

Overweight and School Performance Among Primary School Children: The PIAMA Birth Cohort Study

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The aim of this study was to assess the association between overweight and school performance among primary school children prospectively and including a broad range of potential confounding factors. In addition it was investigated what factors mediate this association. For this purpose, data of 2,159 12-year-old children who participated in the Prevention and Incidence of Asthma and Mite Allergy (PIAMA) birth cohort study were used. Two indicators of school performance were parental reported when children were 12 years of age and included (i): the score on a standardized achievement test that Dutch children have to complete at the end of their primary education (Cito)-test and (ii): the teacher's advice regarding a child's potential performance level in secondary education. Children's height and weight were measured by a trained research assistant at the age of 8 and by their parents at the age of 12. Overweight was defined using age and gender specific cut-off points. Multivariate regression analyses were performed to assess the association between overweight and school performance. Besides, both confounder and mediation analyses were conducted. Results showed lower Cito-test scores and lower teacher's school-level advice among overweight children. These associations were no longer significant when adjusting for parental educational level, skipping breakfast, and screen time. This study found no independent association between overweight and school performance among primary school children. Results showed strong confounding by parental educational level.

Obesity (2011) doi:10.1038/oby.2011.327

INTRODUCTION

Worldwide, countries are facing the striking consequences of overweight among children. Previously performed studies suggested that the wide range of physical, psychological, and social consequences of overweight (1–3) may affect school performance of overweight children. Although most studies that investigated the association between childhood overweight and school performance observed lower school performance among overweight children (4–13), some studies stated that direct causality between overweight and school performance is unlikely (14–16). They suggested a number of underlying pathways to explain the observed association via confounding and mediation. Among the confounders are parental socioeconomic factors which are important in predicting both a lower school performance and overweight among children (6,7,11,14–15). Second, early life factors such as birth weight, breastfeeding duration, maternal smoking during pregnancy, and maternal age at the time of birth are

known to be associated with both childhood overweight and cognitive functioning (17–20). Third, there is growing evidence that poor dietary intake and physical inactivity induce overweight and, also independently, reduce school performance (6,11,14,21,22). Concerning potential mediating factors, psychological and psychosocial problems among overweight children such as being depressed (7,13,23) or bullied may reduce school performance (24,25). Moreover, overweight, and especially obese, children suffer more often from physical health problems (2–3,26), which may influence school performances. Finally, these psychological, psychosocial, and health problems may in turn result in increased school absence, which is likely to negatively influence school performance (11,25).

Due to the limited number of well-designed prospective studies that included all the above mentioned factors which are likely to influence the association between childhood overweight and school performance, evidence for this association

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Received 26 January 2011; accepted 21 September 2011; advance online publication 27 October 2011. doi:10.1038/oby.2011.327

remains ambiguous. It is however of great importance to dispel uncertainties concerning this association since worsened school performance in primary school may contribute to the lower level of college acceptance, employment, and socioeconomic status observed when overweight children reach (young) adulthood (1,27).

Moreover, in contrast to most previously performed research, this study included repeated measurements of overweight and is therefore able to assess the effects of becoming and staying overweight during childhood. Therefore, this study aimed to assess the association between overweight and school performance of primary school children in a prospective cohort study including a broad range of potential confounding factors. In addition it was investigated what factors mediate this association.

METHODS AND PROCEDURES

Study design and subjects

The study population consisted of children who participated in the Dutch Prevention and Incidence of Asthma and Mite Allergy (PIAMA) birth cohort study. In this study, pregnant women were recruited from the general population in three different regions of the Netherlands ($n = 4,146$). Their children were born in 1996–1997 and have been followed up to the age of 12 years (28). All procedures involving children and their parents were approved by the ethics committees of all participating University Hospitals (Utrecht, Rotterdam, and Groningen) as well as The Central Committee on Research Involving Human Subjects.

Data were collected mainly by annual postal questionnaires, which included questions on the child's weight and height, lifestyle, and different aspects of health and disease. At the age of 8 years, the children were invited for a medical examination, which included measurement of weight and height. The study protocol was approved by the medical ethics committees of the participating institutes and all parents gave written informed consent.

Of the baseline population of 4,146 mothers, 183 (5%) were lost to follow-up before any data on the child had been collected. The study therefore started with 3,963 newborns. When the medical examination of 8-year-olds was planned, 3,668 children (88% of 4,146) were still in the study, 3,522 children were invited and 2,214 participated (63% of those invited) (Figure 1).

A new follow-up wave started when the children were ~12 years of age, including the 3,541 children who either participated in the medical examination when they were 8 years of age or whose parents completed one of the two most recent annual questionnaires. Those children as well as their parents received a questionnaire about the children's health and lifestyle. A few months later a new questionnaire was sent to the 2,706 parents who completed this questionnaire or whose children completed the questionnaire and still lived in the Netherlands, in which additional information concerning school performance was collected. This final questionnaire was completed by the parents of 2,495 children (63% of the baseline population) (Figure 1). For this study only children who were in the final grade of primary school or had started their secondary education were included, resulting in a study population of 2,159 children. Height and weight was known for 1,543 8-year-old children and 1,918 12-years-old children.

School performance

In the Netherlands, secondary education consists of several levels which prepare children for vocational education, higher professional education or university. In order to assign children to the most appropriate secondary educational level, first of all an academic achievement test is administered at the end of their primary education. The most commonly used test for this purpose is the central institute for test develop-

ment (Cito)-test which is developed by the Cito (29). This test includes questions concerning spelling, math, study skills, and world studies. On average, a prevocational secondary education is recommended to children with a Cito-test score between 501 and 536, a senior general secondary education is recommended to children with a score ranging from 537 to 544, and a pre-university education is recommended to children with a score between 544 and 550 (29). Within the regression analysis, the Cito-test scores were standardized to a mean of 0 and a s.d. of 1. Second, school teachers advise on a suitable secondary school-level based on the Cito-test score as well as the entire school career, skills, and characteristics of the child. It is common that students receive the advice to participate in a mixed class of two educational levels (e.g., mix of senior general and pre-university education), after the first year in secondary education it is decided what educational level is most appropriate. This results in seven options for secondary school education level, therefore a seven-point scale concerning teacher's school-level advice was included in all analysis. Both the Cito-test score and the school teacher's advice were measured when the children were 12 years of age and were reported by the parents and were used as indicators for school performance in this study.

Overweight

At 8 years of age, height and body weight were measured by trained research assistants during a medical exam, all children only wore light underwear. At 12 years of age parents measured and reported height and body weight of their children. Parents were instructed to actually measure their children's height and weight respectively, using a tape measure and scale. BMI was calculated by dividing weight in kilograms by squared height in meters. To define overweight international age and gender specific cut-off points were used (30).

Potential confounding factors

Based on literature, as described in the introduction, a distinction was made between potential confounding and mediating variables. These factors are statistically identical, as they can influence the investigated association. However, in contrast to mediating factors, confounding factors are not on a hypothesized causal pathway between overweight and school performance.

Maternal smoking during the first 4 weeks of the pregnancy (1 = yes, 2 = no), maternal age at the time of birth in years, gender of the child, breastfeeding duration in weeks, and birth weight of the child in grams were assessed using questionnaires administered during pregnancy and the first year of the child's life.

Parental educational level was measured by means of a questionnaire completed by the parents when the children were 1-year-old and included in analyses as an indicator for socioeconomic status. Both parents were asked to report their educational level separately on a seven-point answering scale (1 = completed primary school; 7 = completed university). Maternal and paternal educational level was classified in three categories; high, intermediate, and low education.

Lifestyle factors included physical activity (How many days per week are you at least 1 h physically active? (this means that you play sports, have physical activity at school, ride your bike, play in the neighborhood etc.)), screen time (total number of hours television and video viewing per week), and skipping breakfast (number of days per week) which were assessed by self-report of the children at the age of 12.

Potential mediating factors

Children's psychological health was assessed using the five-item version of the Mental Health Inventory (MHI-5). The MHI-5 includes questions concerning feeling nervous, calm, happy, depressed, and anxious. The scores on the five items (ranging from 1 to 5) were added and transformed into a total score ranging from 0 to 100. Scores of 60 or less indicate children to be psychologically unhealthy, whereas scores of 61 or more indicate good psychological health (31).

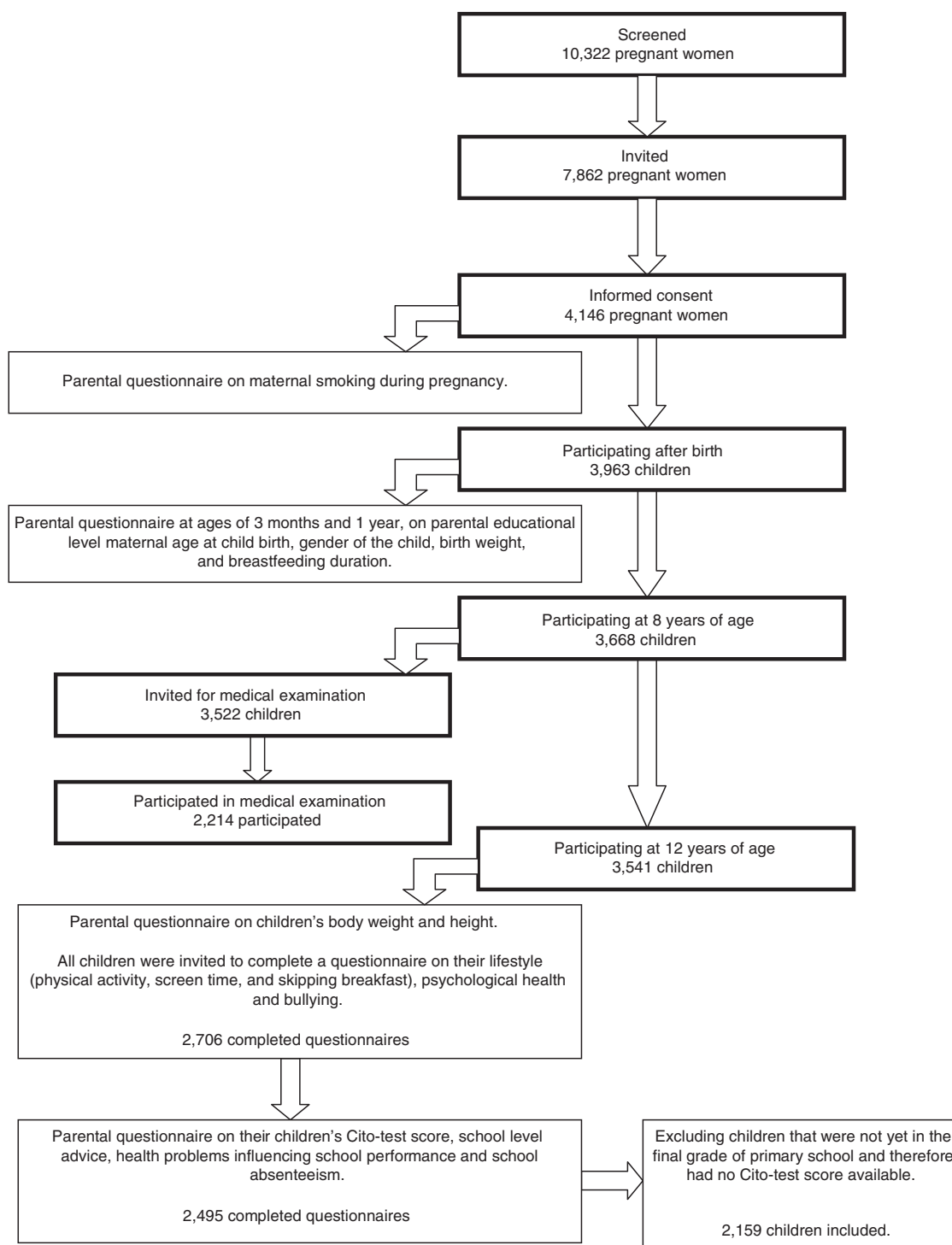


Figure 1 Flow-chart of the PIAMA birth cohort study. Cito, central institute for test development; PIAMA, Prevention and Incidence of Asthma and Mite Allergy.

Being bullied at school (number of occasions in the past year: 1 = never; 5 = once or more per week) was included in the analyses as a psychosocial factor which was assessed by self-report of the children at the age of 12.

Whether the children had health problems influencing their school performance was assessed at the age of 12 years by parental-report.

Finally, school absenteeism due to illness (number of days absent from school during the current school-year) was assessed at the age of 12 years by parental-report.

Statistical analyses

Statistical analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC). Separate analyses were performed for children who were overweight at 8 years of age (compared to children not overweight at this age), who were overweight at 12 years of age (compared to children not overweight at this age), who were overweight at both ages (compared to children who were not overweight at 8 and 12 years of age), and who became overweight between the age of 8 and 12 years (compared to children who remained their normal-weight between the age

of 8 and 12). For each of the analyses only children with full data on all of the included variables were included. The association between childhood overweight and Cito-test z-score was analysed using univariate and multivariate linear regression analyses, whereas the association between childhood overweight and teacher's school-level advice, was analysed using univariate and multivariate generalized linear mixed models. Confounder analyses were performed to assess which potential confounding factors were significantly associated with both overweight and school performance. Based on these analyses, multivariate regression analyses were adjusted for parental educational level, skipping breakfast, and screen time. Mediating analyses were performed as described by Baron and Kenny (32). It was assessed what potential mediating factors were significantly associated with both overweight and school performance. Moreover, these variables had to influence the crude association between overweight and school performance resulting in a change of the β -value of >10%. In addition, for factors that revealed to be mediating factors according to the methods of Baron & Kenny, we conducted a Sobel's error term test. This tests the influence of the potential mediating factor on the dependent and independent variable according to the following formula; $\sqrt{(b^2 \times s_a^2 + a^2 \times s_b^2)}$ (32). These analyses revealed being bullied at school to be a mediating factor, which was included in the multivariate analyses accordingly. However, to test theoretical assumptions, additional analyses were performed including all potential confounding and mediating factors in different models. Results were considered significant when $P < 0.01$.

RESULTS

Descriptive characteristics

The mean age of children at follow-up was 12.1 years, 51% were girls and the majority of the children (87%) were in the final grade of primary school (Table 1). At the age of 8, 14% of the children were overweight, 11% of the children aged 12 years were overweight. Of all 12-year-old overweight children, 73% were already overweight at 8 years of age. Concerning the total population, 9% of the children were overweight at both 8 and 12 years of age and 4% of the children became overweight between the age of 8 and 12 years. The mean score on the Cito-test was 539, 29% of the students received a pre-university educational level advice from their teachers compared to 12% who received a prevocational secondary educational level advice (Table 1). Due to relatively high loss-to-follow-up rates, in this study, among lower educated parents the distribution of parental educational level differed slightly from the PIAMA baseline data.

The association between overweight and school performance

Univariate regression analyses showed that 8-year-old overweight children scored lower on their Cito-test and were advised to attend a lower level of secondary education by their teachers compared to their normal-weight peers (Table 2). Analyses with overweight at 12 years of age and overweight at both 8 and 12 years of age showed similar results. Becoming overweight between 8 and 12 years of age was not associated with Cito-test z-scores or teacher's school-level advice (Table 2).

The associations of overweight at 8 years of age, overweight at 12 years of age, and overweight at both 8 and 12 years of age with school performance were no longer significant when parental educational level, skipping breakfast, and screen time

Table 1 Descriptive statistics of the study population ($N = 2,159$)

Variable	N	Mean (s.d.)	%
<i>At 0–1 year of age:</i>			
Gender (% girls)	2,159		51
Birth weight (g)	2,153	3,546 (536)	
Breastfeeding duration >16 weeks	2,159		37
Maternal age at childbirth (years)	2,154	30.8 (3.8)	
Maternal smoking during pregnancy	2,138		15
Maternal educational	2,156		
Low			18
Intermediate			42
High			41
Paternal educational	2,139		
Low			21
Intermediate			33
High			46
<i>At 8 years of age:</i>			
Age (years)	1,543	8.2 (0.4)	
BMI (kg/m ²)	1,543	16.4 (2.0)	
Overweight	1,543		14
Obesity	1,543		3
<i>At 12 years of age:</i>			
Age (years)	2,151	12.1 (0.3)	
BMI (kg/m ²)	1,918	17.5 (2.5)	
Overweight	1,918		11
Obesity	1,918		1
Overweight at both 8 and 12 years	1,276		9
Became overweight between 8 and 12 years of age	1,205		4
Cito test-score (range 501–550)	1,738	539 (7.9)	
School-level advice provided by teachers ^a	2,128		
Prevocational secondary education			21
Senior general secondary education			16
Pre-university education			29
MHI-5 score	2,608	80.0 (10.5)	
Screen time (h/week)	2,026	21.2 (8.7)	
Daily physically active for at least 1 h	2,058		20
Skipping breakfast	2,084		
Never			95
1–2 days/week			4
3–6 days/week			1
Always			0
Health problems influencing school performance	2,159		1
Bullied at school weekly	2,092		3
School absenteeism (number of days in last year)	2,142	3.2 (6.1)	

Cito, central institute for test development; MHI, mental health inventory.

^aThe percentages of children that were advised to participate in a mixed class of two educational levels were not included in this table.

Table 2 The association between overweight and school performance

	Cito-test z-score β (95% CI)	Teacher's school-level advice β (95% CI)
<i>Crude analyses</i>		
Overweight at 8 years of age	-0.24 (-0.00; -0.40)*	-0.44 (-0.74; -0.14)*
Overweight at 12 years of age	-0.37 (-0.53; -0.21)**	-0.68 (-0.98; -0.37)**
Overweight at both 8 and 12 years of age	-0.36 (-0.57; -0.14)**	-0.67 (-1.07; -0.27)*
Became overweight between 8 and 12 years of age	-0.29 (-0.62; 0.03)	-0.63 (-1.25; -0.02)
<i>Adjusted analyses^a</i>		
Overweight at 8 years of age	-0.12 (-0.28; 0.04)	-0.11 (-0.40; 0.18)
Overweight at 12 years of age	-0.16 (-0.32; 0.00)	-0.29 (-0.60; 0.01)
Overweight at both 8 and 12 years of age	-0.17 (-0.38; 0.04)	-0.23 (-0.63; 0.16)
Became overweight between 8 and 12 years of age	-0.15 (-0.46; 0.17)	-0.47 (-1.04; 0.11)

CI, confidence interval; Cito, central institute for test development.

^aModel of the analyses adjusting for parental education level, skipping breakfast, and screen time.* $P < 0.01$; ** $P < 0.001$.

were added to the model (Table 2). Table 3 displays the different models that were tested to verify theoretical assumptions concerning confounding (model 1–3) and mediating factors (model 4–7) within this association. These results show that early life factors did not influence the association, whereas parental educational level, lifestyle factors, being bullied at school MHI-5 score, and health problems caused the association to become insignificant (Table 3). Based on confounding and mediation analyses, only parental educational level, screen time, and skipping breakfast were revealed to be actual confounding factors, whereas being bullied at school was revealed to be an actual mediating factor (Sobel's error term 2.28; $P = 0.02$). However, as none of the tested associations remained significant after adjusting for confounding factors, being bullied at school was not included in any of the final regression models.

DISCUSSION

The aims of the current study were to assess the association between childhood overweight and school performance among primary school children using data from a prospective cohort study and including a large range of potential confounding factors, and to investigate what factors mediate this association. Initially, results showed lower school performance among overweight children compared to normal-weight children; however, this association was no longer significant when analyses were adjusted for parental educational level, skipping breakfast, and screen time. Therefore, this study adds evidence for the assumption that a direct association between overweight and school performance among primary school children is unlikely.

Parental educational level revealed to confound the association most, which is in line with previously performed studies

Table 3 The association between overweight at 12 years of age and school performance adjusted according to theoretical assumptions

	Cito-test z-score β (95% CI)	Teacher's school-level advice β (95% CI)	Factors included in each model
<i>Crude model</i>			
Model 1	-0.22 (-0.38; -0.07)*	-0.36 (-0.66; -0.06)	Parental educational level
Model 2	-0.23 (-0.38; -0.07)*	-0.32 (-0.64; -0.01)	Parental educational level, maternal age at birth, maternal smoking during pregnancy, birth weight, and breastfeeding duration
Model 3	-0.15 (-0.31; 0.01)	-0.27 (-0.57; 0.03)	Parental educational level and skipping breakfast, screen time and physical activity
<i>Adjusted model</i>			
Model 4	-0.13 (-0.29; 0.03)	-0.24 (-0.55; 0.06)	Confounding factors (i.e., parental education level, skipping breakfast, and screen time)
Model 5	-0.13 (-0.29; 0.03)	-0.26 (-0.56; 0.04)	Confounding factors and being bullied
Model 6	-0.16 (-0.32; -0.00)	-0.28 (-0.58; 0.02)	Confounding factors and MHI-5 score
Model 7	-0.14 (-0.29; 0.02)	-0.30 (-0.60; -0.00)	Confounding factors and health problems that influence school performance
Model 8	-0.13 (-0.29; 0.03)	-0.32 (-0.62; -0.02)	Confounding factors, being bullied and school absenteeism
Model 9	-0.16 (-0.32; -0.00)	-0.33 (-0.62; -0.03)	Confounding factors, MHI-5 score and school absenteeism

Cito, central institute for test development; MHI, mental health inventory.

* $P < 0.01$; ** $P < 0.001$.

among young children (14,15). These studies reported that parental socioeconomic factors are strong predictors of children's school performance and weight status. Besides parental educational level, skipping breakfast and screen time were found to confound the association between overweight and school performance; these findings are in line with existing literature (21,22,33–36). Both factors are suggested to reduce cognitive performance while at the same time, independently, increasing the likelihood of becoming overweight (21,22,33–36).

Although a previously performed study reported a significant mediating influence of weight-related bullying on school performance (16), within the current study the mediating influence of being bullied at school could not be tested, as none of the associations remained significant after adjustment for confounding factors. Even though previous conducted studies report higher prevalence rates of bullying among overweight children and lower levels of academic achievement among bullying victims (37,38), it remains unclear if and to what extent bullying at school actually mediates the association between overweight and school performance among primary school children.

Strengths and limitations

A strength of this study was the use of prospective data. As children's weight status was measured at different points in time, the association between overweight at different age(ranges) and school performance at the age of 12 could be investigated. This resulted in insights into the longitudinal association between childhood overweight and school performance. Besides, in contrast to other studies, the current study included a large range of potential confounding variables, including psychosocial and lifestyle factors. This enabled us to provide insight into the different pathways that could explain a possible association between overweight and school performance. Finally, this study used both an objective (Cito-test score) and a subjective (teacher's school advice) measure as indicators of school performance.

However, some limitations have to be considered. First of all, the data greatly relied on self-reports of both children and their parents, among which the height and body weight of children at 12 years of age. Although the prevalence of overweight tends to be underestimated, in most cases self-reported or parental reported height and weight are closely correlated to those measured by trained professionals (39,40). Therefore, we expect that the association between overweight and school performance among 12-year-old children provides an accurate estimate of the actual association. Besides, children's school performance data was self-reported by their parents. Since there is no scientific evidence for the magnitude of the bias created by this self-reporting, our results might over or underestimate the actual association between overweight and school performance. However, it is expected that the bias of the reported scores in this paper did not change our final conclusions. The Cito-test scores are an important measure for children's future education, the possibility that parents might have forgotten their

child's score was thought to be minimal. Moreover, it was not expected that parents deliberately reported incorrect scores on a large scale and it was also not expected that parents of overweight children more often deliberately reported incorrect scores. Second, the distribution of parental educational level differed slightly from the PIAMA baseline data due to higher drop-out among lower educated parents. This could have lead to slightly higher levels of school performance and a lower prevalence of overweight among this study population compared to the average Dutch population. However, we do not believe that this influenced the current findings concerning the association between overweight and school performance. Third, since the effect of overweight on school performance is expected to be the most apparent among severely overweight children, the small number of extreme overweight (obese) children in the current study population may partly explain the absence of an association in this study. Previously performed studies show that the pathways that were expected to explain the association between overweight and school performance (e.g., health problems and psychological issues) are more common among obese children (23,26).

Conclusion and implications for future research

In conclusion, the current study found no conclusive evidence for an association between overweight and school performance among primary school children. Instead, parental educational level revealed to be a strong predictor of children's school performance.

Since it is expected that the severity of weight-related health, psychological, and psychosocial problems increases with age, the impact of these factors on children's school performance might increase accordingly. Therefore, it is recommended to investigate the association between overweight and school performance among children in secondary schools. The large range of potential confounding and mediating factors, as reported in this study, should be included and a large population-based sample from a prospective cohort study should be used.

ACKNOWLEDGMENTS

Research relating to this abstract was funded by The Netherlands Organization for Health Research and Development; The Netherlands Organization for Scientific Research; The Netherlands Asthma Fund; The Netherlands Ministry of Housing, Spatial Planning, and the Environment; and The Netherlands Ministry of Health, Welfare, and Sport.

DISCLOSURE

The authors declared no conflict of interest.

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