# Reviews of Scientific Evidence and Policies on Nutrition and Physical Activity

Objective Area C: A comprehensive review of the scientific evidence on the effect of overweight/obesity and/or inadequate physical activity on school or work performance

Written by ICF Consulting Services Ltd

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## Contents

# Preface

## About this project

Overweight, obesity and their related diseases represent a leading cause of morbidity and mortality, and pose a major challenge for the sustainability of healthcare systems of EU Member States. The growing prevalence of overweight and obesity among all age groups across Europe constitutes a serious concern for policy makers. Tackling this issue requires a comprehensive response that reflects the multifactorial and complex nature of obesity and overweight. One particularly important area of focus has been on the development of preventative strategies which include nutritional and physical activity interventions.

The European Commission Directorate General for Health and Food Safety (DG SANTE) recognises the significant challenges policy makers face in developing effective and efficient policy interventions relating to diet and physical activity. One such challenge includes the complexity and breadth of the evidence base. By providing independent, accurate summaries of recent and relevant information and statistics on determinants of diet and physical activity and their impact on health, this project aims to support policy makers to continue to develop policy instruments which enable people to make healthier lifestyle choices. In particular, this project aims to support the development of healthier behaviours in vulnerable and/or at-risk subpopulations (including children, pregnant and lactating women, and older adults) and low socio-economic status groups (including low income and education).

## About this series

This evidence review is one of eight reviews relating to different determinants of diet and physical activity.

Seven of the reviews are of the scientific evidence and policies in the following areas:

- Knowledge, attitudes and behaviours contributing to positive energy balance (objective area A1);
- Dietary and physical activity patterns in Europe (objective area B1);
- Consumption of fruit juices, artificially and sugar-sweetened beverages and its impact on weight status and health (objective area B2);
- Consumption of high-fructose syrup and its impact on weight status and health (objective area B3);
- Relationship between weight status and physical activity with school and work performance outcomes (objective area C);
- Early warning indicators of obesity and physical inactivity trends (objective area D);
- Nutrition and physical activity guidelines for specific population groups (objective area E).

Building on these seven reviews, the final review (objective area A2) examines specifically the evidence for effective and efficient policies and interventions in terms of promoting, supporting and improving nutritional and physical activity behaviours at both individual and population level.

All reviews, and their summaries, are available on the DG SANTE webpage here.

## Approach and purpose

The reviews have been designed to provide policymakers with summaries of recent and relevant evidence in these key areas of interest. Given the broad scope of each of the reviews, it should be stressed that they are not intended to be rigorous systematic reviews of all literature published in this field. Rather, they are intended as pragmatic

reviews combining a comprehensive search methodology with expert academic input, facilitated through workshops, to provide a practical and accurate summary of key issues and tackling broad lines of enquiry, with the greater aim of supporting the development and improvement of policies in this area. Each of the project's eight methodologies and analyses was reviewed by DG SANTE and academic experts in these topics.

While the methods to conduct this comprehensive literature review are systematic, it is *not* a systematic review. This review does not systematically analyse literature to identify *all* relevant published data and/or appraise its quality. Methods to conduct the literature review consisted of five steps: (1) refining the research questions, (2) developing a search approach and databases, (3) conducting literature searches, (4) screening articles for inclusion; and (5) abstracting and synthesising relevant data.

To minimise bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria), agreed with DG SANTE, to guide searches and inform screening and selection processes for data inclusion. Due to the immense number of literature search results at step 3, the application of quite limiting exclusion criteria at step 4 was deemed necessary. This may however have resulted in not screening all potentially relevant literature. All relevant articles that were found appropriate for inclusion were reviewed for relevance to each objective area, and the scope of the specific research questions. Furthermore, the inclusion of different types of scientific evidence (from systematic reviews and peer-reviewed original articles down to BSc theses) and the presentation of this scientific evidence next to grey literature information presented a challenge in terms of maintaining an understanding of the quality and weight of the evidence. The authors addressed this to some extent by structuring the document in such a way that peer-reviewed and grey literature are clearly identified. The full methodology and steps taken for each review is included in Annex of this document.

DG SANTE and the Joint Research Centre (JRC) provided input on all stages of the project and comments on the literature reviews. Expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed.

The methodology used across all eight reviews remained consistent, and within each review a detailed summary of the approach is provided, along with a full bibliography for further reading.

## Glossary

The following definitions are common definitions that are used across all eight objective areas. Where a study uses a different definition, this will be highlighted on an individual basis in the review.

*Table 1. Definitions of terms used across the reviews*

| Term | Definition | Source |
|---|---|---|
| Adult obesity | An abnormal or excessive fat accumulation that presents a risk to health, with a BMI of 30 or more. | World Health Organisation (WHO) (http://www.who.int/topics/obesity/en/) |
| Adult overweight | An abnormal or excessive fat accumulation that presents a risk to health, with a BMI equal to or more than 25. | WHO (http://www.who.int/topics/obesity/en/) |
| Alcopops | Pre-mixed beverages containing a spirit, wine or malt combined with a non-alcoholic drink. | 1. Anderson, P., Suhrcke, M. and Brookes, C. (2012) An overview of the market for alcohol beverages of potentially particular appeal to minors. London: HAPI. |
| Artificially sweetened beverages (ASBs) | Beverages sweetened with low-calorie or zero-calories sweeteners such as sucralose, aspartame, saccharin, stevia or sugar alcohols. | ICF definition based on all literature identified in objective area B2 literature review |
| Body Mass Index | A person's weight (in kilograms) divided by the square of his or her height (in metres). | WHO (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html) |
| Child/adolescent obesity | There are different systems available to measure child or adolescent obesity for different ages.<br>Children under 5 obesity is weight-for-height greater than 3 standard deviations above WHO Child Growth Standards median;<br>Children aged 5-19 overweight is BMI-for-age | WHO<br>http://www.who.int/mediacentre/factsheets/fs311/en/<br>(Other definitions are available for different national and international systems). |

| Term | Definition | Source |
|---|---|---|
| | greater than 2 standard deviation above the WHO Growth Reference median. | |
| Child/adolescent overweight | There are different systems available to measure child or adolescent overweight for different ages.<br><br>Children under 5 overweight is weight-for-height greater than 2 standard deviations above WHO Child Growth Standards median;<br><br>Children aged 5-19 overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median. | WHO<br><br>http://www.who.int/mediacentre/factsheets/fs311/en/<br><br>(Other definitions are available for different national and international systems). |
| Exercise | Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective. | WHO<br><br>(http://www.who.int/dietphysicalactivity/pa/en/) |
| Insufficient physical activity | Physical activity that does not meet WHO recommended levels of at least 60 minutes a day of moderate-vigorous activity for children and adolescents and at least 150 minutes of moderate-intensity aerobic physical activity throughout the week for adults. | WHO<br><br>http://www.who.int/mediacentre/factsheets/fs385/en/ |
| Physical activity | Any bodily movement produced by skeletal muscles that requires energy expenditure. | WHO<br><br>(http://www.who.int/topics/physical_activity/en/) |
| Physical inactivity | A lack of physical activity | WHO<br><br>(http://www.who.int/diet |

| Term | Definition | Source |
|---|---|---|
| | | physicalactivity/pa/en/) |
| Sedentary behaviour | Any waking behaviour characterized by an energy expenditure ≤1.5 metabo lic equivalents (METs) while in a sitting or reclining posture. | Tremblay, M. S., et al. (2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *The International Journal of Behavioral Nutrition and Physical Activity*, *14*, 75. http://doi.org/10.1186/s12966-017-0525-8 |
| Sugar sweetened beverages (SSBs) | Any beverage with added sugars. This includes soft drinks, soda, fruit drinks, punch, sports drinks, sweetened tea and coffee drinks, energy drinks and sweetened milk. These beverages may be sweetened with added sugars such as sucrose (table sugar) or high fructose corn syrup, which is what distinguishes them from 100% fruit juice and beverages with non-caloric sweeteners (e.g., aspartame, saccharin or sucralose). | US Department of Agriculture. 2010. *US Department of Health and Human Services. Dietary guidelines for Americans, 2010.* 7th edition, Washington (DC): US Government Printing Office |

## Objective C: A comprehensive review of the scientific evidence and policies on the effect of overweight/obesity and/or inadequate physical activity on school or work performance

This report presents the findings of a peer-reviewed literature and grey literature review related to the effect of overweight/obesity and/or inadequate physical activity on school or work performance. It has four sections:

Introduction, describing the relevance of this topic, the scope of the review, and the principal research questions;

Methodology, describing how the review was undertaken and relevant findings extracted;

Findings from the peer-reviewed and grey literature, presented according to each research question; and

Conclusions drawn from the review overall and an assessment of the current scientific evidence, including any gaps in the knowledge.

# 1 Introduction

Overweight and obesity have become major public health concerns. Worldwide, obesity has nearly tripled between 1975 and 2016 (WHO 2017) and recent data[1] suggest that Europe is second to the United States in proportion of overweight and obese adults. Across the EU 28 Member states the proportion of men that were overweight or obese in 2014 ranged from 53.6% (Netherlands) to 67.5%(Croatia) and from 36.1% (Italy) to 55.2% (Malta) of women (European Commission – Eurostat 2016).[2] Among children aged 6-9 years in 13 countries across the WHO European region in 2009/10[3], prevalence of overweight or obesity (WHO definitions) ranged from 18% to 57% among boys and from 18% to 50% among girls; 6% to 31% of boys and 5% to 21% of girls were obese (Wijnhoven et al., 2014)

In addition to increases in overweight and obesity, people of all ages throughout Europe and other developed countries are engaging in insufficient amounts of physical activity. The World Health Organization (WHO) recommends that children and adolescents should engage in 60 minutes of moderate intensity physical activity daily, and adults aged 18-65 should engage in 30 minutes of moderate intensity, or 20 minutes of vigorous intensity physical activity, at least five days per week. However, according to WHO figures, in 2010, 23% of adults aged 18 years and over were insufficiently physically active. European surveillance data indicates that 59% of European Union citizens never or seldom exercise or play sport (Eurobarometer 2014). Perhaps more worrying are the global WHO figures for adolescents, which found that in 2010 81% of adolescents aged 11–17 years were insufficiently physically active. Adolescent girls were less active than adolescent boys, with 84% versus 78% not meeting the daily 60 minute recommendation (WHO 2014).

The health consequences of overweight, obesity and physical inactivity have been well documented, at an individual and socioeconomic level. For example, in 2007, the UK Foresight project projected that obesity would account for 13% of UK healthcare costs in 2050 (Foresight 2007a). However, there are potentially other non-health related impacts of overweight, obesity and physical inactivity – including impacts on the labour market

[1] These data are based on the European Health Interview Survey (EHIS), which consists of four modules on health status, health care use, health determinants and socio-economic background variables. EHIS targets the population aged at least 15 and living in private households. See http://ec.europa.eu/eurostat/web/microdata/european-health-interview-survey

[2] EHIS 2013 to 2015, (Europe Commission – Eurostat, 2016) . See: http://ec.europa.eu/eurostat/statistics-explained/index.php/Overweight_and_obesity_-_BMI_statistics#Body_mass_index

[3] The last published wave of international results from the Child Obesity Surveillance Initiative (COSI), malta and Cyprus results not included in anlysis due to late submission to database

through impaired performance, that have been calculated as the indirect costs of obesity (OECD 2010). This review considers these consequences by first looking at the potential influence of overweight, obesity or physical inactivity upon children and their performance at school. We then consider the evidence for the consequences of these health behaviours on work performance. The UK Foresight project also involved the creation of a sophisticated obesity map (Foresight 2007b); a visual illustration of 108 different variables with obesity and their different interdependencies, demonstrating the multidisciplinary and complex nature of the issue. It highlights, in particular, the complex association between physical (in)activity and overweight and obesity. Our review does not examine this relationship between overweight/obesity and physical inactivity, but where studies have examined it we have discussed findings with consideration of this association.

## 1.1 Scope of the review

The purpose and scope of this review is to examine the associations between overweight/obesity or physical (in)activity with school or work performance. We have used the term cognitive outcomes to broadly refer to the various types of measures used to assess academic performance, time on task, attention and other indicators in studies reviewed. Among workers, we consider measures such as productivity and work participation, as well as absenteeism and presenteeism.

## 1.2 Research questions for this review

In this review, we focus on the most current literature (peer-reviewed original research and systematic reviews, as well as grey literature) that addresses the relationships between overweight/obesity or physical activity and school or work performance. The research addressed the following questions specified for the review:

- What are the **consequences** of overweight, obesity and physical (in)activity for **students' performance** (from kindergarten to college)?
- What are the **consequences** of overweight, obesity and physical (in)activity for **workers' performance**?

The findings from the third research question (mentioned below) are included in Objective A2, as an overarching objective area report on existing policies in the broader thematic area of nutrition and physical activity:

- What policies are more effective and efficient in this area (information, advertising, taxation, reformulation, regulations, partnerships, etc.)?

# 2 Methodology

The review is based primarily on peer-reviewed literature (which is prioritised), with grey literature used to supplement any gaps (but treated with caution and the strength of the evidence assessed). For each set of literature, specific search terms and inclusion and exclusion criteria were used and quality checks undertaken. The research questions and search terms were confirmed with DG SANTE at the outset, and then refined during a review point within the process.

After the initial searching and extraction of literature, drafts were provided to DG SANTE and the Joint Research Centre (JRC) for review. Workshops with experts from relevant academic and policy-making fields were then held to discuss findings and highlight any additional sources to fill gaps, in order to improve the series of reviews. The final outputs of the study ('the reviews' as presented here for objective C) were then reviewed by a topic expert at the University of Birmingham.

While the methods to conduct this comprehensive literature review are systematic it is not a systematic review.

More information on the methodology can be found in the Annexes.

## 2.1 Peer review method

To search for and extract the most relevant peer reviewed literature the following steps were taken: refining the research questions; developing a search approach and databases; conducting literature searches; screening articles for inclusion; and abstracting and synthesizing relevant data.

A total of 10,621 search hits of peer reviewed literature were initially retrieved using selected search terms per research question. A total of 700 duplicates were found and removed from the search hits resulting in 9,921 search results for objective C. From the 2509 articles, the team screened 400 of the most recent titles and abstracts (200 for each of the two research questions, to create a manageable amount of material within the resources for the study; and on the premise that the most recent material was most relevant science). From the 400 most recent titles and abstracts screened, 265 were deemed of potential relevance and reviewed as full texts. From these 265 full texts, 24 publications were selected for inclusion in this final review. Search terms for the research questions and bibliography of included sources can be found in Annex 2 and Annex 3.

## 2.2 Grey literature method

To search for and extract the most relevant grey literature the following steps were taken: searching for publications using agreed keywords and databases; screening of search results, exclusion of less relevant literature, and extraction and review of remaining documents. The grey literature search process was a more fluid and dynamic process, where hand searching was also utilised to find the most relevant sources.

A total of 55,448 search hits of grey literature were initially identified using selected search terms. A total of 531 search hits were retrieved and saved for objective C. From the 531 articles, the team excluded 460. From the 71 deemed relevant and reviewed as full texts, 40 publications were selected for inclusion. The full grey literature searching and extraction methodology is outlined in Annex 4.

# 3 Findings and discussion

## 3.1 Research Question 1: What are the consequences of overweight, obesity and physical (in)activity in students' performance (from kindergarten to college)?

The findings from the reviews are presented in response to each research question, with subsections relating to different themes and illustrated by relevant findings from the peer-reviewed and grey literature. Not all themes emerged in the same way in the two reviews and as a consequence, findings from either review are presented in the order that best exemplifies that message.

Definitions of terms used were made explicit in peer-reviewed literature but not in the grey literature, where 'overweight', 'obesity' and 'physical inactivity' were sometimes not given exact classifications. Ages of 'children', 'young people' and 'adolescents' were also not referred to. Indeed, the conclusions presented in the grey literature tended to be more general than those of peer-reviewed studies – specifics are given where possible.

A summary of key messages for each research question is presented first for ease of understanding.

### 3.1.1 **Summary**

Peer-reviewed research found mixed evidence for an inverse association between overweight or obesity and cognitive outcomes, with some patterns identified but no strong conclusive relationship emerging.

In the peer-reviewed studies, where an inverse association between weight (overweight and obesity) and cognitive outcomes has been observed, subsequent analyses have found these relationships weaken or become nonsignificant when variables such as parent socioeconomic position, child physical activity, race/ethnicity or weight-based teasing are introduced. This suggests that these are key confounding factors in the association between weight and cognitive outcomes.

Review articles additionally suggest that an influence of social-cultural factors, such as parent education levels or school climate (e.g., presence of bullying), may independently affect the relationship between obesity and academic achievement. This suggests a complex causal pathway for overweight/obese school age children's academic performance.

- Both peer-reviewed literature and grey literature reviews found evidence that aerobic activity is beneficial for cognitive outcomes.

A variety of measures were found in review articles to assess physical activity and academic performance. This variability in measures across research likely explains differences in effect sizes or associations found.

### 3.1.2 Consequences for overweight and/or obesity and academic performance

**There is mixed evidence in peer-reviewed literature for an inverse association of overweight and/or obesity with student performance – present for some groups of young people, with achievement in certain subjects, but not for all.** There appears to be some limited systematic review evidence (Martin et al. 2017, Taras and Potts-Datema 2005) of an inverse association between overweight/obesity and student academic performance but it was not of a conclusive nature. Across studies, age, grade-level, sex, physical (in)activity and diet were commonly, but inconsistently, reported as other associated factors of this relationship.

While Taras and Potts-Datema (2005) concluded obesity was broadly associated with poorer levels of academic performance, a recent systematic review of 31 longitudinal studies

(Martin at al. 2017) could only find this association between overweight or obesity and lower maths attainment among adolescent girls. From the 31 studies of 17 cohorts,[4] Martin and colleagues identified 5 studies of high quality that found this inverse association for overweight 13-14 year old girls and three studies, of similar high quality, that found it for obese girls. However they did find that the relationship between obesity with adolescent girls' maths attainment was mediated by being the victim of weight-related bullying and executive cognitive functions. Still, the authors ultimately concluded that the association between obesity and academic performance is not well established.

Alongside specific subject attainment, Taras and Potts-Datema (2005) also considered more general cognitive abilities (memory, general intelligence). In their review of 10 articles from 1994-2004 which assessed associations between obesity among international[5] school-aged children and academic outcomes (e.g. academic performance and student absenteeism) they found that overweight and obesity in school-aged children are associated with poorer levels of academic achievement. However, there was too sparse data available to draw conclusions on the associations between overweight/obesity and school absenteeism levels. The authors note that some experimental designs controlled for influence of low family income and low parent education levels. These social-cultural factors are theorized to independently affect levels of both obesity and academic achievement.

- **Individual population-based Studies identified also found a lack of conclusive evidence for an inverse association between overweight or obesity and academic achievement.** This included two studies (Carter et al. 2010, Roberts et al.2010), that found complicated but still inverse associations between being overweight or obese and test scores. Others either did not find associations between school age children's overweight/obesity levels and school performance at all (Afzal and Gortmaker 2015); or an identified association became statistically insignificant when these studies adjusted for socio-cultural-environmental factors in their analyses (e.g. for socioeconomic status of their parents) (Krukoswki et al. 2009, Li et al. 2008, Datar et al.2005).

- Using a large representative sample of Canadian children (n = 4,664) from a longitudinal database, Carter et al. (2010) found that children who were always obese, or developed obesity over the course of the study, did not perform at the same level on standardized mathematics examinations as children who were never obese, but the difference was not statistically significant[6]. Furthermore, children who were obese at baseline and no longer obese at follow-up, scored significantly higher on the standardized maths test than those children who were never obese ($p<0.0001$). This latter finding was a novel one, which the authors suggest may be due to biological reasons- that peak adiposity during infanthood supports optimal brain development. An alternative explanation they also discuss was that high SES parents are more likely to have heavier children that grow out of obesity, but perform well academically because of their early socioeconomic environment.

- In a study of 1,989 youth aged 10-14 years, Roberts et al. (2010) found that, when controlling for parent education, students classified as 'overweight' and 'obese' based on BMI, scored significantly lower on the standardized tests than students in the 'desirable weight' category. The researchers also found a significant positive

[4] 11/31 studies performed secondary analysis of the Early Childhood Longitudinal Study—Kindergarten Class (ECLS-K) in the USA. The other studies used datasets from the USA; Canada; UK; Netherlands; Australia and Taiwan, with five studies from Australia, Germany, Taiwan, Thailand, and Peru using primary data for their prospective analyses

[5] U.S., Asia, Western Europe, and South American

[6] Obesity was determined based on child height and weight as reported by the mother. Researchers used the IOTF age- and sex-specific body mass index cut-offs when the cohort was aged 2–5 years and 8–11 years.

association between aerobic fitness (based on the California mandated fitness assessment FitnessGram®) and higher performance on standardized academic achievement tests.[7] Subsequent analyses indicate that the significant relationship observed between BMI and test scores may be mediated by aerobic fitness.

- Afzal and Gortmaker (2015) used data from the U.S. National Longitudinal Survey of Youth (NLSY), and found little evidence of a significant longitudinal relationship between obesity (BMI levels) and cognitive test scores among a nationally representative cohort of youth. The authors note that the detrimental effects of obesity on cognitive abilities or school performance may take several years to manifest. Still, the six year follow-up period for the NLSY failed to capture significant changes.

- In an unadjusted analysis of data from a cohort of 2,519 children aged 8-16 years[8], Li et al. (2008) looked at the associations between BMI, cognitive functioning (CF) and academic performance (AP). They found a significant negative association between BMI and CF when accounting for parent demographics, sports participation, physical activity, and sedentary screen time in statistical models. However, when adjusting for parent demographics, no statistically significant associations were found between BMI and AP in their sample.

- Among a sample of 11,192 children attending kindergarten, Datar et al. (2005) found that children with a BMI ≥ the 95$^{th}$ percentile had significantly lower maths and reading scores when compared with those with a BMI ≤ the 95$^{th}$ percentile. However, after accounting for -other potential factors, such as socio-economic status, this association was not statistically significant. Instead, mother's education and child race/ethnicity were significantly associated with performance on the standardized examinations.

- Krukowski et al. (2009) found that students who were overweight or obese were more likely to have poor academic performance when compared with their normal weight peers. Associations between weight status and academic performance were assessed among a random sample (n=1,071) of parents in the southern U.S who were surveyed about their child's school performance, demographics, height and weight and experience of teasing. However, this relationship was no longer significant when weight-based teasing was introduced into the analysis. Those who were teased were less likely to perform well academically when compared with those who had not been teased about their weight. This suggests that weight-based teasing was the key influence on performance, rather than the weight itself.

The grey literature was more likely to emphasise a strong negative association between overweight or obesity and cognitive outcomes, but also acknowledged similar mediating factors and psychosocial explanations for any relationships observed. A WHO systematic review of peer-reviewed studies from 1995-2008 (Suhrcke and De Paz Nieves 2011) looking at children aged 1-18 years, as well as expert testimony and a background evidence review, for the two-day WHO/HBSC 2006 Forum held in Italy (Mathieson and Koller 2006) found that:

[7] FitnessGram® refers to a comprehensive battery of physical fitness assessments developed by the Cooper Institute for Aerobics Research to assess health-related physical fitness.

[8] From the US National Health and Nutrition Examination Survey,

- Overweight and obesity are negatively associated with educational outcomes but there is contradictory evidence about gender differentiation (Suhrcke and De Paz Nieves 2011);
- Overweight and obesity in children may negatively affect their psychosocial, emotional and physical development (Mathieson and Koller 2006); and
- Poor nutrition, e.g. skipping breakfast or substituting healthier food for high fat or sugary-food (associated with overweight and obesity) can impair a child's ability to concentrate at school, which can harm their performance (Mathieson and Koller 2006)

A German study (District Office of the Rhine Neckar Metropolitan Region 2006) found an association between weight and academic performance varied with age. An analysis of parent-reported child behaviour questionnaires in Rhine-Neckar Metropolitan Region and Heidelberg, Germany, found a relationship between obesity and poorer school performance in primary school children. However, there was no significant statistical relationship found among secondary school children. They also found that obese primary school children needed more help with their homework.

Studies published in grey literature were also identified, which found only small, non-significant effects of weight status on cognitive outcomes. All of which had either small samples or self-report methodologies. A study in Quebec (Aimé 2012), found that obesity (measured by BMI score) did not impair students' performance in certain subjects: French, Maths, English and science, but did lead to significantly worse results in physical education. The study was undertaken with 346 children aged 8-12 years in the Outaouais region of Quebec. The author raises concerns that absenteeism from physical education (PE) classes and subsequent poorer performance in that subject may result from stigma-induced lower self-esteem among overweight and obese children. The author argues that rather than the actual weight of a child adversely affecting performance in PE, it may be their perception of their weight that puts them at risk.

Merot et al. (2007) report a study of 97 young people (average age 12.4 years) from the Hautes-Alpes region, France, which observed a relationship between obesity and delayed reading ability, but indicated this association was not statistically significant. They found an average delay of 26 months in reading ability among obese young people (22 and 30 months for obese girls and boys, respectively) in comparison with young people who were of a healthy weight.

**Grey literature described different explanations or mechanisms for any association between weight and academic performance.** In trying to understand this relationship, Suhrcke and De Paz Nieves (2011) in their WHO systematic review caution that the complex nature of obesity can impede a clear assessment of causality. Three other reviews (Cullen 2011, Merot et al. 2007, Mathieson and Koller 2006), suggest psychosocial explanations for this association.

The 2006 WHO Forum report suggests children's sense of self-worth and confidence can be undermined by stigma from others about their weight (expressed through teasing). Furthermore, self-consciousness about weight or lack of fitness can lead youth to avoid physical activity (Mathieson and Koller 2006).

In a paper for a British Psychological Society working group, Cullen (2011) reviewed academic literature, empirical data and grey literature on exercise, pharmacological and psychological intervention programmes and found that:

- Severely obese children and adolescents may miss more school days than the general student population.

- Obese children have lower expectations of themselves in terms of school performance and educational future, and may also be subject to lower expectations from their teachers.
- Bullying of obese children can provoke them to retaliate with violence, unfortunately resulting in their own exclusions, early exit from education and thus lower attainment.

As part of their mixed-methods study of literature, secondary data and their own fieldwork, Merot et al. (2007) reviewed several studies, which indicated that obesity could negatively affect academic performance due to psychosocial issues, including lack of sleep and depression. They also cite evidence that obesity can lead to the secretion of substances that can damage cerebral neurons, leading to a deterioration of cognitive performance. However, they do not provide in-depth detail on the pathway for this relationship.

### 3.1.3 Consequences of physical (in)activity and academic performance

**Systematic reviews identified a positive relationship between physical activity and school performance, but found different strengths of association and some evidence of no association at all**. There was wide variation in study design and outcomes relating to academic performance and physical (in)activity in the peer-reviewed literature we identified. Three systematic reviews (Santana et al. 2017, Singh et al. 2012 and Rasberry et al. 2011) found either: a weak to moderate positive association between different measures of physical fitness (as opposed to activity) and cognitive performance; a positive association between physical activity and academic performance (but few high quality studies to show this association); or, a positive association between physical activity and academic performance, but in only half of studies considered. These findings are further described below:

- In a systematic review of 45 studies, Santana et al. (2017) found positive associations between different measures of physical fitness (PF) [9]and academic performance (AP)[10] in samples ranging from 42 to 2,550,114 participants. 34 studies reported a strong positive association between AP and cardiorespiratory fitness (CRF), but evidence for this relationship mainly came from cross-sectional studies. Seven studies also reported a positive association between clustered PF components (e.g. CRF, knee push-ups, wall sitting and strength) and AP in longitudinal prospective studies. The authors found that most of the studies showed weak to moderate associations between PF (of different measures) and AP, but results suggest that clusters of PF components can positively contribute to AP in youth.
- Singh et al. (2012) also found evidence of a positive association between physical activity[11] and academic performance[12]. In their systematic review of 14 longitudinal studies, using observational (n=10) or intervention designs (n=4), they examined the relationship between physical activity and academic performance among samples ranging from 53 to 12,000 children and adolescents (aged 5-18 years). They found a significant positive association across studies but only 2 out of 14 were high quality papers, and they underlined the need for further research to confirm their findings.
- In a systematic review of 43 peer-reviewed publications, Rasberry et al. (2011) identified consistent, positive associations between school-based physical activity and

[9] Cardiorespiratory fitness (CRF), muscular strength and endurance, body composition, flexibility, balance, agility, coordination, reaction time and power.

[10] Grade point averages, clustered achievement tests, specific tests for reading or arithmetic skills (reading speed, fluency and comprehension,) and the ability to solve logical/arithmetic problems.

[11] Self-reported athletic participation; teacher-reported or school administrator-reported physical education participation; parent-reported aerobic activity levels, exercise behaviour or participation in a sports team or league.

[12] Self-reported grades; cognitive test scores; or both.

academic performance[13]. Studies were observational or interventions, which examined this association in four different school-based contexts; (1) physical education, (2) recess (school breaks), (3) classroom-based physical activity, and (4) extracurricular physical activity. Across studies reviewed, 251 associations were assessed to determine the strength and direction of relationships between physical activity and academic performance. They found that approximately half (127) of the studies showed a significant positive association between physical activity and academic performance, but 48% did not show a statistically significant association, and 1.5% showed a significant negative association.

**Studies that assessed interventions targeting school age children found positive associations between physical activity and school performance**. However, studies used small samples and some employed self-report methods to assess physical activity. One study found no significant positive association between extra-curricular physical activity and school performance. Three studies including a meta-analysis (Howie et al. 2015, Fedewa and Ahn 2011, Donnelly and Lambourne 2011) found positive associations between school-based physical activity and academic performance. Sanchez-Alcaraz Martinez and Del Mar Andreo Bernal (2009) looked at physical activity outside of school, but found no positive association.

- Fedewa and Ahn's (2011) meta-analysis of 59 intervention studies of school-aged children found a statistically significant positive effect of interventions designed to increase physical activity[14] and school-age children's cognitive outcomes[15]. However, there was considerable variation in the measures for physical activity and cognitive outcomes. Further analyses showed that effect sizes were largest ($p<0.01$) for mathematics (0.44), intelligence quotient (IQ) scores (0.39), and reading (0.36). Effect sizes were also greatest for physical activity interventions that: involved small (0.47) and medium (0.39) group classes, provided a total of 36-70 hrs of activity during the academic year (0.45), made the intervention/physical activity available three days per week (ES 0.45), and involved physical activity that focused on development/motor skills (0.47) and cardiovascular fitness (0.40).
- Howie and colleagues (2015) found that an intervention involving physical activity breaks during classroom instruction was significantly positively associated with performance on mathematics examinations. Students from four fourth-grade and four fifth-grade classrooms with either 10- or 20-minute physical activity breaks demonstrated significant increases in mathematics lesson scores, when compared to students in classrooms with a 10-minute session of sedentary activity[16]. The researchers did not find statistically significant changes in scores for students in the minute activity break condition as compared to those in the sedentary lesson condition. It should be noted that the sample size for this particular study was relatively small (n=96 students across grades 9-12).
- Donnelly and Lambourne (2011) conducted a 3-year cluster randomized trial of a physical activity curriculum intervention, which included 584 children (intervention n=316, control n=268) in grades 2 and 3 at baseline. Following the intervention (75 minutes physical activity instruction time per week), they observed significant

[13] Cognitive skills and attitudes; academic behaviours and academic achievement.

[14] Resistance/circuit training; perceptual motor training; regular PE; aerobic training and different combinations of activities.

[15] Overall Effect size from all studies = .28, $p<.01$ (Standard Error [*SE*], .04). Effect size of studies with experimental/quasiexperimental designs = .35, $p<.01$ (*SE*, .04).

[16] Students participated in four conditions; 10 minute of sedentary classroom activity; 5-min, 10-min, and 20-min exercise breaks, with each classroom participating in different intervention on a consistent time and day each week.

increases in academic achievement among students in the intervention schools, compared to those in control schools.

- Sanchez-Alcaraz Martinez and Del Mar Andreo Bernal (2009) found no significant association between levels of physical activity and school performance in 148 students aged 10-12 years (65 male, 83 female). Students exercised 2.12 +/- 1.65 hours per week outside of school hours. Outcomes were based on students' grades and self-reports from formal assessments that measured their exercise levels (frequency and in comparison to their peers) and TV viewing behaviour (Short Exercise Test Krece Plus, Physician-based Assessment and Counselling for Exercise [PACE] and Comparative Physical Activity Scale).

In the grey literature we identified six literature reviews or reports from expert groups (British Heart Foundation National Centre (BHFNC) for Physical Activity and Health 2015, Expert Group on Health-enhancing physical activity 2015, Brooks 2014, C3 Collaborating for Health 2012, Currie et al. 2012, Kino-Quebec [no date]) which also described the positive effects of physical activity and sport participation on student performance, while one thesis project (Brown 2011) found that an association may be dependent on psychosocial factors.

- In a review of the evidence on the benefits of walking for physical and mental health, the charity C3 Collaborating for Health (2012) found that walking or cycling to school is associated with improved cognitive performance in students (age not specified). They also reported that walking can increase the size of the hippocampus and prefrontal cortex, which has been shown to be beneficial for improving memory. A report from an expert group on health-enhancing physical activity also found that physical activity and sport participation can have a positive impact on cognitive development, classroom behaviour and psychosocial outcomes such as higher life satisfaction, lower rates of bullying, better self-esteem or self-image (Expert Group on Health-enhancing physical activity 2015).
- An evidence briefing prepared by British Heart Foundation National Centre (BHFNC) for Physical Activity and Health reported that physical activity in early years can improve school readiness in younger children. However, they indicated the effect on cognitive development is more established in older children (exact ages not specified). They note emerging evidence that physical activity in early years can improve language skills, attention and self-regulation, although the exact mechanisms affecting this association remain unclear.
- Brooks' (2014) rapid review of evidence for Public Health England made an explicit link between physical activity and pupil health and attainment. It reported that the level of moderate-to-vigorous exercise undertaken by UK pupils aged 11 years positively affected their grades in English, maths and science at ages 11 and 13 years, as well as their final GCSE exam results (aged 16). For girls in particular, the amount of moderate-to-vigorous activity predicted their increased science scores at 11 and 16 years.
- A summary paper for the Quebec government looking at a 2008 systematic review (Kino-Quebec)[17] found that increased physical activity helps children (age unspecified) to achieve better academic grades. However, they reported that reducing physical activity hours to increase classroom learning of other subjects had no positive effect on academic outcomes. The review found that decreasing classroom learning in favour of physical education enabled students to achieve either similar or even better grades.

[17] A summary is presented of Trudeau F and Shepard RJ (2008) Physical education, school physical activity, school sports and academic performance International Journal of Behavioural Nutrition and Physical Activity 5:10 cited in Kino-Quebec [no date].

- A mixed-methods PhD thesis study looking at the impact of "Move It", an extracurricular sports intervention in three London schools, could not find sufficient evidence to support the conclusion that sport participation increases educational attainment (Brown 2011). The author suggests that the effect of sport on academic attainment is dependent on other psychosocial factors, such as the confidence that is often present in young people who choose to engage in these kinds of activity.

## 3.2 Research Question 2: What are the consequences of overweight, obesity and physical (in)activity in workers' performance?

The focus of findings in the peer-reviewed literature on associations between overweight, obesity and physical (in)activity and workers' performance primarily related to quantifying indirect socioeconomic costs or levels of work participation. We present these findings alongside further reflections from the grey literature on these same key areas. We found a limited amount of evidence so discuss findings relating to weight and physical (in)activity together. We end our discussion with the grey literature findings examining the association between overweight, obesity and physical (in)activity on other elements of work performance.

### 3.2.1 Summary

Synthesis of the peer-reviewed literature on the relationship between overweight, obesity, physical inactivity and work performance is challenging due to the heterogeneity of measures such as ranges of BMI assessed and outcome measures used (e.g. cost of sickness absence for employers; rates of morbidity or premature mortality in workers). Despite this heterogeneity, trends across North American and European studies, that use a variety of measures, similarly identify that overweight and obesity contribute to the majority of costs of these health conditions, primarily in indirect costs, such as absenteeism, presenteeism (presence at work but decreased productivity), or early retirement.

U.S. studies of university and hospital employees also indicate that obesity exerts a strong effect on workplace injuries. A BMI ≥40 kg/m$^2$ among employees is associated with increased rates and associated costs of workers' compensation claims, including type or placement of injury, and nature and cause of injury. In particular, a combination of obesity and high risk employment (e.g., patient services) creates increased risk of workplace injury.

Costing models may consider only a portion of variables that relate to the indirect costs of overweight. As a result, it is likely costs are underestimated.

Excessive weight and lack of physical activity are risk factors that can lead to decreased workforce participation.

The grey literature also reported on the negative relationship between weight status and other aspects of work performance – on the job productivity, rate of employment, salary and job satisfaction. In the latter three elements, the grey literature suggests there is a gendered aspect of this relationship, reporting significant effects only for women.

### 3.2.2 Overweight, obesity and physical inactivity consequences for productivity

There is a negative association between overweight, obesity and physical inactivity with workplace productivity, which many studies have modelled economically. However, due to the wide scope of studies and the absence of standardised measures of productivity across the literature it is challenging to summarise the results of these studies. (Dee et al. 2014). Loss of productivity due to overweight, obesity, and inactivity is generally understood and

assessed as an indirect cost rather than direct cost (i.e. related health care costs). The indirect costs to employers are measured in early mortality or absenteeism, for example. However, these costs are also measured in presenteeism, i.e. employees are present in the workplace, but have low productivity, or by their presence in the workplace, they increase their risk of workplace injury (e.g., lower back injury) and subsequent workers' compensation claims.

In a review of five studies, Dee et al. (2014) identified the indirect costs for overweight and obesity across 2 European and 2 North American nations – these are included in Table 2 below. The authors conclude that available evidence suggests that as population BMI increases, indirect costs (e.g., loss of productivity) also increase. This finding is observed across studies, despite their heterogeneity in terms of scope, methodological approaches, data quality, and data sources. Another study modelling these indirect costs (Asay et al. 2016) examined the relationship between health behaviours (physical inactivity and obesity) and work performance due to absenteeism[18]. The authors studied a sample of adults aged 18-64 years old, who were employed for at least one year, and were continuously enrolled from 2008 to 2011 in one of the two U.S. commercial healthcare claims databases: MarketScan Health Risk Assessment (n=229,615) and Medical Expenditure Panel Survey (MEPS) (n=24,006). The analyses demonstrated that obesity had the highest total cost to U.S. employers for absenteeism at $11.2 billion per year. This was higher than the cost for smoking, physical inactivity, hypertension or diabetes. Absenteeism due to physical inactivity was estimated to cost employers $9.1 billion per year.

A retrospective cohort study (Ostbye, Dement, and Krause 2007) assessed the relationship between BMI and number and types of workers' compensation claims, associated costs, and lost workdays. The sample was 11,728 healthcare and university employees with at least one health risk appraisal between 1997 and 2004. Results indicated a clear linear relationship between BMI and rate of claims. Employees in obesity class III (BMI ≥40 $kg/m^2$) had 11.65 claims per 100 FTEs, as compared to 5.80 for employees of recommended weight levels. Medical claims costs followed a similar trend ($51,091 vs. $7,503 per 100 FTEs) and indemnity claims costs ($59, 178 vs $5,396 per 100 FTEs). BMI most strongly affected the following worker compensation claims:

- For body parts: lower extremity, wrist or hand, and back.
- For nature of injury or illness: pain or inflammation, sprain or strain, and contusion or bruise.
- Cause of illness or injury: falls, slips, lifting or exertion.

The authors identify that the combination of high-risk occupation (e.g., patient services or hospital parking/traffic operations) and obesity was particularly detrimental. The authors conclude that BMI exerts a strong effect on workers' likelihood of injuries.

In the grey literature we also found five studies or reviews that discussed the economic impact or indirect costs of (undefined) obesity and physical inactivity, but employing different cost models. There appears to be strong evidence of a link between obesity and physical inactivity and loss of productivity, but a less clear explanation of the causality of that relationship. This is consistent with the evidence relating to school academic performance discussed above.

Much of the literature emphasised a link between obesity and physical inactivity and a loss of productivity at work, expressed as 'indirect economic costs'. However, there was variance across studies regarding which factors were considered to contribute to these calculations. The findings are summarised in Table 2 below.

[18] Physical inactivity was defined as exercising fewer than 4 to 5 times per week for at least 30 minutes of moderate activity each time; obesity was assessed through self-reported height and weight and absenteeism as the number of workdays missed because of injury or sickness.

*Table 2. Indirect costs of obesity across different countries*

| Country | Amount of costs | Factors considered | Source | Type of source |
|---|---|---|---|---|
| **Canada** | CA$5 billion | Morbidity due to long and short term disability | Dee et al. 2014 | Peer-reviewed:<br>Review of studies that evaluated the direct costs and indirect costs of both overweight and obesity. |
| **USA** | $42.8 billion USD | Presenteeism and absenteeism | | |
| **Sweden** | SEK 2.93 billion | Lost productivity due to increased mortality | | |
| **Germany 1** | €5.019 billion (as of 2002) | Sickness absence, early retirement and mortality using human capital approach | | |
| **Ireland** | €728 million per year | Rates of premature mortality, work absenteeism, lost output | Loughnane and Murphy 2015 | Grey literature:<br>Evidence review of peer-reviewed literature, impact assessments, policies reducing obesity. |
| **England** | £2 billion a year | Rates of premature mortality, work absenteeism, lost output | Suhrcke et al., 2005 drawing on work of National Audit Office 2001 | Grey literature:<br>Book for the European Commission on the contribution of health to the EU- reviews academic literature and reports from international organisations (e.g. WHO) after key word search of 4 databases. |
| **Germany 2** | €12.8 billion | Morbidity and premature mortality calculated using disability-adjusted life years (DALYS) lost as a result of four physical | Centre for Economics and Business Research (CEBR)<br>2015 | Grey literature:<br>Evidence review of literature, discussions from April 2015 roundtable and economic modelling data. |
| **UK**[20] | €12.3 billion | | | |
| **Italy** | €10.6 billion | | | |

| | | | | |
|---|---|---|---|---|
| | | inactivity-related disorders.[19] | | |
| **Any** | €910 million per 10 million people. | Rates of premature mortality, sickness absence and disability affecting work | WHO Regional Office for Europe , 2015 | Strategy document with background evidence review. |

Two reviews (McDaid et al 2015; Loughnane and Murphy 2015) highlighted that these costing models consider only a portion of variables which might be considered to contribute to a loss of productivity, and that psychosocial factors should also be considered, suggesting the costs are underestimated and may be far more.

McDaid et al. (2015), in their book discussing the economics of health promotion written for WHO, assert that as studies have mostly been cost-of-illness studies (cross-sectional, and restricted to particular time periods) or used mathematical modelling on virtual population cohorts, they do not provide a full picture. Explanations for the association between obesity and loss of productivity that are based in the real experience of workers are missing. The authors highlight that non-communicable diseases such as obesity are associated with mental health problems, which can lead to reduced participation in the workforce and reduced career opportunities.

Loughnane and Murphy (2015) also note that the costing model they refer to, while considering reduced productivity (through premature mortality, work absenteeism and reduced effectiveness among the labour force) does not fully capture the social and economic cost of obesity related illnesses, low self-esteem and mental health issues, for both individuals and wider society.

### 3.2.3 Obesity and physical inactivity consequences for work participation

**The peer-reviewed literature found that lack of physical activity and excessive weight are health risk factors that can lead to decreased workforce participation and increased absenteeism.**

Klarenbach et al. (2006) assessed the associations between obesity and work participation using data from the Canadian Community Health Survey 2000 to 2001 (N=73,531). Increasing severity of obesity was associated with decreasing likelihood of active participation in the workforce, which is independent of other demographic, socioeconomic, and health conditions.

To determine associations between BMI and workforce participation, Tunceli et al. (2006) used data from the US nationwide longitudinal Panel Study of Income Dynamics (PSID) cohort. The authors analysed data from 4,290 respondents (1,895 men and 2,395 women) who participated in both the 1986 (baseline) and the 1999 (follow-up) surveys and were of working age: 18 years and older in 1986 and less than 65 years old in 1999.[21] Their findings included:

[20] The difference between this and the England figure above may be due to the different factors considered in the model.

[19] Authors used existing population attributable fractions data, (proportion of cases that would not have occurred if risk factor – physical inactivity- was absent) to calculate the cases or deaths of four main inactivity related disorders: CHD, Type II Diabetes, colorectal and breast cancer, and inactivity-related mood and anxiety disorders.

[21] Tunceli et al. examined self-reported employment status and the presence of work limitations due to health. Presence of obesity at baseline was determined by BMI using self-reported weight and height measurements.

The authors discovered a significant trend between baseline BMI categories and employment at follow-up, where obese men and women were less likely to be employed.

- In 1999, women who were employed and categorized as obese were more likely to report a work limitation i.e., any physical or nervous condition that limited the type or amount of work. A similar trend existed with men, although it was not statistically significant.
- The authors conclude that obesity results in future work productivity losses with reduced participation and increased limitations.

Physical activity can contribute to a lack of workforce participation throughout employees' careers, even contributing to early retirement. To examine associations between health and labour market positions among older adults (50 to 64 years old) in Europe, Alavinia and Burdorf (2008) studied 11,462 respondents of the Survey on Health and Ageing in Europe (SHARE) - a longitudinal study that collects medical, social, and economic data on the population over 50 in ten European countries[22]. The study measured work status in six categories: paid work, retired, unemployed, homemaker, disabled, or other. The work status of respondents differed by country. Retirement status ranged from 8.4 percent in The Netherlands to 47.8 percent in Austria. They found that:

- Self-reported poor health was strongly associated with nonparticipation in the workforce.
- Self-reported poor health was significantly associated with early retirement in seven of ten countries and with unemployment in six of ten.
- Physical inactivity and obesity had an effect on nonparticipation in the labour market, which was consistent across most European countries, except France.

#### 3.2.3.1 Other aspects of work performance

**The grey literature review found evidence that further explored the association between weight status, in particular (as opposed to physical activity) and different aspects of work performance: presenteeism, rate of employment, salary and job satisfaction; a gendered pattern emerged in some cases.** As well as one review looking at presenteeism/loss of on-the-job productivity, we found five studies or reviews that reported a gendered negative relationship between obesity and employment, salary, and/or job satisfaction, significant only for women.

***Presenteeism***

A review of 37 papers emphasised the adverse link between obesity and physical inactivity with reduced on-the-job productivity (presenteeism) as a result of linked health issues. Oortwijn et al. (2011) found evidence that the average percentage of productivity loss (presenteeism) among workers with cardiovascular disease is 7% (equivalent to a half hour per day).

***Rate of employment***

Coudin and Souletie (2016) analysed results from the French Work and Career (*Santé et itineraire professionelle (SIP))* survey waves of 2006 and 2010. They found that obesity (measured by BMI scores) was negatively related to employment- in the 2010 wave of the survey obese women were less likely to be employed than non-obese women (71% v 81%). For men, there was only a slight difference in employment status of 84% v 86%. The authors calculated that an increase of BMI by one point (equal to a weight gain of 2.7kg) reduced the probability of employment for obese women by 0.5%. Controlling for age, education and health status variables, obese women had a 7.1% less chance of being recruited.

[22] Sweden, Denmark, The Netherlands, Germany, Austria, Switzerland, France, Italy, Spain, and Greece

Two further sources in our review reported a link between BMI and employment status. An OECD analysis of data from wave five of the Survey of Health, Ageing and Retirement in Europe 2013 survey (SHARE) (n=17,398 adults) found that across 14 countries, obese people were less likely than 'normal-weight' people to be employed. 59% of obese people aged 50-59, versus 72% non-obese adults of the same age were employed in 2013 (OECD, 2016). However, this association was reported to vary depending on gender and job characteristics. A literature review of empirical data, and intervention programmes which supported policy guidance for European policy-makers from the WHO (Loring and Robertson 2014), similarly found that obese women are less likely to be upwardly socially mobile, more likely to be unemployed and suffer absenteeism from work.

***Salary***

An OECD review found that obese people earn up to 18% less than non-obese people, even when in equivalent posts doing similar jobs (OECD 2015). Elsewhere, a gendered relationship was also found relating to salary. Coudin and Souletie (2016) calculated, again from the 2010 wave of the French Work and Career survey, that a similar 1 point increase in BMI score was associated with a reduction in salary of 0.3% for obese women, but that there was no significant difference for men. For obese workers as a whole, hourly wages were found to be 6-9% less than for non-obese workers. Two literature reviews (Suhrcke et al. 2005; Giovanni et al. 2015) identified a number of studies which support this conclusion for women – that a higher BMI is linked to depressed wages and earnings, and Giovanni et al. (2015) also found there was age variation in this relationship among Italian workers. There was no relationship between obesity and wages for young Italian workers.

***Job satisfaction***

The micro-analysis by Giovanni et al. (2015) of data from the 2006/2008/2010 Italian ISFOL Participation, Labour, Unemployment Survey (n=38,000) (PLUS) found a negative relationship between overweight and obesity and nine aspects of job satisfaction. There were significant gender differences about whether overweight or obesity is most distressful, and which is most related to job satisfaction. For men it was more distressing to be overweight, for women, obesity. Overweight men were dissatisfied with their work environment, organisation of work time, pay, and development of skills. Obese females were dissatisfied with their work duties and career opportunities. Obese men were only dissatisfied with their development of skills and job stability, while overweight women were not dissatisfied at all. The relationship is only significant when looking at these individual components – overall job satisfaction was not significantly affected. They also found no significant effect in a gross-income analysis.

None of the studies provided strong, single explanations for why these links between employment and wages and weight exist. They do however propose similar reasons to those discussed above for lower productivity; lower education levels, health complaints leading to absenteeism or presenteeism and labour market discrimination against obese women due to social stigma (Coudin and Souletie 2016; Giovanni et al. 2015; Loring and Robertson 2014; Suhrcke et al. 2005). Figueras and McKee (2012) call for more research into the explanation for this complex relationship between obesity, socioeconomic factors and workplace productivity, and the variation that exists across studies and countries.

# 4 Conclusion

Among children and young people evidence for the associations between overweight and/or obesity with academic performance is not conclusive or straightforward. While earlier systematic review evidence found an inverse association between overweight and obesity in children and adolescents and different aspects of academic performance (including grades or test scores, measures of memory or general intelligence), more recent systematic review evidence could only find an association between the overweight or obese weight status of adolescent girls and attainment in mathematics. Population-based studies (including longitudinal) evidence indicates that other socioeconomic or psychosocial factors (such as parental socioeconomic status or weight-based teasing) may influence this relationship. The use of subjective self-report measures may also explain the variability in associations found.

The literature suggests physical activity can positively impact cognitive and academic performance among young people. However, it is not possible to conclude the strength of this association due to high heterogeneity in study designs and methods.Evidence from studies of physical activity interventions or school-based physical activity in particular, including a meta-analysis, do show a positive association between physical activity and academic attainment but there is little consensus on the type, intensity or duration of physical activity, or for what kind of academic attainment this association can be most strongly established. Research that adopts more consistent methodologies is required to facilitate better comparisons across studies, and to investigate other factors that may influence this association.

Overweight and obesity have a negative impact on employment and work performance in adulthood. National economies are incurring significant indirect costs as a result of different aspects of lost work productivity, resulting from overweight, obesity or physical inactivity. Factors that may be associated with obesity and workforce participation, besides chronic illness and depression, include acute disorders that limit physical capacity, personal preferences for leisure activities, as well as discrimination in hiring practices. Evidence suggests that a significant negative impact of obesity on elements of work-related performance (rates of employment, salary and aspects of job satisfaction) is felt mainly by women. However, further research is needed to understand how gender may mediate these associations.There are therefore some indications that overweight, obesity and/or physical (in)activity may have an impact on the cognitive 'working' performance of individuals across the life course, either in the school or workplace setting. This provides some additional non-health-related motivations for seeking to improve the health behaviours of individuals in Europe. However, given the complexity and inconclusive nature of the evidence, relating to children and adolescents in particular, these areas should be considered as part of a broader holistic approach to tackling overweight, obesity and physical in activity and should continue to be investigated.

# Annex 1 Peer-reviewed literature review methodology

This sub-section describes the approach taken to gather and synthesise the evidence.

## A1.1 Research questions for this review

In this comprehensive review, current literature was gathered and synthesised to address Objective C. This literature review provides a review of relevant, recent studies using the methodology presented below to summarise this topic. While the methods to conduct this comprehensive literature review are systematic it is not a systematic review. Note that unlike a systematic review, this review does not systematically analyse literature to identify *all* relevant published data and/or appraise its quality

To explore the topic objective C, the literature review was conducted around the following agreed upon questions.

- What are the **consequences** of overweight, obesity and physical (in)activity in **students' performance** (from kindergarten to college)?
- What are the **consequences** of overweight, obesity and physical (in)activity in **workers' performance**?

The findings from the third research question (mentioned below) are included in a separate report (Objective A2), as an overarching objective area report on existing policies in the broader thematic area of nutrition and physical activity.

- What policies are more effective and efficient in this area (information, advertising, taxation, reformulation, regulations, partnerships, etc.)?

The methodology for the peer-reviewed literature is described below, with greater detail on search terms provided in other Annexes.

## A1.2 Peer-Reviewed Literature

Methods to conduct the literature review consisted of five steps: (1) refining the research questions, (2) developing a search approach and databases, (3) conducting literature searches (Stage 1 below), (4) screening articles for inclusion (Stage 2 below); and (5) abstracting and synthesizing relevant data (Stage 3 below).

In step 1, in partnership with DG SANTE the research questions above were confirmed. In step 2, the 3 stage approach noted below and databases were confirmed. To minimise bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria) to guide searches and inform screening and selection processes for data inclusion. Steps 3, 4 and 5 followed the process below:

- Conduct searches and document results (Stage 1)
- Screening search results (title and abstract) for relevance (Stage 2)
- Review full publication and abstract key characteristics and study findings (Stage 3)

Searches were conducted in multiple databases and screened following the procedures below. Following the literature review pilot, it was agreed to merge Stages 1 and 2.

### A1.2.1 Stage 1: Conduct Searches and Document Results

In Stage 1, searches were conducted using search terms and criteria agreed with DG SANTE, with filters set for databases to ensure accurate inclusion and exclusion of literature, as shown in tables below. The search terms used were specific to each of the two research questions. Literature searches were conducted in Pubmed, EBSCO (CINAHL, ERI PsycInfo) and Embase. Searches included publications with all availability types (i.e. free full text and pay/subscription access).

*Table 1. Inclusion and Exclusion Criteria Applied at Stage 1*

| Set Database Filter to Include: | Set Database filters to exclude: |
|---|---|
| • Published between 1/1/2005-5/31/2016 | • Articles published before 1/1/2005 |
| • Peer-reviewed scientific publications<br>- Original research<br>- Systematic reviews<br>- Meta-analyses | • Editorial comments/commentaries<br>• Dissertations<br>• Theses<br>• Opinion articles |
| • Article published in English, French, German, Italian Polish and/or Spanish | Article not published in English, French, German, Italian Polish and/or Spanish |

In addition to reviewing studies in databases noted above, in order to help ensure inclusion of high quality literature (e.g., literature having gone through more formal quality assessments) systematic reviews and meta-analyses were reviewed for inclusion in the literature review. Searches for systematic reviews were conducted in Cochrane Review and healthevidence.org.

As noted a separate search was carried out for each research question, resulting in 2 groups of publications for screening for C. After the searches, the results were reviewed to ensure they accurately met search parameters and duplicates were removed for screening in Stage 2.

### A1.2.2 Stage 2: Screening search results (title and abstract) for relevance

At stage 2, two screening levels were used: level 1 quality check and level 2 screening. Stage 2 screenings were done simultaneously. These screening inclusion and exclusion criteria are shown below.

#### A1.2.2.1 Stage 2 Level 1 Initial Screening (Quality check)

Search hits from all databases searched in Stage 1 were grouped by the two research questions and search terms to which they were related. Duplicate hits were deleted, and search hits by research question were organised from the most recent publications in 2016 going back in time to 2005, saved in an Excel file for that specific research question, and provided to reviewers for screening. These date parameters were agreed with DG SANTE as part of the pragmatic approach to managing the review material.

Using screening criteria in Table 1 reviewers screened the title and abstract of up to the first 200 hits per research question in each Excel file to identify literature to move forward for review. This was done to ensure the screening process was manageable given project timelines yet captured the most recent and relevant literature.[23]

#### A1.2.2.2 Stage 2 Level 2 Initial Screening (Quality check)

Simultaneous with the Level 1 initial screening check, more detailed overall inclusion and exclusion criteria were applied by the reviewers to the title and abstract to screen publications. These criteria are shown in Table 3 below under Level 2.

[23] Results for each research question were screened separately, however, as screening took place, team members considered if articles might be relevant to other research questions, and if so, coded the article as such.

*Table 2. Stage 2 Inclusion/Exclusion Criteria: Levels 1 and 2 Screening*

| **Stage 2 – Level 1** | | |
|---|---|---|
| **Category** | **Inclusion Criteria** | **Exclusion Criteria** |
| **Date** | Published between 1/1/2005-5/31/2016[24] | Articles published before 1/1/2005 |
| **Publication Type** | Peer-reviewed scientific publications<br>- Original research<br>- Systematic reviews<br>- Meta-analyses | • Editorial comments/commentaries<br>• Dissertations<br>• Theses<br>• Opinion articles<br>• Non-academic journal |
| **Language** | Article published in English, French, German, Italian Polish and/or Spanish | Articles in all other languages |

[24] During screening, publications prior to 2005, and publications such as commentaries, dissertations or editorials were screened out, as were publications focusing on animals (rather than humans). Also note that ad hoc searches conducted post screening to supplement screened literature could have include literature post 2016.

*Table 3. Overall screening criteria for stage 2*

| Stage 2 – Level 2 | | |
|---|---|---|
| **Category** | **Inclusion Criteria** | **Exclusion Criteria** |
| **Geography** | • Studies conducted in America, Australia, Canada, European Countries, Great Britain, Mexico or Brazil | • Studies in all other countries |
| **Human subject** | • Human-focused research | • Animal-focused research |
| **Behavior/ Outcome** | • Studies specific to how physical activity contributes to school or work performance<br>• Studies specific to association with overweight or obesity status and school or work performance | • Studies specific to physical activity with relation to health without mention of school or work performance<br>• Studies specific to overweight or obesity status with relation to health without mention of school or work performance |
| **General population** | • Studies where the population of focus includes children, adults or older adults in the general population | • Studies where the population of focus is a narrow population such as critically ill, hospitalized patients, people with a chronic condition or terminal illness, those incarcerated, etc. |
| **Weight Status/ BMI** | • Studies that examine the association of performance with weight status/BMI or physical (in)activity | • Studies that examine the association of performance with metabolic indicators (adiponectin, ghrelin, cholesterol etc.), environment or genetics |

From 400 publications screened in stage 2, 265 publications were deemed of potential relevance, coded as "Include" and selected for full article review after Stage 2 screening.

### A1.2.3 Stage 3: Full Article Review and Synthesis

265 articles were exported for review of full text in this objective C literature review. After reading the full text, if the article was still deemed relevant for inclusion (based on consideration of the objective and if the article helped answer research questions), it was saved for use and reference in the bibliography. Following the reading of the articles' full text in this stage, 15 publications were selected for inclusion.

At each stage in this process, the team met to discuss successful strategies, challenges, and recommendations to improve the literature review processes. Note that although this is a comprehensive literature review and does not include a formal quality assessment process commonly conducted in systematic reviews, the team documented study designs (e.g., cross sectional, experimental) and the articles were checked by reviewers for signs of bias and poor quality research design. Furthermore, the lead reviewer for each objective area conducted blind quality assurance checks for up to 10% of the coded articles. Any disagreements were discussed as a group and resolved with the review task lead.

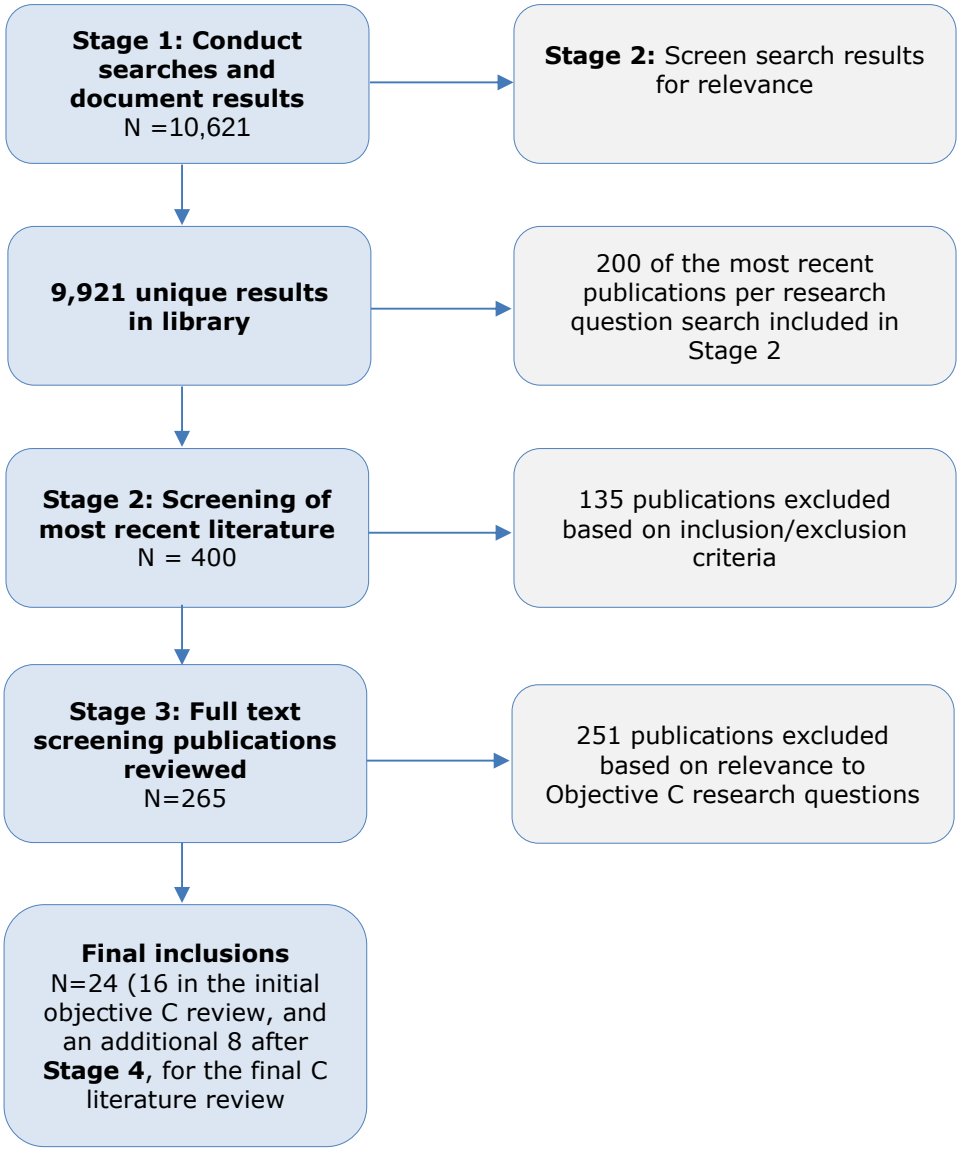
### A1.2.4 Stage 4: External expert reviews and input

Upon completion of the draft set of comprehensive literature reviews, subsequent to review by DG SANTE and the Joint Research Centre (JRC), expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed. As a result of this exercise, seven additional references were screened and incorporated into these reviews.

### A1.2.5 Number of included and excluded publications

The diagram in Figure 1 below shows the number of articles identified in peer-reviewed literature searches, and the filtering out of literature at successive stages to arrive at the final number of 24 publications whose full text was reviewed and summarised for this review. The diagram also includes additional relevant references identified at the expert workshop, and one further source that was identified through the grey literature search that were screened and incorporated into this final comprehensive review.

*Figure 1. Diagram showing number of included and excluded publications at each stage – peer reviewed literature*




As shown in Figure 1**,** a total of 10,621 search hits of peer reviewed literature were retrieved. A total of 700 duplicates were found and removed from the search hits resulting in 9,921 search results for objective C. From the 2509 articles, the team screened 400 of the most recent titles and abstracts (200 for each of the two research questions, to create a manageable amount of material within the resources for the study; and on the premise that the most recent material was most relevant science). From the 400 most recent titles and abstracts screened, 265 were deemed of potential relevance and reviewed as full texts. From the 265 deemed relevant and reviewed as full texts, 16 publications were selected for inclusion in this final review. In addition, 8 additional articles were included in Stage 4 (after the expert workshop).

## Annex 2 Peer-reviewed literature search terms

**Objective C Search Terms Per the C Research Questions**

**RQ1: What are the consequences of overweight, obesity and physical (in) activity in students' performance (from kindergarten to college)?**

| Primary Term | | Combined with: | | Combined with: | |
|---|---|---|---|---|---|
| "Overweight" | [tiab] | "Academic performance" | [tiab] | "Students" | [tiab] |
| "Obese" | [tiab] | "Academic achievement" | [tiab] | "College students" | [tiab] |
| "Obesity" | [tiab] | "School performance" | [tiab] | "Children" | [tiab] |
| "Weight status" | [tiab] | "School attendance" | [tiab] | "Adolescents" | [tiab] |
| "Physical activity" | [tiab] | "Concentration" | [tiab] | "Schools" | MeSH |
| "Physical inactivity" | [tiab] | "GPA" | [tiab] | "Students" | MeSH |
| "Exercise" | [tiab] | "Achievement" | MeSH | | |
| "Fitness" | [tiab] | "Cognition" | MeSH | | |
| "Sedentary" | [tiab] | "Exercise/psychology" | MeSH | | |
| "Body Mass Index" | [tiab] | "Physical fitness/psychology" | MeSH | | |
| "Body Mass Index" | MeSH | "Educational status" | MeSH | | |
| "Exercise/physiology" | MeSH | | | | |

**RQ2: What are the consequences of overweight, obesity and physical (in) activity in workers' performance?**

| Primary Term | | Combined with: | |
|---|---|---|---|
| "Overweight" | [tiab] | "Work performance" | [tiab] |
| "Obese" | [tiab] | "Work productivity" | [tiab] |
| "Obesity" | [tiab] | "Employer health costs" | [tiab] |
| "Weight status" | [tiab] | "Absenteeism" | [tiab] |
| "Physical activity" | [tiab] | "Absenteeism" | MeSH |
| "Physical inactivity" | [tiab] | "Employment" | MeSH |
| "Exercise" | [tiab] | "Employer health costs" | MeSH |
| "Fitness" | [tiab] | "Cost of illness" | MeSH |
| "Sedentary" | [tiab] | | |
| "Body Mass Index" | [tiab] | | |
| "Body Mass Index" | MeSH | | |
| "Exercise/physiology" | MeSH | | |

## Annex 3 Peer reviewed literature bibliography

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# Annex 4 Grey literature review

## A4.1 Detailed search and review methodology

The review followed a process with five main stages:

Searching for publications using set keywords and databases;

Screening of search results for relevance;

Screen results against inclusion/exclusion criteria, quality and relevance;

Extraction of full texts and final screening process; and

External expert reviews and input.

## A4.2 Stage 1: Conducting searches and documenting results

### A4.2.1 Searching for grey literature

The search terms initially used for objective C were agreed upon in the inception phase (Table 4). The main key words were either specific to the objective or broader thematic terms; i.e. for Objective C the main key words included both 'Obesity' and 'Physical activity'. A second list of search terms was also used – these combination words were used to guide the search and produce the most relevant results; for objective C, the key word 'Obesity' would be combined with the broader term 'academic performance'.

*Table 4. Search terms used for objective C grey literature review*

| **Search Parameters** | |
|---|---|
| **Parameters** | |
| • Scientific evidence and policies of EU Member State initiatives<br>• Published in English, French, German, Italian, Polish and/or Spanish<br>• Date range (1995 – 2017) | |
| Key Words and Combinations of Search Terms | |
| **Key Words** | **Combined With** |
| Obesity | Prevention programs (programmes) |
| Overweight | Prevention policies |
| Body Mass Index (BMI) | Policy evaluations |
| Unhealthy eating | Regulation |
| Healthy eating | Monitoring |
| Physical activity | Health determinants |
| Physical inactivity | Health outcomes |
| Physical education | Public health |
| | Work performance (productivity, absenteeism, presentism, work place adaptation) |
| | Workers , employees, staff |
| | School performance (attainment, absenteeism, drop-out rates) |
| | Students, school children |
| | Cognitive development |

| | |
|---|---|
| | Academic performance (by grade level)<br>Member States (of the EU) / Country (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom) |

### A4.2.2 Using set key words in databases, search engines and websites

In order to appropriately link and define the relationship between the key and combination search terms, the Boolean operators 'AND', 'NOT' and 'OR' were used in the search engines. In particular, the use of 'AND' helped to narrow the number of hits to ensure that only documents which included all the search terms showed up. Further, if a search led to a high number of irrelevant hits, a repeat search was conducted and key words which were separated by spaces or other characters (e.g. Health impacts) were enclosed in quotation marks (e.g. "health impacts") to return only those documents that matched the search terms exactly.

The set key words and combination words were used to generate results in databases, search engines and websites recommend by the pilot review:

- Search Europa
- European Sources
- Eurostat
- NICE
- Open grey
- WHO websites

European Sources, Search Europa and NICE yielded the most results for objective C. The grey literature review was a dynamic and fluid process. After the initial searches and extraction of sources, hand searching on Google was used to produce specifically relevant results. This is described further in the section below.

### A4.2.3 Additional hand searching

As per the recommendation made in the pilot review, hand searching was also used to supplement the key word searches. Hand searching involved extending the basic key word searches by using additional, contextual information. For example, in objective C, phrases such as "Which aspects of work performance (productivity, absenteeism, presentism, work place adaptation) are associated with obesity?" were used to generate the most applicable results. This process ensured that highly-focused and relevant search results were generated for the original key words, in this case, "academic performance", "school performance", and, "work performance". All hand searches for this objective were completed on Google.

## A4.3 Stage 2: Screen Search Results for Relevance

Most databases, search engines and websites offered the use of a relevancy filter[25] which automatically sorts results in order of their applicability to the key terms in the search

[25] 'Sorting by relevance' on databases and search engines enables a connection to be established between the information in the database, the search string entered and any search filters chosen. If the keywords appear in a Title or Author field, the system shows these results first in the list of search returns. Less relevant articles e.g. ones where the keyword appears less often or may only appear in the actual content, appear later in the list of search results.

engine. When a relevancy filter was not available, the links were manually screened by the appearance of the key search terms in the title of the source and the abstract (where available). For database and search engines, initially the top 50 most relevant search results were looked at per search string. If there were less than 50 results, all were looked at. The titles and abstracts were then examined for key search terms in the grey literature and relevance to the research questions.

Extra hand searching was conducted when search strings did not produce enough relevant information, and/or, when the top 50 results did not produce the most relevant literature. Hand searching involved extending the basic key word searches by using additional, contextual information. In total 531 results were included.

Following the expert workshop (see stage 5 below), experts recommend further sources which were reviewed in the final redraft of the review.

Overall 89 results from the literature searches for Objective C were saved into a library.

### A4.4 Stage 3: Screen results against inclusion/exclusion criteria, quality and relevance

Results were then screened against agreed inclusion and exclusion criteria detailed in Table 5 below.

*Table 5. Grey literature inclusion and exclusion criteria*

| Inclusion | Exclusion |
|---|---|
| Published between 2005-2017 | Published or enacted prior to 2005 |
| Government reports from European Commission, European Parliament and EU Member States. | Non-nutrition and physical activity themed/focused |
| Think tank reports/publications | Industry-produced publications |
| Academic papers, conference papers and abstracts | Industry-produced project evaluation reports |
| Bibliographies | Industry-produced good practice reports |
| Programme evaluation reports[26] | Publications focusing on animal nutrition and physical activity |
| Standard/best practices documents | Blog or personal think thought pieces |
| Policy initiatives at European and/or national level- run by governments, not-for profit organisations | Newsletters or news articles |
| Industry funded publications (As regards the grey literature reviews, particular care will be exerted in assessing any inclusion of industry-funded literature. These will be justified and discussed with the client). | Theses and dissertations (2010 and older) |
| Primary theme/focus is human | |

[26] For example: Hallsworth M, Ling T. (2007) *The EU platform on diet, physical activity, and health: second monitoring progress report. Cambridge: RAND Corporation*, http://www.rand.org/content/dam/rand/pubs/technical_reports/2008/RAND_TR609.pdf

| Inclusion | Exclusion |
|---|---|
| nutrition and physical activity | |
| Publication available via accessible databases | |
| Published in English, French, German, Italian, Polish and/or Spanish | |
| Theses and dissertations (post-2010 only) | |

Due to the large number of results still returned after this screening the data parameters were further refined to only include those reports published 2005-2017.

Following this criteria screening and exclusion of search results, the remaining 89 results were checked for quality and relevance.

### A4.4.1 Exclusion based on quality checklist

The quality check was based on the AACODS checklist (AACODS)[27] which included:

- Authority
  - Is the author credible?
- Accuracy
  - Is the document supported by documented and authoritative references?
  - Is there a clearly stated methodology?
  - Is the document representative of work in the field?
- Coverage
  - Have limitations been imposed and are they clearly stated?
- Objectivity
  - Can bias be detected (if so the bias was clearly stated in the extraction form)?
- Date
  - Does the document have a clearly stated date relating to the content?
- Significance
  - Is the document relevant?
  - Would the document enrich the findings?

### A4.4.2 Exclusion based on relevance to research questions

The remaining grey literature was examined further so that only results most relevant to the objective were extracted. In particular, each article was examined for text relating to the key terms and questions under the objective. For example, in objective C, the text was examined for reference to the research question '*What are the consequences of obesity for school performance?* 'In total 18 results were excluded during this screening process; 71 results were extracted.

[27] Please see the full outline of the AACODS checklist here: https://dspace.flinders.edu.au/jspui/bitstream/2328/3326/4/AACODS_Checklist.pdf

## A4.5 Stage 4: Extraction of full texts and final screening process

A data extraction template in Excel was used to capture the following categories of information: 1) identifying information for each publication, 2) study design characteristics, 3) sample characteristics, 4) intervention characteristics, 5) content (behaviour/outcome) focus, 6) description of results, 7) assessment of rigour/bias and 8) objective specific information.

After extraction, the review author read through all of the extracted data and a final screening process excluded more results due to quality or a lack of enough relevant information, now made obvious after extraction. Sources were also excluded from the grey literature where this was superseded by either more rigorous peer reviewed research on the same theme, or more recent statistics.

A thematic analysis was applied to the remaining extracted data and their findings synthesised with those of the peer reviewed literature. Any identified bias in sources which passed the inclusion criteria is highlighted in the analysis.

## A4.6 Stage 5: External expert reviews and input

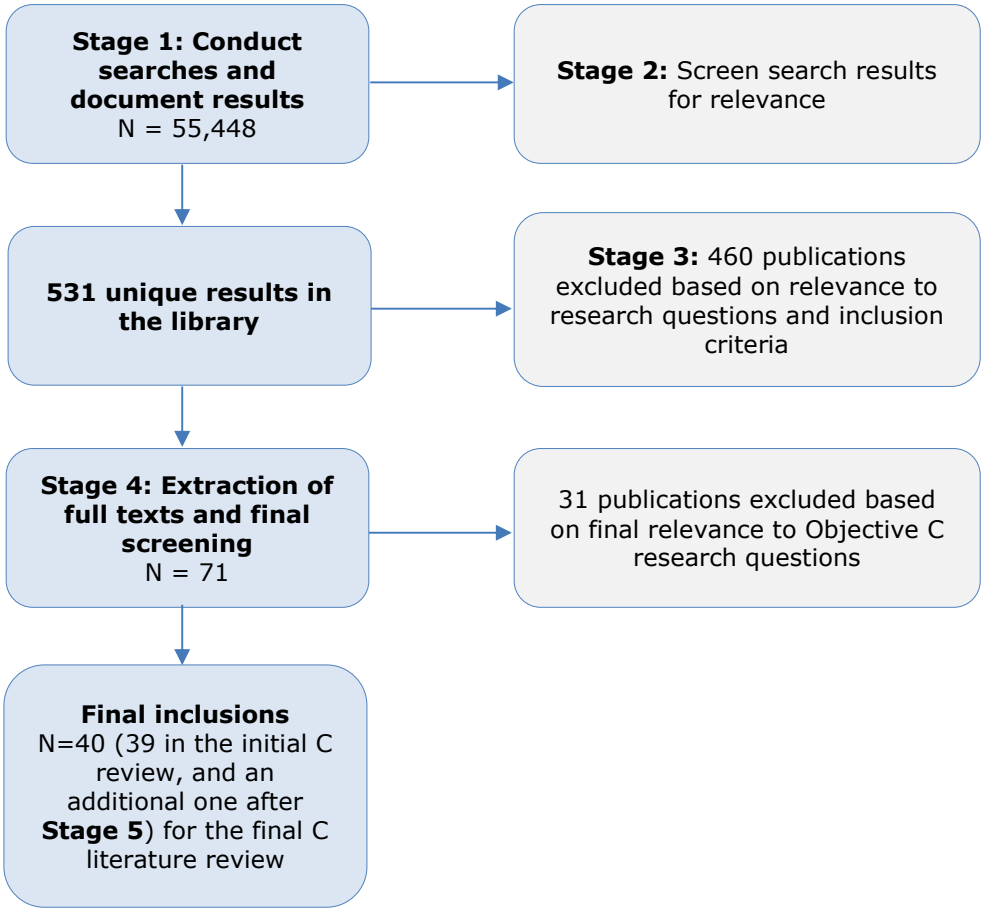
Upon completion of the draft set of comprehensive literature reviews, expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed. As a result of this exercise, one additional reference was screened and incorporated into these reviews.

## A4.7 Number of included and excluded references

The diagram in Figure 2 below shows the number of articles identified in grey literature searches, and the filtering out of literature at successive stages to arrive at the final number of 35[28] publications whose full text was reviewed and summarised for this review. The diagram also includes additional relevant references proposed by external experts, and incorporated into this final comprehensive review.

[28] The full list of references included from the grey literature can be found in Annex 5 and includes three publication recommend by the external expert review panel.

*Figure 2. Diagram showing number of included and excluded grey literature publications at each stage*




As shown in Figure 2, a total of 55,448 search hits were retrieved. From the 531 results saved in the library, 460 were excluded based on the relevance to Objective C research questions. Following this, 71 results were extracted fully. An additional 31 publications were then excluded based on inclusion/exclusion criteria, quality of evidence and relevance to the research questions. In Stage 5, supplementary searches were conducted and/or articles recommended by experts during the workshops were looked at and another one grey literature sources were included in the final review.

## Annex 5 Grey literature bibliography

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