



## Short Communication

## Increased body weight affects academic performance in university students

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## ABSTRACT

For K-12 students, obesity has been linked to student educational achievements. The study objective was to determine whether academic performance in university students is correlated with BMI. Students from two consecutive academic years (Jan–May 2013 and Jan–May 2014) were given an optional class survey in May, as extra credit. Of the 452 students that completed the survey, 204 females and 75 males ( $N = 279$ ; 73% female and 27% male) consented to participate in the study. The number of correct answers to problem-solving questions (PSQs) and the overall final grade for the class were compared to the calculated BMI using linear regression with a Pearson's R correlation and unpaired *t*-tests. BMI was significantly negatively correlated with student's final grades ( $P = 0.001$  Pearson's  $r = -0.190$ ) and PSQs were positively correlated with final grades ( $P < 0.001$ ; Pearson's  $r = 0.357$ ). Our findings show a correlation between healthy body weight and improved academic performance. Further, the data suggest that future research in the area of body weight, diet, and exercise and any correlations of these with academic performance in college students are warranted.

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## 1. Introduction

Obesity and/or being overweight have been implicated as factors in poor academic performance for elementary and high school-aged students. Several studies have implicated early childhood and adolescent obesity and/or being overweight, in poor performance in school (Burkhalter and Hillman, 2011; Yates et al., 2012). Substantially fewer studies have examined whether the link between poor academic performance and obesity and/or being overweight persists into college. Clarke et al. examined body mass index (BMI) in individuals from age 19 to age 30, and found that high school seniors who expected to graduate from colleges or universities had 34% reduction in their odds of being persistently overweight into adulthood (Clarke et al., 2013). Franz and Feresu assessed 77 college-aged participants and found a negative correlation between both GPA and ACT scores with BMI (Franz and Feresu, 2013).

Many strategies to enhance college and university-level problem-solving skills have been employed with variable success (Niu et al., 2012). College students need to be able to analyze, synthesize, and evaluate information and then apply these abilities to real-world situations. Blooms taxonomy provides a framework for devising learning goals with higher order problem-solving outcomes (Bloom et al., 1956). The impact of weight gain during college (Nicoteri and Miskovsky, 2014; Ogden et al., 2014) and any association between college-level learning,

cognition, problem-solving skills and academic performance has not been reported. Therefore, the present study sought to ask whether BMI was correlated with differences in final course grades and problem-solving skills in university-aged students.

## 2. Methods

## 2.1. Study design

Using a cross-sectional study design, the investigation involved two consecutive years of data. The study protocol was approved by the Institutional Review Board at Virginia Tech. Students provided written consent.

## 2.2. Study population

A total of 470 students from two consecutive academic years enrolled in a departmental required class in advanced metabolic nutrition, were given an optional class survey as extra credit. Of those, 452 students completed the survey. Slightly >50% of the students consented to participate in the research study, which consisted of 204 females and 75 males (141 juniors, 125 seniors, 12 5th year students, and 1 graduate student), with an average age of  $21.3 \pm 1.4$ .

## 2.3. Body mass index (BMI) calculations

BMI was calculated in Excel (Microsoft, Redmond, WA) by the researchers using student self-reported height (feet and inches) and

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weight (pounds). At the end of the semester reported BMI was used for comparisons with academic performance and problem-solving questions.

#### 2.4. Problem-solving questions and iClicker™ grading

Class was held twice a week, with at least one problem-solving question (PSQ) asked during each lecture. An average of 4–5 iClicker questions were asked each class period, but most did not meet the criteria as a PSQ. Students received class participation points for answering, but there was no credit given for correct answers. PSQs were defined as those that required students to use and interpret data to answer the question or they were questions that required students to assimilate information they had already learned to answer the question. For the data from a problem-solving question to be included in this study, 40% of the students in the study must have answered the question correctly. There were 16 questions that met these criteria (see supplementary material for questions) each year. The percentage correct for the 16 questions was used in correlations with BMI and class grades. Each PSQ was a multiple-choice question.

Students purchased their personal handheld response system device ([www.iClicker.com](http://www.iClicker.com)) and registered them online. Registered devices were then linked to individual students in the iGrader™ software ([www.iClicker.com](http://www.iClicker.com)). Points were assigned for daily participation, and not for answering correctly; however, only the data from those students that consented to the study were viewed and analyzed for correct answers after final grades for the semester were submitted.

#### 2.5. Statistical analyses

Gender differences were measured using an unpaired *t*-test with a Tukey's post hoc test. For correlations between BMI, problem-solving scores, and final grades, a Pearson's *r* correlation was employed using the GraphPad Prism software (San Diego, CA). The table is presented as means  $\pm$  standard error of the mean (SEM), and correlations are presented with Pearson's *r* and 95% confidence intervals in text and *R*<sup>2</sup> in the figure. Significance was set at *P* ≤ 0.05.

### 3. Results

#### 3.1. Gender differences do not affect academic performance, but do affect BMI levels

A total of 204 females and 75 males that consented to be a part of this study self-reported BMI (through height and weight), participated in PSQs, and received a final grade for the class (Table 1). The average BMI did not significantly change from the beginning to the end of the semester (data not shown).

#### 3.2. Problem-solving scores were associated with academic performance but not correlated with student's BMI

At least one PSQ was asked per lecture and students answered using personal response systems. The student's problem-solving score (as assessed by percent correct answers to PSQs) was not correlated

with their self-reported BMI, either as a group (Fig. 1A, Pearson's *r* = 0.065), or when separated by gender (data not shown). Student's ability to answer PSQs correctly in class was highly correlated (*P* < 0.001) with their overall academic performance as assessed by their final grade in the class (Fig. 1B, Pearson's *r* = 0.357, 95% CI 0.2501 to 0.4554). When the data was separated by gender, the significant correlation was maintained for both females and males (data not shown).

#### 3.3. Overall academic performance in the course was negatively correlated with BMI

To examine whether academic performance was correlated with BMI, final course grades were used. BMI was negatively correlated with student's final grade (Fig. 1C, *P* = 0.001 Pearson's *r* = -0.190, 95% CI -0.3012 to -0.07473), and this was true for both females (Fig. 1D, *P* = 0.008, Pearson's *r* = -0.186, 95% CI -0.3153 to -0.04993) and males (Fig. 1E, *P* = 0.007, Pearson's *r* = -0.308, 95% CI -0.5000 to -0.08705), despite males having a significantly higher reported BMI. As shown in graphs 1C–E, individual students with BMIs in the obese ( $\geq 30$ ) and overweight (25–29.9) categories were more likely to have a lower final grade than those students with BMIs in the normal or underweight categories.

### 4. Discussion

This study demonstrated a significant association between BMI and academic performance, as assessed by final grade in a junior/senior college level course. Problem-solving skills however, which were correlated with academic performance in the course, were not correlated with BMI. Our data are also consistent with other studies, where elementary or high school children who showed improvements in BMI had a statistically significant improvement in academic performance (Hollar et al., 2010a, b; Melnyk et al., 2013). The results are concerning, as data suggest that college freshmen show an approximately 1.55 kg (3.42 lb) body weight gain with 1.17% increased fat gain over their four years of college, where college students should be weight stable (Fedewa et al., 2014). Taken together with our data, this weight gain may be a factor in a student's academic performance, and may lead to lower scores than their weight-stable peers, a potentially significant variable in college success.

The continued need for research in this area is of paramount importance given that previous research indicates that adolescents who consumed fast food at least weekly were significantly less likely to report expectations that they would attend college (McDade et al., 2011). There is also evidence to support a possible role of high fat or high fat/high sugar diets in cognitive decline (Francis and Stevenson, 2013; Freeman et al., 2014). Another study showed that college students in health-related majors ate more fruits and vegetables than non-health majors (Ferrara et al., 2013). This is important because Kang et al. showed that 95% of college students are failing to eat the recommended amount of fruit and vegetables, and >60% say they are not getting enough physical activity (Kang et al., 2014), potential variables that could be related to academic performance.

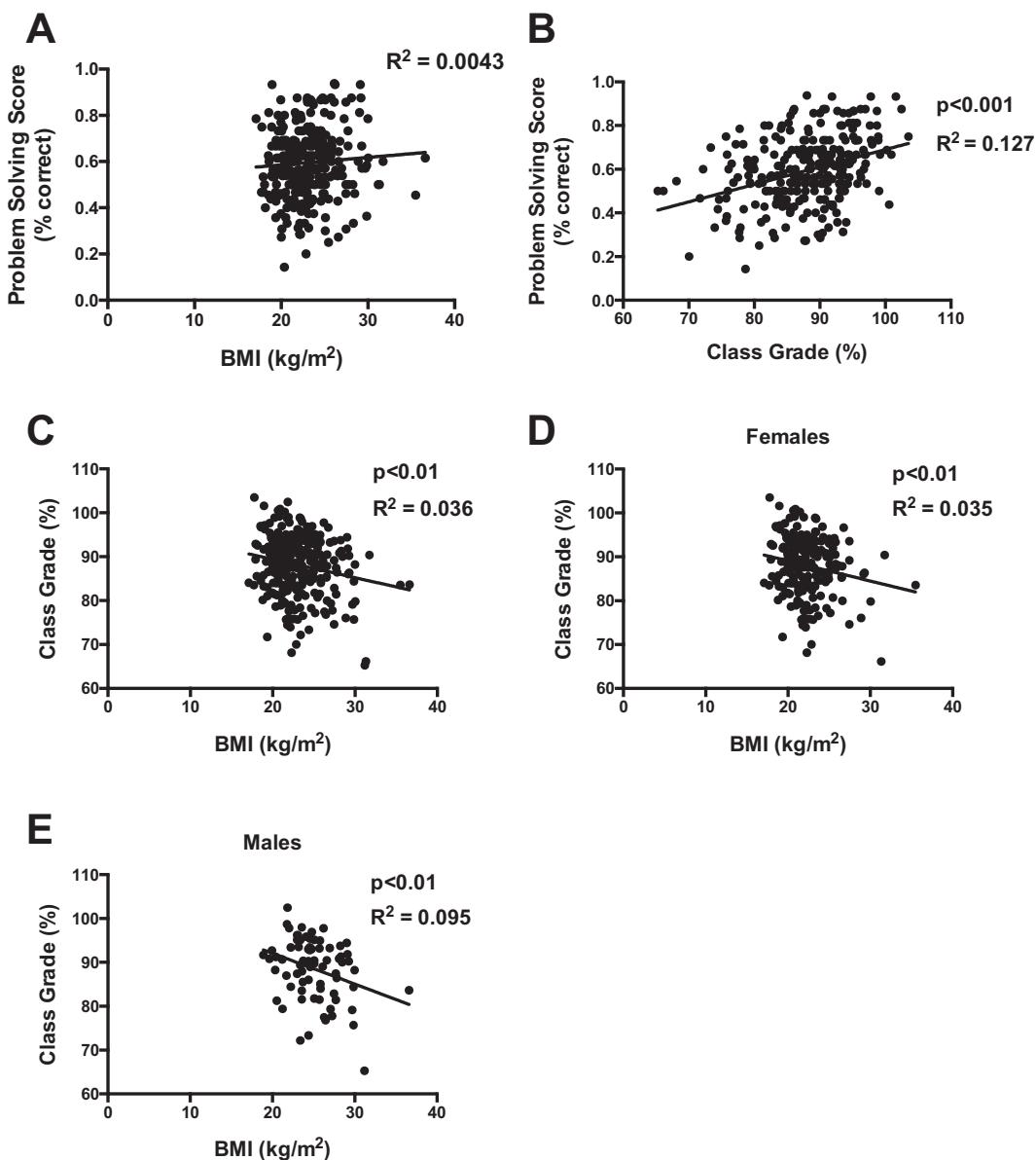
#### 4.1. Limitations

In this study, a strong and significant correlation was found between problem-solving skills and academic performance. Surprisingly, while academic performance correlated with BMI, problem-solving skills did not. There may be several reasons for this. First, the questions used for problem-solving skills were not scored for a grade, but rather students only needed to answer the question to get class participation points. Given this, some students might not have answered to their best abilities, and this could have influenced our ability to assess problem-solving skills with those questions. In addition, the majority of the course grade (67%, year 1 and 68%, year 2) is based on multiple-choice exams. Most of

**Table 1**

Demographic information on participants. Values shown are the means  $\pm$  standard error for the indicated value. There was a significant difference in BMI between male and female participants. All other comparisons were non-significant. *P* ≤ 0.001 (\*\*\*)�.

	Females	Males
n	204	75
Age	21.1 $\pm$ 0.06	21.6 $\pm$ 0.16
BMI	22.3 $\pm$ 0.19	25.1 $\pm$ 0.35***
Problem solving score (%)	0.59 $\pm$ 0.01	0.64 $\pm$ 0.02
Class grade (%)	88.0 $\pm$ 0.47	89.4 $\pm$ 0.96



**Fig. 1. Problem-solving scores were not correlated with BMI while final grades were negatively correlated with BMI.** Problem-solving score, shown as the percentage of PSQs answered correctly throughout the semester, was not correlated to BMI, calculated from self-reported height and weight, for all students (A). Correctly answered PSQs (percent) were correlated with final class grades (percent) for all students (B). Final class grades (percent) were negatively correlated to BMI, determined from self-reported height and weight, for all students (C), females (D), and males (E).

the questions on these exams were based on memorization and understanding of concepts, with only a few questions on each exam requiring the use of higher-level analysis skills. Thus, it is possible that our data shows that the influence of BMI is limited to lower level skills in Bloom's Taxonomy (remembering and understanding) versus higher-order analyzing and evaluation skills, which the problem solving questions demanded (Bloom et al., 1956). Studies in rodents and humans suggest that at least one complication of obesity is a deficiency in performance on tests of learning and memory (Freeman et al., 2014). The mechanism for these declines in cognitive function are still widely debated, and include insulin resistance affecting neuronal function, and obesity leading to the production of inflammation and reactive oxygen species within the brain resulting in neuron cell death (Freeman et al., 2014).

Another limitation of our study was the use of only two consecutive years of a large nutrition-related lecture class for analysis. We acknowledge this limitation and further studies should expand to multiple classes with students from different majors. Since one of the limitations of

this study was the self-report of body weight and height by students, a study with researcher-based measurements is warranted.

#### 4.2. Future directions

Given the association of higher BMI with lower college class performance, future studies should look at food intake recalls to examine whether diet itself influences academic performance. Specifically, studies should be extended to other college majors to obtain sufficient numbers of individuals with different dietary and exercise regimens to add to the evidence-based associations between BMI and academic performance.

#### 5. Conclusion

This study serves as a starting point for future studies examining the relationships of body weight and BMI differences, as well as food intake,

on academic performance at a variety of education levels. Our data suggest that improved BMIs could possibly lead to improved academic performances within a college course. College and university professors, staff and administrators should be aware of these results as they suggest that health promotion interventions that lead to improved body weight and body fat percentage may have the potential to improve overall academic performance. In addition, the results of our study suggest that a healthy diet, which could contribute to a healthy BMI, should be emphasized during student's undergraduate education. For example, George et al. found that a healthy diet correlated with college success, as measured by overall grade point average (George et al., 2008). Unfortunately, BMI was not measured in this study. However, in one recent study, nutrition education at the workplace did lead to a small reduction in BMI over a short 9-month period (Geaney et al., 2016). Improvements in healthy eating at colleges and universities could be addressed through the inclusion of healthy options in dining halls, nutrition education during orientation, a required nutrition class, and/or providing nutritional information on dining hall purchases, each of which may lead to an increase undergraduates in a healthy BMI range, thereby possibly increasing overall college success rates.

## Disclosure

The authors declare no conflict of interest. Materials, including data files can be obtained directly from the authors, with permission.

## Transparency document

The Transparency document associated with this article can be found, in the online version.

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ASA recruited subjects, analyzed data, interpreted data, searched the literature, generated figures and wrote the manuscript. DJG consented subjects, interpreted data, searched the literature and wrote the manuscript. Both authors were involved in editing the paper and had final approval of the submitted and published versions. Research was funded by *The Center for Instructional Development and Educational Research* (CIDER) at Virginia Tech, as an Instructional Enhancement Grant to DJG and ASA. The publishing fee was supported by a grant from the Virginia Tech Open Access Subvention Fund to DJG. The manuscript is dedicated to the memory of Dr. Craig Brians, acknowledging his zest for teaching, and thanking him for insightful conversations on pedagogy.

## Appendix A. Problem-solving questions (PSQs)

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.pmedr.2016.12.020>.

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