Body mass index and academic achievement in Chinese elementary students: The mediating role of peer acceptance

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ABSTRACT

This study was designed to investigate the potential mechanism of the relationship between children's BMI and academic achievement. In total, 1380 Chinese elementary students (11.75 years old) were invited to participate. BMI, peer acceptance and academic achievement were assessed based on various sources (school reports, peer nominations and cognitive tests). The results indicated that the children's BMI was negatively associated with their academic achievement and that peer acceptance played a mediating role in this relationship. Additionally, we found that this effect was consistent across different genders. These findings highlight the importance of children's BMI in building positive relationships with peers and facilitating academic achievement.

1. Introduction

Childhood obesity has been a major public problem over the past few decades in both developed and developing countries. Since 1980, the prevalence of overweight and obesity has increased remarkably, with growth rates of approximately 6% in developed countries and 5% in developing countries (Ng et al., 2014). In China, the prevalence of childhood obesity has tripled in the past 10 years (Ma, Cai, & Wang, 2012). According to a recent report, the obesity rate has increased to 8.5% and 5.1% in 4th grade boys and girls, respectively (China National Assessment of Education Quality, 2018). A large number of studies have suggested that childhood obesity is associated with both metabolic and cardiovascular complications (Daniels, 2006) and poor social-emotional and cognitive development, such as delinquent problems and aggressive and disruptive behaviors (Goodman & Whitaker, 2002); internalizing problems, including depression, anxiety, social withdrawal and low self-esteem (Britz et al., 2000; Goodman & Whitaker, 2002; Rofey et al., 2009; Wang & Veugelers, 2008); and poor executive functioning (Tsal, Chen, Pan, & Tseng, 2016). In addition to these variables, there has been increasing interest focused on the link between obesity and academic achievement.

Many previous studies have shown an inverse relationship between childhood overweight or obesity and academic achievement in ethnically and socioeconomically diverse samples. For example, Shakotko, Edwards, and Grossman (1981) found that childhood obesity was inversely associated with scores on the Wechsler Intelligence Scale for Children (WISC) and the Wide Range Achievement Test (WRAT) in adolescence using data from the National Health Examination Surveys. Another national sample study (the National Longitudinal Survey of Adolescent Health) also reported that obesity was negatively correlated with GPA among white, female adolescents and that the GPA (Grade Point Average) of obese girls was approximately 10% lower than that of normal-weight girls (Sabia, 2007). Obese children and adolescents also have more negative subjective feelings about their academic performance. Falkner et al. (2001) found that obese adolescents perceived themselves to be worse students than normal-weight adolescents and had lower future educational goals. A review of 10 studies suggested that overweight and obese were associated with poor school function, including lower math and reading scores, IQ scores, GPA, educational persistence, absenteeism and grade retention (Taras & Potts-Datema, 2005).

The relationship between obesity and poor academic performance has yet to be defined, and the mechanism underlying this relationship remains unclear. Previous studies have indicated that obesity may affect academic achievement in several ways. First, obesity may cause certain health problems (e.g., sleeping disorders and cardiovascular risks), and then these health problems may affect academic achievement (Cottrell, Northrup, & Wittberg, 2008). Second, obesity may result in lower peer acceptance, which adversely affects academic achievement (Zeller, Reiter-Purtill, & Ramey, 2008). Third, obesity may affect

academic achievement through children's mental health (e.g., depression, self-esteem) (Puder & Munsch, 2010). Fourth, obesity may result in lower levels of behavioral and emotional school engagement (Caird et al., 2014). Fifth, obesity may affect academic achievement through children's cognitive abilities (e.g., executive functioning and working memory) (Mond, Stich, Hay, Krämer, & Baune, 2007). However, most of these mechanisms have been inferred based on indirect evidence. To the best of our knowledge, only two recent studies have directly explored the mechanism underlying the relationship between obesity and poor academic performance using mediating analyses. In the study of Wu, Chen, Yang, and Li (2017), the digit span memory from the Wechsler Adult Intelligence Scale 4th Edition (Zhang, 2009) was used to measure children's working memory. The Chinese, English, and mathematics scores of the previous year were collected and recorded as the children's academic achievement. The results showed that the relationship between body mass index (BMI) and academic achievement was partially mediated by children's working memory. Another study found that the relationship between BMI and GPA was partially mediated by students' school engagement (Finn, Faith, & Seo, 2018). Although these two studies explored plausible mechanisms, neither of them offered sufficient explanations, and most of the association between obesity and academic achievement is likely due to other mediating pathways.

We propose that the relationship between obesity and academic achievement may also be mediated by peer acceptance. Previous research has shown that obese youth often have problematic social functioning and poor peer relationships. For example, obese youth often self-report higher levels of both relational (e.g., withdrawing from friendships or spreading rumors or lies) and overt (e.g., name-calling, teasing, hitting, kicking, or pushing) victimization than their normal-weight peers (Janssen, Craig, Boyce, & Pickett, 2004; Neumark-Sztainer, Story, & Faibisch, 1998). Moreover, overweight and obese school-aged children are more likely to be not only victims but also perpetrators of bullying behaviors than their normal-weight peers (Janssen et al., 2004). Studies that have used photographic and video data have also found negative attitudes about obese peers; children often use negative attributes (e.g., "ugly," "lazy," and "sad") to describe their obese peers (Bell & Morgan, 2000; Latner & Stunkard, 2003). Zeller et al. (2008) also observed that obesity was negatively associated with peer reports of similar ratings and that this relationship could be mediated by youth's attractiveness and athletic ability.

As children grow older in school, peers may play increasingly important roles in the social system (Del Valle, Bravo, & López, 2010). Positive peer relationships are associated with more material (e.g., sharing learning resources) and emotional (e.g., mitigating the negative effects of academic pressure) support from peers, which contributes to higher academic achievement (Boulton, Don, & Boulton, 2011; Gallardo, Barrasa, & Guevara-Viejo, 2016; Raposa, Laws, & Ansell, 2016). Previous studies have found that peer acceptance is positively associated with academic success, while peer rejection is positively associated with academic difficulties (O'Neil, Welsh, Parke, Wang, & Strand, 1997). Longitudinal studies have also found that peer acceptance could positively predict students' academic success in the next semester (Gallardo et al., 2016). The studies mentioned above suggest that peer acceptance may be a mediating variable between obesity and academic achievement.

Although the negative relationship of children's overweight and obesity with academic achievement seems robust in these previous studies, it has not always been consistent between different genders. For example, using a nationally representative sample from the US, Datar and Sturm (2006) found that transitioning from not overweight to overweight between the beginning of kindergarten and the end of third grade was significantly associated with reductions in mathematics and reading test scores, but this link appeared only among girls. Similarly, Ding, Lehrer, Rosenquist, and Audrain-McGovern (2009) reported that the negative association between BMI and academic attainment was

stronger in girls than in boys. However, a recent longitudinal study did not support gender differences in this relationship; the researchers found that adolescents in the consistently low-to-normal BMI group had higher mean reading scores and math scores than adolescents in the gradually increasing BMI and consistently higher BMI groups for both genders. Due to the mixed results, the gender effect should be further explored.

In the current study, we aimed to explore the relationship between BMI and academic achievement and the mediating role of peer acceptance in Chinese children in the 5th and 6th grades. Although meta-analyses (He, Chen, Fan, Cai, & Huang, 2019) have found that the relationship between BMI and academic achievement was smaller in elementary school than that in middle and high school, from the perspective of developmental cascades, the risk factors in the early period could be predictors of a "snowball" cascade of maladjustment in the future (Bukowski, Laursen, & Hoza, 2010). Exploring the mechanism underlying this relationship in the early period is highly important for intervention. In contrast to most studies measuring the peer relationship by using a single rater, we measured peer acceptance by using peer judgments. Compared to a single rater (e.g., parent or self), peers provide multiple perspectives and more objective information regarding the "fit" between an individual and peer group norms (Zeller et al., 2008).

As previous studies have found a significant effect of family socioeconomic status (SES) on children's academic achievement (White, 1982), we explored these effects after controlling for SES. Then, we used multiple group comparisons in structural equation modeling (SEM) to test the gender difference in the relationship. We hypothesized that BMI would be negatively associated with academic achievement. We further hypothesized that peer acceptance would function as a mediator in this relationship and that the relationship would be stronger in girls than in boys.

2. Method

2.1. Participants and procedure

The sample included 1380 5th and 6th grade students from four elementary schools in Beijing, China. A total of 726 were boys (52.6%), and 630 were girls (45.7%) (gender information was lacking for 24 students). The mean age of the children was 11.75 years (SD = 0.69). A total of 773 children (56.0%) were in 5th grade 5, and 607 (44.0%) were in 6th grade.

Before the investigation, unified training of the investigators (psychology and pedagogical postgraduates) was conducted. The children's height and weight were measured in school. Students completed the Chinese language and math test in class. The students independently nominated up to three classmates they liked best and least at school. The parents of all children provided consent for the use of the data from the questionnaire in the current study.

2.2. Measures

2.2.1. Academic achievement

We tested the students' academic achievement using the standardized Mathematics Achievement Test and Chinese Language Achievement Test for elementary school students (grades 5–6). The Mathematics Achievement Test mainly assesses students' knowledge of numbers and algebra, space and shapes, and statistics and probability. The Chinese Language Achievement Test mainly evaluates language knowledge, cultural knowledge, and the ability to understand and interpret information (Dong & Lin, 2011).

For the Mathematics Achievement Test, the average difficulty coefficient was 0.67, and the average discrimination coefficient was 0.39. For the Chinese language Achievement Test, the average difficulty coefficient was 0.69, and the average discrimination coefficient was

0.34. Students completed the tests in class within 45 min. The original scores for children in the three grades translate ranged from 0 to 100. Then, the scores were standardized by grade and summed to create a potential variable as the index of students' academic achievement.

2.2.2. Peer acceptance

Peer acceptance is an important indicator of peer relationships (Parker & Asher, 1987, 1993). In this study, children were asked to nominate up to three classmates they liked best (positive nomination) and three classmates they least liked whom they would not want to interact with (negative nomination). Then, the total number of times that each student was positively and negatively nominated by classmates was calculated. Subsequently, peer acceptance was determined by subtracting the number of negative nominations from the number of positive nominations, and the values were standardized within classes to permit appropriate comparisons. This procedure has been proven to be valid for use with Chinese children (Chen, Huang, Chang, Wang, & Li, 2010).

2.2.3. Body mass index

BMI (BMI = weight/height^2) has traditionally been used as a measure of weight status in obesity-related research. The weight and height of children were reported by the school. In these schools, the students undergo a physical examination at the beginning of each semester. The weight and height of the children is measured objectively in the physical examination. Each child's weight in kilograms was divided by his or her height in meters squared to calculate the BMI variables.

2.3. Data analysis

SEM was used to test the hypothesized models, and Mplus 7.0 was used for the data analysis. Bias-corrected bootstrapped 95% confidence intervals of the indirect effects were derived from 1000 resamples. A mediated effect is considered to be significant if the interval does not include zero. The bootstrap method is preferred over other methods, as it does not impose the assumption of normality of the sampling distribution of indirect effects (MacKinnon, Lockwood, & Williams, 2004). Less than 5% of the data were missing for all variables included in the analysis. Missing values were estimated using full information maximum likelihood (FIML). FIML produces less biased estimates than listwise deletion or mean substitution even when the assumption of missing at random (MAR) is not fully met (Acock, 2005; Schafer & Graham, 2002).

3. Results

Table 1 presents the means, standard deviations, and correlations of BMI, peer acceptance, academic achievement and the control variables (family highest education level, family income, child age and child

gender) in this study. Before testing the hypothesized model, we examined the correlations between all variables to obtain a preliminary understanding of the data, and the results showed that the majority of correlations were in the expected directions. BMI was negatively associated with children's peer acceptance and academic achievement, and peer acceptance was positively associated with academic achievement.

We then used SEM to test the hypothesized model. Of the demographic variables, only family highest education level was significantly associated with academic achievement. The final structural model is presented in Fig. 1. The structural model showed a good fit to the data: $\chi2$ ($df = 3$) = 20.916, CFI = 0.967, TLI = 929, RMSEA = 0.056, SRMR = 0.020. As shown in Fig. 1, among all the controlling variables, family highest education level ($\beta = 0.19$, $p < .001$) and family income ($\beta = 0.15$, $p < .001$) were significantly associated with academic achievement. After adjusting these controlling variables, the results showed that BMI was negatively associated with peer acceptance ($\beta = -0.07$, $p < .01$) and academic achievement ($\beta = -0.07$, $p < .05$) and that peer acceptance was positively associated with academic achievement ($\beta = 0.24$, $p < .001$). The bootstrap result showed that the indirect effect was significant ($\beta = -0.02$, $p < .05$), which suggested that peer acceptance played a mediating role in the relationship between BMI and academic achievement.

To investigate the hypothesis regarding the moderating role of gender, multiple group comparisons were conducted. The results showed that both the unconstrained model and the constrained model fit the data well. However, the difference in the chi-square was not significant, $\Delta\chi2 = 4.24$, $df = 3$, $p > 0.05$, suggesting that the processes by which BMI was related to academic achievement was the same for boys and girls.

4. Discussion

In the present study, we explored the relationship between BMI and children's academic achievement and the mediating role of peer acceptance in this relationship. Consistent with the previous literature (e.g., Taras & Potts-Datema, 2005), the results showed that BMI was negatively associated with academic achievement. However, the correlation between these two variables was small. This result is consistent with the latest meta-analysis (He et al., 2019). In their study, the authors found a weak negative correlation between BMI and academic achievement ($-0.067 < r < 0.155$). In addition, the authors found that this relationship was moderated by different regions and grades. Regarding the region, Asia showed the smallest pooled effect size ($r = -0.066$), followed by North America ($r = -0.106$), and Europe showed the largest pooled effect size ($r = -0.204$). Regarding the grade, elementary school students showed the smallest pooled effect size ($r = -0.075$), followed by a larger pooled effect size among middle school students ($r = -0.128$) and the largest pooled effect size among high school students ($r = -0.184$). Therefore, the small correlation in our study is reasonable because our sample comprised

Table 1
Correlations between all variables used in the current study.

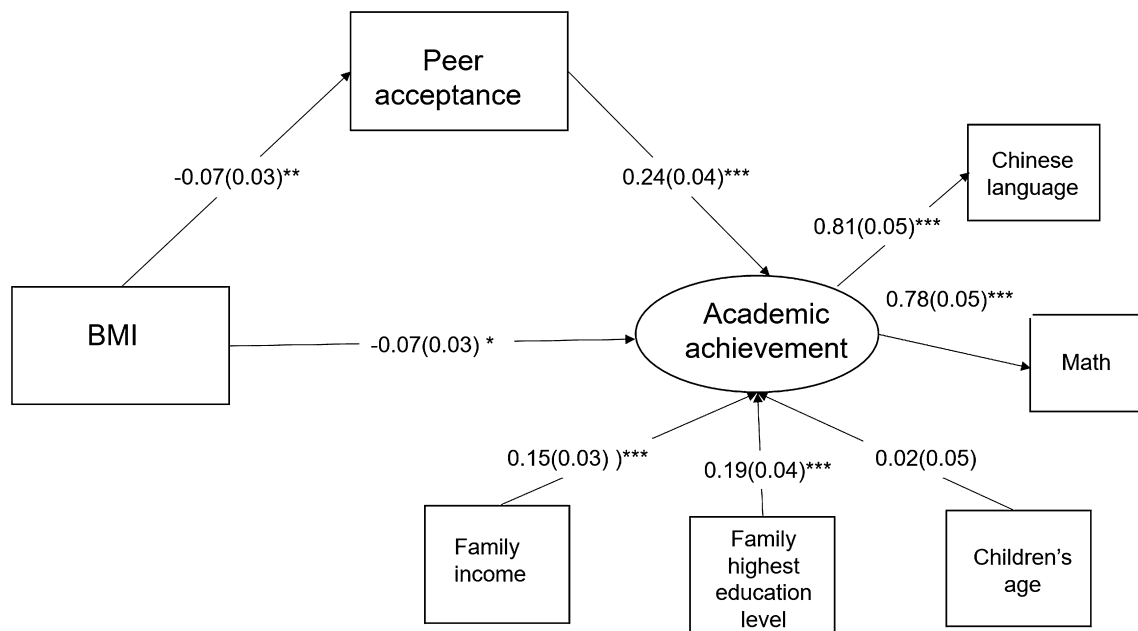|	1	2	3	4	5	6	7	8
1. BMI	1							
2. Peer acceptance	−0.074**	1						
3. Math4 Chinese language	−0.078**	0.198**	1					
	−0.079**	0.224**	0.646**	1				
5. Family highest education level	−0.015**	0.042	0.214**	0.197**	1			
6. Family income	−0.044**	0.068*	0.208**	0.190**	0.503**	1		
7. Age	0.089**	−0.022	0.021	0.020	−0.167**	−0.064*	1	
8. Gender	−0.198**	0.050	−0.058*	0.099**	0.028	−0.037	−0.040	1

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

Fig. 1. Structural model (the standard error (SE) is shown in parentheses). *p < .05; **p < .01; ***p < .001.

Chinese elementary students.

We also found a significant relationship between family SES and academic achievement. In a review that included 29 studies, almost half of the studies reported that SES may explain much of the negative relationship between obesity and academic achievement (Caird et al., 2014). However, we still found a significant relationship between obesity and academic achievement, even after controlling for family SES.

The mediation analysis in this study indicated that Chinese children's BMI was predictive of their academic achievement via peer acceptance. Children who are obese tend to be less accepted by their peers. This effect may occur in various ways. First, obese children often have problematic social functioning. Overweight and obese school-aged children are more likely to be not only victims but also perpetrators of bullying behaviors than their normal-weight peers (Janssen et al., 2004). Parents also characterize their obese children and adolescents as experiencing greater social difficulties. In addition, some nonsocial factors can also contribute to the relationship between BMI and peer acceptance. For example, obese children and adolescents commonly report being "embarrassed doing physical activity and playing sports" (Faith, Leone, Ayers, Heo, & Pietrobelli, 2002). When obese youth join in physical activity, they more often receive negative verbal commentary from peers. Studies have also found that obesity is associated with peer liking ratings mediated by the characteristics of being attractive and athletically competent.

Peer acceptance may also contribute to academic success through both instrumental and emotional mechanisms. For example, well-accepted children are more likely to receive academic assistance from peers (Bowker et al., 2010). Peer acceptance is also positively related to school belonging, school engagement, academic motivation and enhanced self-worth (Fredricks, Blumenfeld, & Paris, 2004; Furrer & Skinner, 2003). A longitudinal study found that peer acceptance in kindergarten could predict later academic performance during the elementary school years after controlling for previous academic achievement (Buhs, Ladd, & Herald, 2006). This relationship may be especially strong in elementary school-age children because the major social concern of children during this period is integration into their peer group (O'Neil et al., 1997).

The results of the multiple group comparisons showed that there was no gender difference in the relationship between BMI and academic achievement. This result was inconsistent with some previous studies that found a gender effect. In these studies, the researchers observed that the relationship between obesity and academic achievement was stronger in females than in males (Datar & Sturm, 2006; Ding et al., 2009). However, a meta-analysis of 60 studies showed that although females showed a larger effect size than males, the statistical test for gender effect was not statistically significant (He et al., 2019). In addition, this gender effect might be further moderated by other variables (Black, Johnston, & Peeters, 2015; Wingfield, Graziano, McNamara, & Janicke, 2011). For example, in the meta-analysis by He et al. (2019), the authors found that there was no gender difference in the correlation between BMI and academic achievement in fourth-grade students but that there was a significant gender difference in fifth-grade students. In a recent longitudinal study, the researchers also found no gender difference in the relationship between BMI and academic achievement, but they did find that parental warmth played a protective role only for girls but not for boys. These results indicated that moderating variables need to be further explored.

Nevertheless, several limitations of this study should also be taken into consideration. First, the relationship between BMI and peer acceptance may not be direct. BMI may influence peer acceptance by mediating some variables (such as attractiveness and athletic ability). Thus, serial mediation models are needed to explore the complex mechanisms underlying the relationship between BMI and academic achievement. Second, the current study was cross-sectional and thus could not determine causal relationships; therefore, longitudinal studies are needed. Third, all the data were obtained from students in Beijing, which is the capital city of China. Thus, the generalizability of the findings is unknown, and more studies are needed to determine whether these results apply to other samples.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All procedures in this study were approved by the Institutional Review Board of the Collaborative Innovation Center of Assessment toward Basic Education Quality, Beijing Normal University and Institutional Review

Board of Faculty of Education, Northeast Normal University.

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