

The association between obesity and academic performance in youth: A systematic review

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Abstract

Previous studies have found that obesity could influence academic performance. The aim of this study was to systematically review the scientific evidence on the association between obesity and academic performance in school children. A systematic review of English articles was undertaken using databases PubMed/Medline, ERIC, LILACS, SciELO and Web of Science. Cross-sectional and longitudinal studies examining the association between obesity and academic performance in children and adolescents, published between Jan 1990 and December 2016, were included. Risk of bias was assessed using Strengthening the Reporting of Observational Studies in Epidemiology (STROBE). Thirty-four studies (23 cross-sectional and 11 longitudinal) matched all inclusion criteria and were included. Seven studies were classified as low risk of bias, 23 as medium risk, and four as high risk. After controlling for covariates such as socioeconomic status, parental education, and physical activity, the association between obesity and academic performance become uncertain for most of the studies (55.9%). Therefore, at present there is insufficient evidence to support a direct link between obesity and poor academic performance in school age children. In order to clarify this issue we need more longitudinal studies with adequate sample sizes and that control for potential confounders.

Introduction

In addition to the well-established harmful effects of obesity on physical health and mortality (1), obesity has also been linked to poor academic performance (2,3). Some studies have suggested that individuals with obesity have lower intelligence quotient (IQ) and exhibit poorer executive function, memory, attention and motor skills compared to normal weight peers (4-8). Successful academic performance is important during the school years, and is also a strong predictor of occupational and social success in adult life (9).

Some studies have suggested that adiposity may directly influence cognition, learning and memory functioning (5,10). However, weight-related bias or discrimination, commonly experienced by children with obesity, may influence self-esteem by internalizing and externalizing behavior problems thus mediating or moderating children's academic performance (11-13). It is still unclear whether excess adiposity itself affects academic performance, or if this effect is mediated by other factors observed in individuals with obesity, such as poor self-esteem (14), anxiety/depression (15), teasing and social rejection (16), poor attendance at school (17), and low physical fitness (18,19).

To our knowledge, only one review, published more than a decade ago, examined the association between obesity and academic performance (20). The authors concluded that obesity is negatively associated with academic performance. However, the review was not conducted systematically and did not assess study quality. The aim of this study was to perform a systematic review on the association between obesity and academic performance in school-aged children.

Methods

This systematic review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria (21).

Types of Studies

Cross-sectional and longitudinal studies were considered for this review. The inclusion criteria were studies: (1) published in English; (2) performed with students <20 years - if age was missing, school grade was used to verify participant's age; (3) where the main objective was to analyze the association between obesity and academic performance, where obesity was set as the independent variable and academic performance as the dependent variable; (4) that used at least one objective measure of the main outcomes measured at any follow-up period; and (5) published prior to December 2016. Review articles, validation studies, conference abstracts, monographs, dissertations were not included. We also did not include studies conducted with special populations, such as individuals with developmental disabilities, developmental delays, cognitive impairment or metabolic abnormalities.

Search strategy

A two-phase search strategy was used to identify relevant studies. First, electronic data bases were systematically searched: PubMed/ Medline, ERIC, LILACS, SciELO and Web of Science. The search for key-words/terms was performed with the MeSH – Medical Subject Headings through the U.S. National Library of Medicine (NLM) and DeCS – Descriptors in Health Science from the Virtual Health Library (Biblioteca Virtual da Saúde- BVS). Search strategies included the combination of variations between two groups of key-words/terms including, but not limited to the following

examples: (1) obesity (“body mass index”, “body composition”, “adiposity”, “fatness”, “overweight”, “weight status”, “body fat”; and (2) “academic achievement”, “academic performance”, “school performance”, “educational status” “school attendance”.

During the second phase, the titles and abstracts for potentially relevant articles were screened by two researchers (CCA and LPA) with expertise in the topics studied. A complete copy of the paper was obtained for studies that met the initial screening criteria. All of these papers were examined by two researchers (CCA and LPA), with discrepancies being resolved by discussion. If the reviewers were unable to reach a consensus a third researcher (WLP) was consulted. The references from the included studies were examined to identify other potential studies that would meet inclusion criteria for this review.

Data extraction

The following information was extracted: (a) year of publication, (b) study design, (c) location, (d) sample size, (e) age of study population, (f) school year (grade), (g) independent variables (body mass index [BMI], body composition) and dependent variable (academic performance), (i) control variables used in the analysis (j) main finding.

Risk of bias

The risk of bias was assessed using the adapted Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (22) statement according to Lubans et al. (23). A score of zero (absent or inadequately described) or one (present and explicitly described) was assigned to the following questions: (1) Does the study describe the eligibility criteria for participant selection? (2) Are participants randomly

chosen from the population? (3) Does the study report the sources and details of the method for measuring academic performance and did the instrument have acceptable reliability? (4) Does the study report the sources and details of the assessment methods for measuring obesity and did the instrument have acceptable reliability? (5) Does the study report the power calculation and use a statistical method that is adequate to test the hypothesis? (6) Does the study report the number of participants for each outcome measurement and does this number represent at least 80% of the total sample? A score for each article ranged from zero to six points. Studies with ≤ 2 were considered high risk of bias, studies that achieved three to four points were classified as medium risk and those that had scores of five to six were classified as low risk of bias.

The level of association between obesity and academic achievement was reported as follows: (a) *No Association*, if less than 33% of the studies indicate a significant association; (b) *Uncertain association*, if 34% to 59% of the studies indicate a significant association; (c) *Positive/negative association*, if 60% to 100% of the studies indicated a significant association (in the same direction); (d) *Strong evidence of positive/negative association*, if 60% to 100% of the studies indicate a significant association (in the same direction) and if more than 59% of the studies deemed low risk of bias found a significant association (22).

Results

Study selection

Our initial search identified 9317 papers. After removing duplicates, 9262 remained. Most (9200) did not meet the criteria specified based on the title and abstract. Sixty-two studies were carefully examined. Of these, 28 did not meet the inclusion criteria (13 did not use objective measures for academic performance [24-3]), nine were conducted

in adults [2,37-44], and six were review studies [45-50]. Therefore, 34 studies were included in this systematic review (Figure 1).

Figure 1 here

Characteristics of included studies

Table 1 shows the main characteristics and results of the 34 studies. Half of the studies (N= 17) were conducted in the United States (10,18,19,51-64). Two studies were conducted in Canada (65,66), and two studies in Colombia (67,68). The other studies were conducted in Kuwait (69), Portugal (70), United Kingdom (71), Taiwan (72), Iran (73), Denmark (74), Korea (75), Finland (76), Japan (77), Chile (78), Italy (79), Spain (80), and Netherlands (81). Twenty-three studies were cross-sectional, and 11 studies had longitudinal design.

Table 1

Risk of Bias

From the 23 cross-sectional studies, four were classified as high risk of bias (13,69,76,78), 16 as medium risk of bias (10,51,53,55,57,59,61-63,67,68,73-75,77,80) and three as low risk of bias (56,60,69). From the 11 longitudinal studies, seven studies were classified as medium risk of bias (52,58,64,65,72,76,81), and four as low risk of bias (18,54,66,71).

Participants

The sample size of the studies ranged from 37 to 18.746, and included students from kindergarten through high school. Eight (23.5%) studies did not report age

(18,51,52,55,67,72,75,77). Studies were conducted in both genders, except Heshmat et al. (73), which was conducted only in boys.

Dependent variable outcome: academic performance

Academic performance was measured by standardized tests (knowledge in reading, writing, mathematics and general knowledge) in 29 studies. The others used grades achieved in those disciplines (61,69,72,75,77). All studies used reliable measures for academic performance.

Independent variable outcomes

Twenty-nine studies directly measured weight and height. In two studies these measurements were self-reported (75,79). Three studies did not describe how weight and height measurements were made for calculating BMI (63,71,78).

Two studies assessed waist circumference (63,78). Body composition was measured in four studies (one used Dual-energy X-ray absorptiometry [59], one used skinfold thickness [70], and two used bioelectrical impedance [60,61]. Body Mass Index (BMI) was stratified according to the International Obesity Task Force (IOTF) (82) in five studies (66,70,72,76,81). One study (73) used Must et al. (83) and one used a National standardized equation (61). Twenty-two studies used Centers for Disease Control CDC charts (84) to classify BMI. Bisset et al. (65) used both (CDC) charts (84) and IOTF (82). Four studies did not report the criteria for BMI categorization (63,74,78,79).

Analysis

Eight studies conducted a random sample of the population (18,54,55,58, 64,66,69,75).

Ten studies reported the statistical power of the analysis

(54,56,58,60,65,66,69,71,74,77) while 24 studies did not report power analyses or sample size calculations (10,18,19,51-53,57,59,61-65,67,68,70,72,73,75,76,78-81).

Thirteen studies did not report any adjustment for potential confounding factors in their analysis (51,56-58,60,61,63,68,73,76,79,80,81).

The association between obesity and academic performance was assessed by multivariate linear regression analyses in 16 studies.

(18,51,53,54,58,59,62,64,67,71,72,74,77-79,81), logistic binomial regression in six studies (53,61,67,69,75,80), ordinary least squares in one study (55), structural equation for mediation in one study (76), analyses of covariance in four studies (10,57,63,70), and ANOVA in one study (19). Three studies did simple correlation (51,56,60), and two did Student t-tests (56,73). Five studies provided details regarding variable selection (backward or forward) and analysis of the residual distribution in the final model (18,55,71,72,81). Only Carter et al. (66) performed the final model analysis by multi-collinearity using variance inflation factors. Five studies had relatively small sample sizes in relation to others and did not provide information about statistical power (51,61,63,73,79). The sample size of studies that used regression analyses ranged from 37 to 18746 students.

Main findings

Table 2 summarizes the level of scientific evidence for the associations between obesity and academic performance in school-age children. In summary, according to pre-

established criteria, 11/23 cross-sectional studies (47.8%) and 4/11 longitudinal studies (36.3%) reported a negative association between obesity and academic performance.

Table 2 here

None of the cross-sectional studies (0/4) with low a risk of bias found a significant association between obesity and academic performance after adjusting for socioeconomic status (SES), ethnicity, age, physical activity level and parental educational level (56,60,69). Two of these studies conducted with large populations (>1000 participants) (60,69), found no association between obesity and academic performance after adjusting for parental education and SES.

Half of the 16 cross-sectional studies with a medium risk of bias reported a significant negative association between BMI and academic performance (51,55,59,61,63,73,75,77). However, two of these studies (63,73) did not adjust the analysis for confounders, and did not report statistical power calculations. In two of these studies (51,59) the negative association remained even after adjustments for age, sex, IQ, SES and cardio-respiratory fitness. Morita et al. (77) found that obesity was negatively associated with academic performance only in girls. This association was significant in an unadjusted analysis and after adjustments for physical fitness, SES and sedentary behavior. Alternatively, Kang et al. (75) found a negative association between obesity and academic performance only in boys, after adjustment for father's education, family income, physical activity, sleeping time and time spent on electronic devices. Another study (61) showed a negative association between BMI, fatness and academic performance after controlling the analyses for gender, ethnicity and age. However, due to a small sample size (N=45 students) and weak statistical power caution should be

used in interpreting these results. Of the remaining 8 studies with a medium risk bias, one found a positive association between obesity and academic performance (53) and the other seven studies did not find any significant association (10,57,62,67,68,74,80). The duration for the longitudinal studies varied considerably (from 18 months up to 18 years) (18,58). Two out of four longitudinal studies with low risk of bias reported a significant negative association between BMI and academic performance (54,71). These studies followed more than 5,000 children for five (54) and six years (71). The results revealed that children with obesity, or who became obese during childhood, had lower academic performance compared to normal weight children. In the study of Booth et al. (71) a strong association between obesity and academic performance was found in girls after adjusting for birth weight, maternal smoking during pregnancy, SES, physical activity and pubertal status. In boys obesity was not significantly associated with academic performance.

From the seven longitudinal studies with medium risk of bias, one study reported a negative association between overweight and academic performance in girls only. This study followed 7000 children for up to four years (52). Another study with medium risk of bias followed 8061 children for eight years and reported that academic performance might have been mediated by obesity (76).

Seven longitudinal studies, including two with low risk and five with medium risk of bias did not find association between obesity and academic performance when controlling for parental education screen time, family, school and teacher characteristics, SES and maternal education (18,58,64-66,72,81). Chen et al. (72) followed 409 children for six years. Only gender was controlled in the model, since the authors considered the sample size insufficient for conducting additional analyses. Veldwijk et al. (81) followed 2,159 children for four years and did not find a significant

association between obesity and academic performance after the analysis was adjusted for parental education, skipping breakfast, and screen time. Zavodny (64) followed 15795 children for seven years, and Kaestner and Grossman (58) followed 2500 for seven years. Neither study found any significant association between obesity and academic performance after adjustments for family, and child characteristics.

Datar et al. (18) followed 11192 children for up to 18 months and did not report a significant association between outcomes. Bisset et al. (65) followed 5754 children for three years and reported that maintaining overweight during mid childhood was not associated with poorer academic performance. In a study (66) with an 11 year follow up of 4647 children from birth to 11 years old no significant association between obesity and academic performance was found.

Discussion

This systematic review expands a previous review (20) by including studies conducted up until 2016, and by including a qualitative assessment of the studies. While Taras and Potts-Datema (20) suggested that obesity could be associated with poor academic performance, our results revealed no strong evidence for this association.

Overall, only 15 of the 34 studies that met our criteria found a significant negative relationship between obesity and academic performance. Eleven of the 23 cross-sectional studies and four of the 11 longitudinal studies reported a significant negative relationship between obesity and academic performance. When considering study quality, 2/8 studies with low risk of bias and 9/23 studies with medium risk of bias reported a significant negative relationship between obesity and academic performance. When controlled for covariates such as SES, parental education, physical activity, sedentary behavior and health related risk factors the association between obesity and

academic performance was weakened or disappeared (10,18,55,56,59,60,63,68-70).

While insufficient data exist to support a significant relationship between obesity and academic performance, more high quality studies are needed to bring greater clarity to the issue.

Outcome assessments

Academic performance is highly dependent on the instrument used to quantify academic achievement. In the current literature, several different tools have been used for measuring this outcome, ranging from teacher reported classroom behavior, teacher reported children's effort, overall grades and standardized tests. The variability in measurement tools makes it difficult to compare between studies.

Obesity is supposed to affect children's cognitive function, which comprises attention and set shifting (85,86), inhibitory control (87), abstract reasoning, and visual-spatial organization (5). Different methods are appropriate for specific cognitive functions, which may explain the lack of agreement among studies. Many of the test items that comprise standardized tests of academic performance are impacted by processing speed and rapid decision making; processes known to be negatively related to obesity (88).

The results of studies using standardized tests that focus on specific aspects of performance, such as math or reading skills, tend to be more precise than tests that are more global in nature. The development of a 'gold standard' measurement method would help our ability to study the association between obesity and academic performance.

Another point to consider is that the effects of obesity on children's academic performance may be only observed later in life (24,89). The causal processes linking

academic performance and obesity differs between the development stages. The studies included in this review studied children from different ages, grades and weight history. Future studies should assess the impact of early onset obesity on later academic performance.

Influence of confounders

Many variables could influence the association between obesity and academic performance (18,55,57,60,64,65,68,69,81). Gurley-Calvez and Higginbotham (55) suggested that SES could moderate this association. Race/ethnicity and mother's education may be stronger predictors of academic performance than obesity (68). Body characteristic (such as obesity) are more likely to be noticed by children than socioeconomic characteristics, suggesting that obesity stigma per se could affect overweight children's academic performance (18).

Few studies have controlled the analysis for physical activity/physical fitness (10,18,52,60,62,69,71,74,76-78). There is some evidence that physical activity/physical fitness may positively modulate cognition and academic performance (16,68), as children with obesity are more likely to have low physical activity level and physical fitness (89,90).

Reporting Effect Size

Only one study (63) presented the effect size of the association between obesity and academic performance. This study showed a small effect size in the association between obesity and spelling skills (-0.28) and medium effect between obesity and arithmetic (-0.60). The lack of reported effect sizes in the included studies limits the estimation of the magnitude of association.

Limitations

The present study has some limitations that should be considered. A literature search was performed only in journals indexed in the electronic databases PubMed / Medline, ERIC, LILACS, Web of Science and SciELO. It is possible that some studies were missed. All studies in this review were observational and thus no conclusions about causality could be made. Additional limitations of the literature include reliance on BMI as a proxy measure of adiposity since only one study used DXA, which is considered the gold standard of adiposity measurement.

Conclusions

Through a rigorous and comprehensive systematic review including qualitative evaluation of the studies, we concluded that there is not strong evidence to support the association between obesity and poor academic performance in school age children. The evidence in this area is limited by a preponderance of cross-sectional studies, failure to adjust for confounding factors, and absence of adequate power analyses. Overall the balance of evidence suggests that while obesity may be related academic performance, it is not possible from existing published research to determine if there is a causality link between the two.

As the nature and impact of childhood obesity on children's development continues to be studied, the development and assessment of more comprehensive conceptual and assessment models is needed. Identifying effective models for evaluating children's obesity and academic performance would be beneficial for researchers, clinicians, school representatives, families, and policies makers.

Conflicts of interest statement

The authors have no conflicts of interest to disclose.

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Table 1 Main results of studies about the association between obesity and academic performance in children and adolescents.

Table 2 Distribution of the studies that investigated cross-sectional and longitudinal associations by risk of bias and the level of scientific evidence.

Figure 1 Flow chart of the study selection process