Do associations between education and obesity vary depending on the measure of obesity used? A systematic literature review and meta-analysis

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ABSTRACT

Background: Consistent evidence suggests a relationship between lower educational attainment and total obesity defined using body mass index (BMI); however, a comparison of the relationships between educational attainment and total obesity (BMI ≥30 kg/m²) and central obesity (waist circumference (WC) ≥102 cm for men and ≥88 cm for women) has yet to be carried out. This systematic literature review (SLR) and meta-analyses aimed to understand whether i) the associations between education and obesity are different depending on the measures of obesity used (BMI and WC), and ii) to explore whether these relationships differ by gender and region.

Methods: Medline, Embase and Web of Science were searched to identify studies investigating the associations between education and total and central obesity among adults in the general population of countries in the Organisation for Economic Co-operation and Development (OECD). Meta-analyses and meta-regression were performed in a subset of comparable studies (n=36 studies; 724,992 participants).

Results: 86 eligible studies (78 cross-sectional and eight longitudinal) were identified. Among women, most studies reported an association between a lower education and total and central obesity. Among men, there was a weaker association between lower education and central than total obesity (OR central vs total obesity in men 0.79 (95% CI 0.60, 1.03)). The association between lower education and obesity was stronger in women compared with men (OR women vs men 1.66 (95% CI 1.32, 2.08)). The relationship between lower education and obesity was less strong in women from Northern than Southern Europe (OR Northern vs Southern Europe in women 0.37 (95% CI 0.27, 0.51)), but not among men.

Conclusions: Associations between education and obesity differ depending on whether total or central obesity is used among men, but not in women. These associations are stronger among women than men, particularly in Southern European countries.

Introduction

The most recent global estimates for adults suggest that 11.6% (95% confidence interval (CI) 10.6%–12.6%) of males and 15.7% (95% CI 14.6%–16.8%) of females were obese in 2016 (NCD-RisC, 2017). The prevalence is highest among high income countries (Afshin et al., 2017), with a mean prevalence of 19.5% (95% CI not reported) in OECD countries in 2015 (OECD, 2017). This poses enormous individual and public health risks as obesity is associated with increased all-cause mortality and significant morbidity (Abranches et al., 2015; Carbone et al., 2013, 2018; Thijssen et al., 2015). Total obesity is usually identified using body mass index (BMI), where a BMI ≥30 kg/m² is classed as obese in both men and women (WHO, 2000). However, central obesity has received increased attention because of the additional prognostic information it may provide for some health outcomes, such as cardiovascular disease and type 2 diabetes (Balkau et al., 2007; Janssen et al., 2004). Central obesity is usually identified measuring waist circumference (WC) (>102 cm for men and >88 cm for women). Although there
are more precise measures of adiposity, such as body fat mass derived from skinfold thickness or dual energy X-ray absorptiometry (DXA), BMI and WC are the most commonly utilised measures as they are inexpensive and practical to use in epidemiological studies and routine clinical practice (Hu, 2008).

The complex factors that play a role in the development of obesity can be described by the ‘social determinants of health’ model (Whitehead and Dahlgren, 1991), which describes the multiple socioeconomic circumstances that can together influence a person’s behaviour and health. Previous reviews have shown that lower socioeconomic position (SEP) is associated with obesity in high-income countries (Cohen, Rai, Rehkopf, & Abrams, 2013a; El-Sayed et al., 2012; Kim et al., 2017; McLaren, 2007; Newton et al., 2017; Parsons et al., 1999; Senese et al., 2009), but not in low-income countries (Cohen, Rai, Rehkopf, & Abrams, 2013a), suggesting that region (or more specifically economic status of a country) may modify the relationship between SEP and obesity. In studies examining SEP-obesity associations in high income countries, this was reported more consistently among women than men, suggesting that gender may modify the relationship between SEP and obesity (Cohen, Rai, Rehkopf, & Abrams, 2012a; El-Sayed et al., 2012; Kim et al., 2017; McLaren, 2007; Newton et al., 2017; Senese et al., 2009). Importantly, most of these studies focussed on BMI and few compared the associations of indicators of SEP with total and central adiposity. One review indicated that men and women with cumulative exposure to lower SEP across life had a higher mean BMI compared with those with a higher SEP across life; however, men with a lower SEP across life had lower mean WC compared with men with a higher SEP across life (Newton et al., 2017). Therefore, associations between SEP and obesity may differ depending on whether the outcome is total or central obesity, but this has not been investigated.

Most reviews about SEP and obesity use multiple indicators of SEP including educational attainment, occupation, income or deprivation (El-Sayed et al., 2012; McLaren, 2007; Newton et al., 2017; Senese et al., 2009). However, McLaren (2007) reported that adiposity outcomes vary by SEP indicator and thus they cannot be used interchangeably. This review focuses on educational attainment (numbers of years at school/highest qualifications obtained), because more so than occupation or income, it is an important indicator of SEP in early life, reflecting a family’s lifestyle, material and intellectual resources, and it is also a strong predictor of SEP and life chances across adulthood (Beebe-Dimmer et al., 2004; Smith et al., 1997). It has been proposed that increased health literacy and material and financial resources among people with higher levels of educational attainment lead to healthier lifestyles and reduced obesity rates (Hulshof et al., 1991; Mazzocchi et al., 2009). Other advantages of studying educational attainment over other SEP indicators is that it is easy to measure, usually has a high response rate when measured in studies and can be assessed in all people regardless of age or working circumstances (Galobardes et al., 2006). Understanding the link between educational attainment and different definitions of obesity may lead to the development of targeted education-based policy interventions that help to prevent obesity and related chronic diseases (Devaux et al., 2011).

We therefore aimed to conduct a systematic literature review (SLR) and meta-analysis to: 1) understand whether the associations between educational attainment and obesity are different depending on the measures used to identify obesity (BMI and WC), and 2) explore whether these relationships differ by gender and region.

Methods

The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The following PICO model defined the search strategy (Table S1): Population (P), adults (aged ≥16 years) from the Organisation for Economic Co-operation and Development (OECD) countries (as of 2020 (OECD, 2020a)); Intervention/exposure (I), educational attainment/years of education; Comparison (C), none (limited to observational studies); and Outcome (O), total obesity (BMI ≥30 kg/m²) and central obesity (WC > 102 cm for men and WC > 88 cm for women).

Inclusion and exclusion criteria

Medline, Embase and Web of Science were searched for studies from January 1, 2000 until February 28, 2021 to summarise the literature most relevant to today’s social environment. The inclusion criteria were 1) peer-reviewed articles including statistical analysis with an effect size for the association between educational status and obesity in the total study population and/or by gender, 2) total obesity or central obesity defined by BMI ≥30 or WC > 102 cm for men and WC > 88 cm for women (WHO, 2000), 3) participants aged ≥16 years, 4) cross-sectional or prospective observational cohort studies, 5) OECD countries as of March 2020 (OECD, 2020a), and 6) English language articles only. Conference abstracts were excluded.

We focussed specifically on the state of total obesity or central obesity as weight change is not a definite proxy for excess adiposity. Only studies with participants aged ≥16 years were included in this review as children and younger adolescents were unlikely to have completed their education. Lastly, Cohen et al. (2013a) reported that the direction of the association between education and obesity depends on a country’s economic status; therefore, only countries within the OECD as of 2020 were included to minimise sources of heterogeneity between studies.

Screening

Titles and abstracts were independently screened by RW and JG, and disagreements were solved through consensus discussion. Subsequently, full texts were screened by one reviewer (RW) and a random sample of 10% by a second reviewer (JMG) to confirm agreement. Disagreements of inclusion and exclusion of articles were resolved with an independent reviewer (SV). Reference lists of two previously conducted systematic literature reviews (Cohen, Rai, Rehkopf, & Abrams, 2013a; Kim et al., 2017) and of the included studies were also screened.

Data abstraction

Descriptive data on study population and design were extracted from all manuscripts using a standard pro forma. If a study presented results from unadjusted and adjusted models, only the independent effect sizes from the adjusted models were included in this review. If different countries, ethnicities or multiple time points were assessed in one article, estimates from each country, ethnicity or time point were reported as separate ‘data points’ where possible, though some studies pooled multiple time points into one data point. Countries were grouped by geographic region using the United Nations ‘M49 standard’ (UNSD, 1999).

Data synthesis

For both BMI and WC, meta-analyses were performed if studies stratified results based on gender and if they reported an odds ratio (OR) with three or four educational categories. For BMI, an additional meta-analysis was performed for studies that estimated the effect of education with the relative index of inequality (RII) separately for men and women. RII is a regression based measure that compares the risk of obesity between those with the lowest and the highest education in a sample (Mackenbach & Kunst, 1997). For the meta-analyses, pooled ORs were calculated using random-effect models. The lowest with the highest educational category was compared; if studies did not report in this order, an inverse of the OR and 95% CI was calculated. All meta-analyses were checked for publication bias using the Egger’s test for asymmetry. Moreover, random-effect meta-regression analyses were
performed to investigate differences between measures (BMI vs WC),
gender (women vs men) and regions. Only the different regions in
Europe were included in the meta-regression as there was a lack of data
on the other regions. All statistical analyses were performed using Stata
version 14, with Metan and Metareg packages. Studies that did not meet
the above criteria for the meta-analyses and meta-regression are re-
ported in a narrative summary.

Quality assessment

Study quality was assessed by RW using the Quality In Prognosis
Studies (QUIPS) tool (Hayden et al., 2013), recommended by the
Cochrane Prognosis Methods Group (Riley et al., 2019). Six domains
were evaluated for each study: study participation, study attrition,
prognostic factor measurement, outcome measurement, confounding
and statistical analysis and reporting. For each domain, the risk of bias
was rated ‘low’, ‘moderate’ or ‘high’.

Results

The initial database search identified 3230 articles of which 2506
were unique records (Fig. 1). After full-text review and reference list
screening, 86 studies were included.

Description of included studies

Studies from thirty-two OECD countries were included in this review,
representing all geographic regions of the M49 standard, except for
South America. Of the 86 studies, the majority were cross-sectional
(n=78), which means that the exposure (educational attainment) and
outcome (obesity) were measured at the same time point. The median
sample size of all studies was 6548 (interquartile range (IQR): 3410,
11,497). Mean age ranged from 18 years (SD: not reported (NR)) (a
sample of 18 year old Portuguese conscripts) (Padez, 2006) to 68.7 years
(SD: 0.2 [sic]) (Pérez-Hernández et al., 2017), but the majority of studies
(n=78, 90.7%) reported a mean age of above 40 years. Overall, studies
were of good quality (Table S6). The domains ‘attrition/response rate’,
‘outcome measurement’ and ‘statistical analysis’ received the most
moderate to high bias ratings due to, respectively, no information about
missing data, self-reported instead of measured height and weight data
and no reporting of the obesity reference category (healthy weight or
non-obese). The measurement of educational attainment and catego-
risation of educational level varied across studies (Table S3). Tables 1
and 3 report estimates comparing the lowest and highest educational
categories.

Association between educational attainment and obesity defined by BMI

In total, 85 studies reported on associations between education and
obesity defined using BMI (Table S3). There were eight longitudinal

![Fig. 1. PRISMA flowchart of the selection of studies.](image-url)
Table 1

Association between education and total obesity defined by BMI ≥30 kg/m² lowest vs highest educational categories.

| Country (year(s) of survey) | Women | Men |
|-----------------------------|-------|-----|
| **Eastern Europe (total inverse associations)** | 6 out of 6 (100%) | 4 out of 6 (66.7%) |
| Czech Republic (Roskam et al., 2010) (2002) | RII 5.3 (1.3, 18.2) | RII 3.6 (1.1, 12.2) |
| Hungary (Devaux & Sassi, 2013) (2000, 2003) | RII 2.9 (95% CI NR) | RII 1.8 (95% CI NR) |
| Hungary (Roskam et al., 2010) (2000, 2003) | RII 2.3 (1.6, 3.3) | RII 1.4 (1.0, 2.2) |
| Hungary (Rurik et al., 2014) (2013) | OR 2.4 (2.2, 2.7) | OR 1.5 (1.4, 1.7) |
| Poland (Zatorzetska et al., 2011) (2011) | OR 2.1 (1.7, 2.5) | OR 1.5 (1.2, 1.9) |
| Slovak Republic (Roskam et al., 2010) (2002) | RII 5.9 (1.4, 24.2) | RII 1.6 (0.5, 4.8) |
| **Meta-analysis pooled RII** | 5042 | |
| **Northern Europe (total inverse associations)** | 6 out of 6 (100%) | 4 out of 6 (66.7%) |
| Denmark (Sarlio-Lahteenkorva et al., 2006) (1994) | RII 1.9 (95% CI NR) | RII 1.4 (95% CI NR) |
| Estonia (Klibiemiene et al., 2004) (1994, 1996, 1998) | RII 2.2 (1.7, 2.9) | RII 1.7 (1.3, 2.3) |
| Estonia (Roskam et al., 2010) (2002, 2004) | OR 2.3 (1.6, 3.2) | OR 0.9 (0.6, 1.5) |
| Finland (Suhnder and Uutela, 2007) (Bianuarily 1993-2007) | OR 1.5 (1.3,18) | OR 1.4 (1.2, 1.8) |
| Finland (Sarlio-Lahteenkorva et al., 2006) (1994) | OR 2.7 (1.8, 3.9) | OR 1.7 (1.3, 2.3) |
| Finland (Klibiemiene et al., 2004) (1994, 1996, 1998) | OR 1.8 (1.4, 2.3) | OR 1.7 (1.3, 2.2) |
| Finland (Roskam et al., 2010) (Bianuarily 1994-2004) | RII 1.6 (1.1, 2.4) | RII 1.5 (1.0, 2.3) |
| Finland (Laskozeni et al., 2004) (2000, 2001) | OR 1.7 (0.7, 1.6) | OR 1.2 (0.6, 2.3) |
| Finland (Seppanen-Nuutinen et al., 2009) | OR 1.7 (1.3, 2.2) | OR 1.8 (1.3, 2.3) |
| Finland (Salonen et al., 2009) (2004) | OR 1.4 (0.9, 2.1) | OR 1.3 (0.7, 2.2) |
| Latvia (Roskam et al., 2010) (1998, 2000, 2002, 2004) | RII 1.5 (0.9, 2.5) | RII 0.9 (0.5, 1.6) |
| Lithuania (Klibiemiene et al., 2004) (1994, 1996, 1998) | OR 1.4 (1.1, 1.9) | OR 1.2 (0.8, 1.7) |
| Lithuania (Roskam et al., 2010) (Bianuarily 1994-2004) | RII 2.7 (1.8, 3.9) | RII 1.0 (0.6, 1.6) |
| **Southern Europe (total inverse associations)** | 6 out of 6 (100%) | 4 out of 6 (66.7%) |
| Spain (Roskam et al., 2010) (2011) | RII 2.1 (95% CI NR) | RII 1.1 (95% CI NR) |
| Italy (Roskam et al., 2010) (2002) | RII 1.8 (0.8, 4.0) | RII 1.4 (1.7, 6.9) |
| Republic of Ireland (Roskam et al., 2010) (1995, 2002) | RII 2.0 (0.9, 4.2) | RII 1.3 (0.7, 2.7) |

Table 1 (continued)

| Country (year(s) of survey) | Women | Men |
|-----------------------------|-------|-----|
| **Eastern Europe (total inverse associations)** | 6 out of 6 (100%) | 4 out of 6 (66.7%) |
| Republic of Ireland (Hughes et al., 2017) (2007) | RII 1.7 (95% CI NR) | RII 1.5 (95% CI NR) |
| Sweden (Lindstroem et al., 2003) (1994) | OR 2.3 (1.4, 3.8) | OR 2.3 (1.5, 3.5) |
| Sweden (Molarius, 2003) | OR 2.3 (1.3, 4.2) | OR 2.5 (1.3, 4.8) |
| Sweden (Devaux & Sassi, 2013) | RII 3.3 (95% CI NR) | RII 2.8 (95% CI NR) |
| Sweden (Roskam et al., 2010) (2000, 2001) | OR 3.9 (2.1, 7.0) | RII 4.3 (2.4, 7.8) |
| **Meta-analysis pooled RII** | 90,037 | 2.25 (1.85, 2.74), I² = 32.1% |

| Women | Men |
|-------|-----|
| **Southern Europe (total inverse associations)** | 6 out of 6 (100%) | 4 out of 6 (66.7%) |
| Greece (Tsatsas et al., 2010) (2003) | OR 1.6 (1.2, 2.0) | OR 1.3 (1.0, 1.7) |
| Italy (Devaux & Sassi, 2013) (1995, 2000, 2003, 2005) | RII 6.8 (95% CI NR) | RII 6.0 (4.7, 7.7) |

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Table 1 (continued)

| Country (year(s) of survey) | N | Association with obesity (effect size (95% CI)) |
|-----------------------------|---|-------------------------------------------------|
| **Women** | **Men** | **Women** | **Men** |
| **Italy** | **(Roskam et al., 2010)** | **6 out of 6 (100%)** | **4 out of 6 (66.7%)** |
| **Portugal** | **(Padez, 2006)** | **(Annually 1986–2000)** | **102,540** |
| **Spain** | **(Roskam et al., 2010)** | **(1996, 1999, 2005)** | **39,640** |
| **Portugal** | **(Moreira & Padrão, 2006)** | **(1998)** | **12,297** |
| **Portugal** | **(Roskam et al., 2019)** | **(1998, 1999)** | **1621** |
| **Portugal** | **(Sardinha et al., 2012)** | **(2009)** | **6908** |
| **Portugal** | **(Gio et al., 2018)** | **(2013)** | **4819** |
| **Spain** | **(Santos and Barros, 2003)** | **(NR)** | **741** |
| **Spain** | **(Martinez-Ros et al., 2001)** | **(1995)** | **3091** |
| **Spain** | **(Aranguren et al., 2001)** | **(1994)** | **5388** |
| **Spain** | **(Gutiérrez-Fisac et al., 2002)** | **(1995, 1997)** | **2880** |
| **Spain** | **(Devaux & Sassi, 2013)** | **(1995, 1997, 2001, 2003)** | **39,826** |
| **Spain** | **(Rosckam et al., 2010)** | **(2001)** | **7741** |
| **Spain** | **(Férez-Hernández et al., 2013)** | **(2000)** | **2699** |
| **Spain** | **(Palomo et al., 2014)** | **(NR)** | **2833** |
| **META-analysis pooled OR** | **61,651** | **6.05 (4.90, 7.34), I^2=0.0%** |
| **META-analysis pooled ORs** | **177,775** | **3.19 (2.20, 3.20), I^2=96.0%** |
| **Eastern Asia (total inverse associations)** | **5 out of 5 (100%)** | **OR 2.8 (1.3, 5.6)** |
| **Japan** | **(Asbara et al., 2020)** | **(2018)** | **5425** |
| **South Korea** | **(Yoon et al., 1998)** | **(1998)** | **7962** |
| **South Korea** | **(Devaux & Sassi, 2013)** | **(1998, 2001, 2005)** | **19,113** |
| **South Korea** | **(Chung & Kim, 2012)** | **(2012)** | **17,245** |
| **South Korea** | **(Chung & Kim, 2009)** | **(2016)** | **9991** |
| **META-analysis pooled OR** | **25,207** | **2.27 (1.57, 3.29), I^2=68.7%** |
| **Western Asia (total inverse associations)** | **4 out of 4 (100%)** | **OR 2.2 (0.4, 11.9)** |
| **Turkey** | **(Martorell et al., 2000)** | **(1993)** | **2401** |
| **Turkey** | **(Darsun et al., 2018)** | **(Biannually 2008–16)** | **13,546** |
| **Turkey** | **(Bilgic et al., 2019)** | **(2015)** | **833** |
| **Turkey** | **(Kılıçarlan et al., 2006)** | **(NR)** | **1500** |
| **META-analysis pooled OR** | **1500** | **1.41 (0.56, 3.58), I^2=0.0%** |
| **Northern America (total inverse associations)** | **Canada** | **(Huot et al., 2004)** | **10,014** |
| **USA** | **(Martorell et al., 2000)** | **(1988–94, NR how many cross-sectional surveys included)** | **5219** |
| **USA** | **(Borders et al., 2006)** | **(2003)** | **5078** |
| **USA** | **(Coogan et al., 2012)** | **(2009)** | **21,457** |
| **USA** | **(von Hippel & Lynch, 2014)** | **(2010)** | **8665** |
| **USA** | **(Hales et al., 2018)** | **(2014, 2016)** | **10,792** |
| **META-analysis pooled OR** | **15,092** | **1.28 (0.78, 2.11), I^2=82.2%** |
| **Central America (total inverse associations)** | **4 out of 5 (100%)** | **OR 2.4 (1.4, 4.0)** |
| **Mexico** | **(Martorell et al., 2000)** | **(1987)** | **3681** |
| **Mexico** | **(Barenblatt et al., 2010)** | **(2000)** | **38,901** |
| **Mexico** | **(Perez Ferrer et al., 2014)** | **(2012)** | **U 9588** |
| **META-analysis pooled RII** | **14,531** | **1.34 (0.97, 1.83), I^2=78.9%** |
| **Oceania (total inverse associations)** | **4 out of 4 (100%)** | **OR 2.0 (1.6, 2.3)** |
| **Australia** | **(Lawler et al., 2005)** | **(1996)** | **14,099** |
| **Australia** | **(Cameron et al., 2003)** | **(2000)** | **11,247** |
| **Australia** | **(Brown & Siahpush, 2007)** | **(2001)** | **26,863** |
| **Australia** | **(Devaux & Sassi, 2013)** | **(1995, 2001, 2005)** | **80,215** |
| **META-analysis pooled RII** | **14,099** | **2.20 (1.59, 3.04), I^2=0.0%** |
| **Total inverse associations of all studies** | **87 out of 101** | **OR 2.4 (1.4, 3.6)** |
| **META-analysis of all studies** | **227,763** | **2.95 (2.37, 3.68), I^2=89.9%** |
| **META-analysis of all studies** | **497,229** | **2.02 (1.78, 2.31), I^2=92.7%** |
studies (follow-ups were five (Camões et al., 2010), 10 (Chung and Kim, 2020), 13 (von Hippel & Lynch, 2014), 14 (Coogan et al., 2012), 23 (Salsberry and Reagan, 2009), 29 (Cohen, Rehkopf, Deardorff, & Abrams, 2013b), 33 (Salonen et al., 2009) and 36 years (Kim, 2016)). Six studies reported results of multiple countries (Devaux & Sassi, 2013; Drewnowski et al., 2005; Hughes et al., 2017; Klumbiene et al., 2004; Roskam et al., 2016; Sarlio-Lähteenkorva et al., 2006). Another six studies, all performed in the USA, reported on multiple ethnicities (Beltrán-Sánchez et al., 2016; Cohen, Rehkopf, Deardorff, & Abrams, 2013b; Ng et al., 2011; Qobadi and Payton, 2017; Salsberry and Reagan, 2009; Zhang and Wang, 2004). Therefore, the 83 studies included 101 data points for women, 91 for men and 35 data points for studies that combined men and women. 82 of the 83 studies reported results adjusted for covariates, and for three studies it was not clear (Killeen et al., 2006; Rurik et al., 2014; Zatoniska et al., 2011). 65 studies reported stratified results for men and women (Table 1), five studies were eligible for the meta-analysis for studies that reported on the association of education modelled as RII, and 31 studies were included in the meta-analysis of studies that compared three or four educational categories. In both these meta-analyses, there was no evidence of publication bias using Egger’s test (p=0.217 and p=0.686, respectively) (funnel plots are shown in Figs. S1 and S2).

Of the data points including women, 86.1% (87/101) found an association between lower levels of education (for example, fewer years of schooling or no qualifications) and higher odds of total obesity. This was 65.9% (60/91) for men. Subgroup meta-analysis of data points that reported on the association of education modelled as RII and Odds of obesity showed higher pooled ORs for women (2.95 (95% CI 2.37, 3.68), $I^2=89.9\%$ and 2.02 (95% CI 1.78, 2.31), $I^2=92.7\%$ compared with men (2.12 (95% CI 1.80, 2.48), $I^2=63.2\%$ and 1.46 (95% CI 1.16, 1.83), $I^2=98.6\%$). These gender differences were tested in meta-regression analyses (Table 2a) and were found to be statistically significant: adjusted for region and number of educational categories the ORs were 1.66 (95% CI 1.32, 2.08), $I^2=58.92\%$ for the RII subset of studies and 1.40 (95% CI 1.09, 1.81), $I^2=94.46\%$ for the OR subset of studies. Statistical heterogeneity was higher in studies that looked at the odds of obesity with three and four educational categories compared with RII, and subgroup meta-analysis indicate high statistical heterogeneity particularly in Western and Southern Europe (Table 1).

The association between a lower education and total obesity was more consistent in women than men in Northern America and Eastern, Western and Southern Europe compared with Northern Europe and Oceania, where effect sizes differed less between genders. These differences were confirmed by the meta-regression analyses in a subset of RII and studies with three or four educational categories respectively, which showed that there was a stronger association between a lower education and total obesity in women compared with Northern Europe (ORs for Northern vs Southern Europe: 0.37 (95% CI 0.27, 0.51), $I^2=20.31\%$ and 0.59 (95% CI 0.40, 0.88), $I^2=91.81\%$), but this was not the case for men (ORs for Northern vs Southern Europe 0.77 (95% CI 0.40, 1.51), $I^2=67.05\%$ and 0.88 (95% CI 0.66, 1.16), $I^2=74.00\%$) (Table 2b).

There were no statistically significant differences between other regions in Europe (Table S5), and due to a small amount of studies it was not possible to formally test differences between the other regions.

### Association between educational attainment and central obesity defined by WC

16 studies reported on WC (Table S4), of which 12 stratified results based on gender and eight studies were included in the meta-analysis (Table 3). In 81.8% (9/11) (Cameron et al., 2003; Camões et al., 2010; Ko et al., 2015; Marques-Vidal et al., 2008; Pérez-Hernández et al., 2017; Rurik et al., 2014; Sardinha et al., 2012; Stringhini et al., 2012; Yoon et al., 2006) of studies of women, a relationship between lower education and central obesity was found, with a pooled OR of 1.7 (95% CI 1.3, 2.1), $I^2=82.5\%$. This was 50.0% (6/12) (Cameron et al., 2003; Marques-Vidal et al., 2008; Pérez-Hernández et al., 2017; Rurik et al., 2014; Sardinha et al., 2012; Stringhini et al., 2012) for studies of men, with a pooled OR of 1.3 (95% CI 1.1, 1.6), $I^2=74.4\%$. Similar to the results for BMI, among women there was more likely to be an association between lower levels of education and increased odds of central obesity than among men (OR women vs men 1.63 (95% CI 1.05, 2.54)) (Table 4). At least one study of every region reported on WC, except for Western Asia, Northern America and Southern America. There were no clear differences in the effect sizes or the direction of the association between different regions; however, it was not possible to formally test this due to a small amount of studies. There was no evidence of publication bias in the meta-analysis using Egger’s test (p=0.652) (funnel plot is shown in Fig. S3).

### Table 2B

Meta-regression to confirm regional differences for the association between education and total obesity defined by BMI ≥30 kg/m², in a subset of studies modelling RII (n=5 studies) and OR with three to four educational categories (n=30 studies).

|                      | Subset of RII studies included in meta-analysis OR (95% CI) | Subset of OR studies with three or four educational categories included in meta-analysis OR (95% CI) |
|----------------------|------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| **Women**            |                                                            |                                                                                                   |
| Extended            |                                                            |                                                                                                   |
| Northern vs Western  | 0.50 (0.36, 0.68), $I^2=31.42\%$                           | 0.72 (0.52, 1.00), $I^2=74.75\%$                                                                  |
| Europe               |                                                            |                                                                                                   |
| Northern vs Southern | 0.37 (0.27, 0.51), $I^2=20.31\%$                           | 0.59 (0.40, 0.88), $I^2=91.81\%$                                                                  |
| Europe               |                                                            |                                                                                                   |
| Men                  |                                                            |                                                                                                   |
| Northern vs Eastern  | 1.00 (0.41, 2.42), $I^2=67.83\%$                           | 1.06 (0.64, 1.75), $I^2=45.21\%$                                                                  |
| Europe               |                                                            |                                                                                                   |
| Northern vs Southern | 0.77 (0.40, 1.51), $I^2=67.05\%$                           | 0.88 (0.66, 1.16), $I^2=74.00\%$                                                                  |

OR, odds ratio; CI, confidence interval. Only the estimates of statistically significant differences between regions are shown here; however, comparisons of all regions that have enough data points are shown in Table S5.
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Table 3
Association between education and central obesity defined by WC > 102 cm for men and WC > 88 cm for women for the lowest vs the highest educational categories.

| Country (year of survey) | N      | Association with a highest obesity (effect size (95% CI)) |
|-------------------------|--------|--------------------------------------------------------|
|                         |        | Women | Men |
| **Eastern Europe (total inverse associations)** |        |       |     |
| Hungary (Burik et al., 2014) (2013) | 40,331 | 1 out of 1 (100%) | 1 out of 1 (0%) |
| Northern Europe (total inverse associations) | – | 0 out of 1 (0%) |     |
| Denmark (Nielsen et al., 2005) (2003) | 783 | 9.4 (95% CI 0.3, 25.0) | OR 1.0 (0.6, 1.7) |
| Western Europe (total inverse associations) | 7603 | 2 out of 3 (66.7%) | 2 out of 3 (66.7%) |
| France (Czernichow et al., 2004) (1996) | 6705 | OR 0.9 (0.6, 1.3) | OR 1.2 (0.9, 1.8) |
| Switzerland (Marques-Vidal et al., 2008) (2003) | 6186 | OR 2.6 (2.0, 3.5) | OR 1.4 (1.0, 2.0) |
| Switzerland (Stringhini et al., 2012) (2006) | 6303 | RII 2.6 (2.1, 3.3) | RII 1.5 (1.2, 1.9) |
| Southern Europe (total inverse associations) | 16,073 | 3 out of 4 (75%) | 2 out of 4 (50%) |
| Greece (Tzaniz et al., 2013) (2003) | 16,073 | OR 1.1 (0.9, 1.4) | OR 1.0 (0.8, 1.4) |
| Portugal (Camões et al., 2010) (2008) | 1621 | RR 2.0 (1.4, 3.3) | RR 0.8 (0.6, 5.0) |
| Portugal (Sardinha et al., 2012) (2009) | 6908 | OR 3.3 (2.6, 4.2) | OR 1.6 (1.1, 2.2) |
| Spain (Pérez-Hernández et al., 2017) (2010) | 2699 | OR 2.6 (1.8, 3.7) | OR 1.4 (1.0, 2.0) |
| Eastern Asia (total inverse associations) | 2 out of 2 (100%) | OR 2.9 (2.0, 3.9) | OR 0.8 (0.5, 1.1) |
| South Korea (Yoon et al., 2006) (1998) | 7962 | PR 2.5 (1.7, 3.3) | PR 0.8 (0.6, 1.0) |
| South Korea (Ko et al., 2015) (2010) | 6178 | 1 out of 1 (100%) | 1 out of 1 (100%) |
| Oceania (total inverse associations) | 12,477 | OR 2.7 (1.6, 4.4) | OR 2.3 (1.7, 3.2) |
| Australia (Cameron et al., 2003) (2000) | 11,247 | 9 out of 11 (81.8%) | 6 out of 12 (50.0%) |
| **Total inverse associations of all studies** | 98,111 | 1.3 (1.3, 2.1) | 1.9 (1.1, 1.6) |
| **Meta-analysis** | 98,111 | 1.7 (1.3, 2.1) | 1.3 (1.1, 1.6) |

N, sample size; CI, confidence interval; OR, odds ratio; h, highest education; l, lowest education; NR, not reported; RII, relative index of inequality; RR, risk ratio; PR, prevalence ratio. Only the estimate of the most recent year and of the lowest vs the highest or the lowest vs the lowest education categories are shown here; however, all estimates are shown in Table S4. Results that show an inverse association (i.e. an association between lower education and obesity) based on statistical significance. *Included in meta-analyses and meta-regression analyses (Fig. 2 and Table 4).

Comparison of the results for BMI and WC

15 studies reported on both BMI and WC in the same sample. Eight of these reported on both men and women and had comparable educational categories and were included in the meta-analysis (Fig. 2). The pooled ORs of total obesity were larger for both men and women (respectively, 1.66 (95% CI 1.31, 2.10) and 2.52 (95% CI 2.04, 3.11)) than for central obesity (1.32 (95% CI 1.09, 1.59) for men and 2.15 (95% CI 1.60, 2.88) for women). Meta-regression indicated that men were less likely to have an association between lower education and central obesity compared with total obesity (OR central vs total obesity 0.79 (95% CI 0.60, 1.03)) (Table 4). This was less so the case among women (OR central vs total obesity 0.84 (95% CI 0.48, 1.47)).

Table 4
Meta-regression of a subset of studies reporting an OR for both BMI and WC for the association between education and obesity stratified by gender and obesity measure.

| Meta-regression BMI vs WC | Women (pooled OR (95% CI)) | Men (pooled OR (95% CI)) |
|--------------------------|-----------------------------|--------------------------|
| Not adjusted             | 0.84 (0.54, 1.33)            | 0.79 (0.53, 1.18)         |
| Adjusted for region and number of educational categories of the studies | 0.84 (0.48, 1.47) | 0.79 (0.60, 1.03) |
| **Meta-regression women vs men** | BMI (OR (95% CI) | WC (OR (95% CI)) |
| Not adjusted             | 1.52 (1.02, 2.29)            | 1.63 (1.05, 2.54)         |
| Adjusted for region and number of educational categories of the studies | 1.53 (0.96, 2.44) | 1.64 (0.97, 2.76) |

OR, odds ratio; CI, confidence interval. Based on eight studies that reported OR and that used three or four educational categories. Only the effect sizes of the lowest vs the highest education categories were included in the meta-analysis and meta-regression.

Discussion

This SLR investigated how the association between education and obesity varies depending on the measure used to identify obesity, for men and women and between different regions of the OECD. The results show that, in OECD countries, the association between lower education levels and total and central obesity is stronger among women than men. Among men, more studies reported an association between lower education and total obesity compared with central obesity. Moreover, the association between lower education and total obesity was stronger among Southern compared with Northern European women.

The results of this SLR are similar to those found in a previous SLR, published in 2017, looking at the associations between multiple measures of SEP across life (i.e. parents or own occupation, income, education or material possessions) and obesity. Men and women with a lower life course SEP had a higher mean BMI; however, mean WC was lower among men with a lower compared to a higher life course SEP, whereas the opposite was seen for women (Newton et al., 2017). This may suggest that educational inequalities manifest differently in men and women due to occupational differences. Research has shown that lower SEP was linked to increased occupational physical activity among men (i.e. manual occupations), but not among females (i.e. administrative or caring occupations) (Beeenackers, Kamphuis, & Giskes, 2012; Stalsberg & Pedersen, 2018) Increased occupational physical activity in men with lower education levels may lead to increased lean muscle mass (Bann et al., 2014), resulting in higher BMI but normal WC. By contrast, this happens less often in women (Wardle et al., 2002).

In general, the relationship between a lower SEP and obesity defined by BMI in high income countries have been confirmed by other SLRs among women, whereas more inconsistent results were found among men (Cohen, Rai, Rehkopf, & Abrams, 2013a; El-Sayed et al., 2012; Kim et al., 2017; McLaren, 2007; Newton et al., 2017; Senese et al., 2009); two of these focussed specifically on education (Cohen, Rai, Rehkopf, & Abrams, 2013a; Kim et al., 2017). Mechanisms through which education and SEP may affect obesity are outlined in the 'social determinants of health' model (Whitehead and Dahlgren, 1991), where education influences living and working conditions and social and community networks which, in turn, influence individual lifestyle factors and health. This has been supported by studies that show that in high-income countries higher educated individuals eat healthier diets (Irala-Estévez et al., 2000) and perform more leisure time physical activity (Stalsberg and Pedersen, 2018), presumably due to increased health literacy (Hulshof et al., 1991) and having better financial and emotional support (Berkman, 1995). The 'health belief model' might help us to understand the stronger association between education and obesity observed among women compared with men, where perceiveed severity, susceptibility, benefits and barriers influence weight control practices (Saghafi-Asl...
Fig. 2. Meta-analyses of studies reporting an OR for both BMI and WC for the association between education and obesity, stratified by measure and gender.

*Studies are ordered in the same way as Tables 1 and 3, based on region and date of survey.*
et al., 2020). Compared with men, women experience increased weight-related ideals, where a lower weight is seen as healthier and more attractive (perceived benefit of weight control practices). These weight-related ideals might be more difficult to sustain for women with a lower SEP (Jeffery & French, 1996) (perceived barrier for weight control practices). Because of this, education may influence weight to a greater extent in women; however, this needs further investigation.

Our review also indicated geographical variation regarding the influence of gender on the relationship between education and obesity defined by BMI; in women, the association between lower education and obesity was stronger in Southern compared with Northern Europe. This difference was not seen in men. This might be explained by the fact that Northern European countries (compared to other OECD countries) have had a longstanding progressive agenda for gender equality, with concrete policies to ensure women and men from all educational backgrounds are equally represented in the workforce (Borchorst & Stim, 2008; OECD, 2018). This has proven effective as figures show that compared to other OECD countries, Northern European countries have smaller gender gaps in labour market participation and working hours, and mothers are more likely to work (Bann et al., 2014). In contrast, women with lower levels of education in Southern Europe often have a more ‘traditional’ role and participate less in the workforce, which might be reinforced by limited opportunities to work part-time and less financial support for child care (Jura-Guerrero & Naldini, 2018). Participating in the workforce increases social support, which may lead to increased empowerment to access health care services, and increase income levels to support a healthy lifestyle (Berkman, 1995).

There are some disadvantages to using education as an indicator for SEP. Firstly, the meaning of education differs for different birth cohorts; trends of improving educational opportunities have resulted in increased educational attainment for women and ethnic minorities in recent decades, which means that people with lower levels of education are overrepresented in older birth cohorts (Galobardes et al., 2006). These effects have not been accounted for in the included studies. Although using a publication cut-off of the year 2000 might have reduced these effects, there were still studies that included data from 1987 (Table 1) and, thus, there will be some generational differences unaccounted for. One of the inclusion criteria was participants aged ≥16 years; as some included participants might not have finished their formal education yet, in some studies the highest levels of educational attainment may be underrepresented. Nonetheless, the results of four studies that included participants aged ≥16 years (Devaux & Sassi, 2013; Martorell et al., 2000; Ogna et al., 2014; Tecichaya and Lorentz, 2012) do not differ substantially from the rest of the studies that included participants aged ≥18 years. Furthermore, qualifications and quality of education are not standardised across different countries and therefore makes comparisons across countries challenging (OECD, 2020b). However, the advantages of using education as an indicator in observational studies is that it is easy to measure and usually has a high response rate when assessed in clinical and epidemiological studies (Galobardes et al., 2006). Although BMI and WC are the most commonly used measures of obesity in research and clinical settings, it is recognised that these measures lack some precision and do not directly measure fat mass. The relationship between life course SEP and body composition using more sophisticated, but more expensive, measures, such as DXA, computer tomography and magnetic resonance imaging, is assessed in another SLR (Staatz et al., 2019).

Most studies reported a low or moderate risk of bias in most of the domains of the QUIPS tool (Table S6). When studies relied on self-reported height and weight to calculate BMI, they scored a ‘moderate risk of bias’ in the outcome measurement domain, as self-reported height and weight data are prone to social desirability bias and consequently measurement error bias (i.e. underreporting of weight and over reporting of height) (Stomnml and Schoenborn, 2009). Moreover, many studies presented no information about the reference category of obesity (healthy weight or non-obese), which impacted the score on the ‘statistical analysis’ domain. Despite these variabilities, the results were mostly consistent between studies and, therefore, unlikely to influence our conclusions. Most studies were cross-sectional and reverse causality cannot be ruled out (i.e. childhood obesity leads to lower education), a possibility that is supported by previous studies that showed that a proportion of the association is accounted by the reverse causation (Kim et al., 2017; Howe et al., 2020). Because some studies have pooled data from multiple years, the survey years range from 1987 to 2016; in this time period, obesity has increased substantially (Afshin et al., 2017). Variability in obesity prevalence (Table S2) across and within countries may partly be due to variations in survey years. Sample selection bias may also play a role; for example, the national prevalence of obesity in France was estimated to be 11.9% (95% CI 11.5%, 12.3%) in 2003 (Charles et al., 2008) whereas Roskam et al. (2010) reported an obesity prevalence of 6.0% in 2004, indicating that the study sample is not generalizable to the whole population of France at that time. Lastly, the Egger’s test has been criticised because type 1 errors are likely to occur, leading to an overestimation of the presence of publication bias (Peters et al., 2006; Schwarzer et al., 2002; Sterne et al., 2000). However, as none of the results from our Egger’s tests were statistically significant, i. e. they did not indicate publication bias, this was not a concern in our review. Nonetheless, it is important to note that we only included formally published data in English language journals, and may therefore have missed some studies that were published in other languages.

A strength of this systematic literature review is that established protocols were followed and a large number of studies were synthesised. Furthermore, meta-analyses and meta-regression were performed in a subset of studies to formally test differences between measures, gender and region. To take into account the heterogeneity in definitions of education, it was decided to perform subgroup meta-analysis in studies with a similar education definition, where studies were combined based on the number of educational categories. This means that studies that did not define education based on three or four categories or did not estimate the relationship between education and obesity using RII were omitted for the meta-analyses; as a result, it is important to interpret the findings of the meta-analysis with some caution. Statistical heterogeneity was slightly reduced when adjusting for region or educational categories; the high degree of the remaining statistical heterogeneity might be caused by other factors, such as the inconsistent reporting of the obesity reference category. Moreover, only studies from OECD countries were included so that we could compare results of countries of a similar economic status. However, this does limit generalisability of our findings to countries outside the OECD. Although OECD countries are all considered high-income countries, there are still large differences socioeconomically, with the highest gross domestic product (GDP) of US $ 118,582 in Luxembourg and the lowest GDP of US $ 14,994 in Colombia (OECD, 2021a) in 2020 and in income inequality, with a Gini coefficient (an indicator of income inequality, where zero would represent an equal income for everyone) of 0.37 in the UK in 2019 and 0.26 in Belgium in 2018 (OECD, 2021b). Moreover, there are institutional and cultural differences between OECD countries, such as costs of further education, equal opportunities for men and women and compulsory military service (e.g. in South Korea and Israel) that may reflect educational attainment differences in different countries (OECD, 2020b). This means that direct comparison between countries may be problematic. Lastly, the majority of studies adjusted their analyses for relevant covariates such as age, gender (if applicable), other socioeconomic indicators and birth year.

This SLR has shown that both BMI and WC are important when researching obesity inequalities, particularly when examining gender differences. This might also be the case for other more accurate indicators (i.e. body fat percentage); therefore, there is a need to ensure a wide range of indicators of obesity are included in population surveys and public health interventions.

When devising strategies to prevent and treat obesity, it is important to take into account educational differences. A previous SLR indicated
that targeted weight loss interventions for low SEP individuals delivered at schools, communities and primary care settings were effective in reducing weight in the short term (Bambara, Hillier, & Cairns, 2015). Further research should also investigate whether interventions such as raising the compulsory education age reduces obesity levels over time.

In conclusion, this review strengthened the knowledge that lower educational attainment is associated with obesity, particularly for women. In addition, this study found that the association differed depending on the measure of obesity used: among men, there was more consistent evidence of the association between lower educational attainment and total obesity than central obesity, indicating the importance of using multiple measures of adiposity in future research and public health interventions.

CRediT authorship contribution statement

Rozemarijn Witkam: Conceptualization, Methodology, Formal analysis, Writing – original draft. James M. Gwinnutt: Conceptualization, Methodology, Formal analysis, Supervision, Writing – review & editing. Jennifer Humphreys: Conceptualization, Methodology, Supervision, Writing – review & editing. Julie Gandrup: Formal analysis, Writing – review & editing. Rachel Cooper: Writing – review & editing. Suzanne M.M. Verstappen: Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100884.

Ethics statement

As we did a systematic literature review, no ethics approval and consent were needed for this study.

References

Abranches, M. V., Oliveira, F. C., Conceição, L. L., & Peluzio, M. D. (2015). Obesity and diabetes: The link between adipose tissue dysfunction and glucose homeostasis. Nutrition Research Reviews, 28(2), 121-132.
Ahnín, A., Forouzanfar, M. H., Reitsma, M. B., et al. (2017). Health effects of overweight and obesity in 195 countries over 25 years. New England Journal of Medicine, 377(1), 15–26.
Aranceta, J., Perez-Rodrigo, C., Serra-Majem, L., et al. (2001). Influence of sociodemographic factors in the prevalence of obesity in Spain. The SEEDO 97 Study. European Journal of Clinical Nutrition, 55(6), 430–435.
Asahara, S. I., Miura, H., Ogawa, W., & Tamori, Y. (2000). Sex difference in the association – obesity with personal or social background among urban residents in Japan. Plos One, 15(11), e0242105.
Balbok, B., Deanfield, J. E., Després, J. P., et al. (2007). International day for the evaluation of abdominal obesity (IDEA): A study of waist circumference, cardiovascular disease, and diabetes mellitus in 168,000 primary care patients in 63 countries. Circulation, 116(17), 1942–1951.
Bambara, CI, Hillier, FC, Cairns, JM, et al. (2015). Public Health Research. How effective are interventions at reducing socioeconomic inequalities in obesity among children and adults? Two systematic reviews. In Southampton. NIHR Journals Library, Bann, D., Cooper, R., Wills, A. K., Adams, J., & Kuhl, D. (2014). Socioeconomic position across life and body composition in early old age: Findings from a British birth cohort study. Journal of Epidemiology & Community Health, 68(6), 516–523.
Bayram, S., Köseler, E., Kriztan, G., Aciğer Ok, M., Yesil, E., Köse, B., Özdemir, M., Müftüoğlu, S., Saka, M., Aksoydan, E., Tayfur, M., Türker, F. P., & Ercan, A. (2019). Effects of reproductive and sociodemographic factors on obesity in Turkish women: A cohort study. Progress in Nutrition, 21(1), 85, 77.
Beebe-Dimmer, J., Lynch, J. W., Turrell, G., et al. (2004). Childhood and adult socioeconomic conditions and 31-year mortality risk in women. American Journal of Epidemiology, 159(5), 481–490.
Beennackers, M. A., Kamphuis, C. B., Gitske, K., et al. (2012). Socioeconomic inequalities in occupational, leisure-time, and transport related physical activity among European adults: A systematic review. International Journal of Behavioral Nutrition and Physical Activity, 9, 116.
Beltrán-Sánchez, H., Palloni, A., Riumen, F., & Wong, R. (2016). SES gradients among Mexicans in the United States and in Mexico: A new twist to the hispanic paradox. Demography, 53(5), 1555–1581.
Berkmann, J. F. (1995). The role of social relations in health promotion. Psychosomatic Medicine, 57(3), 245–254.
Borchorst, A., & Simi, B. (2008). Woman-friendly policies and state feminism: Theorizing Scandinavian gender equality. Feminist Theory, 9(2), 207–224.
Borders, T. F., Rohrer, J. E., & Cardarelli, K. M. (2006). Gender-specific disparities in obesity. Journal of Community Health, 31(1), 57–68.
Brown, A., & Siahpush, M. (2007). Risk factors for overweight and obesity: Results from the 2001 national health survey. Public health, 121(8), 603–613.
Buttenheim, A. M., Wong, R., Goldman, N., & Pehley, A. R. (2010). Does social status predict adult smoking and obesity? Results from the 2000 Mexican national health survey. Global Public Health, 5(4), 413–426.
Cameron, A. J., Zimmer, P. Z., Dunstan, D. W., et al. (2003). Overweight and obesity in Australia: The 1999-2000 Australian diabetes, obesity and lifestyle study (AusDiab). Medical Journal of Australia, 178(9), 427–432.
Camões, M., Lopes, C., Oliveira, A., Santos, A. C., & Barros, H. (2010). Overall and central obesity incidence in an urban Portuguese population. Preventive Medicine, 50(1-2), 50–55.
Carbone, S., Elagizi, A., & Lavie, C. J. (2018). Obesity and mortality risk in heart failure: When adipose tissue distribution matters. European Journal of Heart Failure, 20(9), 1278–1280.
Carbone, S., Shah, K., & Van Tassell, B. (2013). Obesity and diastolic heart failure: Is inflammation the link. Translational Medicine, 3, e124.
Charafeddine, R., Van Oyen, H., & Demarest, S. (2009). Trends in social inequalities in obesity: Belgium, 1997 to 2004. Preventive Medicine, 48(1), 54–58.
Charen, M. A., Ewchegwe, E., & Bashford, A. (2008). Monitoring the obesity epidemic in France: the obepe surveys 1997-2006. Obesity, 16(9), 2182–2186.
Chung, W., & Kim, R. (2020). A reversal of the association between education level and obesity risk during ageing: A gender-specific longitudinal study in South Korea. International Journal of Environmental Research and Public Health, 17(16).
Chung, W., Ji, L., Lee, S., Kim, R., & Kim, J. (2017). Gender-specific interactions between education and income in relation to obesity: A cross-sectional analysis of the fifth Korea national health and nutrition examination survey (KNHANES V). BMJ open, 7(12), e014276.
Cohen, A. K., Rai, M., Rehkopf, D. H., & Abrams, B. (2013a). Educational attainment and obesity: A systematic review. Obesity reviews. An Official Journal of the International Association for the Study of Obesity, 14(12), 989–1005.
Cohen, A. K., Rehkopf, D. H., Beardorff, J., & Abrams, B. (2013b). Education and obesity at age 40 among American adults. Social Science & Medicine, 78, 34–41.
Coogan, P. E., Wise, L. A., Cozier, Y. C., Palmer, J. R., & Rosenberg, L. (2012). Life course educational status in relation to weight gain in African American women. Ethnicity & Disease, 22(2), 198–206.
Czemichow, S., Bertras, S., Preziosi, P., et al. (2004). Indicators of adiposity in middle-aged participants of the SU.Vi.MAX study: Relationships with educational level, smoking status and physical inactivity. Diabetes & Metabolism, 30(2), 153–159.
Devaux, M., & Sassi, F. (2013). Social inequalities in obesity and overweight in 11 OECD countries. The European Journal of Public Health, 23(3), 464–469.
Devaux, M., Sassi, F., Church, J., Cecchini, M., & Borzoni, F. (2011). Exploring the relationship between education and obesity. OECD Journal: Economic Studies, 2011 (1), 1–40.
Drewnowski, A., Moudon, A. V., Jiao, J., et al. (2005). Food environment and socioeconomic status influence obesity rates in Seattle and in Paris. International Journal of Obesity, 38(2), 206–214, 2014.
Dursun, B., Cesar, R., & Mocan, N. (2018). The Impact of education on health outcomes and behaviors in a middle-income, low-education country. Economics and Human Biology, 31, 94–114.
El-Sayed, A. M., Scarborough, P., & Galea, S. (2012). Unevenly distributed: A systematic review of the health literature about socioeconomic inequalities in adult obesity in the United Kingdom. BMC Public Health, 12, 18.
Faeh, D., Braun, J., & Bopp, M. (2011). Prevalence of obesity in Switzerland 1992-2007: The impact of education, income and occupational class. Obesity reviews. An Official Journal of the International Association for the Study of Obesity, 12(3), 151–166.
Gaio, V., Antunes, L., Namorado, S., et al. (2018). Prevalence of overweight and obesity in Portugal: Results from the 2015 Portuguese health examination survey (INSEIF 2015). Obesity Research & Clinical Practice, 12(1), 40–50.
Galobardes, B., Shaw, M., Lawlor, D. A., Lynch, J. W., & Davey Smith, G. (2006). Indicators of socioeconomic position (part I). Journal of Epidemiology & Community Health, 60(1), 7–12.
Groth, M. V., Fagt, S., Stockmarr, A., Matthiessen, J., & Biltoft-Jensen, A. (2009). Dimensions of socioeconomic position related to body mass index and obesity among Scandinavian women and men. Scandinavian Journal of Public Health, 37(4), 418–426.

Gutiérrez-Fisac, J. L., Regidor, E., Banegas Banegas, J. R., & Rodríguez Artalejo, F. (2002). The size of obesity differences associated with educational level in Spain, 1987 and 1995/97. Journal of Epidemiology & Community Health, 56(7), 457–460.

Hales, M., Fryar, C., Ogden, C., & Bataller, I. (2012). Differences in obesity prevalence by demographic characteristics and urbanization level among adults in the United States, 2013-2016. Jama, 319(23), 2419–2429.

Hayden, J. A., van der Windt, D. A., Cartwright, J. L., Côté, P., & Bombardier, C. (2013). Assessing bias in studies of prognostic factors. Annals of Internal Medicine, 158(4), 280–286.

Howe, L. D., Kanaan, J., Harrison, S., et al. (2020). Effects of body mass index on relationship status and socio-economic position: Mendelian randomization and within-study in UK Biobank. International Journal of Epidemiology, 49(4), 1173–1184.

Hu, F. (2008). Obesity epidemiology. Oxford University Press.

Hughes, J., Kabir, Z., Kee, F., & Bennetts, K. (2017). Cardiovascular risk factors using repeated cross-sectional surveys to assess time trends in socioeconomic inequalities in neighbourhoods. BMJ Open, 7(1), e013442.

Hulshe, K. F., Lokwir, M. R., Kok, F. J., et al. (1991). Diet and other life-style factors in high and low socio-economic groups (Dutch Nutrition Surveillance System). European Journal of Clinical Nutrition, 45(9), 441–450.

Huot, I., Paradis, G., & Leduc, M. (2004). Factors associated with overweight and obesity in Quebec adults. International Journal of Obesity, 28(6), 766–774.

Icke, A., Moebus, S., Feuerenger, A., et al. (2007). Widening of a social gradient in obesity risk? German national health surveys 1990 and 1998. European Journal of Epidemiology, 22(10), 685–690.

Irala-Estévez, D. J., Groth, M., Johannson, L., et al. (2000). A systematic review of socio-economic differences in health habits in Europe: Consumption of fruit and vegetables. European Journal of Clinical Nutrition, 54(9), 706–714.

Janssen, I., Katzmarzyk, P. T., & Ross, R. (2004). Waist circumference and not body mass index is the relevant indicator of obesity risk? German national health surveys 1990 and 1998. Obesity Reviews, 5(6), 450–456.

Jeffery, R. W., & French, S. A. (1996). Socioeconomic status and weight control practices among 20- to 45-year-old women. American Journal of Public Health, 86(7), 1005–1010.

Jurado-Guerrero, T., & Naldini, M. (2018). Child and family policy in Southern Europe. Handbook of family policy. Edgair Elgar Publishing.

Kaplan, M. S., Huguet, N., Newson, J. T., McFarland, B. H., & Lindsay, J. (2003). Prevalence and correlates of overweight and obesity among older adults: Findings from the Canadian national population health survey. Journal of clinical epidemiology series A, Biological sciences and medical sciences, 58(11), 1018–1030.

Kilc˘arslan, A., Isildak, M., Guven, G. S., et al. (2006). Demographic, socioeconomic and educational characteristics of urbanized populations in Estonia, Finland and Lithuania. International Association for the Study of Obesity, 18(6), 660–672.

Ko, K. D., Cho, B., Lee, W. C., et al. (2015). Obesity explains gender differences in the association between educational level and metabolic syndrome in South Korea: The Korean Health Study. Scientific Reports, 5, 10501.

Ko, K., Chen, L., Lee, W. C., et al. (2015). Obesity explains gender differences in the association between educational level and metabolic syndrome in South Korea: The Helsinki Health Study. Scientific Reports, 5, 10501.

Kaplan, M. S., Huguet, N., Newson, J. T., McFarland, B. H., & Lindsay, J. (2003). Prevalence and correlates of overweight and obesity among older adults: Findings from the Canadian national population health survey. Journal of clinical epidemiology series A, Biological sciences and medical sciences, 58(11), 1018–1030.

Kilc˘arslan, A., Isildak, M., Guven, G. S., et al. (2006). Demographic, socioeconomic and educational characteristics of urbanized populations in Estonia, Finland and Lithuania. International Association for the Study of Obesity, 18(6), 660–672.

Kojima-Eguchi, M., Oizumi, M., Isacsson, S. O., & Merlo, J. (2003). Increasing prevalence of overweight, obesity and diabetes among high and low socio-economic groups (Dutch Nutrition Surveillance System). International Journal of Epidemiology, 32(6), 1184.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.

Koivukangas, V., Leskinen, A., & K爸爸l¨a, E. (2002). Education and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128 9 million children, adolescents, and adults. Lancet (London, England), 390(10113), 2627–2624.
Sardinia, L. B., Santos, D. A., Silva, A. M., et al. (2012). Prevalence of overweight, obesity, and abdominal obesity in a representative sample of Portuguese adults. PloS One, 7(10), e49443.

Sarrio-Lahenteenkorva, S., Lissia, I., & Lahelma, E. (2006). The social patterning of relative body weight and obesity in Denmark and Finland. The European Journal of Public Health, 16(1), 36–40.

Stommel, M., & Schoenborn, C. A. (2009). Accuracy and usefulness of BMI measures based on self-reported weight and height: Findings from the NHANES & NHIS 2001–2006. BMC Public Health, 9, 421.

Stringhini, S., Spencer, B., Marques-Vidal, P., et al. (2012). Age and gender differences in the social patterning of cardiovascular risk factors in Switzerland: The CoLaus study. PloS One, 7(11), e49443.

Sulanders, T. T., & Uutela, A. K. (2007). Obesity and education: Recent trends and disparities among 65- to 84-year-old men and women in Finland. Preventive Medicine, 45(2–3), 153–156.

Tichiyaya, A., & Lorentz, N. (2012). Socioeconomic inequality and obesity prevalence trends in Luxembourg, 1995-2007. BMC Research Notes, 5, 467.

Tjønneland, E., van Gaan, A., & van der Klaauw, P. M. (2015). Obesity and osteoarthritis, more than just wear and tear: Pivotal roles for inflamed adipose tissue and dyslipidaemia in obesity-induced osteoarthritis. Rheumatology, 54(4), 588–600.

Trotzas, T., Vlahavas, G., Papadopoulou, S. K., et al. (2010). Marital status and educational level associated to obesity in Greek adults: Data from the national epidemiological survey. BMC Public Health, 10, 732.

UNSD. (1999). Standard country or area codes for statistical use [Available from: https://unstats.un.org/unsd/methodology/m49/#fn1.

Vinci, L., Krieger, J. P., Braun, J., et al. (2019). Clustering of sociodemographic and lifestyle factors among adults with excess weight in a multilingual country. Nutrition, 62, 177–185.

von Hippel, P. T., & Lynch, J. L. (2014). Why are educated adults slim–Causation or selection? Social Science & Medicine, (105), 131–139.

Wardle, J., Waller, J., & Jarvis, M. J. (2002). Sex differences in the association of socioeconomic status with obesity. American Journal of Public Health, 92(8), 1299–1304.

Whitehead, M., & Dahlgren, G. (1991). What can be done about inequalities in health? Lancet (London, England), 338(8774), 1059–1063.

WHO. (2000). Obesity: Preventing and managing the global epidemic. World Health Organization.

Yoon, Y. S., Oh, S. W., & Park, H. S. (2006). Socioeconomic status in relation to obesity and abdominal obesity in Korean adults: A focus on sex differences. Obesity, 14(5), 909–919.

Zatorovska, K., Janik-Koncewicz, K., Regubska-Ilow, B., et al. (2011). Prevalence of obesity - baseline assessment in the prospective cohort: PONS study. Annals of agricultural and environmental medicine. AAEM, 18(2), 246–250.

Zhang, Q., & Wang, Y. (2004). Trends in the association between obesity and socioeconomic status in U.S. Adults: 1971 to 2000. Obesity Research, 12(10), 1622–1632.