be expanded upon with larger, more representative samples.

The survey data collection technique commonly used with cross-sectional studies may also present a limitation of this study. Particularly, relying on self-report of height and weight for the major outcome of BMI could lead to inaccuracies. However, studies have indicated self-reported weight in this population was strongly and significantly correlated with actual measurements. [40] That being said, female, white, and/or overweight or obese participants have an increased likelihood of underestimating weight and overestimating height, which underestimates BMI. [40, 41] Since this study was majority white, females, with unknown actual measurements, the resulting BMI, and subsequent logistic model analysis, should be interpreted with caution.

Finally, the scope of this study is limited in that it did not gather information on actual dietary behavior, including what types of items participants purchased from vending machines, which may act as an intervening variable between vending usage and weight status. However, previous findings suggest measuring vending item choice may not make a large difference due to inconclusive results on its effect on the outcome of BMI, [16, 20] the large homogeneity of unhealthy items present in vending machines on this and other college campuses, [21-23] as well as the homogeneity of college students' unhealthy choices, regardless of healthy item availability. Nonetheless, future research should measure, test and confirm the intermediate impact of vending item choice or dietary behaviors to determine the appropriateness of including this variable in the conceptual model testing FVU as a predictor of BMI.

4.2. Conclusions

The overall purpose of this study was to provide formative evidence that would contribute to the current lack of evidence regarding the relationship between frequency of vending machine usage and weight status in the college population. In doing so, we found a significant difference between measures of weight status with different frequencies of vending usage. Specifically, college students who purchased items from vending machines at least once a month had 4.5 times greater odds of being overweight or obese compared to participants who used vending machines less frequently or not at all. Therefore, implementing healthy vending interventions could be beneficial for college students, with the largest impact on those who are already overweight or obese who are using vending machines most frequently. However, the results of this study should be interpreted with caution, due to the potential issues with representativeness of the study sample, issues with internal and external validity, and lack of current research to compare the findings. We suggest future studies expand upon our research to further test and confirm the association between FVU and BMI, while also incorporating additional confounding and effect modifying variables, to strengthen and build upon these findings. Finally, while this study did not seek to establish causation between FVU and BMI, future research should test the impact of interventions aimed at reducing the frequency of vending usage in this population on changes in weight status.

Acknowledgements

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2014-67001-21851.

References

[1] Arnett, J. J., Emerging adulthood. A theory of development from the late teens through the twenties. Am Psychol., 2000. 55 (5): p. 469-80.

[2] Dinger, M. K., Physical activity and dietary intake among college students. American Journal of Health Studies, 1999. 15 (3): p. 139-148.

[3] Odlaug, B. L., et al., Prevalence and correlates of being overweight or obese in college. Psychiat Res., 2015. 227 (1): p. 58-64.

[4] Levitsky, D. A., C. A. Halbmaier, and G. Mrdjenovic, The freshman weight gain: A model for the study of the epidemic of obesity. International Journal of Obesity & Related Metabolic Disorders, 2004. 28 (11): p. 1435-1442.

[5] Holm-Denoma, J. M., et al., The "freshman fifteen" (the "freshman five" actually): Predictors and possible explanations. Health Psychol., 2008. 27 (1 Suppl): p. S3-9.

[6] American College Health Association, National College Health Assessment II: Undergraduate Student Reference Group Executive Summary Spring 2015. 2015, American College Health Association: Hanover, MD.

[7] Center for Disease Control and Prevention. Adult Obesity Facts. 2015 [cited 2015 October 2, 2015]; Available from: http://www.cdc.gov/obesity/data/adult.html.

[8] Nelson, M. C., et al., Emerging adulthood and college‐aged youth: an overlooked age for weight‐related behavior change. Obesity, 2008. 16 (10): p. 2205-2211.

[9] Nelson, M. C., et al., Understanding the perceived determinants of weight-related behaviors in late adolescence: A qualitative analysis among college youth. J Nutr Educ Behav., 2009. 41 (4): p. 287-292.

[10] Larson, N. I., et al., Adolescent snacking behaviors are associated with dietary intake and weight status. J Nutr., 2016. 146 (7): p. 1348-1355.

[11] Sebastian, R. S., J. D. Goldman, and C. W. Enns, Snacking Patterns of U.S. Adolescents. 2010, United States Department of Agriculture.

[12] Pelletier, J. E. and M. N. Laska, Campus food and beverage purchases are associated with indicators of diet quality in college students living off campus. Am J Health Promot., 2013. 28 (2): p. 80-87.

[13] Laska, M. N., et al., How we eat what we eat: Identifying meal routines and practices most strongly associated with healthy and unhealthy dietary factors among young adults. Public Health Nutr., 2015. 18 (12): p. 2135-45.

[14] Vella-Zarb, R. A. and F. J. Elgar, The 'Freshman 5': A meta-analysis of weight gain in the freshman year of college. J Am Coll Health., 2009. 58 (2): p. 161-166.

[15] Caruso, M. L., E. G. Klein, and G. Kaye, Campus-based snack food vending consumption. J Nutr Educ Behav., 2014. 46 (5): p. 401-5.

[16] Park, H. and A. Papadaki, Nutritional value of foods sold in vending machines in a UK university: Formative, cross-sectional research to inform an environmental intervention. Appetite, 2016. 96: p. 517-25.

[17] Byrd-Bredbenner, C., et al., Sweet and salty. An assessment of the snacks and beverages sold in vending machines on US post-secondary institution campuses. Appetite, 2012. 58 (3): p. 1143-1151.

[18] Voss, C., NEMS-V Research Final Report. 2011, Iowa Department of Public Health.

[19] Smith-Jackson, T. and J. J. Reel, Freshmen women and the "Freshman 15": Perspectives on prevalence and causes of college weight gain. J Am Coll Health., 2012. 60 (1): p. 14-20.

[20] Spanos, D. and C. R. Hankey, The habitual meal and snacking patterns of university students in two countries and their use of vending machines. J Hum Nutr Diet., 2010. 23 (1): p. 102-7.

[21] Lillehoj, C. J., et al., Vending assessment and program implementation in four Iowa worksites. Health Promot Pract., 2015. 16 (6): p. 814-25.

[22] Rudley, M. and S. Ramsay, Assessment of a university's vending machines indicates need for nutritional standards. J Acad Nutr Diet., 2014. 114 (9): p. A76-A76.

[23] Sankavaram, K., et al., What's in a snack? Nutritional assessment of university vending options. J Nutr Educ Behav., 2015. 47 (4): p. S87-S88.

[24] Seymour, J. D., et al., Impact of nutrition environmental interventions on point-of-purchase behavior in adults: A review. Prev Med, 2004. 39 Suppl 2: p. S108-36.

[25] Kolb, B., Marketing Research: A Practical Approach. 2008, London: Sage Publications.

[26] Freedman, M. R., Gender, residence and ethnicity affect freshman BMI and dietary habits. Am J Health Behav, 2010. 34 (5): p. 513-24.

[27] Debate, R. D., M. Topping, and R. G. Sargent, Racial and gender differences in weight status and dietary practices among college students. Adolescence, 2001. 36 (144): p. 819-33.

[28] Ogden, C. L., et al., Prevalence of Obesity Among Adults and Youth: United States, 2011-2014. NCHS Data Brief, 2015 (219): p. 1-8.

[29] Piernas, C. and B. M. Popkin, Snacking increased among U.S. adults between 1977 and 2006. J Nutr., 2010. 140 (2): p. 325-32.

[30] Larson, N., et al., Secular Trends in Meal and Snack Patterns among Adolescents from 1999 to 2010. J Acad Nutr Diet, 2016. 116 (2): p. 240-50.e2.

[31] Faul, F., et al., G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods, 2007. 39 (2): p. 175-191.

[32] Qualtrics., Qualtrics. 2015: Provo, UT.

[33] Center for Disease Control and Prevention, Body mass index: Considerations for practitioners. 2016, Department of Health and Human Services,.

[34] Dohoo, I., W. Martin, and H. Stryhn, Methods in Epidemiologic Research. 1st ed. ed. 2012, Charlottetown, PEI, Canada: VER Inc.

[35] SPSS Inc., SPSS Statistics for Mac,. 2014, IBM Corp.: Armonk, NY.

[36] StataCorp., Stata Statistical Software: Release 13.. 2013, StataCorp LP.: College Station, TX.

[37] Klapheke, A., A Comparison of Demographics and Purchasing Behaviors of Snack Vending Consumers at Different Locations in a Large University, in Human Ecology: Human Nutrition. 2012, The Ohio State University. p. 51.

[38] IBIS World. Vending Machine Operators in the US: Market Research Report. 2017 January 2017 [cited 2017 April 6]; Available from: https://www.ibisworld.com/industry/default.aspx?indid=1113.

[39] Berteus Forslund, H., et al., Snacking frequency in relation to energy intake and food choices in obese men and women compared to a reference population. Int J Obes (Lond), 2005. 29 (6): p. 711-9.

[40] Gunnare, N. A., K. Silliman, and M. N. Morris, Accuracy of self-reported weight and role of gender, body mass index, weight satisfaction, weighing behavior, and physical activity among rural college students. Body Image, 2013. 10 (3): p. 406-10.

[41] Larsen, J. K., et al., Validity of self-reported weight and height and predictors of weight bias in female college students. Appetite, 2008. 50 (2-3): p. 386-9.