Associations of Adiposity with Measured and Self-Reported Academic Performance in Early Adolescence

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Abstract

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Objective: To examine the associations of adiposity with measured and self-reported academic performance independently of demographics and physical activity among U.S. adolescents.

Research Methods and Procedures: We surveyed 666 students 11 to 14 years old from seven middle schools in Los Angeles, CA. Weight and height were measured. Actual grade point average was obtained from school records. Self-reported school grades and physical activity time were measured by questionnaire. Adiposity measures included BMI, BMI percentile (≥85th percentile defined as at-risk-of-overweight), and percentage body fat (bioimpedance).

Results: After adjusting for gender, ethnicity, age, and physical activity time, overweight at-risk status, BMI, and percentage body fat were negatively related to only self-reported ($p < 0.01$) but not measured grades. Level of moderate-to-vigorous physical activity time was negatively related to measured and self-reported grades, independently of adiposity ($p < 0.01$).

Discussion: To our knowledge, this is the first study to examine both body mass and body fat in relation to measured and self-reported school grades. Adiposity did not relate to actual academic performance in a sample of predominantly Latino and Asian-American adolescents. The use of measured vs. self-reported academic outcomes may represent different constructs and influence study conclusions. Cultural factors may also play a role in our findings, but this requires further study.

Key words: overweight, adiposity, physical activity, school performance, academic performance

Introduction

Overweight is now a major health problem among U.S. adolescents, with 16% estimated as overweight (BMI ≥ 95th percentile) and another 15% as at risk of being overweight (BMI ≥ 85th percentile) (1). Much research has documented childhood overweight as a significant risk factor for chronic diseases (2–4), but little research has been conducted to examine its associations with academic performance, particularly among U.S. adolescents. In addition, to our knowledge, no study has examined the possible role of body fat in addition to that of body mass in academic performance. A better understanding of the role of adiposity in academic performance is needed as schools increasingly play an important part in the combat against obesity.

A few studies have investigated overweight in relation to some measures of academic performance (5–8). For instance, one study in Thailand (7) found that overweight was associated with poor school performance in adolescence (grades 7 to 9) but not in mid-childhood (grades 3 to 6). Two other studies among adolescents in Finland confirm these findings (5,9). Other overweight-related school outcomes studied previously include increased absenteeism and a higher likelihood of being held back in school (8).

Using U.S. nationally representative data from over 10,000 kindergartners followed through first grade, Datar et al. (6) showed that overweight children had lower reading and math test scores compared with normal-weight chil-

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dren, but these differences disappeared after adjusting for socioeconomic status (SES),[1] home environment indices, and other demographic covariates. To our knowledge, only one study has investigated body mass and academic performance among U.S. adolescents; that study showed that overweight was a predictor of lower academic performance only in school environments that promoted stigmatization (10).

The causative role of overweight in school performance is unclear. Adiposity might be a surrogate of socioeconomic effects, as the study by Datar et al. (6) demonstrates, or its effect might be confounded or reduced by other measures, such as psychosocial health or level of physical activity (11–17). Some research has shown a beneficial effect of physical activity on lowering levels of obesity (18) and increasing school performance in youth (17,19,20), although it is not clear whether overweight might, in fact, be due to lowered physical activity levels in those same individuals. In the current study, we aimed to investigate, in a sample of U.S. adolescents, whether BMI and percentage body fat were related to either measured or self-reported school grades, independently of ethnicity, gender, age, and level of physical activity.

Research Methods and Procedures

Subjects

Eight middle schools were conveniently selected from three school districts and the Archdiocese in the greater Los Angeles area (two from each school district and the Archdiocese) to participate in a study on determinants of physical activity in Latino and other minority adolescents based on their ethnic diversity. One school dropped out due to competing class time. Seven schools participated in the study. Students were sampled in two to four classrooms from each school (total n of students = 666, 73% female). The ethnic distributions of schools were identified through data from the California Board of Education and the Roman Catholic Archdiocese. In our sample, 68% of students were Latino, 18.8% were Asian/Pacific Islander, 8% were white, and 5.2% were other.

Procedures

Because this study was initially developed to study determinants of physical activity in girls, physical education teachers at each school recruited either all-girl mandatory physical education classes or classes with the highest number of girls. To provide data for studying generalization across genders, students of both genders in recruited classrooms were invited to participate in the study. Apart from gender, students were of mixed socioeconomic background and represented a wide range of athleticism and academic performance levels.

Student recruitment took place across 3 days. On the first day, the principal investigator explained the research project and distributed parental consent forms. On the second day, trained data collectors returned to pick up consent forms and distribute waiver forms to those students who had not returned the consent forms. Waiver forms provided parents who had not yet consented with a second opportunity to provide written refusal for their child to participate in the study. All forms were provided in English and Spanish. Data collectors returned once more to pick up remaining consent and waiver forms.

On the scheduled day of the survey, the data collectors returned to the classrooms and distributed written assent forms to all students who had not provided written parental refusal. Data collectors explained that students would be eligible to participate only if they provided written personal assent (by signing the student assent form). Students who provided parental consent and written personal assent completed the full survey. Students whose parents did not supply either written consent or written refusal but who did provide written personal assent completed a short form of the questionnaire that was developed in strict compliance with the California Education Code Section 51,513. Students who were ineligible to participate in the survey (those whose parents had provided written refusal and those who did not provide written personal assent) were asked to read or do schoolwork quietly. The survey was a self-administered paper-and-pencil questionnaire that required a single class period (45 to 60 minutes). The consent and survey administration procedures were approved by the University of Southern California Institutional Review Board and the relevant boards and committees from the participating schools. Consent and participation rates were more than 85%.

Measures

Demographics. Age (date of birth), gender, and ethnicity were self-reported.

Academic Performance. Students were ask to self-report their grades in the last year on a four-point scale (0, mostly Fs to 4, mostly As) (21). Actual, measured grade point average (GPA; four-point scale) for the previous year was also collected from the school administration for all children who provided signed informed consent.

Adiposity. Weight and height were measured by trained staff to calculate BMI. BMI percentiles were calculated based on the latest Centers for Disease Control and Prevention growth chart (22). A dichotomous weight status variable was created based on those at risk of being overweight (BMI $\geq$ 85th percentile) vs. those with normal weight (5th $\leq$ BMI $<$ 85th percentile). Percentage body fat was

[1] Nonstandard abbreviations: SES, socioeconomic status; GPA, grade point average; SE, standard error; MET, metabolic equivalent.

Table 1. Sample characteristics (total $n = 666$ students)

Variable	*n* (variable without missing data)	% (*n*) or mean ± standard deviation
Female	666	73.1% (487)
Latino	666	68.0% (453)
Asian/Pacific Islander	666	18.8% (125)
White	666	8.0% (53)
Other ethnicity	666	5.2% (35)
Age (years)	666	12.50 ± 0.66
At risk of overweight (BMI ≥ 85th percentile)	638	41.1% (262)
BMI (kg/m^2)	638	22.10 ± 5.26
Percent body fat (%)	647	26.30 ± 11.31
Blocks of moderate and high activity per day	551	5.19 ± 4.51
Measured GPA (0 = "all grades failing"; 4 = "straight As")	647	2.73 ± 0.87
Self-reported grade average (0 = "Fs"; 4 = "As")	614	2.83 ± 0.96

GPA, grade point average.

measured using foot-to-foot bioelectric impedance analysis (Tanita Corp., Arlington Heights, IL), which has been validated in children previously (23,24). Foot-to-foot bioelectric impedance was done with a step-on scale that transmits low-grade electric current from one foot to another through the lower abdomen. The technology is based on the differential conductivity of muscle tissue (more conductive due to higher water content) vs. fat tissue.

Physical Activity. Physical activity patterns were examined using a modified version of the Previous Day Physical Activity Recall, a self-report measure that has been validated in adolescent samples (25). We modified this instrument to include activity during earlier hours in the morning and later at night. In addition, we provided more types of physical activity as cues. The Previous Day Physical Activity Recall asks children the type and intensity of activities for 30-minute blocks of time from the moment they awaken to the moment they go to bed. The number of 30-minute blocks in which energy expenditure was estimated at <3 metabolic equivalents (METs; light physical activity), 3 METs or greater (moderate-to-vigorous physical activity), and 6 METs or greater (vigorous physical activity) was summed over one day.

Statistics

When the dichotomous adiposity measure was used, 22 underweight (BMI < 5th percentile) individuals were excluded from analysis. The distributions of both actual GPA and perceived grades were approximately normal (with few individuals in the left tail of the curve), so they were not transformed. Linear mixed models were used to better account for intra-school and intra-class correlation because students were sampled based on classroom and school clusters. Intercept was set as random in all mixed models. We first compared the unadjusted means of measured and self-reported grades between students at risk of overweight and normal-weight students. Subsequently, in separate multivariate models, either actual GPA or self-reported grade average was regressed on one of the three adiposity measures (overweight at-risk status, BMI, or percentage body fat), adjusting for gender, ethnicity, age, and blocks of moderate and high physical activity time. All analyses were conducted using the SPSS/PC statistical program (version 13.0 for Windows; SPSS, Inc., Chicago, IL), with an α value set at 0.05.

Results

Table 1 shows the characteristics of the sample. On average, the students had a BMI of 22.1 ± 5.3 kg/m^2 and percentage body fat of 26.3 ± 11.3% (mean ± standard deviation). However, 41.1% of the students were classified as at risk of overweight or overweight (BMI ≥ 85th percentile). There was a slight discrepancy between self-reported and actual, measured grades, with students reporting their perceived grade average to be 2.83 ± 0.96 while the actual average GPA was 2.73 ± 0.87.

Table 2 shows the unadjusted mean comparisons of measured GPA and self-reported grades between normal-weight students and students at risk of being overweight (Table 2) based on mixed model analysis. No difference was found between normal-weight students and students at risk of overweight in measured GPA [mean ± standard error

Table 2. Unadjusted actual GPA and perceived grades by weight status*

Variable	Normal weight	Overweight	*P*
Actual GPA (4 = "straight As")	2.77 ± 0.12	2.69 ± 0.12	0.21
Perceived grade average (0 = "Fs"; 4 = "As")	2.92 ± 0.10	2.70 ± 0.10	0.01

GPA, grade point average. Results from mixed models accounting for intra-school and intra-class correlation.
* Normal weight: 5th ≤ BMI < 85th percentile; at risk of overweight: BMI ≥ 85th percentile.

(SE) = 2.77 ± 0.12 vs. 2.69 ± 0.12, $p = 0.21$]. However, compared with students at risk of overweight, normal-weight students had higher self-reported grades (mean ± SE = 2.92 ± 0.10 vs. 2.70 ± 0.10, $p = 0.01$).

Mixed-model analyses were conducted to examine the unique effects of overweight status, BMI, and percentage body fat on either measured GPA or self-reported grade average, adjusting for gender, ethnicity, age, and physical activity (Tables 3 and 4). Results showed that after adjusting for covariates, none of the adiposity measures independently explained the variance in measured GPA ($\beta \pm$ SE = −0.05 ± 0.07 for normal weight vs. at risk of overweight, $p = 0.47$; −0.01 ± 0.01 for BMI, $p = 0.36$; −0.003 ± 0.003 for percentage body fat, $p = 0.27$). In contrast, all of the adiposity measures were independently related to self-reported grade average ($\beta \pm$ SE = 0.21 ± 0.08 for normal weight vs. at risk of overweight, $p = 0.01$; −0.02 ± 0.01 for BMI, $p = 0.001$; −0.01 ± 0.003 for percentage body fat, $p = 0.001$).

In addition, in all final models (Tables 3 and 4), results also revealed that boys had significantly lower measured and self-reported grades than girls ($p < 0.01$). White and Asian students had significantly higher measured and self-reported grades than Latinos ($p < 0.05$). Both measured and self-reported grades decreased with increasing age ($p < 0.01$) and blocks of moderate-to-vigorous physical activity time ($p < 0.05$).

Discussion

To our knowledge, this is the first study to investigate the association of both percentage body fat and body mass with measured and self-reported academic performance in a sample of mostly Latino and Asian-American adolescents. Adiposity was not related to measured GPA. However, adiposity was uniquely associated with self-reported grades, after adjustment for demographic covariates and physical activity. Of note, higher levels of moderate-to-vigorous physical activity were associated with both lower measured and self-reported grades, independently of adiposity, gender, age, and ethnicity.

That overweight at-risk status was not associated with actual school grades parallels previous findings in the U.S.

Table 3. Adjusted mixed models of measured GPA on adiposity measures

Parameter	Models of measured GPA (mean ± standard error)		
Intercept	2.92 ± 0.12*	3.02 ± 0.18*	3.00 ± 0.15*
At risk of overweight (BMI ≥ 85th percentile)	−0.05 ± 0.07	–	–
BMI (kg/m^2)	–	−0.01 ± 0.01	–
% body fat	–	–	−0.003 ± 0.003
Male	−0.35 ± 0.11*	−0.33 ± 0.10†	−0.35 ± 0.10*
Asian§	0.33 ± 0.11†	0.31 ± 0.10†	0.30 ± 0.10†
White§	0.36 ± 0.13†	0.29 ± 0.13‡	0.28 ± 0.13‡
Other Ethnicity§	−0.22 ± 0.16	−0.23 ± 0.16	−0.23 ± 0.16
Age (years, centered)	−0.20 ± 0.06†	−0.19 ± 0.06†	−0.19 ± 0.06†
Blocks of moderate and high activity time	−0.02 ± 0.01‡	−0.02 ± 0.01†	−0.02 ± 0.01†

GPA, grade point average. None of the adiposity measures were statistically significant after the inclusion of covariates.
* $p < 0.001$; † $p \leq 0.01$; ‡ $p \leq 0.05$.
§Latino was the reference category.

Table 4. Adjusted mixed models of perceived grade on adiposity measures

Parameter	Models of self-reported grades (mean ± standard error)		
Intercept	3.06 ± 0.11*	3.51 ± 0.19*	3.33 ± 0.15*
At risk of overweight (BMI ≥ 85th percentile)	−0.21 ± 0.08†	–	–
BMI (kg/m^2)	–	−0.02 ± 0.01*	–
% body fat	–	–	−0.01 ± 0.004*
Male	−0.30 ± 0.12†	−0.29 ± 0.11†	−0.39 ± 0.11*
Asian§	0.40 ± 0.12*	0.39 ± 0.12*	0.38 ± 0.12*
White§	0.34 ± 0.15‡	0.31 ± 0.14‡	0.28 ± 0.14‡
Other ethnicity§	−0.04 ± 0.18	−0.07 ± 0.18	−0.08 ± 0.18
Age (years, centered)	−0.29 ± 0.07*	−0.27 ± 0.07*	−0.27 ± 0.07*
Blocks of moderate and high activity time	−0.02 ± 0.01‡	−0.02 ± 0.01†	−0.02 ± 0.01†

* $p < 0.001$; † $p \leq 0.01$; ‡ $p \leq 0.05$.
§ Latino was the reference category.

For instance, among young U.S. children (6), although Datar et al. showed a significant effect of adiposity on academic performance in unadjusted analysis, in multivariate analysis, those authors found that adiposity was, in fact, a surrogate of socioeconomic differences among individuals and did not seem to play a causative role in academic performance. In the only other study of U.S. adolescents, it was shown that adiposity played a role in academic performance only in schools with high levels of romantic activity and athletic participation that resulted in niche picking (10). We did not have measures of the school environment to test these hypotheses further, but our data support the idea that adiposity or overweight status per se is not a risk factor for lower academic achievement.

Our study stands in contrast to several studies in non-U.S. youth, as reviewed by Taras and Potts-Datema (8). Discrepancies in findings may, in part, be due to differences in methodology. Both adiposity and academic achievement measures varied widely across studies. For adiposity, studies relied on BMI, BMI percentile, percentage of ideal weight, or percentile of skinfold thickness. Our study is the first to include percentage body fat. Variables of academic achievement across studies ranged from intelligence quotient scores or GPA to subject-specific standardized test scores. Only one other study in Thai adolescents used GPA as the outcome (7). Cultural differences may also play a role in the differences in findings. We have a predominantly Latino and Asian sample in the current study. Different cultures may have different expectations and attitudes toward sport participation and academic pursuits (26,27), and this idea warrants much further research.

Another possibility for the discrepancy, put forth by Datar et al. (6), is that there may be a time lag for the effect of adiposity on academic performance. This is evidenced in the study by Mo-suwan et al. (7), where the effect of adiposity was seen only in grades 7 to 9 but not in grades 3 to 6. The significant effect in the Finnish studies was also observed among older adolescents (5,9). In our sample, children ranged from 11 to 14 years in age. Therefore, although the direction of the β coefficients in our results is consistent with the hypothesis, it is possible that a significant effect of adiposity can be readily observed only in older adolescents. More longitudinal studies are needed to examine this.

To test whether the severity of overweight influenced our results, we compared actual GPA scores between adolescents with a BMI ≥ 95th percentile vs. those with a BMI between the 5th and 95th percentiles. We found that there was no difference in these two groups after adjusting for gender, ethnicity, age, and physical activity ($p = 0.61$). This finding is consistent with the non-significance of continuous adiposity measures such as BMI or percentage body fat after adjustment for covariates in our study. Therefore, we rule out the possibility that in our sample, lower academic performance might be uniquely explained by severe overweight only.

In contrast to findings of measured GPA, all three measures of adiposity remained significantly related to self-reported school grades, after adjustment for ethnicity, gender, age, and physical activity. It is possible that psychosocial correlates of overweight such as low self-esteem, depression, and stress mediate this relationship. However, low self-reported academic performance was not necessarily a good predictor of low measured GPA ($r = 0.63$). Therefore, it appears that being overweight per se may indicate a diminished perception of academic performance but not necessarily actual performance. Most importantly, our results suggest that self-reported and measured

school grades may be two unique constructs, and their differences need to be considered in the design and evaluation of studies.

Models with and without physical activity were estimated because physical activity might be a confounder of the potential effect of adiposity on academic achievement (no difference in the findings of adiposity). We found physical activity to be negatively related to measured and self-reported school grades independently of adiposity, indicating that physical activity did have a unique effect on school performance and that more moderate-to-vigorous activity time was associated with lower academic achievement. Although this finding is consistent with studies examining adiposity and school performance (6), it stands in contrast to findings of other research showing a positive effect of physical fitness on academic performance (17,19,20). Besides potential cultural factors, it has been suggested that lower physical fitness rather than activity is more predictive of gains in body fat in children (28). It is possible that our proxy measure of physical activity was not representative of physical fitness per se, and that for physical activity to have an effect on academic or cognitive outcomes, it must first impact one's fitness level. The negative and significant effect of physical activity in our and other studies may also be indicative of more athletically inclined students spending less time on academic work, although our sample represented a range of athletic and academic abilities. Future research needs to better delineate physical fitness and physical activity time and to study the effect of these in conjunction with adiposity on academic performance.

There are several limitations to our study. The study is cross-sectional; therefore, no causality could be inferred. We had more girls than boys due to the gender-specific aims of the larger study from which data for the current paper were derived. In addition, we were not able to fully examine adiposity and ethnicity interactions due to the large proportion of Latinos and small proportion of other groups in our sample. We also relied on only one measure of measured or self-reported academic performance, which may reflect a limited aspect of overall school performance. Finally, we did not have an individual measure of SES, although measured academic performance was non-significant despite the lack of control for SES. However, in spite of these limitations, the mixed modeling approach is a strength of our study relative to the other studies using clustered samples because failure to account for the intra-class correlations within classes and schools would result in an underestimation of SEs, therefore making it more likely to reject a true null hypothesis (29).

In conclusion, because the rate of overweight continues to rise among U.S. adolescents, there is an urgent need to understand the implications of this epidemic on measures of cognitive and academic performance. This study helps bridge a gap in the literature by examining whether adiposity is associated with either measured or self-reported school grades, independently of physical activity, in a sample of mostly Latino and Asian-American adolescents. Greater adiposity was related to only lower perceived, but not actual, academic performance. High levels of moderate-to-vigorous physical activity were associated with lower academic performance, measured or self-reported. Cultural factors might play a role in these findings and warrant further research.

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