

# Childhood obesity and educational attainment

## A systematic review

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### Author contributions

The protocol was developed by SO, KO, JK, CS and JT. Consultation processes were developed and/or implemented by JK, KO and SO. Identification and coding of included studies was conducted by JC, JK, KO and CS. Data extraction tools were developed by JK, KO, SO and JT. Data were extracted and/or synthesised by, JC, JK, AO, KO, CS and JT. The report was prepared by JC, JK, KO, SO, CS and JT. SO and JT supervised the review process and provided detailed input to the conceptual framework of the review, and advice on perspectives and participation. JT and AO assisted in the interpretation of statistics.

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## **Abbreviations**

BMI	Body mass index
FE	Fixed effects
GPA	Grade point average
IV	Instrumental variables
NCB	National Children's Bureau
OLS	Ordinary least squares
PIAT	Peabody Individual Achievement Test
SAT	Standard assessment test
SEM	Structural equation models
SES	Socio-economic status
WHO	World Health Organization



## **Preface**

### **Scope of this report**

This report describes the findings and methods of a systematic review of research which explores the relationship between obesity and educational attainment.

This review forms part of the core programme of Department of Health-funded work at the EPPI-Centre, Social Science Research Unit, Institute of Education, University of London. It complements two other systematic reviews from the EPPI-Centre, one of which explores the relationships between obesity and sedentary behaviour and another which examines children's views about obesity, body size, shape and weight. Also included in this body of work are a map and a searchable database of schemes tackling obesity and overweight in children and young people in England, a systematic map of reviews of social and environmental interventions to reduce childhood obesity, and a systematic review of young people's views about obesity, body size, shape and weight (forthcoming).

### **How to read this report**

Because this is a systematic review, using explicit and rigorous methods to synthesise evidence, the report is necessarily detailed. The review contains a large number of studies using complex statistical models for analyses. Without compromising on the transparency that is expected of a systematic review, we have taken a number of steps to construct this report around the requirements of readers more interested in its findings than research methods.

In order to give due prominence to the findings of the review, we have divided the report into two sections: Part I focuses on the findings of the review with only a brief description of the methods; Part II describes the review methods and study findings in detail.

Chapters 2 and 3, containing the results of consultations with young people and teachers, and the synthesis of studies, have been structured to aid quick reading. Chapter 4 contains a comparison of the perspectives of teachers, young people and researchers regarding the relationship between obesity and attainment. Each major section has a summary of findings which can be used by readers wanting to skim-read the report, and key findings are listed in Evidence Statements preceding the executive summary. A detailed appraisal of the results of each contributing study can be found in Part II of the report.





## **Evidence statements**

1. Twenty-nine studies were included in the review. Overall, the evidence suggested that higher weight is weakly associated with lower educational attainment among children and young people.
2. Differences between the average attainment of overweight and non-overweight children were marginal, with potentially negligible real-world implications for test scores and grade point averages.
3. It appeared that little of the variation in achievement was explained by weight status alone.
4. Almost half of the studies reviewed found that other factors, such as socio-economic status (SES), can probably better explain much of the negative association between weight status and attainment.
5. On the basis of a stakeholder consultation exercise, few young people thought that obesity and educational attainment were associated whereas most teachers thought that there was such an association; both teachers and young people perceived poor mental and emotional health as being factors which might explain an association, should one exist.

## **The evidence base**

1. SES was identified as a particularly important moderator of the association between weight status and attainment. Some studies failed to take this into consideration, and it is possible that they consequently overestimate the strength and/or direction of the relationship.
2. Studies varied widely in the type and number of moderating variables that were incorporated into their statistical models, which can affect the results obtained.
3. During the consultation exercise, teachers and young people suggested causal pathways whereby low academic attainment resulted from poor mental and emotional health associated with obesity. Only four of the 29 studies adjusted for such variables. This may represent a divergence between the perspectives of researchers and those of stakeholders, or limitations in the data available (i.e., data on certain variables were not collected). Whichever is the case, this serves as an example of a potentially important causal pathway which has not yet been adequately explored in the research literature.

4. There were some inconsistencies in the findings across the evidence base that were possibly due to the choice of method of statistical analysis. Even within a single study, authors presented different findings derived from the same sample according to the specifications of their different statistical models. Conflicting results between studies may also have been a consequence of authors selecting different samples from the same dataset.

## **Executive summary**

### **Background**

This report describes the findings and methods of a systematic review of research which explores the relationship between obesity and educational attainment. It has been conducted at a time of great concern about levels of obesity in the UK, and the negative physical, psychological and social impacts of obesity. Current research suggests that there may be a relationship between obesity and poor educational attainment. It is likely that obesity and poor school performance are elements of a broader picture of inequalities in health and education, whereby disadvantaged socio-economic groups tend to have poorer health and lower levels of education. However, it is possible that other factors influence obesity and attainment, such as gender, discrimination and poor mental and emotional well-being.

This systematic review was therefore commissioned to address the question: *What do we know about the relationship between childhood obesity and educational attainment, from the research literature?* In order that our review might be informed by those closest to observing any interaction between obesity and attainment, we sought the perspectives of teachers and young people to identify the causal pathways that seemed most pertinent to them.

### **Findings**

#### **Is there a statistical association between obesity and educational attainment?**

While often conflicting, an overall pattern emerges from the research evidence suggesting that there is a weak negative association between obesity and educational attainment in children and young people; i.e. that higher weight is associated with lower educational attainment. Obesity is also associated with other variables, such as socio-economic status, and when these other variables are taken into consideration, the association between obesity and attainment becomes still weaker, and often loses statistical significance.

#### **To what extent does the research evidence explore the influence of the broader determinants of health, and in particular socio-economic position, in explaining any link between obesity and attainment?**

Place of residence, ethnicity, occupation, gender, religion, education, socio-economic status (SES) and social capital were all explored as potential moderating variables in the included research. Twenty-three of 29 studies used a measure of socio-economic status as a moderating variable. Various factors appear to contribute to low educational attainment to some extent, although given the variation in definitions, analyses and quality of data, it is impossible to point to any causative or definite risk factors.

**Authors of the included studies have posited theories suggesting that the link between obesity and educational attainment is moderated by individual and societal factors. Does the research evidence support or refute these?**

Most studies explored the influence of obesity upon attainment. Only two studies examined the influence of attainment upon obesity. Many authors suggested multiple causal pathways, many of which remained untested in their studies. The moderating variables used in statistical analyses of the relationship between obesity and attainment were not consistent with the causal pathways proposed, which is probably a reflection of the constraints imposed upon authors conducting secondary analyses of pre-existing datasets (i.e. they made use of existing variables, rather than collecting their own, tailored data). The most frequently cited factors resulting from obesity and impacting upon educational attainment were poor mental health, stigmatisation and discrimination, disordered sleep, decreased time spent in physical activity and socialising, and absenteeism.

**Different perspectives on obesity and attainment**

Few **young people** initially thought that obesity and educational attainment were associated. However, they considered obesity and educational attainment to be of importance to young people. Young people considered parental influence and circumstances, including family income and poverty, and bullying and emotional health to be the most important factors which might explain an association between obesity and educational attainment.

Most **teachers** said that there was an association between obesity and educational attainment. Bullying, low self-esteem and emotional well-being, poverty and poor diet, and physical activity were commonly cited by teachers as being the most important and credible mediating variables in this association. Teachers also considered gender, ethnicity and parental influence to be important factors.

While **researchers, teachers and young people** identified causal pathways whereby low academic attainment resulted from poor mental and emotional health among obese children and young people, only four studies adjusted for mental and emotional health variables. This may represent a significant divergence in the perspectives of researchers and stakeholders. Alternatively, it may be that in the 23 studies which conducted a secondary analysis of an existing dataset, such data were not available to the authors. Another divergence concerns the impact of reduced participation in sports and social activities. While teachers and young people located this within a broader framework of isolation and lower socialisation suffered by obese children – and thus felt reduced sports participation would result in lower attainment – three studies in the included research proposed a causal pathway in which reduced participation in sports and social activities might lead to increased time spent studying and hence higher attainment.

## **Implications**

There are three important implications arising from this review:

First, that **obesity should not be understood solely as a health issue**. This review, and other research, suggests that one of the most noticeable ways in which obesity affects the lives of children and young people is in their social relationships. Given the paucity of evidence suggesting a causative physiological link between obesity and attainment, any association is likely to be mediated by social factors. We find that stigmatisation, bullying, low self-esteem and young people's exclusion from opportunities for social interaction are suggested as underlying any relationship between obesity and lower educational attainment.

Second, that the **variables used in statistical analyses failed to capture many of the potential causative factors identified by the teachers and young people** (and, often, also of the researchers undertaking those analyses). If large-scale longitudinal datasets are to deliver on their potential to help us understand people's lives, they need to engage with the social lives of their participants and amass not simply data that are straightforward to collect, but information that reflects determining characteristics of people's social experiences, because these are often the key to understanding health and other behaviours.

Finally, we find this body of literature to be one of the least cumulative that we have reviewed. **Data from the same datasets are analysed in different ways**, using different variables, coming to different conclusions with minimal attempts to explain differences in findings. Different statistical models are sometimes employed with little justification for their selection and little acknowledgement that a different method might yield an entirely different result. These are important failings, and it is hoped that work associated with the EQUATOR network will in time lead to improvements (Simera et al. 2010). We should note that these criticisms do not apply to all studies in this review, but it would be true to say that they do apply to many of them.



# Part I: Background and findings of the review



## **1 Background**

This systematic review forms part of the programme of Department of Health-funded work at the EPPI-Centre, Social Science Research Unit, Institute of Education, University of London. It is designed to dovetail with other reviews on childhood obesity carried out by the EPPI-Centre.

This review has been conducted at a time of great concern about levels of obesity in the UK (Butland et al. 2007). In the UK and internationally, there is widespread concern over the rising rates of obesity (World Health Organization 2000). A 2006 report for the Department of Health found that 65% of males and 56% of females were overweight, and over a third were obese (World Health Organization 2000, Zaninotto et al. 2006). A large number of young people in the UK are experiencing a body weight that is above the range considered to be healthy. Annual estimates available for young people aged 11 to 15 in England show an almost year-on-year rise in weight in both boys and girls over the ten years up to 2005. Data from England (2007) indicate that over one in six boys in this age group (17.6%), and nearly one in five girls (19.0%) would be classed as obese (Health and Social Care Information Centre, 2009). The latest data from the Scottish Health Survey provided estimates for girls and boys aged 12–15 in 2008. This found that 19.1% and 15.8% of boys and girls respectively would have been classified as obese and 19.1% and 16.3% would have been classified as overweight (Corbett et al. 2009).

The health and social implications for individuals, communities and wider society are not yet fully understood, but there are well-documented links between obesity and cardiovascular disease, diabetes, osteoarthritis, cancer, dermatological and rheumatic diseases, asthma and other respiratory diseases (Black 1983, Garrow 1991). Obesity may also have economic and cultural consequences (Wanless 2002). It was estimated that the treatment of obesity and its related problems would cost the UK Government £3.5 billion per year by 2010 (National Audit Office 2001).

The UK government has identified obesity as a policy priority. The policy document *Healthy weight, healthy lives* sets out a framework for action in five main areas: promoting children's health; promoting healthier food choices; building activity into our lives, creating incentives for better health and personalised advice and support (Cross-Government Obesity Unit et al. 2008).

### **1.1 Obesity, educational attainment and their determinants**

Obesity represents a major challenge for policy makers, communities and individuals, yet its causes and implications are not entirely understood. Different models proposing direct and indirect pathways for the increase in obesity have been proposed. Some theories argue that individual choices and behaviour are primarily accountable, and indeed, policy makers, practitioners and researchers have in recent years tended to focus on individual behaviour change, and encouraging or enabling people to make healthy choices, in order to counter the rise in the population's weight (Department of Health 2004).

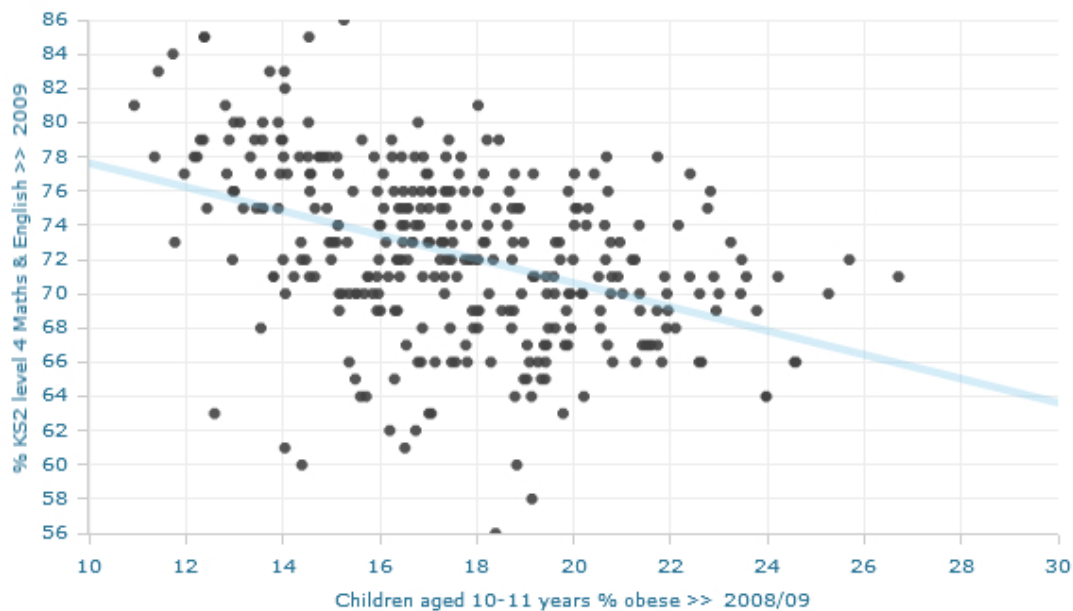
Others assume that biological and genetic factors, social circumstances or wider socio-economic conditions, combined with influences from individuals' social and physical surroundings, are responsible for creating 'obesogenic environments' which promote obesity (Butland et al. 2007, Jones et al. 2007, Swinburn et al. 1999, Swinburn and Egger 2004). The influences impacting on obesity have also been described as a relationship between both 'micro-environments' (e.g. school, workplace, home, neighbourhood) and 'macro-environments' (e.g. education and health systems, government policy and society's attitudes and beliefs) (Lake and Townsend 2006, Swinburn et al. 1999).

The model adopted by researchers, consciously or unconsciously, determines the level of analysis (individual, family, community or wider society) that they conduct and hence the variables and interventions that they consider.

## 1.2 Obesity and attainment

National data suggest that there is a relationship between obesity and educational attainment whereby obesity is associated with lower levels of attainment. For example, the National Obesity Observatory (NOO) has created a set of 'e-atlases', which allow obesity to be examined in relation to its determinants and associated outcomes. Figure 1.1 illustrates the association between achievement at Key Stage 2 level 4 Mathematics and English and levels of obesity in English local authorities. As can be seen, where obesity is high, educational attainment is comparatively low.

**Figure 1.1** Scatter plot of obesity level versus educational achievement in KS2 Mathematics and English at 11 years old in English local authorities (2009)



Source: UK National Obesity Observatory , replicated with permission from the NOO website

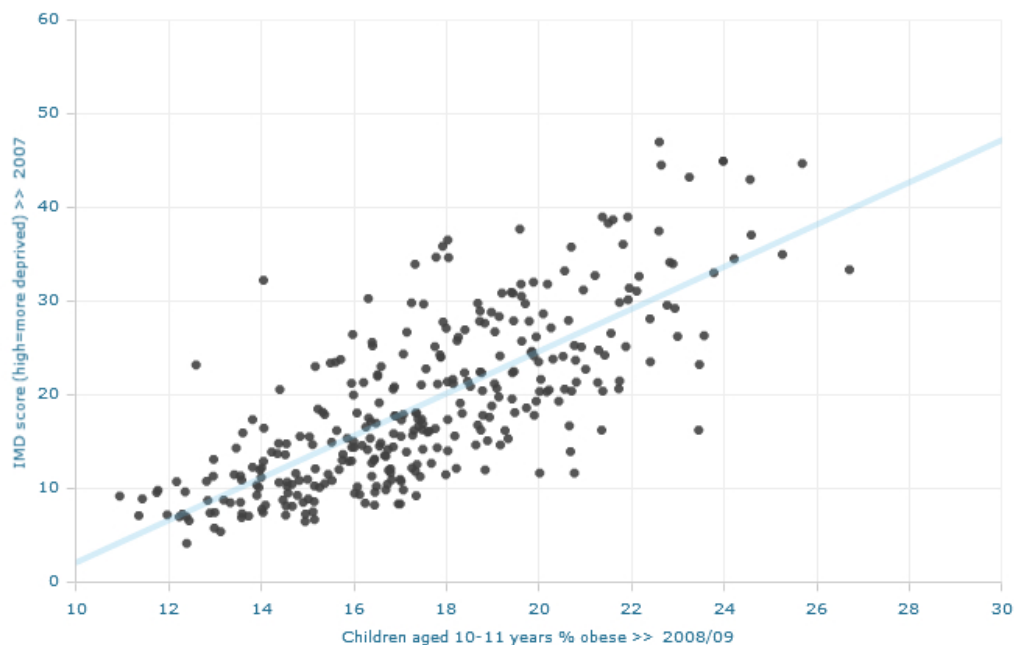
It should be noted that the graph above depicts local authority-level trends rather than individual-level associations. Moreover, while Figure 1.1 may show an association between obesity and attainment, it does not explain *why* the two measures appear to be related. Simply because it is possible to observe a correlation between two values, this does not mean that one necessarily causes the other. (Assuming causation is a well-known logical fallacy, summarised by the phrase *cum hoc ergo propter hoc*: 'with this therefore because of this'.) It may be that a third factor is at work which is related to both obesity and attainment, and this third factor is responsible for the observed relationship. For example, a recent literature review of nine studies concluded that obesity is associated with poor performance at school, as the above correlation suggests, but the review also goes on to suggest that a number of other factors, including family income, low self-esteem, anxiety disorders, depression and absenteeism might explain the observed correlation (Taras and Potts-Datema 2005). Any relationship between obesity and

attainment is therefore unlikely to be a simple case of 'cause-and-effect', and may involve the interaction of multiple factors. One of these is likely to be socio-economic status (SES).

Obesity and poor school performance are likely to be specific elements of a broader picture of inequalities in health and education, whereby disadvantaged socio-economic groups tend to have poorer health and lower levels of education (Wilkinson and Marmot 2003). Obesity is currently linked to low socio-economic status (although this has not always been the case) (Public Health Research Consortium 2008), and children from low income families are at higher risk of poor educational achievement (See Figure 1.2).

Variations in the broader social, economic and environmental determinants of health lead to 'health inequalities', which are recognised to be a major and increasing problem in many countries. Determinants implicated in health inequalities include socio-economic position, occupation, education, place of residence, social capital, ethnicity, religion and gender (Dahlgren and Whitehead 1991). There are therefore strong arguments for applying the framework of inequalities and social determinants of health when exploring possible relationships between obesity and educational attainment. Figure 1.2 demonstrates this issue, showing another correlation, this time between obesity and deprivation. As well as being related to lower educational attainment, obesity is related to deprivation. As stated above, we cannot conclude that obesity causes deprivation (or vice versa), only that there is some kind of relationship between the two. Unpacking the possible causal pathways between factors that are correlated with one another is therefore taken into consideration within this review.

**Figure 1.2** Scatter plot of obesity level versus index of multiple deprivation for children aged 10–11 years in English local authorities (2007)



Source: UK  
National  
Obesity  
Observatory

### 1.3 Causal pathways and moderating variables in relating obesity and attainment

This review examines two types of factors which might explain the observed statistical relationship between obesity and attainment: *causal pathways* and *moderating variables*.

*Causal pathways* are those factors which mediate the relationship between obesity and attainment. These mechanisms are theoretical and it should be borne in mind that the statistical tests used in these studies do not allow us to assume causal relationships. For example, young people who are obese might be subject to bullying and discrimination, which in turn leads to low self-esteem, which in turn leads to low academic performance.

**Obesity → Discrimination → Low self-esteem → Low academic performance**

We have termed these factors ‘causal pathways’, because they describe the path through which obesity might influence attainment.

The other factors we need to consider are *moderating variables*. These impact in some way on factors within the causal pathways, and thus change characteristics of the causal pathway for some, or all, young people. For example, SES is often cited as a variable which influences both obesity and attainment, though as it does not arise as a result of the overweight or educational status of children and young people, it cannot be regarded as being part of a causal pathway. Continuing the example begun above, it may be that the obesity – discrimination – low self esteem – low attainment pathway operates differently for different social groups (maybe young people with higher social capital suffer less

discrimination, for example.) This would thus confound the simple linear relationship outlined above and highlight the importance of specific contextual variables when considering causal pathways.

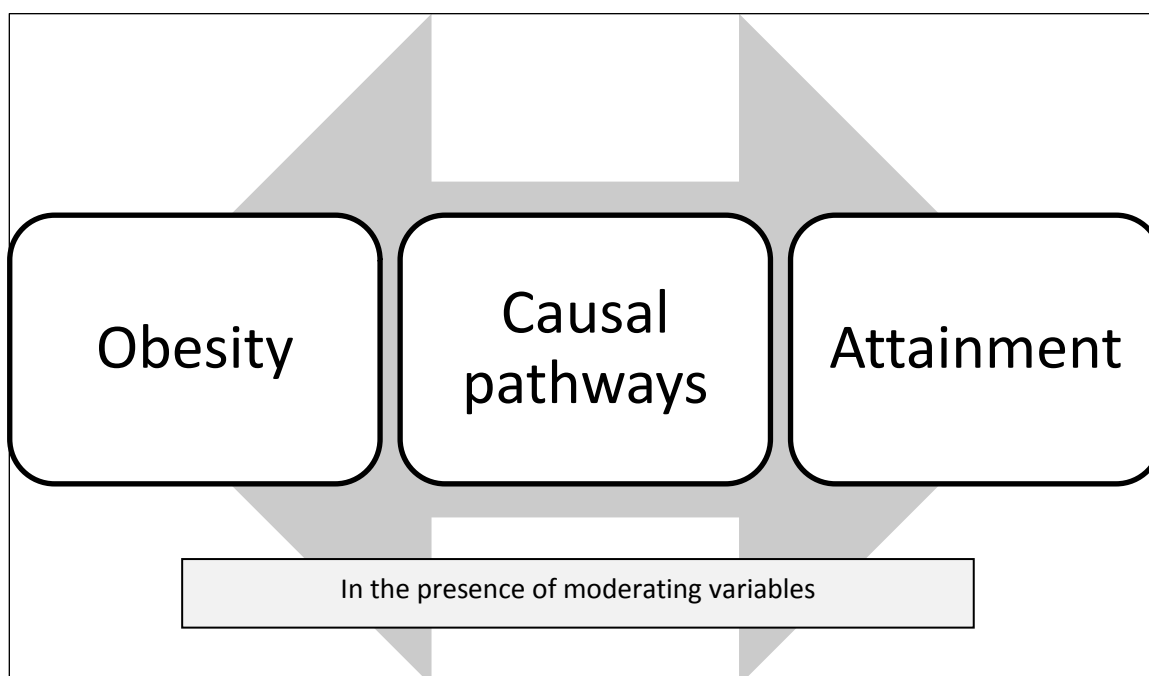
SES



**Obesity → Discrimination → Low self-esteem → Low academic performance**

As a whole, the analytical model for our review is depicted in Figure 1.3. We have a correlation (which may or may not be demonstrated in any one given study) between obesity and attainment, which is explained and mediated by a number of potential causal pathways. In any one causal pathway, the relationship between obesity and attainment may be altered by one or more moderating variables.

**Figure 1.3** The relationship between obesity, educational attainment and potential moderating variables (confounders).



#### 1.4 Perspectives and participation

A substantial body of research supports active public involvement in evidence-informed public health (Staley 2009, Oliver et al. 2004, Oliver 2008, Parker et al. 2003, Popay and Williams 1996, Putland et al. 1997). In addition, a systematic review of the effectiveness of health service interventions aimed at reducing inequalities in health found that a characteristic of successful interventions was that they addressed the expressed or identified needs of the target population (Arblaster et al. 1996). We would argue therefore, that opportunities need to be created for the active participation of young people in research addressing their own health needs, rather than only using top-down expert-led health models.

In this review, opportunities were sought for incorporating the perspectives of those individuals who have first-hand experience of the issues under consideration, i.e. children, young people and teachers. Their perspectives were elicited by means of two consultation exercises.

Teachers and young people provided both causal pathways for the way in which obesity might affect educational attainment, and moderating variables influencing the relationship between obesity and attainment (see Figure 1.3). The variables and pathways identified allowed us to assess the extent to which the research addressed the issues identified by teachers and young people.

## **1.5 Review questions**

This systematic review addresses the following research questions:

What do we know about the relationship between childhood obesity and educational attainment, from the research literature?

Is there a statistical association between obesity and educational attainment?

To what extent does the research literature explore the influence of the broader determinants of health, and in particular socio-economic position, in explaining any link between obesity and attainment?

To what extent did the included studies posit theories explaining the link between obesity and educational attainment as being mediated by individual and societal factors? Are these theories supported or refuted by the research evidence?

## 2 Consultation with teachers and young people

In order to ensure that our analysis was informed by the perspectives of teachers and young people, we held consultations in April and May 2009. In this chapter we report what young people and teachers said about the relationship between obesity and educational attainment, and what they thought might be important moderating variables or explanations for any association. In Chapter 4 of the report we bring together the various perspectives of young people, teachers and researchers, to see the extent to which they differ, and the extent to which the research evidence addresses factors considered to be important by teachers and young people.

### 2.1 Young people's perspectives

The young people we consulted were members of the National Children's Bureau (NCB) Young People's Health Reference Group ([www.ncb.org.uk/pear/home.aspx](http://www.ncb.org.uk/pear/home.aspx)). This group was convened to enable young people's views and opinions to influence public health research agendas. Seventeen young people from Leeds and London aged between 12 and 17 took part. None of the young people were obese or significantly overweight.

The young people were asked for their opinions on:

Whether or not they believe there is an association between obesity and educational attainment;

What factors (reasons or mechanisms) might explain an association, and how important might they be.

**Summary:** Few young people initially thought that obesity and educational attainment were associated. However, they considered obesity and educational attainment to be important. Young people considered parental influence and circumstances, including family income and poverty, and bullying and emotional health, to be the most important factors which might explain an association between obesity and educational attainment.

#### 2.1.1 Explanatory factors

Both obesity and educational attainment were considered to be important issues for young people, but only a few expressed a view that there was a definite association between the two.

##### *Parental influence*

Young people considered parental influence and circumstances to be the most important factor in any relationship between obesity and educational attainment. Parental awareness, aspirations and the home environment were rated as very important. Parents were considered likely to affect both obesity and attainment through several mechanisms. Two were by knowing how to cook and plan meals, and by educating the family about healthy eating and consumption of high energy food types (potentially also affecting concentration at school). A mother's own weight and education were viewed as more important than the father's weight and education in relation to educating young people about health. Bringing young people up with the 'wrong view on food' was viewed as linking obesity and attainment.

Parental health (especially mothers' weight) was also seen as important, as was parental attention to young people (increased attention from parents was seen as being associated with better achievement).

### ***Family income and poverty***

Parental circumstances also included family income and poverty. Wealth was viewed as being linked to both attainment and weight (with poorer young people being seen as larger and achieving lower educational status). Parents' occupation and family income, including how much money they have for food, were considered to be important factors in the relationship between obesity and attainment. Some young people thought that how wealthy someone was could be related to the quality of school they went to. They suggested that poorer people buy ready meals rather than fresh food because they think it's cheaper, thus linking into ideas about wealth, nutrition and knowledge about healthy lifestyles. 'Living somewhere where it's hard to exercise' was rated as being quite important, with the suggestion that well-off areas tend to have better facilities than others. One group suggested that inner cities have limited space to go for a run, and that although people could use a gym, the expense of membership may be a limiting factor.

### ***Bullying and emotional well-being***

Young people stressed the importance of social and emotional factors. They felt that being bullied was an important mediating variable in the relationship between obesity and educational attainment. Bullying was thought to be linked with depression about weight, leading to poor diet or comfort eating, and feeling sad or stressed. Size-related bullying was also considered to be related to lowered attention and concentration through increased insecurity and illness. Emotional health and well-being were also highlighted with 'feeling sad', 'feeling stressed' and 'having no friends because of being fat' all rated as important by the young people.

### ***Other factors***

*Screen time* was thought to be a fairly important link between obesity and attainment. The young people thought that watching TV and playing computer games decreased both physical activity and time spent studying, hence the link to attainment.

*Gender* was considered by the young people to be a moderately important factor. Boys were considered to be judgemental about girls, and girls more concerned about image than boys, both of which were considered to be relevant to obesity and attainment.

How much *sleep* someone gets, *being ill* (e.g. asthma and diabetes), *parental health* and in particular *mother's weight*, and *how someone gets to school* were all mentioned by the young people. However, while these were considered to be important to young people, they were not clear about how they might explain an association between obesity and educational attainment.

## **2.2 Teachers' perspectives**

Eight teachers were involved in the consultation; all but one worked in state-funded schools: three in primary schools, four in secondary schools and one in a field studies centre run by an education charity.

Teachers were asked their opinions on:

Whether or not they believe there is an association between obesity and educational attainment;



What factors (reasons or mechanisms) might explain an association, and how important and credible they might be.

**Summary:** Most teachers said that there was an association between obesity and educational attainment. *Bullying, low self-esteem and emotional well-being, poverty and poor diet, and physical activity* were commonly cited as being the most important and credible mediating factors in this association. Teachers also considered *gender, ethnicity and parental influence* to be important factors.

### 2.2.1 Explanatory factors

Only one teacher thought that there was no association between obesity and educational attainment. Teachers offered a number of causal pathways for an association between obesity and academic achievement; these were often complex and interrelated.

#### ***Bullying and emotional well-being***

Teachers considered that *depression, low self-esteem and low self-worth* were highly credible and important factors in the relationship between obesity and educational attainment. *Bullying and victimisation* were viewed as being highly credible factors in the development and maintenance of low self-esteem and poor emotional well-being, both of which were considered to have a direct link with academic underachievement. Being obese and being bullied or victimised because of it, was thought to have an impact on both joining in physical activities and games, and the ability to maintain strong friendship groups, which were viewed by teachers to be important influences on educational attainment. As described above, a number of teachers discussed the impact of obesity on *personal and social issues*, which were frequently discussed in relation to bullying, emotional well-being and the ability to maintain friendship groups and not to be 'left out'. One teacher reflected that these were *pastoral issues*, perhaps an implicit recognition of the caring role of the school in relation to its pupils. Teachers commented:

*"In terms of a child's poor self-esteem which might arise due to being obese, this would affect self-esteem and confidence which does have a direct link with academic achievement."*

*"Obesity could result in name-calling/bullying especially in terms of underachievement in physical activities which would impact upon academic attainment."*

*"There is no doubt that obese children are often aware of their size and reference may be made to it by other children during arguments. Self-esteem and the ability to maintain strong friendship groups are important in all areas of educational attainment."*

#### ***Poverty and poor nutrition***

Teachers suggested that poverty was an important factor in explaining how obesity and attainment are associated. When talking about obesity, many teachers associated it with poverty resulting in a poor diet, which itself was associated with poor concentration, inattention and poor behaviour, not getting 'off to a good start' in the school day; all of which were seen to link with lower levels of academic achievement. Poverty was also considered to contribute to low aspirations and a lack of parental time, interest and skills to provide both a healthy diet and educational support.

One teacher suggested:

*“There may be a link, to a small extent, but I suspect that the link may be indirect and more associated with socio economic status rather than obesity itself. Put simply, obese children may be more likely to be of a lower socio economic group and have poor diets. Children from these groups may be less likely to attain educationally anyway due to hereditary factors and lack of parental educational support.”*

### **Physical activity**

Obesity was viewed as having a direct impact on levels of physical activity, and children’s comfort with taking part in physical activity and games. Teachers associated physical activity with educational attainment and social exchange. Exercise and physical activity were seen to improve concentration, and achievement in physical activity was thought to impact on self-esteem and confidence. One teacher also discussed the impact of gender on participation in sports and exercise:

*“During the inevitable arguments children have, others will make reference to weight. Boys at primary school often judge each other based on sporting prowess and obese children struggle to play football and other sports and are more likely to be excluded from social groups. Girls become increasingly aware of the need to be attractive and slim and this will affect the self esteem of those who are obese. Girls too, enjoy sporting activity and often attend dance and other sporting clubs before and after school. Obese children who are conscious of their appearance and ability to participate are less inclined to join in and will often miss out on the social aspects of such activities.”*

### **Gender**

Some of the teachers reflected on how gender politics impact upon peer and other people’s expectations of physical appearance and size. They considered that this could influence boys and girls differently in relation to participation in sports and social activities, and lead to a loss of self-esteem in both.

### **Ethnicity**

One teacher noted that a demographic change in ethnicity had influenced the relationship between obesity and attainment in his school, noting that when the school had been predominantly ethnically white British/Irish in the 1980s and early 1990s, there was a linkage between obesity and bullying, low self-esteem, absenteeism and lower attainment. However, since the predominant ethnicities in the school had become South Asian, African and Afro-Caribbean, both obesity and attainment had increased. The teacher attributed this to cultural differences whereby obesity was not considered to be a particularly negative trait in these cultures. He noted that South Asian parental priorities were focused upon academic, rather than athletic achievement:

*“I can think of numerous happy, well adjusted, academically successful pupils from ethnic minority backgrounds who are also overweight. Academic attainment has risen at the same time as rising obesity.”*

### **Parental influence**

Teachers discussed the influence of parents in a number of different ways. Parents were felt to require a lot of support in the area of healthy eating. Some teachers related this back to the issue of poverty, with poor parents thought to lack the time and skills to produce healthy meals.

***Other***

One teacher identified hereditary factors as being linked to obesity and educational attainment:

“Children from these groups may be less likely to attain educationally anyway due to hereditary factors and lack of parental educational support.”

Chapter three takes all of these theories into account, to explore possible associations between obesity and attainment.

### **3 Findings: what is the relationship between obesity and educational attainment?**

#### **3.1 Summary**

##### **Is there a statistical association between obesity and educational attainment?**

While often conflicting, an overall pattern emerges from the research evidence suggesting that there is a weak negative association between obesity and educational attainment in children and young people, i.e. that higher weight is associated with lower educational attainment. Obesity is also associated with other variables, such as socio-economic status, and when these other variables are taken into consideration, the association between obesity and attainment becomes weaker, and often loses statistical significance.

##### **To what extent does the research evidence explore the influence of the broader determinants of health, and in particular socio-economic position, in explaining any link between obesity and attainment?**

Place of residence, ethnicity, occupation, gender, religion, education, socio-economic status (SES) and social capital were all explored as potential moderating variables in the included research. Twenty-three of 29 studies used a measure of SES as a moderating variable. Various factors appear to contribute towards low educational attainment to some extent, although given the variation in definitions, analyses and quality of data, it is impossible to point to any causative or definite risk factors.

##### **Authors of the included studies have posited theories suggesting that the link between obesity and educational attainment is moderated by individual and societal factors. Does the research evidence support or refute these?**

Most studies explored the influence of obesity upon attainment. Only two studies examined the influence of attainment upon obesity. Many authors suggested multiple causal pathways, many of which remained untested in their studies. The moderating variables used in statistical analyses of the relationship between obesity and attainment were not consistent with the causal pathways proposed, which is probably a reflection of the constraints imposed upon authors conducting secondary analyses of pre-existing datasets (i.e. they made use of existing variables, rather than collecting their own, tailored, data). The most frequently cited factors resulting from obesity and impacting upon educational attainment were poor mental health, stigmatisation and discrimination, disordered sleep, decreased time spent in physical activity and socialising, and absenteeism.

#### **3.2 Is there an association between obesity and attainment?**

In this chapter the relationship between obesity and attainment is examined. Our analysis is based on 29 studies which were identified through comprehensive and systematic searches of electronic databases and other sources of research. Full details of the search methods employed and the flow of studies throughout the review are presented in Part II of this report.

Of the 29 studies contributing to the findings of the review, 15 were cross-sectional studies, of which nine were secondary analyses. Fourteen of the 29 studies were secondary analyses of longitudinal data.

Twenty-three of the 29 studies were from the US, with one each from Canada, Iceland, Finland and Korea. Only two of the included studies were based on data gathered in the UK, both of which were secondary analyses of the Avon Longitudinal Study of Parents and Children (ALSPAC study) (Gregg et al. 2008, Von Hinke Kessler Scholder et al. 2009).

The studies are presented according to their findings in Table 3.1 below. Please see Chapter 7 in Part II of this report for in-depth findings of all the included studies, and descriptions of the cohort studies supporting secondary analyses. Please see Appendix 2 of the report to review the characteristics of the included studies.

**Table 3.1** Studies categorised by impact of obesity on attainment. ('Negative' indicates that higher weight is associated with lower attainment; 'positive' indicates that higher weight is associated with higher attainment.)

Significantly positive	Positive trend	No relationship	Negative trend	Significantly negative
Chowdhury (2008) [academic achievement Black and Hispanic >10yrs, boys' reading results]	Chowdhury (2008) [academic achievement all ethnic groups, girls' maths results]	Kim et al. (2003) <sup>†</sup>	Bagully (2006)*	Averett and Stifel (2007)
Gregg et al. (2008) <sup>†</sup>	Datar and Sturm (2006) [persistently overweight girls' reading results]		Chomitz et al. (2009)*	Castelli et al. (2007)
Pesa et al. (2000)	Kaestner et al. (2009) [boys]*		Chowdhury (2008) [girls' reading results]	Datar and Sturm (2006) [newly overweight – girls' maths and reading]
	Kaestner and Grossman (2008) [boys and 9–10 yr old girls]*		Cottrell et al. (2007)*	Ding et al. (2006) [girls]
			Crosnoe and Muller (2004)*	Elrod (2008) <sup>†</sup>
			Datar et al. (2004)*	Florence et al. (2008)

Table 3.1 continued

Significantly positive	Positive trend	No relationship	Negative trend	Significantly negative
			Datar and Sturm (2006) [persistently overweight girls' maths results, all boys' maths and reading results]	Huang et al. (2006) [self-reported grades]
			Ding et al. (2006) [boys]*	Kaestner and Grossman (2008) [reading comprehension, 11–12 yr old girls]
			Fletcher and Lehrer (2008)*	Mikkila et al. (2003)
			Gable et al. (2008)	Sabia (2007) [white girls aged 14–17]
			Huang et al. (2006)* [measured grades]	Shore et al. (2008) [GPA scores]
			Judge and Jahns (2007)*	Sigfúsdóttir et al. (2007)
			Kaestner et al. (2009)* [girls]	Von Hinke Kessler Scholder et al. (2009) [OLS model, fat mass aged 11]
			Li et al. (2008)*	Wendt (2009)
			Sabia (2007)* [white boys, non-white boys and girls]	
			Shore et al. (2008) [Degree of Reading Power scores]	
			Von Hinke Kessler Scholder et al. (2009) [IV model, fat mass aged 9]	
			Wang and Veugelers (2008)	
* Association changes after controlling for moderating variables (in all cases in the direction of negative to no relationship/positive).				
† Results derived from correlation – no adjustment for moderating variables.				

### **3.3 Measures of obesity and attainment**

BMI was used as a measure of obesity in nearly all the studies; other measures included weight only (Kim et al. 2003), and fat mass (Gregg et al. 2008, Vin Hinke Kessler Scholder et al. 2009). BMI as a measure of obesity has been criticised as it does not discriminate between weight attributable to muscle as opposed to fat. Self-reported height and weight used to calculate BMI are susceptible to inaccuracy and therefore studies which use such data should be interpreted with caution. Thirteen studies in this review based measures of BMI upon data which were not measured independently.

Some studies used continuous measures of weight status, whilst others grouped participants into different weight categories. These categories were not always defined in the same way. Where overweight individuals were defined as occupying a higher percentile of the population e.g. >95% as opposed to >85%, this could impact upon the strength of the association found, if we accept that there is indeed a relationship between the two. One study, using different measures of obesity, concluded that although both yielded similar predictions for achievement, the estimates differed according to the measure of fat mass used (Von Hinke Kessler Scholder et al. 2009).

Self-reported measures of academic attainment may also leave studies open to bias. A wide variety of educational measures were employed by researchers, some of which may be less relevant in a UK context than others. For example, many studies used grade point average (GPA) as a measure of educational attainment, reflecting the ubiquitous use of this measure in the US educational system and the predominance of US research in the review.

However, the results of studies in which both obesity and attainment were assessed by means of measurement rather than self-report, did not differ demonstrably from those using self-reported data. Though notably, one study found that overweight at-risk status, BMI and percentage body fat were significantly negatively related to self-reported, but not measured grades (Huang et al. 2006).

### 3.4 Causal pathways

**Number of studies:** 13

**Overall summary:** Thirteen studies, 10 of which were secondary analyses, provided an explicit causal pathway. Ten studies suggested that obesity may result in poor mental health outcomes such as low self-esteem or depression, which in turn impact upon educational attainment. Six studies suggested that obesity may induce discrimination or stigmatisation, phenomena which in turn impact upon educational attainment. Four studies suggested that obesity may cause sleep disorders (e.g. sleep apnoea) and that the resultant sleep-deprived children are less likely to perform well academically. Three studies suggested that obese children may spend less time engaged in physical or social activities, resulting in more time spent studying and higher academic performance as a consequence. Two studies suggested that obese children are more likely to be absent from school, with lower academic performance as a result. One study suggested that a potential mechanism for the relationship between child overweight and academic performance may be the children's underlying cardiovascular risks. One study suggested that obese children may suffer cognitive deficits due to deficiencies of micronutrients such as zinc, iron and iodine, with lower academic performance as a result.

The choice of moderating variables used in statistical analyses of the relationship between obesity and attainment was not consistent with the causal pathways proposed. However, it should be noted that authors of secondary analyses are constrained in their choice of variables, being limited to the data available in pre-existing datasets.

Most studies explored obesity as a predictor of attainment. Only two studies examined attainment as a predictor of obesity (Mikkila et al. 2003, Wang and Veugelers 2008).

Thirteen of the 29 studies, 11 of which were secondary analyses of a pre-existing dataset, provided an explicit causal pathway to describe the means by which obesity may influence educational attainment. Some studies proposed more than one causal pathway in the introduction or discussion. The proposed causal pathways were not always hypothesised *a priori* but often constructed in the light of a study's findings. As noted in Figure 1.3, the theoretical model explaining how obesity influences educational attainment will also inform the choice of moderating variables used in any statistical analysis of the relationship. However, it should be noted that secondary analyses are constrained in their choice of variables, being limited to the data available from the cohort studies they have examined.

#### ***Mental health***

##### **Obesity → Poor mental health → Low academic performance**

Eleven of the 29 studies suggested that obesity may result in poor mental health outcomes such as low self-esteem or depression, which in turn impact upon educational attainment (Averett and Stifel 2007 [depression, self-esteem], Bagully 2006 [self-esteem], Datar et al. 2004 [depression, self-esteem], Huang et al. 2006 [depression, self-esteem], Kaestner and Grossman 2008 [depression], Kaestner et al. 2009 [depression], Von Hinke Kessler Scholder et al. 2009 [depression, self esteem], Sabia 2007 [self-esteem], Shore et al. 2008 [self-efficacy, resiliency], Wang and Veugelers 2008 [self-esteem], Wendt 2009 [depression, self-esteem]). Only one of the 11 studies used any mental health outcome as a moderating variable (Wang and Veugelers 2008 [self-esteem]). However, eight of the other ten studies were secondary analyses and the authors may not have had the opportunity to use such outcomes.



### ***Discrimination and stigmatisation***

#### **Obesity → Discrimination/Stigmatisation → Low academic performance**

Six of the 29 studies, all of which were secondary analyses, suggested that obesity may induce discrimination or stigmatisation, phenomena which in turn impact upon educational attainment (Crosnoe and Muller 2004, Elrod 2008, Kaestner and Grossman 2008, Kaestner et al. 2009, Sabia 2007, Wendt 2009). Discrimination and stigma may impact upon educational attainment because they result in poor mental health, or because discrimination results in a poorer quality of educational input from teachers. Two studies were explicit in suggesting that discrimination and stigma are likely to result in depression (Kaestner and Grossman 2008, Kaestner et al. 2009). One study specified that stigmatisation might take the form of bullying or teasing (Wendt 2009). It is not surprising that none of the six studies used either discrimination or stigmatisation as a moderating variable given that both are difficult to quantify or measure and both were unlikely to have been recorded in the cohort studies used for secondary analyses.

### ***Sleep***

#### **Obesity → Sleep disorders → Low academic performance**

Four of the 29 studies, all of which were secondary analyses, suggested that obesity may cause sleep disorders (e.g. sleep apnoea) and that the resultant sleep-deprived children are less likely to perform well academically (Kaestner and Grossman 2008, Kaestner et al. 2009, Von Hinke Kessler Scholder et al. 2009, Sabia 2007). None of the four studies used sleep variables in their statistical models. It is notable that only one of 29 studies used a sleep variable: bedtime (Wendt 2009).

### ***Recreational activities***

#### **Obesity → Decreased physical activity, decreased socialising → Increased time studying → Higher academic performance**

Three of the 29 studies, all of which were secondary analyses, suggested that obese children may spend less time engaged in physical or social activities, resulting in more time spent studying and higher academic performance as a consequence (Kaestner and Grossman 2008, Kaestner et al. 2009, Von Hinke Kessler Scholder et al. 2009). However, none of the three studies proposing the above pathway used any variable gauging the amount of time spent socialising. One of the three studies used a measure of physical activity, 'Parental outdoor activities with children', as a moderating variable (Von Hinke Kessler Scholder et al. 2009). One of the 29 studies used measures of socialising, romantic involvement and sexual activity (Sabia 2007). Eight studies used physical activity variables, none of which adopted the causal pathway above.

### ***Absenteeism***

#### **Obesity → School absence → Low academic performance**

One of the 29 studies, a secondary analysis, suggested that obese children are more likely to be absent from school, with lower academic performance as a result (von Hinke Kessler Scholder et al. 2009). This study did not use absence from school as a moderating variable, nor did it suggest that absenteeism may occur as a result of stigmatisation. Only one study used absenteeism as a moderating variable (Sigfúsdóttir et al. 2007).

### ***Cardiovascular risks***

#### **Obesity → Cardiovascular risks → Academic performance**

One primary study suggested that a potential mechanism for the relationship between child overweight and academic performance may be the children's underlying cardiovascular risks (Cottrell et al. 2007). The authors used cardiovascular risk factors as moderating variables in their analysis but did not specify the way in which cardiovascular risk factors impact upon academic performance.

### ***Dietary intake***

#### **Obesity → Micronutrient deficiency → Low cognitive ability → Low academic performance**

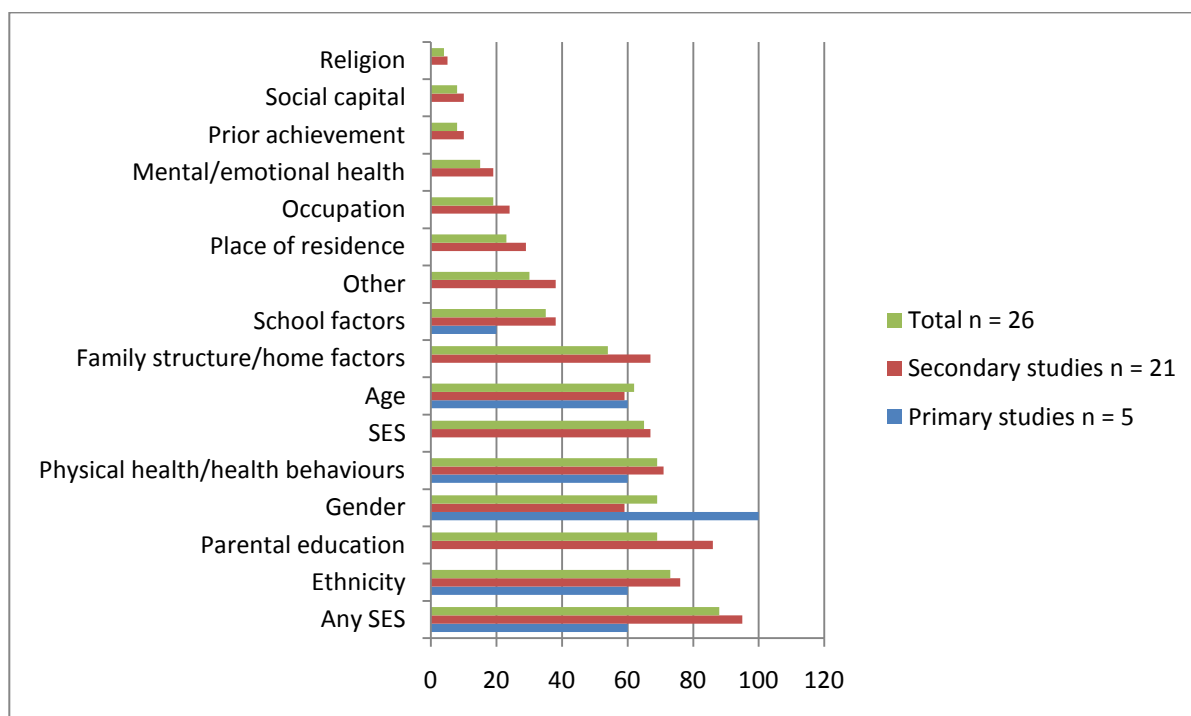
One study, a secondary analysis, suggested that obese children may suffer cognitive deficits due to deficiencies of micronutrients such as zinc, iron and iodine, with lower academic performance as a result (Averett and Stifel 2007). The authors did not use moderating variables relating to cognitive ability or nutrient deficiency in their analysis. One of the 29 studies used a 'diet quality index' measure as a moderating variable (Wang and Veugelers 2008).

### 3.5 Moderating variables

Determinants implicated in health inequalities include place of residence, ethnicity, occupation, gender, religion, education, socio-economic status and social capital (Dahlgren and Whitehead 1991). We have used the PROGRESS-Plus framework (Kavanagh et al. 2009) to categorise the moderating variables used in statistical analyses of the relationship between obesity and educational attainment.

Twenty-six of the 29 included studies made adjustments for moderating variables in examining the relationship between obesity and educational attainment. The percentage of studies using different moderating variables is presented in Figure 3.1.

**Figure 3.1** The percentage of studies using different moderating variables<sup>1</sup>



Twenty-three studies (88%) used a measure of **socio-economic status** as a moderating variable. Some studies used more than one measure of SES. Eleven studies used an income measure to assess SES, including maternal, family and household income. Four studies used free school meals as a proxy measure of SES. Other measures of SES included financial assistance, parental education, employment status and social class.

Of the 14 studies presenting results that suggested a significant negative association between obesity and attainment, four failed to make adjustments for SES. Nine studies reported that after taking socio-economic variables into consideration, the relationship between obesity and attainment was no longer significant.

<sup>1</sup> SES comprises income, benefits/welfare payments and affluence measures. Any SES also includes other measures of socio-economic position such as occupation, education and elements of place of residence.

Nineteen studies (73%) used **ethnicity** as a moderating variable. One study, conducted in Iceland, had a particularly homogeneous population, and because of this homogeneity, demographic factors such as race, ethnicity and religion were considered to be irrelevant and thus were not examined.

Eighteen studies (69%), all secondary analyses, used **parental education** (frequently a proxy measure of SES) as a moderating variable. Nine of the 18 studies using parental education as a moderating variable specified that they were using maternal education.

Eighteen studies (69%) used **gender** and '**physical health/health behaviours**' as moderating variables. However, those studies not using gender as a moderating variable usually conducted separate analyses for males and females. One study had a sample consisting solely of girls (Pesa et al. 2000). Health variables included physical activity, amount of physical education, fitness, genetic markers, cardiovascular risk factors, presence of a chronic illness, alcohol consumption, smoking, birthweight and prematurity.

The next most commonly used variables were **age** (16 studies) and **family structure/home factors** (14 studies). In most cases, the 'family structure' variable was unspecified, but other home variables included parental strictness, parental monitoring, parental disapproval, parent-child interaction, parental involvement and hours of television watching and computer use.

In studies examining the relationship between obesity and attainment, it was surprising how infrequently **school factors** and **prior academic achievement** were taken into consideration (9 and 2 studies respectively). School variables included school performance, school size, school urbanicity, school environment (feels safe or not) and proportion of school population belonging to an ethnic minority.

Only five studies used a **mental and emotional health** variable as a moderating variable, despite the prevalence of causal pathways incorporating mental and emotional health as an important factor in the relationship between obesity and attainment.

It seems likely that the variables employed are more likely to reflect the ease of collecting those particular data (e.g. age, gender, ethnicity) rather than representing a theoretical stance concerning the importance of particular variables in mediating or moderating the relationship between obesity and attainment. It should be noted that secondary analyses are constrained in their choice of variables, being limited to the data available in pre-existing datasets.

## **4 Different perspectives on the link between obesity and attainment**

### **4.1 Introduction**

In Chapter 2 we reported the perspectives of young people and teachers on the relationship between obesity and educational attainment. In this chapter we come back to these perspectives to see the extent to which they are represented in the included research, either as moderating variables or as part of causal pathways. While not a piece of research in its own right, this consultation has enabled us to critique the way in which academia conceptualises the link between obesity and attainment according to the perspectives of those who are closer to observing any interaction between the two. The comparisons between the perspectives of teachers and young people and the moderating variables and causal pathways adopted in the research are shown in Table 4.1.

When hypothesising causal pathways through which obesity may influence educational attainment, it is important to take into consideration potential moderating variables, be they characteristics of individuals or broader social determinants. The theoretical or causal pathway relating obesity to attainment will in turn determine how those variables, with the potential to confound the relationship between the two, are selected.

While we have grouped teachers' and young people's perspectives into those addressing individual characteristics and behaviours and those addressing broader societal factors, we are aware that any division of the influences operating upon complex social phenomena such as obesity and educational attainment will not adequately reflect the interplay between those influences. For example, while self-esteem can be considered as a factor operating at the individual level, in the context of obesity, it is contingent upon the generally negative societal values attributed to overweight people. Moreover, poor mental health is also linked to other factors, such as SES, so it is not possible to disentangle the effects of obesity from other possible influences. Societal values operate in various domains, including peer relationships, families, schools and broader communities; some influences will reinforce one another whereas others will weaken the impact of another and act as 'protective' factors.

### **4.2 Summary**

While researchers, teachers and young people all identified causal pathways whereby low academic attainment resulted from poor mental and emotional health among obese children and young people, only four studies made adjustment for mental and emotional health variables. This represented a significant divergence in the perspectives of teachers and young people and the variables investigated by researchers. One possible explanation may be that, in the 23 studies which conducted a secondary analysis of an existing dataset, useable data on mental health may not have been available to the authors. It is interesting that teachers and young people considered that reduced participation in sports and social activities would have a negative impact upon attainment, whereas three research studies proposed a causal pathway in which reduced participation in sports and social activities was likely to result in increased time spent studying and hence higher attainment.

Table 4.1 Teachers, young people’s and researchers’ perspectives

Suggested factors and mechanisms	Young people	Teacher	Research
<b>Parental influences</b>	Young people considered parental circumstances to be the most important factor in the relationship between obesity and educational attainment. Parents were considered likely to affect both obesity and attainment through several mechanisms; by knowing how to cook and plan meals and by educating the family about healthy eating and consumption of high energy food types. Parental education and health (especially mothers’ weight) was also seen as important; as was parental attention (increased attention from parents was seen as being associated with better achievement).	Poverty was considered to contribute to low aspirations and a lack of parental time, interest and skill in providing both a healthy diet and educational support.	<b>Moderating variables</b> 17 studies used ‘parental variables’ (parental education, parent-child interaction, parental strictness, parental monitoring, parental disapproval, parent reported physical activity, parental health, parental time, age of mother, age of mother at birth of child, maternal depression, mother working, mother working in early childhood, mother’s alcohol consumption, mother’s wage, mother’s marital status)
<b>Family income and poverty</b>	Wealth was viewed as being linked to both attainment and weight (with poorer young people being seen as larger and achieving lower educational status). Parents’ occupation and family income, including how much money they have for food, were considered to be important factors in the relationship between obesity and attainment.	Poverty was considered to contribute to low aspirations and a lack of parental time, interest and skill in providing both a healthy diet and educational support.	<b>Moderating variables</b> 23 studies used ‘SES’ variables.  11 studies used an income measure (maternal, family, household and neighbourhood level income).  4 studies used free school meals as a proxy measure of SES.  Other measures of SES: financial assistance, parental education, employment status and social class.

Suggested factors and mechanisms	Young people	Teacher	Research
<b>Bullying and emotional well-being</b>	Young people rated being bullied as being a particularly important moderating variable in the relationship between obesity and educational attainment. Bullying was thought to be linked with depression about weight, leading to poor diet through comfort eating, and feeling sad or stressed. Size-related bullying was also considered to be related to lowered attention and concentration through increased insecurity, and illness.	Teachers considered that <i>depression</i> , <i>low self-esteem</i> and <i>low self-worth</i> were highly credible and important factors in the relationship between obesity and educational attainment. <i>Bullying</i> and <i>victimisation</i> were viewed as highly credible factors in the development and maintenance of low self-esteem and poor emotional well-being, both of which were considered to have a direct link with academic underachievement.	<p><b>Causal pathways</b></p> <p>Obesity → Poor mental health → Low academic performance (11 studies )</p> <p>Obesity → Discrimination/ Stigmatisation → Low academic performance (6 studies of which 2 specify bullying)</p> <p><b>Moderating variables</b> 4 studies used an ‘emotional well-being’ variable</p>
<b>Screen time</b>	Young people thought that watching TV and playing on computer games decreased both physical activity and time spent studying, hence the link to attainment.		<p><b>Moderating variables</b> 4 studies used ‘screen time’ variables (hours TV watching, home computer use and TV watching)</p>
<b>Gender</b>	Boys were considered to be judgemental about girls, and girls more concerned about image than boys, both of which were considered to be relevant to obesity and attainment.	Some of the teachers reflected on how gender politics impact upon peer and other people’s expectations of physical appearance and size. They considered that this could influence boys and girls differently in relation to participation in sports and social activities, and lead to loss of self-esteem in both.	<p><b>Moderating variables</b> 18 studies used ‘gender’ as a moderating variable.</p>

Suggested factors and mechanisms	Young people	Teacher	Research
<b>Sleep</b>	How much <i>sleep</i> someone gets, was considered to be of some importance in explaining an association between obesity and educational attainment.		<p><b>Causal pathways</b> Obesity → Sleep → Low academic performance (4 studies)</p> <p><b>Moderating variables</b> 1 study used a 'sleep' variable (bedtime)</p>
<b>Ill health e.g. asthma, diabetes</b>	<i>Being ill</i> (e.g. asthma and diabetes), was considered to be of some importance in explaining an association between obesity and educational attainment.		<p><b>Moderating variables</b> 1 study used an 'ill health' variable (presence of chronic illness or not)</p>
<b>Parental health</b>	<i>Parental health</i> and in particular <i>mothers' weight</i> , was considered to be of some importance in explaining an association between obesity and educational attainment.		<p><b>Moderating variables</b> 9 studies used 'parental health' variables (maternal depression, parental health, mother's BMI, mother's alcohol consumption, maternal mental health in pregnancy)</p>
<b>How someone gets to school</b>	<i>How someone gets to school</i> was considered to be of some importance in explaining an association between obesity and educational attainment.		



Suggested factors and mechanisms	Young people	Teacher	Research
<b>Poverty and poor nutrition</b>	How much money a family has available for food was considered to be an important factor in the relationship between obesity and attainment. They suggested that poorer people buy 'ready meals' rather than fresh food because they think it's cheaper.	Poverty was suggested by teachers as being an important factor in explaining how obesity and attainment are associated. When talking about obesity many teachers associated it with poverty resulting in a poor diet, which itself was associated with poor concentration, inattention and poor behaviour, and not getting 'off to a good start' in the school day, all of which were seen to link with lower levels of academic achievement. Poverty was also considered to contribute to low aspirations and a lack of parental time, interest and skill in providing both a healthy diet and educational support.	<p><b>Causal pathways</b></p> <p>Obesity → Micronutrient deficiency → Low cognitive ability → Low academic performance (1 study)</p> <p><b>Moderating variables</b></p> <p>7 studies used 'diet and nutrition' variables (frequency of family dinners, meat consumption at breakfast, frequency of evening meals with family, diet quality index, evening meals at home, use of fast food, energy intake)</p>
<b>Physical activity</b>	Living somewhere where 'it's hard to exercise' was rated as quite important, with the suggestion that well-off areas tend to have better facilities than others. One group suggested that inner cities have limited space to go for a run and that, although people could use a gym, the expense of membership may be a limiting factor.	Obesity was viewed as having a direct impact on levels of physical activity, and children's comfort with taking part in physical activity and games. Teachers associated physical activity with educational attainment and social exchange. Exercise and physical activity were seen to improve concentration, and achievement in physical activity was thought to impact on self-esteem and confidence.	<p><b>Causal pathways</b></p> <p>Obesity → Decreased physical activity; decreased socialising → Increased time studying → Higher academic performance (3 studies)</p> <p><b>Moderating variables</b></p> <p>9 studies used 'physical activity' variables (physical activity, physical exercise, regular exercise, sporting activity, parent reported physical activity, amount of physical education, sedentary activity)</p>

Suggested factors and mechanisms	Young people	Teacher	Research
<b>Ethnicity</b>		One teacher noted that a demographic change in ethnicity had influenced the relationship between obesity and attainment in his school, noting that when the school had been predominantly ethnically white British/Irish in the 1980s and early 1990s there was a linkage between obesity and bullying, low self-esteem, absenteeism and lower attainment. However, since the predominant ethnicities in the school had become South Asian, African and Afro-Caribbean both obesity and attainment had increased.	<b>Moderating variables</b> 19 studies
<b>Hereditary factors</b>		One teacher identified hereditary factors as being linked to obesity and educational attainment.	<b>Moderating variables</b> 3 studies used 'hereditary' variables (genetic markers, proxy genetic markers)
<b>Absenteeism</b>		One teacher noted a link between obesity and bullying, low self-esteem, absenteeism and lower attainment.	<b>Causal pathways</b>  Obesity → School absence → Low academic performance (2 studies)  <b>Moderating variables</b> 2 studies used an 'absenteeism' variable (absenteeism, school attendance)

## **4.3 Comparison of hypotheses of teachers, young people and researchers**

### **4.3.1 Individual characteristics and behaviours**

#### ***Hereditary factors***

One teacher identified ethnicity as a variable bearing upon the relationship between obesity and attainment, but was not clear about the mechanism by which this might operate. Young people did not mention hereditary factors. Three studies used genetic markers as a moderating variable.

#### ***Physical activity***

Teachers identified physical activity as a variable bearing upon the relationship between obesity and attainment. Obese children were thought to be less likely to participate in physical activity and games. Exercise was seen as improving concentration. Athletic achievement was thought to impact upon self-esteem and confidence. Young people discussed opportunities for exercise in the context of the home environment, suggesting that living somewhere where 'it's hard to exercise' was a moderately important factor. The following moderating variables were employed in the included research: physical activity (nine studies), social activities (one study) self-esteem (two studies). It is interesting that teachers and young people considered that reduced participation in sports and social activities would have a negative impact upon attainment whereas three studies in the included research proposed a causal pathway in which reduced participation in sports and social activities might lead to increased time spent studying and hence higher attainment.

#### ***Parental health***

Parental health, and in particular mothers' weight, was considered to be of some importance by the young people. Nine studies used 'parental health' variables, four of which made adjustments for maternal BMI.

#### ***Screen time***

Young people thought that watching TV and playing computer games decreased both physical activity and time spent studying, thus impacting upon both obesity and educational attainment. Teachers did not discuss screen time. None of the included research proposed this causal pathway. Four studies, however, used 'screen time' variables such as computer use and TV watching as moderating variables.

#### ***Sleep***

Young people identified amount of sleep as a variable bearing upon the relationship between obesity and attainment, but were not clear about the mechanism by which this might operate. Teachers did not discuss sleep in relation to obesity or attainment. Three studies proposed a causal pathway in which reduced sleep in obese children resulted in decreased concentration and hence lower attainment. Only one study used sleep as a

moderating variable (bedtime) but this study did not propose reduced sleep as being part of a causal pathway.

### ***Ill health***

Young people identified ill health (e.g. asthma and diabetes), as a variable bearing upon the relationship between obesity and attainment but were not clear about the mechanism by which this might operate. Teachers did not discuss ill health in relation to obesity. One study used 'ill health' as a moderating variable (presence of chronic illness or not).

### ***Absenteeism***

The degree to which pupils are absent from school can reasonably be considered to have an impact upon their educational attainment. However, young people did not discuss absence from school other than in relation to ill health. One teacher noted that different cultural values had a bearing upon the acceptability of obesity (with implications in terms of bullying, self-esteem and absenteeism). Two studies used absenteeism as a moderating variable.

### ***How someone gets to school***

Young people identified the method used to get to school as a variable bearing upon the relationship between obesity and attainment but were not clear about the mechanism by which this might operate. Teachers did not raise this as an issue. None of the studies employed someone's method of getting to school as a moderating variable or a causal pathway.

## **4.3.2 Broader societal factors**

### ***Bullying and emotional well-being***

Both teachers and young people considered bullying and victimisation as being particularly important in mediating the relationship between obesity and attainment. Bullying was thought to be linked to low self-esteem, depression, and lowered attention and concentration, all of which were thought to have a negative impact upon academic performance. Eleven studies suggested a causal pathway whereby low academic performance was related to poor mental and emotional health among obese children. Six studies suggested a causal pathway whereby low academic performance resulted from discrimination and stigmatisation suffered by overweight children. It is particularly interesting to note that of 29 studies, only four used a measure of mental or emotional health as a moderating variable. This may represent a significant divergence between the perspectives of researchers, teachers and young people. Equally, it may be that in the 23 studies which conducted a secondary analysis of an existing dataset, such data were not available to the authors.

### ***Gender***

Both teachers and young people identified gender as a variable bearing upon the relationship between obesity and attainment. Both reflected on the impact of gender politics upon expectations of physical appearance, which would subsequently impact upon participation in sports and social activities. Participation in sports and social activities was viewed as important in terms of self-esteem. Both teachers and young people thought it likely that those with low self-esteem would also have low academic achievement. The following moderating variables were employed in the included research: gender (18 studies), physical activity (nine studies), social activities (one study) and self-esteem (two studies).

### ***Ethnicity***

One teacher identified ethnicity as a variable bearing upon the relationship between obesity and attainment, noting that different cultural values had a bearing upon both the acceptability of obesity (with implications in terms of bullying, self-esteem and absenteeism) and the importance attached to academic achievement. Young people did not suggest that ethnicity was related to obesity or attainment. Nineteen studies used ethnicity as a moderating variable.

### ***Family income and poverty***

Young people viewed relative poverty as a variable bearing upon the relationship between obesity and attainment (with poorer young people being seen as being more likely to be obese and have lower academic achievement). Teachers suggested that poverty contributed to low aspirations and a lack of parental time, interest and skill in providing both a healthy diet and educational support. Twenty-three of the 29 studies used a measure of socio-economic status as a moderating variable.

### ***Poverty and poor nutrition***

Teachers associated poverty with poor diet, which in turn was linked with poor concentration, inattention and poor behaviour, all of which were likely to result in low academic achievement. Young people suggested that poor people may have bad diets, which they also considered to be linked with poor concentration. The following moderating variables were employed in the included research: socio-economic status (23 studies), diet and nutrition (seven studies). One study suggested that obese children may be susceptible to micronutrient deficiency, which would in turn impact upon cognitive ability and academic performance, but did not use moderating variables relating to cognitive ability or nutrient deficiency in any analysis.

### ***Parental influence***

Young people considered parental influence to be the most important variable bearing upon the relationship between obesity and educational attainment. Knowing how to cook and plan meals and educating the family about healthy eating were both considered to be important. Highly educated parents and increased attention from parents were thought to be associated with better achievement. As mentioned earlier, teachers reflected that poverty could contribute to a lack of aspiration, parental time, interest and skill in providing both a healthy diet and educational support. Seventeen studies used parental variables, including parental education, parent-child interaction, parental strictness and parental monitoring.

#### **4.4 Pathways and variables identified only by researchers**

Only one causal pathway was suggested by researchers which was not identified by teachers and young people. In one study, it was suggested that a potential mechanism for the relationship between child overweight and academic performance may be the children's underlying cardiovascular risks, although the authors did not specify the way in which cardiovascular risk factors might impact upon academic performance (Cottrell et al. 2007). Moderating variables considered by researchers but not identified by teachers and young people included: religion, prior achievement and school-level factors such as school performance, family structure and age.

## **5 Discussion and findings**

Twenty-nine studies were included in this systematic review, which revealed an overall negative association suggesting that obesity is associated with lower educational attainment in children and young people. The association is shown to weaken as moderating variables with the potential to confound the relationship are taken into consideration. The extent to which individual moderating variables contribute towards the variation in academic attainment has not been explored. The summary statistic revealing the extent of variation in achievement attributable to weight status was frequently not reported. However, where this value was presented, it appeared that little of the variation in achievement was explained by weight status alone, for example, only 6% in Averett and Stifel (2007) and a mere 1% in Bagully (2006).

Our findings are similar to those of an older review of obesity and school performance (Taras and Potts-Datema 2005), which included nine studies, all demonstrating negative associations between obesity and a range of measures of educational attainment. Unlike the review reported here, they found no positive associations, and it is unclear to what extent the negative association they found diminished as moderating variables were taken into account. The differences in the findings of our review and theirs is likely to be due to the fact that their literature review was not systematic (with no reported search strategy, or critical appraisal of included studies) and had different inclusion criteria (having both a broader age range and range of measures of educational performance). Furthermore, they only included studies published in peer reviewed journals between 1994 and 2004. These factors resulted in two different sets of studies being included in each review.

Our consultations revealed that young people and teachers shared broadly similar views about the relationship between obesity and attainment, and the factors that link them. Parental influences and circumstances, including family income and poverty, bullying and emotional health (especially low self-esteem), and poor diet were considered to be important moderating variables in the relationship. Convergence between the perspectives of teachers, young people and researchers is most obvious in that all three groups have hypothesised that low academic attainment might be explained by poor mental and emotional health among obese children and young people (sometimes attributable to bullying, victimisation and isolation). However, despite this causal pathway being proposed by all three groups, only four of the included studies made an adjustment for a mental and emotional health variable.

The perspectives of young people and teachers are supported by other research evidence which has reported associations between low self-esteem and depression, and both low educational attainment and overweight and obesity (Mustillo et al. 2003, Vila et al. 2004, Zimetkin et al. 2004). Furthermore, there is a body of research documenting the negative impact of weight discrimination on the health, educational and social outcomes of overweight and obese children and young people. A recent systematic review of the views of UK children about obesity and body shape found that:

*“children whatever their body size, did not emphasise the health implications of being overweight. Instead they saw – and had experienced – overweight bodies as having*

*problematic social and psychological consequences, including bullying and isolation.”*  
(Rees et al. 2009, p4).

Victimisation because of weight increases the likelihood that young people will have higher levels of depression and low self-esteem, and will be more likely to avoid physical activity and healthy eating patterns (Puhl and Latner 2004). Research has also shown that some teachers have lower expectations of overweight children than their thinner peers (O’Brien et al. 2007, Puhl and Latner 2004). The prevalence of weight-related discrimination has been labelled as one of the last socially acceptable areas of public discrimination, and has led to calls for action against it (Friedman 2008).

## **5.1 Significance of results**

When thinking about the significance of these findings, there are a number of issues to take into consideration: a) the validity of the statistical models and moderating variables used in the studies; b) the inability to infer causality from these findings; c) the magnitude of the association between obesity and attainment; and d) distinguishing between results which have statistical, as opposed to social significance.

### ***a) Statistical models and moderating variables***

It would appear that the selection of moderating variables employed in statistical models of the relationship between obesity and attainment has a considerable effect upon the results obtained. Failing to take into account the effect of important confounders such as socio-economic status and prior academic achievement should therefore result in reduced confidence in the validity of a study’s findings. Studies varied widely in the degree to which they incorporated moderating variables into their statistical models – both in the type and number selected. It should be noted that the choice of statistical technique also has a major influence on the results obtained and we found that within a study, authors presented different findings derived from the same sample according to the specifications of their different statistical models. We have also noted that conflicting results between studies may be a consequence of authors selecting different samples from the same dataset.

While we would expect the theoretical pathway between obesity and attainment to inform the selection of moderating variables, there was little consistency between the two, probably as a result of the constraints inherent in conducting secondary analyses (i.e. authors made use of existing variables, rather than collecting their own, tailored data). It is also likely that, instead of selecting moderating variables consistent with proposed causal pathways, authors of primary research gather data which are easy to collect or quantify. Where authors have conducted secondary analyses, their studies will also be affected by the quality of pre-existing data (for example, we have previously noted the bias that may accrue from relying upon self-reported measures of obesity and attainment). It should also be noted that different schemes have been used to classify individuals according to their weight status, and this lack of consistency hinders comparisons between studies.



### ***b) Causality***

Neither correlation nor regression is sufficient to show a cause-and-effect relationship between obesity and attainment. However, we can infer causality when the following conditions are met: variables are related, the relationship is large and dose-dependent, and there is a plausible mechanism by which the predictor variable influences the outcome (Rutter et al. 2007). The research evidence in this review does not meet these conditions.

### ***c) Magnitude of the association***

Two of the 29 studies in our review presented data quantifying the magnitude of the association between obesity and education (Crosnoe and Muller 2004, Sabia 2007). However, the attainment measures used in these studies made it difficult to assess whether these results were in accordance with one another.

### ***d) Interpreting significance***

Approximately half of the studies in the review presented results suggesting that there was a statistically significant, negative association between obesity and attainment. However, a statistically significant result should not be confused with a socially significant effect. The average mean differences in attainment between obese and normal-weight children were small, as evidenced by the descriptive statistics reported in the included studies. Crosnoe and Muller (2004) reported that the difference in GPA between obese and non-obese young people was marginal. A second study affirmed that differences in attainment are likely to be very small between obese and non-obese children, reporting that it would take a weight difference of approximately 150 pounds (holding height constant) to produce a one-half letter grade difference in GPA (Sabia 2007). It is questionable whether these results suggest that the influence of obesity on attainment is important.

## **5.2 Strengths and limitations**

A major strength of this review is that, as far as we are aware, it is the only systematic review to explore the relationship between obesity and educational attainment, which has also considered the perspectives of young people and teachers – the teachers and young people who have first-hand experience of the issues. This review therefore brings a unique perspective and furthers our understanding of a complex area which crosses both academic and policy domains. A further strength of this review is that it has been conducted according to principles ensuring that it is transparent, replicable and updateable. Its explicit methods, including comprehensive and sensitive searches of a broad range of research sources, and critical appraisal of a complex body of evidence, provide a high degree of confidence in the findings.

A narrative synthesis of the evidence is presented in this report, as the variation in study designs and statistical models employed by the included studies did not support a statistical synthesis of the numerical data. Some of the weaknesses of this report relate to the limitations of the evidence base rather than the methods employed in the review. We have been unable to assess the extent to which there is a 'dose response' between obesity and educational attainment. We have also been unable to assess the extent to which different moderating variables are most influential in explaining the association between obesity and

educational attainment. However, despite these limitations, many of the included studies were of large populations, with the vast majority controlling for moderating variables including SES.

### **5.3 Implications**

Three important implications arise from this review.

First, obesity should not be understood solely as a health issue. This review, and other research, suggests that some of the most noticeable ways in which obesity affects the lives of children and young people are in their social relationships. Given the paucity of evidence suggesting a causative physiological link between obesity and attainment, any association is likely to be mediated by social factors. We find that stigmatisation, bullying, low self-esteem and young people's exclusion from opportunities for social interaction are suggested as underlying any relationship between obesity and lower educational attainment.

Second, the variables used in statistical analyses failed to capture many of the potential causal pathways identified by the teachers and young people (and, often, also of the researchers undertaking those analyses). If large-scale longitudinal datasets are to deliver on their potential to help us understand people's lives, they need to engage with the social lives of their participants and amass not simply data that are straightforward to collect, but information that reflects determining characteristics of people's social experiences, because these are often the key to understanding health and other behaviours.

Finally, we found this body of literature to be one of the least cumulative that we have reviewed. Data from the same datasets are analysed in different ways, using different variables, coming to different conclusions with minimal attempts to explain differences in findings. Different statistical models are sometimes employed with little justification for their selection and little acknowledgement that a different method might yield an entirely different result. These are important failings, and it is hoped that the work of the EQUATOR network will in time lead to improvements (Simera et al. 2010). We should note that these criticisms do not apply to all studies in this review, but it would be true to say that they do apply to many of them.



## Part II: Methods and detailed findings

## **6 Methods**

### **6.1 Aims**

This systematic review sought to examine studies which explore the relationship between obesity and educational attainment in children and young people aged 6–16.

### **6.2 Review methods**

#### **6.2.1 User involvement**

The Steering Group, which oversees all of the work conducted by the Health Promotion stream, met when the review's question was being set and again when preliminary findings were being drafted. The group was also sent a copy of a draft protocol for the review for comment. Feedback concentrated on the review's proposed methods.

A collaborative working relationship was formed with the National Children's Bureau (NCB), an umbrella body for organisations working with children and young people in England and Northern Ireland. A consultation of young people was planned with the NCB as the first event convened as part of this collaboration. This was complemented by a consultation with school teachers.

#### **6.2.2 Inclusion and exclusion criteria**

Inclusion and exclusion criteria for studies to be included in the map were applied to titles and abstracts. Full reports were obtained for those studies that appeared to meet the criteria or where there was insufficient information to be sure. Inclusion criteria were as follows:

- Reports a measure of obesity or overweight, including BMI, self-reported measures, or other validated obesity measures.
- Reports a measure of educational attainment based on tests or examinations coordinated by schools or other authorities such as Standard Assessment Test (SAT) scores, or regional or national examinations, or other teacher- or researcher-administered assessments.
- Includes children between six (the youngest age for national educational tests in England) and 16 years of age (the statutory school leaving age in England) (if the age range reaches beyond these boundaries, the average age must be between six and 16, or data must be presented separately for this age range).
- Reports the findings of a primary research study or secondary analysis.
- Published in or after 1997, the year in which the WHO identified the global 'obesity epidemic'.
- Published in English.

Exclusion criteria were as follows:

- Studies primarily exploring underweight.
- Reviews and studies of young people's views.
- Studies providing only a measure of intelligence or cognitive functioning.

The initial round of screening was followed by a second round to identify a narrower subset of studies for in-depth analysis. Decisions about which subset to focus on were informed by consultations with teachers and young people. It was decided that the in-depth review would focus on whether studies showed any link between obesity and attainment; what the strength of any link might be; and explanations for the relationship between obesity and attainment explored in the studies.

Thus studies were included in the in-depth review if they:

- used a grade-point average, or a validated attainment measure (not including cognitive performance tests, cognitive prediction test or school functioning tests).
- had data available from a full paper.
- were not from low and middle-income countries as defined by the World Bank.
- passed a quality threshold (see section 6.2.5).

### **6.2.3 Identification of research**

Highly sensitive search strategies were developed using combinations of controlled vocabulary and free-text terms (the latter restricted to the title or abstract fields). Three key concepts were combined: obesity, educational attainment and children and young people. Scoping searches were undertaken to ascertain the free-text terms and the controlled vocabulary applied by the different databases to describe the key concepts. A PubMed search was developed and translated for all databases listed (see Appendix 1 for full details of methods and PubMed search strategy).

Journals previously shown to produce high yields of relevant studies, and relevant journals not indexed in the major bibliographic databases, were hand-searched.

Personal contact was made with key researchers and other systematic reviewers in this area. The reference lists of included studies were scanned for potentially relevant reports. Included studies were also checked to see where they had been cited since publication in order to identify further relevant research.

### **6.2.4 Classification and analysis of studies**

All relevant identified studies were descriptively coded according to a standardised classification system for public health and health promotion research (Peersman and Oliver 1997). Studies were coded according to study type (e.g. survey, secondary analysis, process evaluation), the focus of the study (e.g. physical activity, health promotion), the country in which the research was conducted and the study population (e.g. sex, age group).

These codes were supplemented with codes which were developed specifically for the topic focus of the review and the methods used in the study. Review-specific codes captured information on measures of obesity and attainment, the population (in terms of social determinants of health), data collection methods, potential mediating and moderating variables and social context.

### **6.2.5 Assessing the quality of studies and weight of evidence**

After screening all studies according to the in-depth inclusion criteria, studies were assessed according to six quality criteria. These criteria were informed by those proposed for assessing the quality of epidemiological or correlational research as described by Wong et al. (2008), and by principles of good practice for critical appraisal of primary research (Centre for Reviews and Dissemination 2009).

Six quality criteria covered three main domains relating to sampling, data collection and data analysis.

Each study was assessed according to:

- the appropriateness of the methods for sampling the population under study.
- whether the study reported any response rate.
- the reliability and validity of measurements of obesity and attainment.
- the extent to which investigator(s) controlled for confounding variables when analysing associations between obesity and attainment.
- the extent to which reviewers had concerns about the statistical methods used.
- length of follow-up (longitudinal studies only).

Finally an overall assessment of the soundness of each study was made and agreed between two reviewers. Studies were judged to be of high, satisfactory or low quality based on scores attributed to each of the quality domains. Only those studies which were high or satisfactory were included in the analysis.

### **6.2.6 Data extraction**

Two reviewers used a standardised tool to extract data from the included studies, and then met to agree a finalised version. The following data were extracted:

- strength and direction of link between obesity and attainment.
- variables used in analysis.
- method of statistical analysis.
- causal pathways proposed by the study.

### **6.2.7 Synthesis of evidence**

Of the few systematic reviews which have attempted a synthesis of correlational studies, many do not attempt quality appraisal (perhaps due to a lack of consensus over indicators of quality in epidemiological studies). It is possible that in conducting a meta-analysis of observational studies, a compounding of bias may take place due to known and unknown

confounding, and although some reviews attempt to pool results in a meta-analysis, most summarise the evidence in a narrative summary, as is the case here.

### **6.2.8 Quality assurance process**

One reviewer working independently appraised the quality of all the studies and these appraisals were amended or confirmed in consultation with another reviewer. The same process was followed for data extraction of studies. Disagreements were resolved by the arbitration of a third party where required.

## **6.3 Consultation methods**

### **6.3.1 Young people**

Working with the National Children's Bureau, we consulted its Young People's Public Health Research Group (YPPHRG). The group held two meetings, one in London, one in Leeds, as part of its ongoing programme. Children aged 12–17 took part in the workshops, which lasted approximately three hours. The group from Leeds (N=10) were all white children, while the London group (N=7) was more diverse. None of the children were obese or significantly overweight.

At each meeting, children were introduced to the concept of systematic reviewing, and then to this review. They were asked to write down factors they thought might mediate the relationship between obesity and attainment. Next, they were shown factors we identified in the literature and asked (a) to rank them in order of plausibility and importance and (b) to group them into causal pathways.

Children made notes, offered suggestions in open conversation, and worked in pairs. The facilitators encouraged discussion about causative and coincidental relationships, and how relationships may be mediated by other factors. Factors identified by the children were compared and analysed for similarities and differences. Where possible, the responses were grouped by similarity to form themes.

### **6.3.2 Teachers' consultation**

Our consultation with teachers took the form of a questionnaire that was completed either electronically or in hard copy. It had three sections: the first collected information about the characteristics of the school the teachers worked in; the second section asked the teachers three questions with open-ended response options; finally, the third section presented teachers with a list of variables that might link obesity and educational attainment and asked them to state whether they thought that they were credible and, if credible, how strong the link might be.

Descriptive data about the characteristics of the school or learning environment that the teacher worked in were collected and reported. The results of the open-ended response items were compared and analysed to assess the extent to which teachers reported similar or different potential linking factors and to see the extent to which similar themes emerged from teachers' descriptions of their views and experiences. The results of the final section of

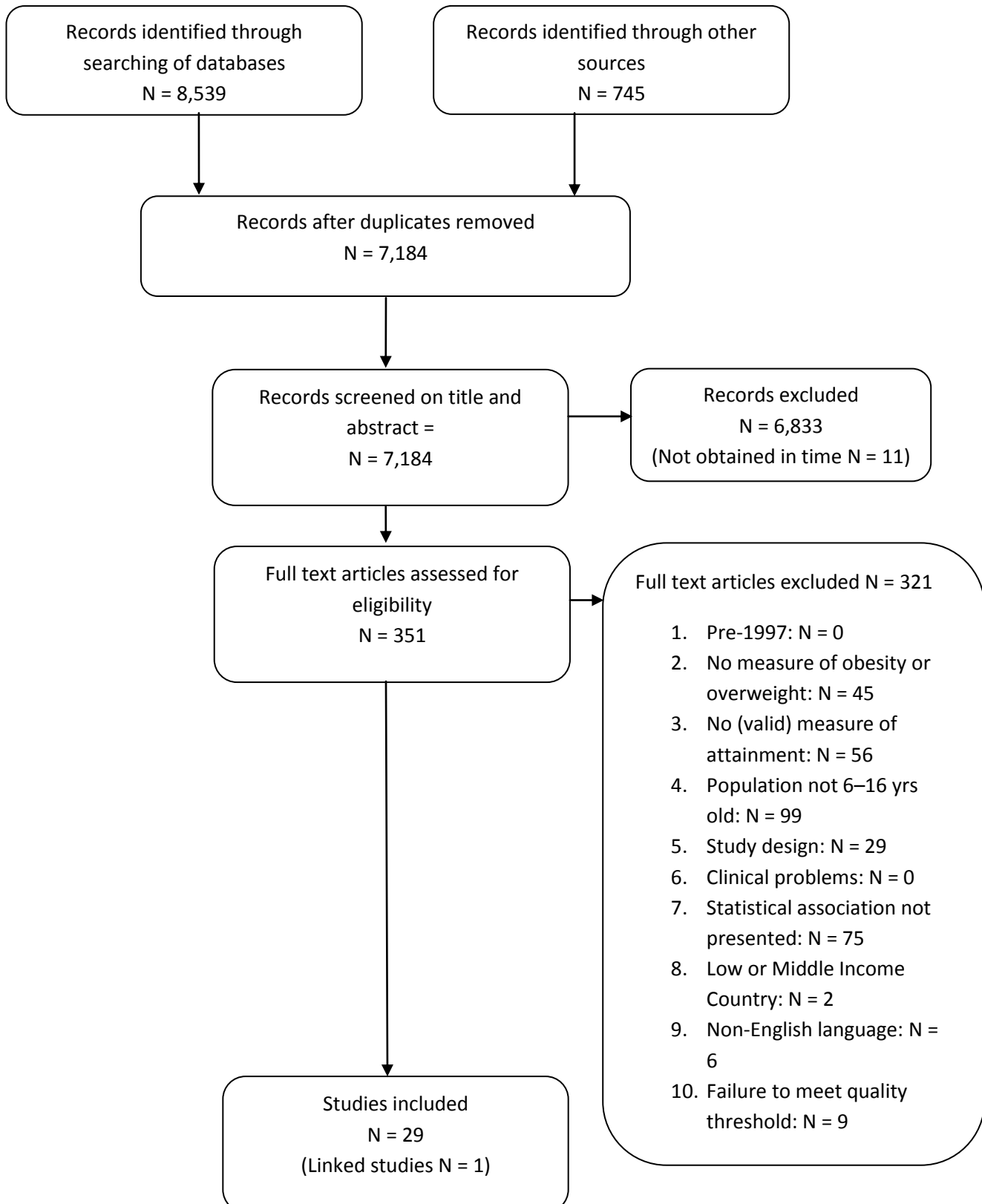


the questionnaire were collated and basic descriptive data presented in a tabular form to facilitate comparisons of teachers' responses, and between teachers and young people.

## 7 In-depth findings

In this section of the report we present summaries of findings of all the included studies, and descriptions of cohort studies. Figure 7.1 illustrates the flow of studies through the review.

**Figure 7.1:** Flow of studies



## **7.1 Direct and indirect associations**

There are a range of statistical tests which can be used to assess the relationship between educational attainment and obesity. Correlation, for example, is a measure of the linear relationship between two variables, giving an estimate of the degree of association between the two. Calculating correlation coefficients does not allow for the prediction of the extent to which one variable will vary as the other changes, nor does it allow the influence of possible confounding or moderating variables (e.g. socio-economic status, ethnicity) to be investigated. Regression, on the other hand, describes the nature of the relationship between an outcome variable and a predictor variable, and multiple regression techniques allow the nature of the relationship between an outcome variable and *several* possible predictor variables to be examined. Structural equation models (SEM) are based on covariance matrices rather than individual observations. Unlike regression methods, SEMs allow analyses to be conducted with more than one outcome variable. Where the relationship between obesity and attainment is described in the report as 'direct', it can be taken to mean that no attempt was made to ascertain the degree to which potential confounders moderated the relationship. An 'indirect' relationship is one in which potential confounders have been taken into consideration in the analysis. Neither correlation nor regression is sufficient to show a cause-and-effect relationship. However we can infer causality when the following conditions are met: variables are related, the relationship is large and dose-dependent, and there is a plausible mechanism by which the predictor variable influences the outcome (Rutter et al. 2007).

Almost all studies reporting a correlation demonstrated a statistical relationship between obesity and attainment (regardless of whether they went on to report further, more sophisticated analyses). The relationship did not always reach statistical significance, but was usually negative (i.e. where obesity was high, educational attainment was low).

## **7.2 Findings from secondary analyses of cohort studies**

This section of the report describes the findings of secondary analyses of the datasets obtained from large cohort studies.

### **7.2.1 Avon Longitudinal Study of Parents and Children (ALSPAC )**

<http://www.bristol.ac.uk/alspac/>

ALSPAC is a large (n = 14,000) cohort study from the United Kingdom, originally comprised of pregnant women enrolled during 1991–2, and now following the children themselves (with data-collection rounds at age 9, 11 and 14 so far). It forms a two-generational resource, with health, social, relationship and educational data, including Key Stage exam results. The cohort is also linked to administrative data provided by the Department for Children, Schools and Families, the Office for National Statistics and the National Health Service database STORK, which provides maternity data and biological sample data.

**Dataset:** Avon Longitudinal Study of Parents and Children (ALSPAC)

**Number of studies:** 2

**Summary of overall findings:** One study found a weak positive correlation between children's fat mass and academic achievement. A second study found a negative impact of fat mass on adolescent academic performance after controlling for a wide range of variables; however a further analysis using instrumental variable (IV) estimates concluded that the association was driven by unobserved characteristics rather than fat mass.

Two studies from the UK made use of survey data from the Avon Longitudinal Study of Parents and Children (ALSPAC) (Gregg et al. 2008, Von Hinke Kessler Scholder et al. 2009). These are the only studies based on analyses of data collected in the UK. The studies used Key Stage scores as indicators of academic attainment, with Gregg and colleagues (2008) using Key stage 1 data (when most children were seven years of age), and Von Hinke Kessler Scholder and colleagues (2009) using Key Stage 3 scores (collected when children were between 11 and 14 years of age). In neither case were these data self-reported. Both studies used direct measures of the fat mass of children obtained by using dual-energy X-ray absorptiometry (DXA). The measurement tools used in these studies can therefore be considered to be more robust and less susceptible to bias than other studies in this review, which relied on potentially inaccurate estimates of obesity and attainment.

In a cross-sectional analysis, Gregg and colleagues (2008) sought to explore the relationship between parental income and a range of child outcomes, including academic performance. A simple correlation using data from a sample of 9,476 children demonstrated a weak but positive relationship between school average achievement at Key Stage 1 aged 7 and individual fat mass, and individual Key Stage 1 results and school average fat mass aged 9.

Von Hinke Kessler Scholder and colleagues (2009) examined the relationship between children's weight and academic outcomes using genetic markers as instruments to account for the possibly inherent nature of body size. They employed two different statistical approaches to a sample of approximately 3,500 adolescents. An analysis using Ordinary Least Squares (OLS) regression which controlled for a wide range of variables including SES, in addition to other maternal and family characteristics, demonstrated a negative impact of fat mass on academic performance at age 11. In contrast, genetic instrumental variable (IV) estimates found no evidence that children's fat mass aged 9 affected their academic performance, with the observed association apparently being driven by unobserved characteristics.

It is difficult to draw comparisons between these two studies because they examine different age groups (children and adolescents) and one study has not made adjustments for any moderating variables in the relationship between obesity and attainment.

### **7.2.2 The National Longitudinal Study of Adolescent Health (AddHealth)**

AddHealth is a longitudinal study of a nationally representative sample of US adolescents in grades 7–12. Four waves of data collection were undertaken through in-home interviews, collating data on the social, economic, psychological and physical well-being and contexts of participants. Wave I took place between September 1994 and April 1995. A sample of 80 high schools was selected from all eligible high schools in the United States that had an 11th grade and at least 30 students in the school. Of the sampled high schools, 70% were recruited for participation. Schools participating in the study provided student rosters and agreed to administer the in-school questionnaire. In each participating school, one 45- to 60-minute class period was set aside for survey completion. If a student was absent on the day of the survey, there was no ‘make-up’ day scheduled. The survey was completed by 90,118 of 119,233 eligible students in grades 7 through 12. In Wave III (2001/2002), biospecimen data, including DNA measures, were collected from 4,882 respondents.

**Dataset:** National Longitudinal Study of Adolescent Health (AddHealth)

**Number of studies:** 5

**Summary of findings:** Two studies found a weak but significant negative association between obesity and achievement (Elrod 2008, Sabia 2007). Two studies found a negative, but non-significant association between obesity and attainment (Crosnoe and Muller 2004, Fletcher and Lehrer 2008). One study found a significant positive association between obesity and attainment (Pesa et al. 2000).

Five studies from the United States conducted secondary analyses on the National Longitudinal Study of Adolescent Health (AddHealth) dataset. A variety of attainment measures were employed in these studies, including grades, grade point averages (GPA), and the Peabody Verbal Test Score. With the exception of the last outcome, all relied upon self-reports from young people. The heights and weights used to calculate BMI in all five studies also relied on self-reported data. It should be noted therefore that all five studies using the AddHealth dataset are susceptible to bias due to inaccurate estimates of both bodyweight and educational attainment.

With a particular focus on the influence of school context, Crosnoe and Muller (2004) examined the educational experiences of adolescents at risk of obesity. Using multi-level modelling on data taken from 11,658 adolescents, the authors demonstrated that the negative longitudinal association between risk of obesity and achievement was stronger in schools with higher rates of romantic activity and lower average body size among students, but unexpectedly weaker in schools with higher rates of athletic participation. Before controlling for other factors, risk of obesity predicted lower academic achievement, accounting for an approximate one-tenth difference in grade point average (e.g., 3.0 versus 2.9). This association held after controlling for sociodemographic characteristics but was negligible and no longer significant after controlling for prior academic achievement and school-level variables.

In a PhD thesis, Elrod (2008) sought to identify whether elective coping mechanisms, including academic performance, extracurricular participation and voluntarism, mediated the relationship between body mass and self-esteem. A simple correlation using data from 3,369 adolescents demonstrated a significant but weak negative association between BMI and academic performance.

Fletcher and Lehrer (2008) examined genetic inheritance among children in the same family to estimate the relationship between several poor health conditions and academic achievement. Using ordinary least squares (OLS) and fixed effects (FE) regression models on data taken from 1,684 adolescents, the authors demonstrated that overweight was significantly associated with lower educational achievement. However, the association became non-significant once genetic markers and family factors were taken into account.

Pesa et al. (2000) sought to determine whether overweight female adolescents differ from normal and underweight female adolescents with respect to a set of psychosocial factors, while controlling for body image, using data taken from 3,197 girls aged 12 to 18. The authors found that overweight girls had better self-reported grades than normal weight or underweight girls. Overweight and underweight girls differed in academic achievement to a greater extent than with any other variable examined.

Sabia (2007) investigated the association between adolescent body weight and academic performance using ordinary least squares (OLS), instrumental variables (IV), and individual fixed effects (FE) models, using data taken from 4,128 adolescents. A wide variety of parental and young people's characteristics were incorporated into the models as moderating variables, including ethnicity and SES. The pattern of findings across models suggested consistent evidence of a significant negative relationship between BMI and grade point average (GPA) for white females aged 14–17. Estimates suggested that a difference in weight of 50 to 60 pounds was associated with an 8 to 10 percentile difference in standing in the GPA distribution. The association between weight status and achievement was negative for white males, but after controlling for moderating variables, did not remain significant. For non-white females and males, the relationship between body weight and academic performance was consistently negative, but did not always remain statistically significant after additional instrumental variables were used in successive models. The OLS model revealed that approximately ten percent of the variation in GPA was attributable to weight status.

### **7.2.3 The Early Childhood Longitudinal Study, Kindergarten Class (ECLS-K)**

<http://nces.ed.gov/ECLS/kindergarten.asp>

The ECLS-K was a longitudinal study that followed the same US children from kindergarten through to the eighth grade. The study used a multi-stage probability sample design with a prospective, nationally representative (with oversampling of particular ethnic minorities) dataset. In the base year of the ECLS-K, a total of 1,277 schools were selected for the sample, incorporating 22,666 students. Direct assessment of outcome measures was made.

**Dataset:** Early Childhood Longitudinal Study – Kindergarten Class (ECLS-K)

**Number of studies:** 5

**Summary of findings:** One study found evidence of a significant, negative association, a negative association, and a positive association between BMI and educational achievement (Datar and Sturm 2006). One other study found evidence of a significant negative association (Wendt 2009). Three studies demonstrated a negative but non-significant association between BMI and educational achievement (Datar et al. 2004, Gable et al. 2008, Judge and Jahns (2007)).

Five studies from the US conducted secondary analyses on the Early Childhood Longitudinal Study – Kindergarten Class (ECLS-K) dataset. All five studies used standardised Item Response Theory (IRT) reading and mathematics test scores as the educational outcome measure. As opposed to other datasets, the ECLS-K obesity and attainment measures were not self-reported and therefore studies examining this dataset are not subject to the same bias as those relying on potentially inaccurately reported obesity and attainment measures.

Using data taken from 11,192 children, Datar et al. (2004) employed multivariate regression to estimate the association between overweight status and mathematics and reading test scores in kindergarten and the end of grade 1, controlling for socio-economic status, parent-child interaction, birth weight, physical activity, television watching and prior achievement. Compared with non-overweight children, overweight children had significantly lower test scores at the end of grade 1. However these differences lost statistical significance after controlling for socio-economic and behavioural variables.

Using data taken from approximately 7,000 children, Datar and Sturm (2006) employed multivariate regression models to examine the association between changes in overweight status and school outcomes between kindergarten entry and the end of third grade, after controlling for ethnicity, SES and other child, family and school characteristics. The authors found that girls who became overweight between kindergarten entry and end of third grade were significantly more likely to score lower on mathematics and reading tests compared to girls who were never overweight. However, for girls who were always overweight there was no significant association between weight status and test scores. The relationship between change in overweight status and school outcomes was weaker among boys. There were no significant differences in test scores between the three groups of boys (persistently overweight, never overweight, newly overweight).

Using data taken from approximately 8,000 children aged five to eight years, Gable et al. (2008) employed multi-level models controlling for gender, ethnicity and SES to examine the academic outcomes of persistent childhood overweight. The authors found that compared with never-overweight peers, children who were overweight for the duration of the study performed less well on assessments of reading and mathematics at first and third grade. Note that this is in direct contrast to the findings of Datar and Sturm (2006), who demonstrated that for girls who were persistently overweight there was no significant association between BMI and test scores. It is interesting that the two studies produce conflicting results when examining similar sample sizes from the same dataset for the same

follow-up period. A notable difference between the two studies is that in addition to gender, ethnicity and a measure for SES, Datar and Sturm (2006) incorporated a further 13 moderating variables into their regression model. However, equally, the differences in their results may be a reflection of differences in the ways in which they selected their sample.

Using data taken from 13,680 children, Judge and Jahns (2007) employed a series of one-way analyses of covariance (ANCOVA) tests, controlling for SES, ethnicity and maternal educational achievement, to examine the relationship between child overweight and educational outcomes in the third grade. The authors found that overweight children had significantly lower mathematics and reading test scores compared with non-overweight children in third grade. However, these differences lost statistical significance after including socio-economic and maternal education variables.

Finally, using data taken from approximately 14,000 children, Wendt (2009) employed econometric models controlling for 20 moderating variables, including gender, ethnicity and SES, to examine the relationship between childhood overweight and educational outcomes. The author found that underweight or overweight children achieve lower test scores, particularly for mathematics. This pattern remained statistically significant, whether contemporaneous weight status or changes in weight status over time were used as moderating variables.

#### **7.2.4 National Longitudinal Survey of Youth 79 and 97 (NLSY)**

[www.nlsinfo.org/nlsy97/nlsdocs/nlsy97/97sample/introsample.html](http://www.nlsinfo.org/nlsy97/nlsdocs/nlsy97/97sample/introsample.html)

The **NLSY79** constituted a sample of 12,686 individuals aged 14–22 years when they were first surveyed in 1979. Participants were interviewed annually till 1994 and are currently interviewed on a biennial basis. The NLSY79 survey focuses on workforce behaviour but the content of the survey is extensive and includes detailed questions on educational attainment, training investments, income and assets and health.

In 1980, a survey of the secondary schools attended by NLSY79 respondents was conducted. Gathered information included school-level characteristics as well as respondent-specific information such as achievement test scores. In 1980–1983, the NLSY79 collected detailed transcript information for potential high school graduates that included coursework, grades and attendance records.

In 1986, a separate survey of all children born to NLSY79 female respondents began, greatly expanding the breadth of child-specific information collected. The child survey includes assessments of each child and additional demographic and developmental information collected from either the mother or child.

The **NLSY97** constituted a sample of approximately 9,000 individuals aged 12 to 16 years as of December 31, 1996. Round 1 of the survey took place in 1997, when both eligible youths and one parent received interviews. Participants were interviewed on an annual basis.



High school transcripts were collected for NLSY97 respondents who provided written permission to contact their schools. The high schools, both public and private, were asked to provide the respondent's transcript, along with course descriptions and information about the school's grading scale. Transcript information is available on the NLSY97 data file for 6,232 respondents, or about 69 percent of the 8,984 respondents who participated in the initial round of the NLSY97.

**Dataset:** National Longitudinal Survey of Youth (NLSY) 79

**Number of studies:** 3

**Summary of findings:** One study (Averett and Stifel 2007) found that BMI exerted a negative effect on mathematics and reading recognition scores. A second study (Chowdhury 2008) produced variable results depending on the statistical model used. Chowdhury variously failed to demonstrate a relationship between obesity and attainment, or found a positive association between obesity and both reading achievement in boys and mathematics results in girls. A third study (Kaestner and Grossman 2008) found inconsistent results reported across different models for girls. However, as Kaestner and Grossman incorporated additional variables into successive models, the overall trend was for a shift from a negative to a weak positive association across all age groups of boys.

Three studies from the US made use of survey data from the National Longitudinal Survey of Youth (NLSY) 79 (Averett and Stifel 2007, Chowdhury 2008, Kaestner and Grossman 2008). The authors exploited the coupling of mother and child data in this cohort study, allowing them to control for maternal moderating variables such as mother's BMI, education and income. While the attainment outcome in these studies (the Peabody Individual Achievement Test (PIAT)) was not self-reported, children's BMI was calculated using heights and weights, which were either self-reported or reported by parents. All three studies are therefore vulnerable to bias as a result of inaccurate estimates of bodyweight.

Averett and Stifel (2007) examined the cognitive effects of childhood malnutrition as manifested in both overweight and underweight children aged 6 to 13. Using Ordinary Least Squares (OLS), Fixed Effects (FE) and Instrumental Variables (IV) models controlling for ethnicity, proxies for SES and several other maternal and child characteristics, they found that increased BMI exerted a significantly negative effect on PIAT mathematics and reading recognition scores. In FE specifications controlling for malnutrition, overweight children had lower reading recognition test scores and underweight children had lower mathematics scores. IV models using mother's historical BMI as an instrumental variable, suggested a stronger negative effect of being overweight on both mathematics and reading test scores than models not taking into account mother's BMI, and often found a negative effect of being underweight. It was notable, however, that only six percent of the variation in achievement was explained by weight status alone.

Chowdhury (2008) examined the association between children's and mothers' bodyweight and childhood educational achievement controlling for maternal SES, gender and ethnicity, in addition to several other maternal and child characteristics. OLS regression, using data taken from 8,594 children aged 6 to 12, found a significantly positive relationship between

BMI and reading achievement for males. For girls, a negative but non-significant association was found for reading, while a positive but non-significant association was demonstrated for mathematics. OLS regression found a non-significant positive association between BMI and academic achievement in Black, Hispanic and White children. However, this relationship was significantly positive in Black and Hispanic children over 10 years old. Results from a fixed effects longitudinal model indicated that there was no significant relationship between children's BMI and test scores.

Kaestner and Grossman (2008) derived estimates of the association between weight and achievement using various regression model specifications controlling for gender, ethnicity and proxies for maternal SES in addition to several other maternal and child characteristics. Simple correlations between weight status and test scores, in a sample of approximately 7,500 children aged 7 to 12, revealed a significant deficit for obese children, particularly girls. However, the results reported across different models were inconsistent. As further variables were incorporated into successive models, the relationship between weight status and achievement changed from negative to positive for 9–10 year old girls. Only one statistically significant negative association was found, which was reading comprehension for 11–12 year old girls. For boys, as further variables were incorporated in successive models, the overall trend was for a shift from a negative association to a weak positive association across all age groups.

It is difficult to conduct comparisons between these three studies and explain why they have different results. The conflicting results may be due to differences in sample sizes and selection methods, and different specifications for their statistical models. Kaestner and Grossman (2008) suggest that the divergence in their results from those of Averett and Stifel (2007) could be due to a variety of factors, but suggest that it is likely to have resulted from the failure of Averett and Stifel to specify and estimate a theoretically consistent model.

**Dataset:** National Longitudinal Survey of Youth (NLSY) 97

**Number of studies:** 2

**Summary of findings:** One study (Bagully 2006) found a negative association between obesity and academic performance, which became insignificant after controlling for socio-economic variables. Similarly, Kaestner et al. (2009) found that after controlling for moderating variables, the association between overweight and educational attainment lost significance.

Two studies from the US made use of survey data from the National Longitudinal Survey of Youth (NLSY) 97 (Bagully 2006, Kaestner et al. 2009). These studies suffer from the same limitations as those employing data from the NLSY79 dataset, in that they are subject to bias from the potentially inaccurate reporting of the heights and weights used to calculate BMI. The indicator of academic achievement, the Peabody Individual Achievement Test (PIAT), was not self-reported.

In a Master's dissertation, examining data taken from 1,503 children aged 13 to 14, Bagully (2006) hypothesised that, through the mechanism of depression, childhood obesity also

leads to lower academic performance. Multivariate analysis, using OLS regression controlling for gender, ethnicity and proxies for SES, in addition to other parental and child characteristics, demonstrated a negative impact of obesity on academic performance, with parental obesity and time spent watching television accounting for part of obesity's total effect. However, after controlling for a variety of socio-economic factors, the negative effect of obesity became statistically insignificant. It was notable that only one percent of the variation in achievement was explained by weight status alone.

Kaestner et al. (2009) obtained estimates of the association between weight and educational attainment in adolescents using several regression models controlling for a variety of maternal and child characteristics, including ethnicity and proxies for SES. For females, after controlling for moderating variables, the negative association between overweight and educational attainment lost significance. For males, after controlling for moderating variables, the relationship between overweight and educational attainment changed from a negative to a positive association. Among males, the only significant estimates were for those in the lowest weight category.

This is one of the few examples where secondary analyses of the same dataset have not produced different results.

### **7.2.5 The Children's Lifestyle and School-Performance Study (CLASS)**

The Children's Lifestyle and School-Performance Study (CLASS) was a large survey of 11,300 fifth-grade children conducted in Nova Scotia, Canada. Educational attainment was assessed by standardised examinations marked by experienced teachers, and heights and weight were measured independently.

**Dataset:** Children's Lifestyle and School-Performance Study (CLASS)

**Number of studies:** 2

**Summary of overall findings:** Two studies found that BMI was negatively associated (though not significantly) with academic performance (Wang and Veugelers, 2008; Florence et al. 2008). Florence et al (2008) found that the association was only significant prior to adjustment for gender and measures of SES.

Two studies made use of data from the Canadian Children's Lifestyle and School-Performance Study (CLASS) (Florence et al. 2008, Wang and Veugelers 2008). Both studies used BMI scores based on measures of height and weight collected by study representatives. Standardised Elementary Literacy Assessment test scores were used as indicators of academic achievement at age 9 and 10. These studies are therefore not subject to the same bias as those relying on potentially inaccurate estimates of obesity and attainment.

In a cross-sectional analysis, Wang and Veugelers (2008) applied structural equation models incorporating a range of variables, including gender, measures of SES, self-esteem and physical activity levels, to assess the interrelationships between bodyweight, self-esteem

and school performance in childhood. The authors' analysis of 4,945 children aged 10 to 11 found that BMI had a negligible but nonetheless negative association with achievement. The relationship was not statistically significant.

Florence and colleagues (2008) employed multi-level regression methods to examine the association between indicators of diet quality and academic performance in a sample of 4,589 children aged 10 to 11. The authors found that whilst overweight students were more likely to fail the elementary literacy assessment than their normal weight peers, BMI was not associated with academic performance after adjustment for gender and SES.

In common with the secondary analysis of NLSY 97, this is one of the few examples where secondary analyses of the same dataset have not produced different results.

### **7.2.6 Georgetown Adolescent Tobacco Research (GATOR)**

The GATOR project was a prospective cohort study following 1,200 ninth graders over a four-year period, collecting psychosocial, genetic and socio-demographic data. All participants were from five high schools selected from the same county in North Virginia, USA, and thus generalisability is limited. All variables (except the genetic markers) were self-reported.

**Dataset:** Georgetown Adolescent Tobacco Research (GATOR)

**Number of studies:** 1

**Summary of findings:** The negative association between BMI and academic performance for males was not significant after adjusting for parental and familial characteristics, but remained significant for females.

One study made use of the data from the Georgetown Adolescent Tobacco Research (GATOR) project (Ding et al. 2006). Using data taken from 807 US adolescents, Ding et al. (2006) employed regression controlling for genetic markers to examine the association between BMI and academic performance. Academic performance was assessed using grade point averages (GPA). Obesity and attainment measures were self-reported and therefore it should be noted that this study is susceptible to bias due to inaccurate estimates of both bodyweight and educational attainment. The authors found that being overweight was significantly associated with lower educational attainment in both males and females. Girls had a significantly stronger negative relationship between obesity and achievement than males. When controlling for genetic markers, obese females continued to demonstrate a decrease in GPA but there was no significant relationship for obese males.

### **7.2.7 Third National Health and Nutrition Examination Survey (NHANES III)**

[www.cdc.gov/nchs/nhanes/about\\_nhanes.htm](http://www.cdc.gov/nchs/nhanes/about_nhanes.htm)

The National Health and Nutrition Examination Survey is a longitudinal study made up of yearly waves of data collection from about 5,000 US participants. Trained examiners administer attainment tests (the Wide Range Achievement Test, Revised – WRAT-R) and body weight and height are independently collected.

**Dataset:** Third National Health and Nutrition Examination Survey (NHANES III)

**Number of studies:** 1

**Summary of findings:** The negative association between BMI and academic performance was not significant after adjusting for socio-economic status.

One study made use of data from the Third National Health and Nutrition Examination Survey (NHANES III). Using data taken from 2,519 US children aged 8–16, Li et al. (2008) employed regression, controlling for ethnicity, gender and SES amongst other variables, to examine the association between overweight and academic performance among school-age children and adolescents. Academic performance was assessed using the WRAT-R. The NHANES III obesity and attainment measures were not self-reported and therefore the study by Li et al. is not subject to the same bias as those relying on potentially inaccurate estimates of obesity and attainment. The authors found that, after adjusting for socio-economic status, the negative association between BMI and academic performance was no longer significant.

### **7.2.8 School Health Promotion Study**

<http://info.stakes.fi/kouluterveyskysely/EN/index.htm>

The School Health Promotion study data is gathered by an anonymous classroom-administered questionnaire that covers living conditions, school experiences, health, health behaviour, health knowledge and experiences of student welfare services in Finland. Schools participate biannually in the study. In 2008 there were 60,000 respondents in the 8th and 9th grade of secondary school (14–16 years), 29,000 respondents in the 1st and 2nd grade of upper secondary school (17–18 years) and 19,000 respondents in the 1st and 2nd year of vocational school (17–20 year olds).

**Dataset:** School Health Promotion Study

**Number of studies:** 1

**Summary of findings:** Children in the middle and highest tertiles for school performance were significantly less likely to be obese than those in the lowest tertile.

Using data taken from 60,252 Finnish children aged 14–16, Mikkila et al. (2003) employed logistic regression analysis controlling for SES, school performance and other diet and exercise variables, to examine the association between academic performance and obesity. This was one of only two studies which examined attainment as a predictor of obesity rather than the reverse. Academic performance was assessed using grade point averages (GPA). The heights and weights used to calculate BMI were self-reported by the adolescents and therefore this study is susceptible to bias due to inaccurate estimates of obesity. The authors found that children in the middle and highest tertiles for school performance were significantly less likely to be obese than those in the lowest tertile.

### **7.2.9 Youth in Iceland**

The Youth in Iceland sample consists of young people aged 14 and 15 from all Icelandic secondary schools who attended the 9th and 10th grades. This represents approximately 80% of the population of Iceland in these age groups. The Youth in Iceland studies are conducted with annual cross-sectional surveys in collaboration with the Ministry of Education, Science and Culture, the municipalities around the country and the Icelandic Centre of Social Research and Analysis. The overall goal of the study is to monitor various health behaviours as well as risk and protective factors. Heights and weights are self-reported.

**Dataset:** Youth in Iceland

**Number of studies:** 1

**Summary of findings:** There was a weak, significantly negative association with academic achievement when controlling for gender, parental education, family structure and absenteeism.

Using data taken from 5,180 Icelandic adolescents, Sigfúsdóttir et al. (2007) employed ordinary least squares (OLS) regression analysis, controlling for SES, gender, family structure and absenteeism, to examine the association between BMI and academic achievement. Academic performance was assessed using grade point averages (GPA). Obesity and attainment measures were self-reported and therefore it should be noted that this study is susceptible to bias due to inaccurate estimates of both bodyweight and educational attainment. The authors found that, after controlling for gender, parental education, family structure and absenteeism, a weak significantly negative association between BMI and academic achievement remained.

### 7.3 Findings of primary studies

**Number of studies:** 6

**Overall summary of findings:** The results of the primary studies were mixed. One study found that overweight at-risk status, BMI and percentage body fat were significantly negatively related to self-reported, but not measured grades (Huang et al. 2006). One study found a general tendency for lower reading scores in overweight students, compared to non-overweight students, which was not significant, and significantly higher grade point averages (approximately 11%) in non-overweight compared to overweight students (Shore et al. 2008). One study found that that BMI was significantly and negatively associated with total academic achievement, reading achievement and mathematics achievement (Castelli et al. 2007). One study found that, despite a negative association, educational attainment was not significantly related to BMI after adjustment for fitness factors (Cottrell et al. 2007). One study found that weight status was significantly associated with achievement in mathematics though not significantly associated with English achievement (Chomitz et al. 2009). A final study failed to find any relationship between bodyweight and academic performance (Kim et al. 2003).

The sample sizes of the primary studies ranged from 259 to 6,463. In all six studies, neither obesity nor attainment outcomes were self-reported, thus avoiding the bias that might arise from inaccurate reporting of these measures.

Castelli et al. (2007) examined the relationship between physical fitness and academic achievement in 259 US public school students in the third and fifth grades. Academic performance was assessed using Illinois Standards Achievement Test (ISAT) scores. The authors used hierarchical regression analysis, controlling for age, gender, school and fitness variables, to examine the association between obesity and academic achievement. Results suggested that BMI was significantly and negatively associated with total academic achievement, reading achievement and mathematics achievement.

Chomitz et al. (2009) also examined the relationship between physical fitness and academic achievement. The authors examined the BMI and Massachusetts Comprehensive Assessment System (MCAS) scores of 1,847 US adolescents. The authors used multivariate logistic regression, controlling for ethnicity, gender, grade and SES (school lunch enrolment) to examine the association between obesity and academic achievement. Results indicated that weight status was significantly negatively associated with passing the mathematics MCAS test though not significantly associated with achievement in English.

The focus of the study by Cottrell et al. (2007) was the relationship between child cardiovascular risks (one of which was BMI) and academic performance in 968 fifth grade US students. Academic performance was assessed using West Virginia Educational Standards Test (WESTEST) scores. The authors used multiple covariate analysis of variance (ANOVA), employing gender, cardiovascular risk factors, fitness factors and SES (school lunch enrolment) as covariates. Mean academic performance scores were significantly affected by children's BMI category after controlling for financial assistance. The lowest scores were recorded among underweight children, followed by children identified as being overweight,

and then those who were at risk of being overweight. However, when additional cardiovascular risk and fitness variables were included in the model, BMI had no association with test scores.

Huang et al. (2006) investigated the associations between BMI and both measured and self-reported academic performance in 666 US adolescents. Academic performance was assessed using grade point averages (GPA). The authors used regression models controlling for gender, ethnicity, age and physical activity. It should be noted that the authors did not make adjustment for the important moderating variable of socio-economic status. After adjusting for other moderating variables, overweight at-risk status, BMI and percentage body fat were significantly negatively related to self-reported but not measured grades. Given that the authors did not adjust for socio-economic status, the results must be interpreted with caution. However, if we assume the results of this study to be valid, it casts doubt upon the validity of the results of those studies using self-reported attainment measures.

The aim of the study by Kim et al. (2003) was to examine the association of dietary behaviours, physical status and socio-economic status with academic performance in Korean adolescents. Academic performance was assessed by using grade point averages taken from the school records of 6,463 students. This was the only study to examine the association between bodyweight and academic performance using weight rather than BMI. Simple correlations revealed that the bodyweight of the students had no relationship with academic performance.

Shore et al. (2008) examined the association between BMI and academic performance in a sample of 566 US children aged 11 to 13, using one-way analysis of variance (ANOVA), controlling for ethnicity, gender and socio-economic status (school lunch enrolment). Academic performance was assessed using grade point averages (GPA) and Degree of Reading Power (DRP) test scores. The authors found that the GPAs of non-overweight students were significantly higher (approximately 11%) than those of the overweight students. There was a general tendency for lower DRP scores in overweight students, compared to non-overweight students, when controlling for demographic variables (although the difference between groups was not significant).



## **7.4 Studies examining the influence of genetic factors**

**Number of studies:** 3

**Overall summary of findings:** Three studies (secondary analyses of different datasets) used genetic factors as mediating variables in the relationship between obesity and academic attainment (Ding et al. 2006, Fletcher and Lehrer 2008, von Hinke Kessler Scholder et al. 2009). Ding et al. found that the negative association between BMI and academic performance for males was not significant after adjusting for parental and familial characteristics, but remained significant for females. Fletcher and Lehrer (2008) found that overweight was significantly associated with lower educational achievement but that this relationship lost significance after genetic markers and family factors had been taken into account. Von Hinke Kessler Scholder and colleagues (2009) presented results suggesting that children's genetic factors did not influence the association between obesity and attainment.

## **7.5 Studies predicting the magnitude of the association between obesity and attainment**

**Number of studies:** 2

**Overall summary of findings:** Two studies presented data predicting the magnitude of the association between obesity and education (Crosnoe and Muller 2004; Sabia 2007). One study estimated that a difference in weight of 50 to 60 pounds was associated with an 8 to 10 percentile difference in standing in the grade point average (GPA) distribution, and report that it would take a weight difference of approximately 150 pounds (holding height constant) for there to be a one-half letter grade difference in GPA (Sabia 2007). Crosnoe and Muller (2004) estimated that risk of obesity predicted an approximate one-tenth difference in GPA, for example 3 versus 2.9. Unfortunately however, it is unclear how similar a one-half letter grade difference is to a one-tenth difference in GPA score. Therefore we cannot assess whether these results are consistent.

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## **Appendix 1: Search strategy**

### **Bibliographic databases**

Eleven electronic databases from the fields of health, public health, education, social science and social care were searched.

- ASSIA
- Australian Educational Index
- British Education Index
- CINAHL
- ERIC
- International Bibliography of the Social Sciences
- Physical Education index
- PsycINFO
- PubMed
- Sociological Abstracts
- Web of Knowledge (Arts and Humanities Citation Index, Social Science Citation Index, Science Citation Index, Conference Proceedings Citation Index- Science)

For each of these databases, indexing and free-text terms which covered obesity and body weight were combined with terms for children and young people and further combined with terms for educational attainment to refine the search. Terms for educational attainment were not used for the following databases: ERIC, British Education Index, Sociological Abstracts, Australian Education Index and the International Bibliography of the Social Sciences. The search strategy was developed on PubMed and translated to the other databases (see below for PubMed search strategy, strategies for all other sources are available on request).

### **Specialist registers**

Specialist registers and catalogues. These databases included ones which indexed dissertation and conference abstracts and focussed on UK and international literature.

Where applicable, the search strategy for bibliographic databases was translated to these registers, using a shortened version of the strategy where limited search functionality was available.

- BiblioMap (EPPI-Centre database of health promotion and public health research)
- British Index to Theses
- British library integrated catalogue
- C2-SPECTR Database
- Child data
- Cochrane Library
- Current Education and Children's Services Research/CERUK plus
- Dart Europe e-theses search



- Dissertation abstracts
- Educational Research Abstracts (ERA)
- EPPI-Centre Database of Education Research
- HEALTH PROMIS
- IOE library catalogue
- National Research Register
- New York Academy of Medicine Grey literature database
- Social Care Online
- Social science research network database
- ZETOC

## **Search engines**

Limited web searches were conducted using the Google and Google Scholar, Scirus and Clusty search engines. The terms used combined obesity and educational attainment concepts.

## **Websites**

Sixteen websites from topic areas of obesity, child health and health promotion, and education were scanned for relevant items.

- Association for the Study of Obesity (ASO)  
[www.aso.org.uk/portal.aspx](http://www.aso.org.uk/portal.aspx)
- Child and adolescent health research unit  
[www.education.ed.ac.uk/cahru/](http://www.education.ed.ac.uk/cahru/)
- Children's Research Centre (The Open University)  
<http://childrens-research-centre.open.ac.uk/>
- Eastern Region Public Health Observatory  
[www.erpho.org.uk/default.aspx](http://www.erpho.org.uk/default.aspx)
- Economic and Social Research Council: Society Today  
[www.esrc.ac.uk/ESRCInfoCentre/index.aspx](http://www.esrc.ac.uk/ESRCInfoCentre/index.aspx)
- ESRC (Economic and Social Research Council) Society today  
[www.esrcsocietytoday.ac.uk](http://www.esrcsocietytoday.ac.uk)
- European Commission  
<http://ec.europa.eu/>
- Healthy school student news  
[www.sheu.org.uk/whoweworkwith/hschsnarchive.htm](http://www.sheu.org.uk/whoweworkwith/hschsnarchive.htm)
- International Association for the study of Obesity (IASO)  
[www.iaso.org/](http://www.iaso.org/)
- International Obesity Taskforce  
[www.ioletf.org/](http://www.ioletf.org/)
- MDRC  
[www.mdrc.org/](http://www.mdrc.org/)
- Merck Frosst/CIHR (Canadian Institute of health Research) Chair in Obesity  
<http://obesity.ulaval.ca/resources/ressources.php?strcible=P>
- National Obesity Forum  
[www.nationalobesityforum.org.uk/](http://www.nationalobesityforum.org.uk/)

- National Obesity Observatory for England  
[www.noo.org.uk/](http://www.noo.org.uk/)
- NHS National Library for Health  
[www.library.nhs.uk/Default.aspx](http://www.library.nhs.uk/Default.aspx)
- The North American branch of the International Life Sciences Institute (ILSI North America)  
[www.ilsina.org/](http://www.ilsina.org/)

### **Asking experts; other sources**

Contact with over 30 experts was made. These included authors of studies identified when undertaking the review and experts recommended to by the advisory group. In addition, the EPPI-Centre e-Newsletter, issued in December 2008, requested information on potentially relevant studies or data, published or unpublished.

Sources of information within the EPPI-Centre from earlier reviews on obesity were searched. Reference lists of views, reviews, and commentary items on obesity and attainment excluded during the screening stage were scanned.

### **PubMed**

29 October 2008

N=930

GCSE OR GCSEs OR SATs OR "Assessment tests" OR "school diploma"[tw] OR "educational development"[tw] OR "school certificate\*"[tw] OR "national tests"[tw] OR "national testing"[tw] OR "secondary education"[tw] OR "primary education"[tw] OR "national examinations"[tw] OR "Key Stage"[tw] OR "grade scores"[tw] OR "ordinary level"[tw] OR "O-level\*"[tw] OR "achievement"[mh] OR "educational measurement"[mh] OR "education"[mh:noexp] OR "mathematics/education"[mh] OR "language arts"[mh] OR "educational status"[mh] OR academic test\*[tw] OR academic examination[tw] OR academic exam[tw] OR academically attain\*[tw] OR academic measure\*[tw] OR academic assess\*[tw] OR academic evaluat\*[tw] OR academic standard\*[tw] OR academic deficien\*[tw] OR academically deficien\*[tw] OR academically perform OR academic performance\*[tw] OR academic achievement\*[tw] OR academic outcome\*[tw] OR academic failure\*[tw] OR academic level\*[tw] OR school perform\*[tw] OR school standard\*[tw] OR school evaluat\*[tw] OR school assess\*[tw] OR school test\*[tw] OR school outcomes[tw] OR school examination[tw] OR school exam[tw] OR school measure\*[tw] OR school performance\*[tw] OR school achievement\*[tw] OR school failure\*[tw] OR school exams[tw] OR test scores[tw] OR testing scores[tw] OR education test\*[tw] OR educational attain\*[tw] OR educational measure\*[tw] OR education assess\*[tw] OR education evaluat\*[tw] OR education standard\*[tw] OR educational standard\*[tw] OR education deficien\*[tw] OR educational deficien\*[tw] OR educationally deficien\*[tw] OR education perform[tw] OR education performance\*[tw] OR education achievement\*[tw] OR educational achievement\*[tw] OR education level\*[tw] OR educational level\*[tw] OR education failure\*[tw] OR education outcome\*[tw] OR education exams[tw] OR educational failure\*[tw] OR educational outcome\*[tw] OR educational test\*[tw] OR examination perform\*[tw] OR examination

standard\*[tw] OR examination assess\*[tw] OR examination outcomes[tw] OR examination performance\*[tw] OR examination achievement\*[tw] OR examination failure\*[tw] OR engagement[tw] OR attainment\*[tw]

AND

child[mh] OR adolescent[mh] OR minors[mh] OR puberty[mh] OR child\*[tw] OR schoolchild\* OR Boy OR boys OR Girl OR girls OR Minors OR Prepubescen\* OR preadolescent\* OR adolescent\* OR teen\* OR student\* OR pupil\* OR kid OR kids

AND

"Body Weight"[mh] OR "Body Size"[mh] OR "body mass index"[mh] OR "overnutrition"[mh] OR "body image"[mh] OR "obesity"[mh]) OR ("body size" OR "body image" OR "Body weights" OR "body shape" OR "overweight" OR "thin" OR "thinness" OR "skinny" OR "obese" OR "obesogenic" OR "obesity" OR "leptogenic" OR ("weight" AND "body"))

AND

1997 : 2008[dp]

## Appendix 2: Characteristics of included studies

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Averett and Stifel (2007)</p> <p>Secondary analysis using NLSY79 dataset</p> <p>Sample size unspecified</p> <p>Quality = GOOD</p>	USA	Obesity	Attainment	BMI (Parental report)	Peabody Individual Achievement Tests (PIAT) ( <i>Measured</i> )	<p>Ordinary Least Squares (OLS), Fixed Effects(FE) and Instrumental Variables (IV) models variously using the following variables:</p> <ul style="list-style-type: none"> <li>Mother's BMI</li> <li>Child's age</li> <li>Birthweight</li> <li>Prematurity</li> <li>Child breastfed</li> <li>Ethnicity</li> <li>Child's place among siblings (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> etc)</li> <li>Number of household members</li> <li>Mother's education</li> <li>Mother's wage</li> <li>Average household income</li> <li>Share of poor households in county</li> </ul>	<p>BMI exerted a significantly negative effect on PIAT mathematics and reading recognition scores. In FE specifications controlling for malnutrition, overweight children had lower reading recognition test scores and underweight children had lower mathematics scores. IV models using mother's historical BMI as an instrumental variable, suggested a stronger negative effect of being overweight on both mathematics and reading test scores than models not taking into account mother's BMI, and often found a negative effect of being underweight. Six percent of the variation in achievement was explained by weight status alone.</p>

Childhood obesity and educational attainment: a systematic review

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Bagully (2006)</p> <p>Secondary analysis using NLSY79 dataset</p> <p>Sample size = 1503</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Peabody Individual Achievement Tests (PIAT) ( <i>Measured</i> )	<p>Multivariate analysis, using OLS regression employing the following variables:</p> <ul style="list-style-type: none"> <li>Gender</li> <li>Ethnicity</li> <li>Health status (chronically ill or not)</li> <li>Attendance at school</li> <li>Time spent watching TV</li> <li>Parental education</li> <li>Parental obesity</li> <li>Class size</li> <li>School environment (feels safe or not)</li> <li>School type (public/private)</li> </ul>	<p>There was a negative impact of obesity on academic performance, with parental obesity and time spent watching television accounting for part of obesity's total effect. After controlling for a variety of socio-economic factors, the negative effect of obesity became statistically insignificant. Only 1% of the variation in achievement was explained by weight status alone.</p>
<p>Castelli et al. (2007)</p> <p>Study conducted in single school district in medium-sized urban community.</p> <p>Sample size = 259</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI ( <i>Measured</i> )	<p>Illinois Standards Achievement Test (ISAT) (<i>Measured</i>)</p>	<p>Hierarchical regression analysis using variables below:</p> <ul style="list-style-type: none"> <li>Age</li> <li>Gender</li> <li>School</li> <li>Fitness variables</li> </ul>	<p>BMI was significantly and negatively associated, with total academic achievement, reading achievement and mathematics achievement.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Chomitz et al. (2009)</p> <p>Study conducted in Cambridge Public School Department, a racially and economically diverse urban public school district.</p> <p>Sample size = Mathematics (1103); English (744)</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Measured)	Massachusetts Comprehensive Assessment System (MCAS) (Measured)	<p>Multivariate logistic regression analyses were conducted to assess the probability of passing the MCAS tests using the following variables:</p> <ul style="list-style-type: none"> <li>Weight status (BMI z score)</li> <li>Ethnicity</li> <li>Gender</li> <li>Grade</li> <li>Socio-economic status (school lunch enrolment)</li> </ul>	Results indicated that despite a negative association, educational attainment was not significantly related to BMI.

Childhood obesity and educational attainment: a systematic review

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Chowdhury (2008)</p> <p>Secondary analysis using NLSY79 dataset</p> <p>Sample size = 8594</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Peabody Individual Achievement Tests (PIAT) ( <i>Measured</i> )	<p>Ordinary Least Squares (OLS) and Fixed Effects (FE) models using the following variables:</p> <ul style="list-style-type: none"> <li>Age of Mother</li> <li>Mother's BMI</li> <li>No. of children of mother</li> <li>Family size</li> <li>Mother works full/part-time</li> <li>Rural/urban</li> <li>Mother's marital status</li> <li>Region of residence</li> <li>Log income of mother</li> <li>Mother's education</li> <li>Mother's alcohol consumption</li> <li>Child age</li> <li>Child behavioural index</li> <li>Child ethnicity</li> <li>Child gender</li> <li>Resident in mother's household</li> </ul>	<p>OLS regression found a significantly positive relationship between BMI and reading achievement for males. For girls, a negative but non-significant association was found for reading while a positive but non-significant association between BMI and mathematics achievement was demonstrated. OLS regression found a non-significant positive association between BMI and academic achievement in Black, Hispanic and White children. However, this relationship was significantly positive in Black and Hispanic children over 10 years old. Results from a fixed effects longitudinal model indicated that there was no significant relationship between children's BMI and test scores.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Cottrell et al. (2007)</p> <p>Study conducted with 5<sup>th</sup> grade students in a rural, primarily white area in West Virginia, US.</p> <p>Sample size = 968</p> <p>Quality SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Measured)	West Virginia Educational Standards Test (WESTEST) (Measured)	<p>Multiple covariate ANOVA with the following covariates:</p> <ul style="list-style-type: none"> <li>Financial assistance (school meal enrolment)</li> <li>Gender</li> <li>Cardiovascular risk factors</li> <li>Fitness factors</li> </ul>	<p>Mean academic performance scores were significantly affected by children's BMI category after controlling for financial assistance. The lowest scores were recorded among underweight children, followed by children identified as being overweight, and then those who were at risk for being overweight. Overall, this model accounted for between 6% and 10% of the variance in the mean test scores. When additional cardiovascular risk and fitness measures were included in the model, BMI status had no significant association with test scores.</p>



Childhood obesity and educational attainment: a systematic review

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Crosnoe and Muller (2004)</p> <p>Secondary analysis using National Longitudinal Study of Adolescent Health (AddHealth) dataset</p> <p>Sample size = 11,658</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Grade point average ( <i>Self-reported</i> )	<p>Hierarchical linear regression models using the following variables:</p> <ul style="list-style-type: none"> <li>Gender</li> <li>Age</li> <li>Ethnicity</li> <li>Family structure</li> <li>Parental education</li> <li>Athletic status</li> <li>Prior academic achievement</li> <li>School type</li> <li>School socio-economic status</li> <li>School minority representation</li> <li>School-level romantic activity</li> <li>School-level BMI</li> <li>School-level athletic participation</li> <li>School-level peer involvement</li> </ul>	<p>Before controlling for other variables, risk of obesity predicted lower academic achievement accounting for an approximate one tenth difference in achievement (e.g., 3.0 vs. 2.9). This association held after the control of sociodemographic characteristics, but was negligible and no longer significant after the control of prior academic achievement and school-level variables.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Datar and Sturm (2006)</p> <p>Secondary analysis using ECLS-K dataset</p> <p>Sample size = Approx. 7000</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Measured)	Standardised Item Response Theory (IRT) reading and mathematics test scores. (Measured)	<p>Multivariate regression using the following variables:</p> <ul style="list-style-type: none"> <li>Gender</li> <li>Age</li> <li>Ethnicity</li> <li>Birth weight</li> <li>Annual family income</li> <li>Mother's education</li> <li>Family structure</li> <li>Maternal depression</li> <li>Parent-child interaction</li> <li>Hours of television watching</li> <li>Parent-reported physical activity</li> <li>Amount of physical education instruction received</li> <li>School size</li> <li>School percent minority</li> <li>School urbanicity</li> </ul>	<p>Girls who became overweight between kindergarten entry and end of third grade were significantly more likely to score lower on mathematics and reading tests compared to girls who were never overweight. For girls who were always overweight there was no significant association between weight status and test scores. The relationship between change in overweight status and school outcomes was weaker among boys. There were no significant differences in test scores between the three groups of boys (persistently overweight, never overweight, newly overweight).</p>

Childhood obesity and educational attainment: a systematic review

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Datar et al. (2004)</p> <p>Secondary analysis using ECLS-K dataset</p> <p>Sample size = 11,192</p> <p>Quality = GOOD</p>	USA	Obesity	Attainment	BMI (Measured)	Standardised Item Response Theory (IRT) reading and math test scores. (Measured)	<p>Regression using the following variables:</p> <ul style="list-style-type: none"> <li>- Baseline test scores</li> <li>- Socio-economic status (Annual family income)</li> <li>- Parent-child interaction</li> <li>- Birth weight</li> <li>- Physical activity</li> <li>- Television watching</li> <li>- Ethnicity</li> <li>- Mother's education</li> <li>- Urbanicity</li> </ul>	<p>Compared with non-overweight children, overweight children had significantly lower test scores at the end of grade 1. However these differences became insignificant after controlling for socio-economic and behavioural variables.</p>
<p>Ding et al. (2006)</p> <p>Secondary analysis using Georgetown Adolescent Tobacco Research (GATOR) dataset</p> <p>Sample size = 807</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Grade point average (Self-reported)	<p>Regression using the following variables:</p> <ul style="list-style-type: none"> <li>Proxy genetic markers (AD, HD, ADHD)</li> <li>Depression</li> <li>Smoker in home</li> <li>Age</li> <li>Age squared</li> <li>Ethnicity</li> </ul>	<p>Overweight was found to be significantly associated with lower educational attainment in both males and females. Girls had a significantly stronger negative relationship between obesity and achievement than boys. However, when controlling for proxy genetic markers, obese females continued to demonstrate a decrease in GPA but there was no significant relationship for obese males.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Elrod (2008)</p> <p>Secondary analysis using National Study of Adolescent Health (AddHealth) dataset</p> <p>Sample size = 3369</p> <p>Quality = SATISFACTORY</p>	USA	-	-	BMI (Self-reported)	Grades in English, Mathematics, History/Social studies, Science ( <i>Self-reported</i> )	Correlation.	Body mass had a significant but weak negative relationship with academic performance.
<p>Fletcher and Lehrer (2008)</p> <p>Secondary analysis using National Longitudinal Study of Adolescent Health (AddHealth) dataset</p> <p>Sample size = 1684</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Peabody Verbal Test Score (Measured) Grade point average ( <i>Self-reported</i> )	<p>Ordinary Least Squares (OLS) and Fixed Effects (FE) models using the following variables:</p> <ul style="list-style-type: none"> <li>Genetic markers (AD,HD, ADHD Depression)</li> <li>Gender</li> <li>Ethnicity</li> <li>Family Income</li> <li>Maternal Years of Education</li> <li>Parents Age</li> <li>Parents Married</li> <li>Birth order</li> <li>Family structure</li> </ul>	Overweight was significantly associated with lower educational achievement. However, this became non-significant once genetic markers and family variables had been taken into account.

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<b>Paper</b>	<b>Country</b>	<b>Predictor variable</b>	<b>Outcome variable</b>	<b>Measure(s) of obesity</b>	<b>Measure(s) of attainment</b>	<b>Statistical approach/moderating variables</b>	<b>Results</b>
<p>Florence et al. (2008)</p> <p>Secondary analysis using Children's Lifestyle and School-performance Study (CLASS) dataset</p> <p>Sample size = 4589</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Measured)	Elementary Literacy Assessment ( <i>Measured</i> )	<p>Multi-level regression using the following variables:</p> <ul style="list-style-type: none"> <li>Gender</li> <li>Parental income</li> <li>Parental education</li> <li>School performance</li> <li>Energy intake</li> </ul>	Overweight students were more likely to fail the elementary literacy assessment than their normal weight peers.

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Gable et al. (2008)</p> <p>Secondary analysis using ECLS-K dataset</p> <p>Sample size = 8000</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Measured)	Reading and mathematics tests (Measured)	Multi-level model using the following variables: Gender Ethnicity Family socio-economic status	Overweight status was not a significant predictor of achievement. However, compared with never-overweight peers, children who were overweight for the duration of the study performed more poorly on assessments of reading and mathematics skills at first and third grade. For children who became overweight at 1 <sup>st</sup> grade and remained overweight, scores were lower than never-overweight peers at 3 <sup>rd</sup> grade. For children who were overweight only at 3 <sup>rd</sup> grade, achievement was similar to never-overweight children.
<p>Gregg et al. (2008)</p> <p>Secondary analysis using ALSPAC dataset</p> <p>Sample size = 9476</p> <p>Quality = SATISFACTORY</p>	UK	-	-	Fat mass (Measured)	Key stage 1 scores (Measured)	Correlation.	A significant, but very weak positive correlation between: School average achievement at Key stage 1 aged 7 and individual fat mass; and individual Key stage 1 results and school average fat mass aged 9.

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Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Huang et al. (2006)</p> <p>Study conducted in 8 middle school conveniently selected from 3 school districts in the greater Los Angeles area, US.</p> <p>Sample size = 666</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	Percentage body fat; BMI ( <i>Measured</i> )	Grade point average ( <i>Self-reported</i> and <i>Measured</i> )	<p>Regression models using the following variables:</p> <ul style="list-style-type: none"> <li>Gender</li> <li>Ethnicity</li> <li>Age</li> <li>Blocks of moderate and high physical activity time</li> </ul>	<p>After adjusting for gender, ethnicity, age, and physical activity time, overweight at-risk status, BMI and percentage body fat were significantly negatively related to self-reported, but not measured, grades.</p>
<p>Judge and Jahns (2007)</p> <p>Secondary analysis using ECLS-K dataset</p> <p>Sample size = 13,680</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI ( <i>Measured</i> )	Item Response Theory (IRT) scores in mathematics and reading ( <i>Measured</i> )	<p>A series of 1-way analyses of covariance (ANCOVA), using the following variables</p> <ul style="list-style-type: none"> <li>SES</li> <li>Mother's educational level</li> <li>Ethnicity</li> </ul>	<p>Overweight children had significantly lower mathematics and reading test scores compared with non-overweight children in third grade. However, these differences became insignificant after socio-economic and maternal education variables had been included.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Kaestner et al. [adolescents] (2009)</p> <p>Secondary analysis using NLSY97 dataset</p> <p>Sample size = Boys = 1404; Girls = 1264</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Peabody Individual Achievement Test (PIAT) ( <i>Measured</i> )	<p>Regression models using the following variables:</p> <ul style="list-style-type: none"> <li>Age</li> <li>Ethnicity</li> <li>Mother's age at birth of respondent</li> <li>Mothers education</li> <li>Family structure</li> <li>Health</li> <li>Smoking</li> <li>Alcohol intake</li> <li>Place of residence</li> <li>Unemployment rate in local labour market</li> <li>County per-capita income</li> </ul>	<p>For girls, after controlling for moderating variables the negative association between overweight and educational attainment lost significance.</p> <p>For boys, after controlling for moderating variables, the relationship between overweight and educational attainment changed from a negative to a positive association. Among boys, the only significant estimates were for those in the lowest weight category.</p>



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<b>Paper</b>	<b>Country</b>	<b>Predictor variable</b>	<b>Outcome variable</b>	<b>Measure(s) of obesity</b>	<b>Measure(s) of attainment</b>	<b>Statistical approach/moderating variables</b>	<b>Results</b>
<p>Kaestner and Grossman [children] (2008)</p> <p>Longitudinal Secondary analysis using NLSY79 dataset</p> <p>Sample size = Approx: Girls = 6000 Boys = 6000</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (2/3 Measured, 1/3 Maternal report)	Peabody Individual Achievement Test (PIAT) (Measured)	<p>Regression models using the following variables:</p> <ul style="list-style-type: none"> <li>Ethnicity</li> <li>Age</li> <li>Gender</li> <li>Grade in school</li> <li>Birth weight</li> <li>Maternal age at birth</li> <li>Maternal age</li> <li>Maternal BMI</li> <li>Maternal education</li> <li>Maternal AFQT test score</li> <li>Marital status</li> <li>No. children born</li> <li>Hours of work and weeks worked per year</li> <li>Mother's family structure</li> <li>Magazines and books in household</li> </ul>	<p>For girls, the results reported across different models were inconsistent. As further variables were incorporated into successive models the relationship between weight status and achievement changed from negative to positive for 9–10 year olds. Only one statistically significant negative association was found which was reading comprehension for 11–12 year olds.</p> <p>For boys, as further variables were incorporated in successive regression models the overall trend was for a shift from a negative association to a weak positive association across all ages groups.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Kim et al. (2003)</p> <p>Students were sampled from 8 cities in South Korea to achieve geographical balance. 16 elementary schools, 14 middle schools and 14 high schools randomly selected. 1–6 classes were randomly selected at each school.</p> <p>Sample size = 6,463</p> <p>Quality = GOOD</p>	Korea	-	-	Weight ( <i>Measured</i> )	Grade point average ( <i>Measured</i> )	Correlation.	Body weight of the students had no relationship with academic performance.
<p>Li et al. (2008)</p> <p>Secondary analysis of NHANES dataset</p> <p>Sample size = 2519</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI ( <i>Measured</i> )	Wide Range Achievement Test, Revised (WRAT-R) ( <i>Measured</i> )	<p>Regressions using the following variables:</p> <ul style="list-style-type: none"> <li>Age</li> <li>Ethnicity</li> <li>Gender</li> <li>Marital status</li> <li>Health status</li> <li>Physical activity</li> <li>Social capital</li> <li>Socio-economic status</li> </ul>	The negative association between BMI and academic performance was not significant after adjusting for socio-economic status.

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Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Mikkila et al.(2003)</p> <p>Secondary analysis of the School Health Promotion Study dataset</p> <p>Sample size = 60,252</p> <p>Quality = SATISFACTORY</p>	Finland	Attainment	Obesity	BMI (Self-reported)	Grade point average ( <i>Measured</i> )	<p>Logistic regression analysis using the following variables:</p> <ul style="list-style-type: none"> <li>Education level of family</li> <li>Economic status of family</li> <li>School performance</li> <li>Physical exercise</li> <li>Use of alcohol</li> <li>School lunch</li> <li>Evening meals at home</li> <li>Use of fast food</li> </ul>	Those children in the middle and highest tertiles for school performance were significantly less likely to be obese than those in the lowest tertile.
<p>Pesa et al. (2000)</p> <p>Secondary analysis using National Longitudinal Study of Adolescent Health (AddHealth) dataset</p> <p>Sample size = 3197 (Girls only)</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Grade point average ( <i>Self-reported</i> )	<p>Multivariate stepdown F-tests and Standardized Discriminant Function coefficients (DFC) covariates:</p> <ul style="list-style-type: none"> <li>Age</li> <li>Ethnicity</li> <li>SES (proxy measure parents education)</li> <li>Grades</li> <li>Self-esteem</li> <li>Depression</li> <li>Body image</li> </ul>	<p>Overweight girls had significantly better self-reported grades than normal weight or underweight girls.</p> <p>A multivariate analysis of variance (MANOVA) revealed significant differences between groups on a combined set of psychosocial factors with grades defining the difference inversely.</p>

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Sabia (2007)</p> <p>Secondary analysis using National Longitudinal Study of Adolescent Health (AddHealth) dataset</p> <p>Sample size = 4128</p> <p>Quality = SATISFACTORY</p>	USA	Obesity	Attainment	BMI (Self-reported)	Grade point average ( <i>Self-reported</i> )	<p>Ordinary least squares (OLS), Instrumental Variables (IV), and individual Fixed Effects (FE) models using the following variables:</p> <ul style="list-style-type: none"> <li>Age</li> <li>Intelligence (AHPVT Score)</li> <li>Ethnicity</li> <li>Romantically involved</li> <li>Sexually active</li> <li>Household receives AFDC</li> <li>Age of mother</li> <li>Age of mother at child's birth</li> <li>Single parent household</li> <li>Mother working</li> <li>Household income</li> <li>Public school</li> <li>Place of residence</li> <li>Region of country</li> <li>Older siblings</li> <li>Alcohol consumption</li> <li>Parental strictness</li> <li>Religious attendance</li> </ul>	<p>The pattern of findings across models suggested consistent evidence of a significant negative relationship between BMI and grade point average (GPA) for white females aged 14–17. Estimates reflected that a difference in weight of 50 to 60 pounds was associated with an 8 to 10 percentile difference in standing in the GPA distribution. The association between weight status and achievement was negative for white males but after controlling for moderating variables did not remain significant. For non-white females and males, the relationship between body weight and academic performance was consistently negative, but did not always remain statistically significant after additional instrumental variables were used in successive models. The OLS model revealed that approximately 10% of the variation in GPA was attributable to weight status.</p>

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Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
						Frequency of family dinners Meat consumption at breakfast Educational aspirations Parental education Parent moved due to school system Parental monitoring Parental disapproval Sporting activity Regular exercise	
Shore et al. (2008)  Study conducted with 6 <sup>th</sup> and 7 <sup>th</sup> grade students enrolled in a large public middle school in a suburb of Philadelphia, Pennsylvania, US.  Sample size = 566  Quality = GOOD	USA	Obesity	Attainment	BMI (Measured)	Grade point average ( <i>Measured</i> ); Degree of Reading Power (DRP) test ( <i>Measured</i> )	One-way ANOVA using the following variables: Ethnicity Gender Socio-economic status (school lunch enrolment)	The GPAs of non-overweight students were significantly higher (approximately 11%) than those of the overweight students. There was a general tendency for lower DRP national percentile scores in overweight students, compared to non-overweight students, when controlling for demographic variables (although the difference between groups was not significant).

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Sigfúsdóttir et al. (2007)</p> <p>Secondary analysis using Youth in Iceland dataset</p> <p>Sample size = 5810</p> <p>Quality = SATISFACTORY</p>	Iceland	Obesity	Attainment	BMI (Self-reported)	Grade point average ( <i>Self-reported</i> )	<p>Ordinary Least Squares (OLS) regression using the following variables:</p> <ul style="list-style-type: none"> <li>SES (Parental education)</li> <li>Gender</li> <li>Family structure</li> <li>Absenteeism</li> </ul>	<p>There was a weak, significantly negative association between BMI and academic achievement when controlling for gender, parental education, family structure and absenteeism.</p>
<p>Von Hinke Kessler Scholder (2009)</p> <p>Secondary analysis using ALSPAC dataset</p> <p>Sample size = Approx 3,500</p> <p>Quality = SATISFACTORY</p>	UK	Obesity	Attainment	Fat mass ( <i>Measured</i> )	<p>Key stage 3 scores (<i>Measured</i>)</p>	<p>Ordinary least squares (OLS), and Instrumental Variables (IV) models variously using the following variables:</p> <ul style="list-style-type: none"> <li>Log income</li> <li>Maternal education</li> <li>Maternal BMI</li> <li>Maternal pre-pregnancy BMI</li> <li>Social class</li> <li>Genetic markers</li> <li>Birthweight</li> <li>Mother's health and health behaviour</li> </ul>	<p>OLS results demonstrated better key stage results for leaner children compared to their heavier counterparts at age 11. In contrast genetic IV estimates found no evidence that children's fat mass aged 9 affected their academic performance, with the observed association apparently driven by unobserved characteristics.</p>

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<p>Wang and Veugelers (2008)</p> <p>Secondary analysis using Children's Lifestyle and School-Performance Study (CLASS) dataset</p> <p>Sample size = 4945</p> <p>Quality = SATISFACTORY</p>	Canada	Obesity; Attainment	Attainment ; Obesity	BMI (Measured)	Elementary Literacy Assessment ( <i>Measured</i> )	<p>Structural equation models incorporating the following variables:</p> <ul style="list-style-type: none"> <li>Place of residence</li> <li>Gender</li> <li>Parental education</li> <li>School performance</li> <li>Self-esteem</li> <li>Household income</li> <li>School neighbourhood level income</li> <li>Diet quality index</li> <li>Physical activity</li> <li>Sedentary activity</li> </ul>	Body weight had a negligible but nonetheless negative association with weight status. The relationship was not statistically significant.

Paper	Country	Predictor variable	Outcome variable	Measure(s) of obesity	Measure(s) of attainment	Statistical approach/moderating variables	Results
<p>Wendt (2009)</p> <p>Secondary analysis using ECLS-K dataset</p> <p>Sample size = Approx 14,000</p> <p>Quality = GOOD</p>	USA	Obesity	Attainment	BMI (Measured)	Item Response Theory (IRT) scores in mathematics and reading (Measured)	<p>Econometric models using the following variables:</p> <ul style="list-style-type: none"> <li>Parental Time</li> <li>Mothers Working Early</li> <li>Quality of Time and Frequency of Evening Meals Together</li> <li>Family Structure and Size</li> <li>Parental Education</li> <li>Household Income</li> <li>Parental Health</li> <li>Food Security Status</li> <li>Frequency of Doctor Visits</li> <li>Bedtime</li> <li>Physical Activity and Physical Education at School</li> <li>Home Computer Using and TV Watching</li> <li>School Lunch Participation</li> <li>Ethnicity</li> <li>Gender</li> <li>Age</li> </ul>	<p>Underweight or overweight children achieved lower test scores, for mathematics. This pattern remained significant, whether contemporaneous weight status or changes in weight status over time were used as moderating variables. Reading scores were significantly and negatively associated with current obesity but not changes of weight status over time.</p>



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<b>Paper</b>	<b>Country</b>	<b>Predictor variable</b>	<b>Outcome variable</b>	<b>Measure(s) of obesity</b>	<b>Measure(s) of attainment</b>	<b>Statistical approach/moderating variables</b>	<b>Results</b>
						Birthweight Place of residence School (public/private)	

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