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Review Article

Family socioeconomic status and childhood adiposity in Europe - A scoping review

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ABSTRACT

Childhood obesity is a considerable public health problem worldwide. In Europe, lower parental socioeconomic status (SES) relates to higher childhood adiposity. This scoping review strives to discover, which SES indicators are the most commonly used and meaningful determinants of childhood adiposity (greater level of continuous adiposity indicator, e.g. body mass index z-score, or overweight or obesity categorized by established definitions). The review focused on studies about European general populations from the 21st century (January 2000–April 2021) considering children and adolescents aged 0–17 years. PubMed and reference lists of articles were searched in February–April 2021. Total of 53 studies with 121 association analyses between different SES indicators and adiposity indicators, were identified and reviewed. Different SES indicators were grouped to 25 indicators and further to six indicator groups. The most used indicator was mother's education (n of association analyses = 24) and the most used indicator group was parental education (n of association analyses = 51). Of all association analyses, 55% were inverse, 36% were non-significant, and 8% were positive. Composite SES (80%), parental education (69%) and parental occupation (64%) indicators showed most frequently inverse associations with obesity measures (i.e. lower parental SES associating with higher adiposity), while parental income (50% inverse; 50% non-significant) and property and affluence (42% inverse; 50% nonsignificant) indicators showed approximately even number of inverse and non-significant associations. Instead, majority of parental employment (60%) indicators, showed non-significant associations and 33% showed positive associations (i.e. higher parental SES associating with higher adiposity). Despite some variation in percentages, majority of the associations were inverse in each age group and with different outcome categorizations. In girls and in boys, non-significant associations predominated. It seems that children with parents of higher SES have lower likelihood of adiposity in Europe. Parents' employment appears to differ from other SES indicators, so that having an employed parent(s) does not associate with lower likelihood of adiposity. Positive associations seem to occur more frequently in poorer countries. Criteria for uniform childhood SES and adiposity measures should be established and used in studies in order to be able to produce comparable results across countries.

1. Introduction

Obesity pandemic has reached alarming proportions and affects public health and economy globally. The pandemic does not concern only adults, but obesity has become a serious health risk also in children. According to estimations by the World Health Organization (WHO), overweight and obesity prevalence in children and adolescents aged 5–19 years, has risen from 4% in 1975 to over 18% in 2016 (World Health Organization, 2021). Moreover, 38.2 million children under the age of 5 years had overweight or obesity in 2019. Obesity rates vary between continents and countries; during recent decades, a former problem of developed and westernized countries has passed on to developing countries while rise in obesity rates in Europe has started to level off (NCD Risk Factor Collaboration (NCD-RisC), 2017; Inchley et al., 2020). According to the results of the WHO European Childhood Obesity Surveillance Initiative (COSI), overweight and obesity rates,

Abbreviations: BMI, body mass index; IOTF, International Obesity Task Force; SES, socioeconomic status; WHO, World Health Organization.

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however, vary considerably also in Europe, the rates being the highest in the Mediterranean region (WHO European Childhood Obesity Surveillance Initiative (COSI), 2021).

Children's body composition evolves along with aging and varies between boys and girls. Thus, children's weight status is usually expressed relative to same-sex peers. Several definitions for childhood overweight and obesity exist (Appendix Table A1). The International Obesity Task Force (IOTF) (Cole et al., 2000) and the WHO (de Onis and Lobstein, 2010; de Onis et al., 2007; WHO Multicentre Growth Reference Study Group, 2006) have defined age- and sex-specific cut-off points for overweight and obesity. In addition, several country-specific weight or body mass index (BMI) percentile cut-off points, waist circumference percentile cut-off points (McCarthy et al., 2001), and continuous adiposity variables (e.g. weight, BMI, BMI z-score, fat mass) have been employed. Hence, one uniform definition to enable fully comparable results is lacking.

Obesity is a result from positive energy balance, which usually derives from unfavorable lifestyle habits, i.e. dietary and physical activity habits, but also for instance sleep and sedentary behavior play a role (Verduci et al., 2021). In childhood, family, and growth environment play an important role in creating facilities for such habits and possible development of obesity (Verduci et al., 2021; Notara et al., 2020). In addition to lifestyle habits, some other factors, such as parent's overweight/obesity (Notara et al., 2020; Whitaker et al., 2010), prenatal smoking (Albers et al., 2018) and unfavorable prenatal diet (Meinila et al., 2021) have been associated with increased risk of childhood obesity. Conversely, breastfeeding seems to protect from extra weight (Verduci et al., 2021; Rito et al., 2019). In adults, socioeconomic status (SES) has been shown to have a strong inverse association with dietary and physical activity habits and obesity (Pampel et al., 2010) – the factors that contribute to an increased risk of childhood obesity. Children themselves don't have an actual SES, but usually parents' SES is used to represent children's SES.

Despite the recent European studies demonstrating childhood obesity to be levelling off (NCD Risk Factor Collaboration (NCD-RisC), 2017; Inchley et al., 2020), inequity in obesity appears to persist. Parental SES demonstrates a significant inverse gradient with childhood overweight and obesity in developed and high-income countries (Barriuso et al., 2015; Buoncristiano et al., 2021; Chung et al., 2016). Yet, in developing and medium to low income countries the association seems to have an opposite direction (Buoncristiano et al., 2021; Dinsa et al., 2012; Sobal and Stunkard, 1989). Several indicators of parental SES in relation to childhood adiposity have been examined in numerous original studies, systematic reviews, and meta-analyses (Notara et al., 2020; Barriuso et al., 2015; Chung et al., 2016). Commonly used family-level SES indicators include different indicators on parental education, occupation, employment, and household income, and various affluence indicators. Of these, parental education and occupation seem to be the strongest inverse indicators of childhood adiposity (Notara et al., 2020; Barriuso et al., 2015). However, more detailed information on which indicators associate most often with childhood adiposity, whether the association remains absent or becomes reversed with some indicators, whether definition and collection method of adiposity information count, and whether the associations are divergent among girls and boys and in different age groups, is needed. Hence, aims of this scoping review were to explore, which are the most used childhood SES and adiposity indicators in Europe during the 21st century, which indicators yield most frequently significant results, and whether the results show different distributions in different sub-populations (in boys and in girls and in different age groups) or according to different outcome categorizations (according to different adiposity definitions and according to collection method of adiposity information).

2. Methods

This study employed a scoping review method (Munn et al., 2018; Sucharew and Macaluso, 2019) to provide an overview on which SES and adiposity indicators have been used in studies covering SES disparities in childhood adiposity, and how these different SES indicators are associated with different adiposity indicators. As this review did not conduct research on human subjects, no approval from any ethical review board was applied.

A non-systematic literature search was conducted in February–April 2021 using PubMed and additionally searching reference lists of articles to retrieve possible missing articles. In PubMed, literature search and data extraction were conducted with combinations of the terms “child”, “childhood”, “adolescent”, “adolescence”, “obese”, “obesity”, “adiposity”, “overweight”, “socioeconomic”, “SES”, “education”, “employment”, “occupation”, “income”, “wealth”, “affluence”, “inequality”, “inequalities”, “disparity”, “disparities” while using PubMed filters to exclude articles with only adult populations or articles published before 21st century. Inclusion criteria for original articles included: 1) European general population data, 2) Published and data collected between January 2000–April 2021 (trend and follow-up articles with earlier study points were included, but only results from the 21st century were utilized), 3) Participants aged 0–17 years, 4) Articles written in English, 5) Main exposure is a family-level SES indicator (excluding country-, area- or school-level indicators and indexes), and 6) Main outcome is childhood or adolescence adiposity indicator (e.g. weight, BMI, BMI z-score, waist circumference, fat mass, fat mass index, or fat percentage), overweight, obesity, or change in one of the preceding. Of the found articles, those not meeting some of the inclusion criteria were excluded. If several articles used same study data and same SES indicators, only the most recent or comprehensive article was included.

Characteristics of all original articles included are specified in an Appendix Table A2. Results are summarized in Tables 1–4: in Table 1, associations with individual SES indicators; in Table 2, associations with grouped SES indicators in boys and in girls; in Table 3, associations with grouped SES indicators in different age groups; and in Table 4, associations with grouped SES indicators according to different outcome definitions. In these tables, all cross-sectional, trend and follow-up results were combined, and, results were grouped into ‘positive’, ‘no’, and ‘inverse’ associations according to direction and statistical significance of the results. ‘Positive’ result denoted a finding when SES indicator received ascending values (higher SES) also adiposity indicator received ascending values (greater prevalence/odds/risk of excess adiposity). Conversely, ‘inverse’ result denoted a finding when SES indicator received ascending values, adiposity indicator received descending values. SES indicators' scale was determined so that higher level denoted longer education or higher degree, less manual or more expertise-demanding occupation, existing employment (vs. unemployed or not working for other reasons) or longer working hours, higher income, greater affluence or more properties. If in one study there were both statistically significant positive or inverse associations, and nonsignificant associations in different subgroups or with different obesity indicators, such studies were grouped according to significant results omitting nonsignificant findings.

3. Results

Altogether 53 original articles were selected covering data from 23 European countries (Table A2) (Bammann et al., 2013; Bibiloni Mdel et al., 2010; Bouthoorn et al., 2014; Bramsved et al., 2018; Farajian et al., 2013; Fernandez-Alvira et al., 2013; Gil and Takourabt, 2017; Grazuleviciene et al., 2017; Grøholt et al., 2008; Hargreaves et al., 2013; Hawkins et al., 2008; Hilpert et al., 2017; Huus et al., 2007; Iguacel et al., 2018; Keane et al., 2012; Khanolkar et al., 2012; Klein-Platat et al., 2003; Kleiser et al., 2009; Lamerz et al., 2005; Lazzeri et al., 2017; Lien et al., 2007; Lioret et al., 2009; Lissner et al., 2016; Magnusson et al., 2008; Matijasevich et al., 2009; Matthiessen et al., 2014; Mikolajczyk and Richter, 2008; Miqueleiz et al., 2014; Moschonis et al., 2010;

Table 1
Associations between SES indicators and childhood adiposity.

	Association with adiposity									
	Total n of association analyses	Positive[a]			No			Inverse[b]		
SES indicator[c]		References	n	%	References	n	%	References	n	%
Composite SES variables[d]	**5**	–	–	–	(Valerio et al., 2006)	1	20	(Bammann, et al, 2013) (Kleiser et al., 2009) (Lioret et al., 2009) (Stamatakis et al., 2010)	4	80
Parental education										
Both parents' education[e]	15	–	–	–	(Gil and Takourabt, 2017) (Salanave et al., 2009) (Sanchez-Cruz et al., 2018)	3	20	(Bammann, et al, 2013) (Bibiloni Mdel et al., 2010) (Bramsved et al., 2018) (Fernandez-Alvira et al., 2013) (Hilpert et al., 2017) (Lien et al., 2007) (Lioret et al., 2009) (Matthiessen et al., 2014) (Miqueleiz et al., 2014) (Nogueira et al., 2013) (Rodrigues et al., 2021) (Stuart and Panico, 2016)	12	80
Mother's education	24	(Patel et al., 2018) (Yardim et al., 2019)	2	8	(Farajian et al., 2013) (Lissner et al., 2016) (Moschonis et al., 2010) (Rotevatn et al., 2019)	4	17	(Bouthoorn et al., 2014) (Grazuleviciene et al., 2017) (Huus et al., 2007) (Keane et al., 2012) (Khanolkar et al., 2012) (Klein-Platat et al., 2003) (Lamerz et al., 2005) (Magnusson et al., 2008) (Matijasevich et al., 2009) (Matthiessen et al., 2014) (Nagel et al., 2009) (Oude Groeniger et al., 2020) (Ruijsbroek et al., 2011) (Semmler et al., 2009) (Valerio et al., 2006) (van den Berg et al., 2013) (van Vliet et al., 2015) (Veldhuis et al., 2013)	18	75
Father's education	12	(Patel et al., 2018)	1	8	(Farajian et al., 2013) (Klein-Platat et al., 2003) (Lamerz et al., 2005) (Lissner et al., 2016) (Matthiessen et al., 2014) (Moschonis et al., 2010)	6	50	(Huus et al., 2007) (Khanolkar et al., 2012) (Magnusson et al., 2008) (Nagel et al., 2009) (van Vliet et al., 2015)	5	42
All parental education indicators combined	***51***	–	***3***	***5.9***	–	***13***	***25.5***	–	***35***	***68.6***
Parental occupation										
Both parents' occupation[e]	15	(Patel et al., 2018)	1	7	(Lien et al., 2007) (Lioret et al., 2009) (Mikolajczyk and Richter, 2008) (Sanchez-Cruz et al., 2018) (Sweeting et al., 2008)	5	33	(Bammann, et al, 2013) (Bibiloni Mdel et al., 2010) (Gil and Takourabt, 2017) (Hargreaves et al., 2013) (Keane et al., 2012) (Ness et al., 2006) (Salanave et al., 2009) (Thibault et al., 2013) (Wijlaars et al., 2011)	9	60
Mother's occupation	4	–	–	–	(Farajian et al., 2013)	1	25	(Khanolkar et al., 2012) (Mutunga et al., 2006) (van Vliet et al., 2015)	3	75
Father's occupation	3	–	–	–	(Khanolkar et al., 2012)	1	33	(Farajian et al., 2013) (van Vliet et al., 2015)	2	67
All parental occupation indicators combined	***22***	–	***1***	***4.5***	–	***7***	***31.8***	–	***14***	***63.6***
Parental employment										
Both parents' employment[e]	3	–	–	–	(Sanchez-Cruz et al., 2018) (Taylor et al., 2005)	2	67	(Iguacel et al., 2018)	1	33
Mother's employment	5	(Hawkins et al., 2008) (Lissner et al., 2016) (Yardim et al., 2019)	3	60	(Farajian et al., 2013) (Lamerz et al., 2005)	2	40	–	–	–
Father's employment	3	(Lissner et al., 2016)	1	33	(Hawkins et al., 2008) (Lamerz et al., 2005)	2	67	–	–	–
Mother's duration of employment	1	–	–	–	(Hawkins et al., 2008)	1	100	–	–	–
Father's duration of employment	1	–	–	–	(Hawkins et al., 2008)	1	100	–	–	–
Mother's working hours	1	(Hawkins et al., 2008)	1	100	–	–	–	–	–	–
Father's working hours	1	–	–	–	(Hawkins et al., 2008)	1	100	–	–	–

(continued on next page)

Table 1 (*continued*)

	Association with adiposity									
	Total n of association analyses	Positive[a]			No			Inverse[b]		
SES indicator[c]		References	n	%	References	n	%	References	n	%
All parental employment indicators combined	***15***	–	***5***	***33.3***	–	***9***	***60.0***	–	***1***	***6.7***
Parental income										
Both parents' income[e]	12	–	–	–	(Bramsved et al., 2018) (Farajian et al., 2013) (Keane et al., 2012) (Klein-Platat et al., 2003) (Lien et al., 2007)	5	42	(Bammann, et al, 2013) (Bouthoorn et al., 2014) (Matijasevich et al., 2009) (Moschonis et al., 2010) (Rotevatn et al., 2019) (Stamatakis et al., 2010) (Stuart and Panico, 2016)	7	58
Mother's income	1	–	–	–	(Magnusson et al., 2008)	1	100	–	–	–
Father's income	1	–	–	–	(Magnusson et al., 2008)	1	100	–	–	–
All parental income indicators combined	***14***	–	–	–	–	***7***	***50.0***	–	***7***	***50.0***
Properties and affluence										
FAS, wealth and affluence composite variables	4	–	–	–	–	–	–	(Lazzeri et al., 2017) (Lioret et al., 2009) (Mikolajczyk and Richter, 2008) (Sigmund et al., 2018)	4	100
House ownership	2	–	–	–	(Farajian et al., 2013) (Moschonis et al., 2010)	2	100	–	–	–
Living space/lack of space	2	–	–	–	(Lamerz et al., 2005) (Taylor et al., 2005)	2	100	–	–	–
Car ownership/n of cars	2	(Taylor et al., 2005)	1	50	(Farajian et al., 2013)	1	50	–	–	–
Persistent poverty	1	–	–	–	(Stuart and Panico, 2016)	1	100	–	–	–
Subjective perceptions on sufficiency of money	1	–	–	–	–	–	–	(Grøholt et al., 2008)	1	100
All properties and affluence indicators combined	***12***	–	***1***	***8.3***	–	***6***	***50.0***	–	***5***	***41.7***
Eligibility to free school meals	1	–	–	–	(Taylor et al., 2005)	1	100	–	–	–
Child's/ adolescent's educational plans	1	–	–	–	–	–	–	(Grøholt et al., 2008)	1	100
All indicators combined	***121***		***10***	***8.3***		***44***	***36.4***		***67***	***55.4***

Underlined n and percentage values denote the most frequent association for SES indicator in question (not applied if only one study exists). Statistical significance not tested.

Abbreviations: FAS, Family Affluence Scale; SES, socioeconomic status;

[a] Positive association denotes associations where while SES indicator receives ascending levels, also adiposity indicator receives ascending levels. This category includes studies where there are only statistically significant positive associations or both significant positive and nonsignificant associations in different subgroups or with different adiposity indicators.

[b] Inverse association denotes associations where while SES indicator receives ascending levels, adiposity indicator receives descending levels. This category includes studies where there are only statistically significant negative associations or both significant negative and nonsignificant associations in different subgroups or with different adiposity indicators.

[c] Higher level in SES indicator denotes: Longer education or higher degree, less manual or more expertise-demanding occupation, existing employment or longer working hours, higher income, greater affluence or more properties

[d] Excluding composite variables based only on wealth and affluence.

[e] Variable is based on higher or lower level of either parent or composite variable from both parents' levels.

Mutunga et al., 2006; Nagel et al., 2009; Ness et al., 2006; Nogueira et al., 2013; Oude Groeniger et al., 2020; Patel et al., 2018; Rodrigues et al., 2021; Rotevatn et al., 2019; Ruijsbroek et al., 2011; Salanave et al., 2009; Sanchez-Cruz et al., 2018; Semmler et al., 2009; Sigmund et al., 2018; Stamatakis et al., 2010; Stuart and Panico, 2016; Sweeting et al., 2008; Taylor et al., 2005; Thibault et al., 2013; Valerio et al., 2006; van den Berg et al., 2013; van Vliet et al., 2015; Veldhuis et al., 2013; Wijlaars et al., 2011; Yardim et al., 2019). Number of participants in the studies ranged approximately between 300 and 20,000. Age of the participants in the studies varied from newborns to teenagers. Cross-sectional ($n = 34$), follow-up ($n = 10$) and trend ($n = 9$) study settings were employed. In this review, all results of different settings are combined in same summaries. Likewise, results produced with different statistical methods and presented in different measures of association are combined. The results from the final adjustment model are utilized.

In almost all studies, SES indicators were self-reported by participants' parents or participants themselves. In only three studies SES data was obtained from registers. Individual SES indicators were grouped to

Table 2
Associations between SES indicators and childhood adiposity according to sex.

SES indicator[c] according to sex[c]	Total n of association analyses	Association with adiposity: Positive[a] References	n	%	No References	n	%	Inverse[b] References	n	%
Boys										
Composite SES variables[d, e]	1	–	–	–	–	–	–	(Stamatakis et al., 2010)	1	100
Parental education[d]	9	(Patel et al., 2018)	1	11	(Farajian et al., 2013) (Lissner et al., 2016)	2	22	(Bibiloni Mdel et al., 2010) (Lien et al., 2007) (Matijasevich et al., 2009) (Matthiessen et al., 2014) [f] (Miqueleiz et al., 2014) (van Vliet et al., 2015)	6	67
Parental occupation[d]	6	(Patel et al., 2018)	1	17	(Bibiloni Mdel et al., 2010) (Farajian et al., 2013) (Lien et al., 2007) (Sweeting et al., 2008)	4	67	(van Vliet et al., 2015)	1	17
Parental employment[d]	3	(Lissner et al., 2016)	1	33	(Farajian et al., 2013) (Taylor et al., 2005)	2	67	–	–	–
Parental income[d]	4	–	–	–	(Farajian et al., 2013) (Lien et al., 2007) (Matijasevich et al., 2009) (Farajian et al., 2013) (Taylor et al., 2005)	3	75	(Stamatakis et al., 2010)	1	25
Properties and affluence[d]	4	–	–	–	(Farajian et al., 2013) (Taylor et al., 2005)	2	50	(Lazzeri et al., 2017) (Sigmund et al., 2018)	2	50
All indicators combined	***27***		***3***	***11.1***		***13***	***48.1***		***11***	***40.7***
Girls										
Composite SES variables[d, e]	1	–	–	–	–	–	–	(Stamatakis et al., 2010)	1	100
Parental education[d]	9	(Patel et al., 2018)	1	11	(Farajian et al., 2013) (Lien et al., 2007) (Lissner et al., 2016) (Matthiessen et al., 2014) (van Vliet et al., 2015)	5	56	(Bibiloni Mdel et al., 2010) (Matijasevich et al., 2009) (Miqueleiz et al., 2014)	3	33
Parental occupation[d]	6	(Patel et al., 2018)	1	17	(Lien et al., 2007) (Sweeting et al., 2008)	2	33	(Bibiloni Mdel et al., 2010) (Farajian et al., 2013) [f] (van Vliet et al., 2015) [f]	3	50
Parental employment[d]	3	(Lissner et al., 2016)	1	33	(Farajian et al., 2013) (Taylor et al., 2005)	2	67	–	–	–
Parental income[d]	4	–	–	–	(Farajian et al., 2013) (Lien et al., 2007)	2	50	(Matijasevich et al., 2009) (Stamatakis et al., 2010)	2	50
Properties and affluence[d]	4	[f] (Taylor et al., 2005) [f]	1	25	(Farajian et al., 2013)	1	25	(Lazzeri et al., 2017) (Sigmund et al., 2018)	2	50
All indicators combined	***27***		***4***	***14.8***		***12***	***44.4***		***11***	***40.7***

Underlined percentage values denote the most frequent association for SES indicator in question (not applied if only one study exists). Statistical significance not tested. Abbreviations: SES, socioeconomic status;

[a] Positive association denotes associations where while SES indicator receives ascending levels, also adiposity indicator receives ascending levels. This category includes studies where there are only statistically significant positive associations or both significant positive and nonsignificant associations in different subgroups or with different adiposity indicators.

[b] Inverse association denotes associations where while SES indicator receives ascending levels, adiposity indicator receives descending levels. This category includes studies where there are only statistically significant negative associations or both significant negative and nonsignificant associations in different subgroups or with different adiposity indicators.

[c] Higher level in SES indicator denotes: Longer education or higher degree, less manual or more expertise-demanding occupation, existing employment or longer working hours, higher income, greater affluence or more properties

[d] All variables in category in question

[e] Excluding composite variables based only on wealth and affluence.

[f] Several variables in the same study in the same indicator group: Significant association acknowledged, and nonsignificant association disregarded.

25 indicators (Table 1) and further to six indicator groups: composite SES indicators, parental education, parental occupation, parental employment, parental income, properties and affluence (Tables 1–4).

Several different continuous adiposity indicators (i.e. weight, BMI, BMI-z-score, fat mass, fat mass index), weight change or overweight/obesity indicators were used in the studies. Overweight/obesity were defined using the International Obesity Task Force (IOTF) cut-off points (Cole et al., 2000), the WHO cut-off points based on percentiles or standard deviations (SD) (de Onis and Lobstein, 2010; de Onis et al., 2007; WHO Multicentre Growth Reference Study Group, 2006), country-specific percentile cut-off points, or waist-circumference percentile cut-off points (McCarthy et al., 2001).

A total of 121 association analyses between SES indicators and adiposity indicator, weight change or overweight/obesity were reviewed. When combining all association analyses together, 55% were inverse (higher value in SES indicator associated with lower adiposity status), 36% were non-significant and 8% were positive (higher value in SES indicator associated with higher adiposity status) (Table 1, Fig. 1). The most used individual indicator was maternal education (24 association analyses) which also had most commonly inverse association with outcome measures when considering number of associations (18 inverse/4 no/2 positive associations). When considering percentages of the associations, composite SES indicators, both parents' education, mother's education, mother's occupation and wealth and affluence composite indicators showed most strong inverse associations with outcome measures (75% or more of the associations inverse). Non-significant associations occurred mostly with father's education, both parents' employment, and father's employment indicators. Only

Table 3
Associations between SES indicators and childhood adiposity according to age groups.

SES indicator[c] according to age groups	Total n of association analyses	Association with adiposity: Positive[a] References	n	%	No References	n	%	Inverse[b] References	n	%
0–10 years										
Composite SES variables[d, e]	3	–	–	–	(Valerio et al., 2006)	1	33	(Bammann, et al, 2013) (Stamatakis et al., 2010)	2	67
Parental education [d]	21	(Patel et al., 2018)	1	5	(Lissner et al., 2016) (Miqueleiz et al., 2014) (Rotevatn et al., 2019) (Salanave et al., 2009)	4	19	(Bammann, et al, 2013) (Bouthoorn et al., 2014) (Bramsved et al., 2018) (Grazuleviciene et al., 2017) (Hilpert et al., 2017) (Huus et al., 2007) (Keane et al., 2012) (Lamerz et al., 2005) [f] (Magnusson et al., 2008) (Nagel et al., 2009) (Nogueira et al., 2013) (Rodrigues et al., 2021) (Ruijsbroek et al., 2011) (Valerio et al., 2006) (van den Berg et al., 2013) (Veldhuis et al., 2013)	16	76
Parental occupation[d]	7	(Patel et al., 2018)	1	14	–	–	–	(Bammann, et al, 2013) (Keane et al., 2012) (Ness et al., 2006) (Salanave et al., 2009) (Thibault et al., 2013) (Wijlaars et al., 2011)	6	86
Parental employment[d]	4	(Hawkins et al., 2008) [f] (Lissner et al., 2016)	2	50	(Lamerz et al., 2005)	1	25	(Iguacel et al., 2018)	1	25
Parental income[d]	7	–	–	–	(Bramsved et al., 2018) (Keane et al., 2012) (Magnusson et al., 2008)	3	43	(Bammann, et al, 2013) (Bouthoorn et al., 2014) (Rotevatn et al., 2019) (Stamatakis et al., 2010)	4	57
Properties and affluence[d]	1	–	–	–	(Lamerz et al., 2005)	1	100	–	–	–
All indicators combined	***43***		***4***	***9.3***		***10***	***23.3***		***29***	***67.4***
10–17 years										
Composite SES variables[d, e]	–	–	–	–	–	–	–	–	–	–
Parental education[d]	10	–	–	–	(Farajian et al., 2013)	1	10	(Bibiloni Mdel et al., 2010) (Fernandez-Alvira et al., 2013) (Klein-Platat et al., 2003) [f] (Lien et al., 2007) (Matijasevich et al., 2009) (Miqueleiz et al., 2014) (Oude Groeniger et al., 2020) (Semmler et al., 2009) (van Vliet et al., 2015) [f]	9	90
Parental occupation[d]	7	–	–	–	(Lien et al., 2007) (Mikolajczyk and Richter, 2008) (Mutunga et al., 2006) (Sweeting et al., 2008)	4	57	(Bibiloni Mdel et al., 2010) (Farajian et al., 2013) [f] (van Vliet et al., 2015) [f]	3	43
Parental employment[d]	2	–	–	–	(Farajian et al., 2013) (Taylor et al., 2005)	2	100	–	–	–
Parental income[d]	4	–	–	–	(Farajian et al., 2013) (Klein-Platat et al., 2003) (Lien et al., 2007)	3	75	(Matijasevich et al., 2009)	1	25
Properties and affluence[d]	6	(Taylor et al., 2005) [f]	1	17	(Farajian et al., 2013)	1	17	(Grøholt et al., 2008) (Lazzeri et al., 2017) (Mikolajczyk and Richter, 2008) (Sigmund et al., 2018)	4	67
All indicators combined	***29***		***1***	***3.4***		***11***	***37.9***		***17***	***58.6***
0–17 years [g]										
Composite SES variables[d, e]	2	–	–	–	–	–	–	(Kleiser et al., 2009) (Lioret et al., 2009)	2	100
Parental education[d]	9	(Yardim et al., 2019)	1	11	(Gil and Takourabt, 2017) (Moschonis et al., 2010) (Sanchez-Cruz et al., 2018)	3	33	(Khanolkar et al., 2012) (Lioret et al., 2009) (Matthiessen et al., 2014) [f] (Stuart and Panico, 2016) (van Vliet et al., 2015) [f]	5	56
Parental occupation[d]	7	–	–	–	(Lioret et al., 2009) (Sanchez-Cruz et al., 2018)	2	29	(Gil and Takourabt, 2017) (Hargreaves et al., 2013) (Khanolkar et al., 2012) [f] (Thibault et al., 2013) (van Vliet et al., 2015)	5	71
Parental employment[d]	2	(Yardim et al., 2019)	1	50	(Sanchez-Cruz et al., 2018)	1	50	–	–	–
Parental income[d]	2	–	–	–	–	–	–	(Moschonis et al., 2010) (Stuart and Panico, 2016)	2	100
Properties and affluence[d]	3	–	–	–	(Moschonis et al., 2010) (Stuart and Panico, 2016)	2	67	(Lioret et al., 2009)	1	33
All indicators combined	***25***		***2***	***8.0***		***8***	***32.0***		***15***	***60.0***

Underlined percentage values denote the most frequent association for SES indicator in question (not applied if only one study exists). Statistical significance not tested. Abbreviations: SES, socioeconomic status;

[a] Positive association denotes associations where while SES indicator receives ascending levels, also adiposity indicator receives ascending levels. This category includes studies where there are only statistically significant positive associations or both significant positive and nonsignificant associations in different subgroups or with different adiposity indicators.

[b] Inverse association denotes associations where while SES indicator receives ascending levels, adiposity indicator receives descending levels. This category includes studies where there are only statistically significant negative associations or both significant negative and nonsignificant associations in different subgroups or with different adiposity indicators.

[c] Higher level in SES indicator denotes: Longer education or higher degree, less manual or more expertise-demanding occupation, existing employment or longer working hours, higher income, greater affluence or more properties

[d] All variables in category in question

[e] Excluding composite variables based only on wealth and affluence.

[f] Several variables in the same study in the same indicator group: Significant association acknowledged, and nonsignificant association disregarded.

[g] Age-range varying between 0 and 17 years and not fitting into other age-categories.

mother's employment showed commonly positive associations with outcome. When looking into indicator groups, indicators belonging to the parental education indicator group were most frequently used (51 association analyses). Parental education and parental occupation groups showed the most inverse associations with outcome, parental income indicators showed even number of inverse and non-significant associations, and parental employment group and properties and affluence group showed mostly non-significant associations (Fig. 1).

A total of 14 studies presented results separately for girls and boys with altogether 27 association analyses for each sex (Table 2). In these summaries, results are presented only for grouped SES indicators due to more limited number of association analyses. When combining all association analyses, in boys 48% were non-significant, 41% were inverse and 11% were positive, while in girls 44% were non-significant, 41% were inverse and 15% were positive. Parental education was the most frequently used SES indicator in these studies (9 association analyses for each sex). In boys, parental education indicator group showed mostly inverse associations, whereas in girls, parental occupation and properties and affluence groups showed a slight majority of inverse associations. Rest of the indicator groups showed mostly non-significant associations or even number of non-significant and inverse associations.

The included studies presented results according to relatively heterogenous age-groups. In this review the age groups were roughly categorized into 0–10 year-olds, 10–17 year-olds, and 0–17 year-olds (i.e. heterogenous age-group: age-range varying between 0 and 17 years and not fitting into the other age-categories) (Table 3). Concerning the younger age-group, 43 association analyses were conducted with 67% being inverse, 23% non-significant and 9% positive. The older age-group totaled 29 association analyses, and the corresponding percentage values were 59%, 38% and 3%. Respectively, of 25 association analyses in the heterogenous age-group, the percentage values were 60%, 32% and 8%. The most frequently used SES indicator in each age-group was parental education, which also showed most commonly inverse associations in each group. Parental occupation showed most commonly inverse associations in the younger age-group and in the heterogenous age-group, but not in the older age group where the associations were most commonly non-significant.

The IOTF cut-offs were the most used criteria to define overweight/obesity with 31 studies utilizing the criteria. Of these studies, altogether 27 studies with 54 association analyses for different SES indicators presented results for overweight (including obesity) and 17 studies with 22 association analyses for obesity (Table 4). Among studies using IOTF-defined overweight as an outcome, when combining all association analyses, 57% were inverse, 41% were non-significant, and 0.2% were positive. Respective percentages for IOTF-defined obesity were 77% (inverse), 23% (non-significant), and 0% (positive). With both outcomes, composite SES indicators, parental education, and parental occupation showed most commonly inverse associations, while parental income and properties and affluence showed most commonly non-significant associations. Moreover, parental employment and childhood overweight showed most commonly non-significant associations, while association analyses with childhood obesity were non-existent. Noteworthy was, that all 11 association analyses between parental education and IOTF-defined obesity were inverse.

Altogether eight studies with 16 association analyses employed childhood overweight or obesity definitions based on WHO criteria (Table 4). Due to relatively small number of association analyses, scrutiny of such studies was conducted combining overweight and obesity outcomes. A slight majority of all association analyses showed an inverse association between SES indicators and overweight/obesity outcomes defined according to the WHO criteria (38%), with nearly thirds showing non-significant (31%) and positive (31%) associations.

The results were also categorized according to a collection method of adiposity information (Table 4). The information was collected by measurements in 41 studies and by participants' or parents' self-reports in 12 studies. The studies using measured adiposity information contained 77 association analyses between SES indicators and outcomes: 60% were inverse, 31% were non-significant and 9% were positive. Composite SES indicators, parental education, parental occupation, and parental income showed most frequently inverse associations, while parental employment and properties and affluence indicators showed most non-significant associations. The studies with self-reported adiposity information contained 16 association analyses between SES indicators and outcomes of which 75% were inverse and 25% were non-significant.

According to The World Bank classification (The World Bank, 2022) most of the studies included were conducted based on populations from high-income countries, and only three utilized data entirely or partly from upper-middle-income economies (Lissner et al., 2016; Patel et al., 2018; Yardim et al., 2019). All these three studies yielded mostly positive and some non-significant associations between SES indicators (parental education, occupation and employment) and adiposity.

4. Discussion

The aim of this scoping review was to summarize information on socioeconomic inequalities in childhood adiposity in Europe in the 21st century, to explore which SES and adiposity indicators are commonly used, which indicators yield commonly inverse associations, and whether the distribution of results differs according to different subpopulations or categorizations of outcome variables. Findings of this review affirmed results of the previous studies and reviews indicating an inverse association between SES and childhood adiposity in Western and high-income countries, so that children with parents with lower SES have greater likelihood of adiposity (Barriuso et al., 2015; Buoncristiano et al., 2021; Chung et al., 2016). Moreover, this review revealed differences in associations depending on SES indicator used, on sex and age of the population, and on categorization and measurement method of the outcome variable.

In line with previous literature, this review demonstrated different parental education and occupation indicators to be the commonly used SES indicators, and of the different indicators, education showed frequently inverse associations with childhood adiposity (Notara et al., 2020; Barriuso et al., 2015; Shrewsbury and Wardle, 2008). Excess

Table 4
Associations between SES indicators and childhood adiposity according to different categorizations.

SES indicator[c] according to different outcome categorizations	Total n of association analyses	Association with adiposity: Positive[a] References	n	%	No References	n	%	Inverse[b] References	n	%
Adiposity according to IOTF										
OW (including OB)										
Composite SES variables[d, e]	3	–	–	–	–	–	–	(Bammann, et al, 2013) (Lioret et al., 2009) (Stamatakis et al., 2010)	3	100
Parental education[d]	22	–	–	–	(Bramsved et al., 2018) (Farajian et al., 2013) (Gil and Takourabt, 2017) (Keane et al., 2012) (Moschonis et al., 2010) (Salanave et al., 2009) (Sanchez-Cruz et al., 2018) (Stuart and Panico, 2016)	8	36	(Bammann, et al, 2013) (Grazuleviciene et al., 2017) (Huus et al., 2007) (Khanolkar et al., 2012) (Klein-Platat et al., 2003)[f] (Lien et al., 2007) (Lioret et al., 2009) (Matthiessen et al., 2014)[f] (Miqueleiz et al., 2014) (Nagel et al., 2009) (Rodrigues et al., 2021) (Ruijsbroek et al., 2011) (van Vliet et al., 2015)[f] (Veldhuis et al., 2013)	14	64
Parental occupation[d]	11	–	–	–	(Keane et al., 2012) (Lien et al., 2007) (Lioret et al., 2009) (Sanchez-Cruz et al., 2018)	4	36	(Bammann, et al, 2013) (Farajian et al., 2013)[f] (Gil and Takourabt, 2017) (Khanolkar et al., 2012)[f] (Salanave et al., 2009) (Thibault et al., 2013) (van Vliet et al., 2015)	7	64
Parental employment[d]	4	(Hawkins et al., 2008)[f]	1	25	(Farajian et al., 2013) (Sanchez-Cruz et al., 2018)	2	50	(Iguacel et al., 2018)	1	25
Parental income[d]	9	–	–	–	(Bramsved et al., 2018) (Farajian et al., 2013) (Keane et al., 2012) (Klein-Platat et al., 2003) (Lien et al., 2007)	5	56	(Bammann, et al, 2013) (Moschonis et al., 2010) (Stamatakis et al., 2010) (Stuart and Panico, 2016)	4	44
Properties and affluence[d]	5	–	–	–	(Farajian et al., 2013) (Moschonis et al., 2010) (Stuart and Panico, 2016)	3	60	(Grøholt et al., 2008) (Lioret et al., 2009)	2	40
All indicators combined	***54***	–	***1***	***0.2***	–	***22***	***40.7***	–	***31***	***57.4***
OB										
Composite SES variables[d, e]	2	–	–	–	–	–	–	(Kleiser et al., 2009) (Stamatakis et al., 2010)	2	100
Parental education[d]	11	–	–	–	–	–	–	(Bramsved et al., 2018) (Huus et al., 2007)[f] (Keane et al., 2012) (Miqueleiz et al., 2014) (Nagel et al., 2009)[f] (Nogueira et al., 2013) (Oude Groeniger et al., 2020) (Rodrigues et al., 2021) (Ruijsbroek et al., 2011) (Stuart and Panico, 2016) (Veldhuis et al., 2013)	11	100
Parental occupation[d]	2	–	–	–	–	–	–	(Keane et al., 2012) (Thibault et al., 2013)	2	100
Parental employment[d]	–	–	–	–	–	–	–	–	–	–
Parental income[d]	4	–	–	–	(Bramsved et al., 2018) (Keane et al., 2012) (Stuart and Panico, 2016)	3	75	(Stamatakis et al., 2010)	1	25
Properties and affluence[d]	3	–	–	–	(Grøholt et al., 2008) (Stuart and Panico, 2016)	2	66.7	(Lazzeri et al., 2017)	1	33.3
All indicators combined	***22***	–	–	–	–	***5***	***22.7***	–	***17***	***77.3***
Adiposity according to WHO criteria[g]										
OW or OB										
Composite SES variables[d, e]	–	–	–	–	–	–	–	–	–	–
Parental education[d]	7	(Patel et al., 2018) (Yardim et al., 2019)	2	29	(Lissner et al., 2016) (Rotevatn et al., 2019) (Sanchez-Cruz et al., 2018)	3	43	(Bibiloni Mdel et al., 2010) (Matijasevich et al., 2009)	2	29
Parental occupation[d]	3	(Patel et al., 2018)	1	33	(Sanchez-Cruz et al., 2018)	1	33	(Bibiloni Mdel et al., 2010)	1	33
Parental employment[d]	3	(Lissner et al., 2016) (Yardim et al., 2019)	2	67	(Sanchez-Cruz et al., 2018)	1	33	–	–	–
Parental income[d]	2	–	–	–	–	–	–		2	100

(continued on next page)

Table 4 (*continued*)

SES indicator[c] according to different outcome categorizations	Total n of association analyses	Association with adiposity: Positive[a] References	n	%	No References	n	%	Inverse[b] References	n	%
								(Matijasevich et al., 2009) (Rotevatn et al., 2019)		
Properties and affluence[d]	1	–	–	–	–	–	–	(Sigmund et al., 2018)	1	100
All indicators combined	***16***	–	***5***	***31***	–	***5***	***31***	–	***6***	***38***
Collection method of adiposity information										
Measured OW or OB										
Composite SES variables[d, e]	5	–	–	–	(Valerio et al., 2006)	1	20	(Bammann, et al, 2013) (Kleiser et al., 2009) (Lioret et al., 2009) (Stamatakis et al., 2010)	4	80
Parental education[d]	31	(Patel et al., 2018) (Yardim et al., 2019)	2	6	(Farajian et al., 2013) (Lissner et al., 2016) (Moschonis et al., 2010) (Rotevatn et al., 2019) (Salanave et al., 2009) (Sanchez-Cruz et al., 2018)	6	19	(Bammann, et al, 2013) (Bibiloni Mdel et al., 2010) (Bouthoorn et al., 2014) (Bramsved et al., 2018) (Fernandez-Alvira et al., 2013) (Hilpert et al., 2017) (Keane et al., 2012) (Khanolkar et al., 2012) (Klein-Platat et al., 2003) [f] (Lamerz et al., 2005) [f] (Lioret et al., 2009) (Magnusson et al., 2008) (Matijasevich et al., 2009) (Nagel et al., 2009) (Nogueira et al., 2013) (Oude Groeniger et al., 2020) (Rodrigues et al., 2021) (Semmler et al., 2009) (Stuart and Panico, 2016) (Valerio et al., 2006) (van den Berg et al., 2013) (van Vliet et al., 2015) (Veldhuis et al., 2013)	23	74
Parental occupation[d]	15	(Patel et al., 2018)	1	7	(Lioret et al., 2009) (Mutunga et al., 2006) (Sanchez-Cruz et al., 2018) (Sweeting et al., 2008)	4	27	(Bammann, et al, 2013) (Bibiloni Mdel et al., 2010) (Farajian et al., 2013) [f] (Hargreaves et al., 2013) (Keane et al., 2012) (Khanolkar et al., 2012) [f] (Ness et al., 2006) (Salanave et al., 2009) (Thibault et al., 2013) (van Vliet et al., 2015)	10	67
Parental employment[d]	8	(Hawkins et al., 2008) [f] (Lissner et al., 2016) (Yardim et al., 2019)	3	38	(Farajian et al., 2013) (Lamerz et al., 2005) (Sanchez-Cruz et al., 2018) (Taylor et al., 2005)	4	50	(Iguacel et al., 2018)	1	13
Parental income[d]	12	–	–	–	(Bramsved et al., 2018) (Farajian et al., 2013) (Keane et al., 2012) (Klein-Platat et al., 2003) (Magnusson et al., 2008)	5	42	(Bammann, et al, 2013) (Bouthoorn et al., 2014) (Matijasevich et al., 2009) (Moschonis et al., 2010) (Rotevatn et al., 2019) (Stamatakis et al., 2010) (Stuart and Panico, 2016)	7	58
Properties and affluence[d]	6	[f] (Taylor et al., 2005) [f]	1	17	(Farajian et al., 2013) (Lamerz et al., 2005) (Moschonis et al., 2010) (Stuart and Panico, 2016)	4	67	(Lioret et al., 2009)	1	17
All indicators combined	***77***		***7***	***9.1***		***24***	***31.2***		***46***	***59.7***
Parents' or participants' self-reported OW or OB										
Composite SES variables[d, e]	–	–	–	–	–	–	–	–	–	–
Parental education[d]	7	–	–	–	(Gil and Takourabt, 2017)	1	14	(Grazuleviciene et al., 2017) (Huus et al., 2007) (Lien et al., 2007) (Matthiessen et al., 2014) [f] (Miqueleiz et al., 2014) (Ruijsbroek et al., 2011)	6	86
Parental occupation[d]	4	–	–	–	(Lien et al., 2007) (Mikolajczyk and Richter, 2008)	2	50	(Gil and Takourabt, 2017) (Wijlaars et al., 2011)	2	50
Parental employment[d]	–	–	–	–	–	–	–	–	–	–
Parental income[d]	1	–	–	–	(Lien et al., 2007)	1	100	–	–	–
Properties and affluence[d]	4	–	–	–	–	–	–	(Grøholt et al., 2008) (Lazzeri et al., 2017) (Mikolajczyk and Richter, 2008) (Sigmund et al., 2018)	4	100
All indicators combined	***16***	–	–	–		***4***	***25.0***		***12***	***75.0***

Underlined percentage values denote the most frequent association for SES indicator in question (not applied if only one study exists). Statistical significance not tested. Abbreviations: IOTF, International Obesity Task Force; OB, obesity; OW, overweight; SES, socioeconomic status; WHO, World Health Organization.

[a] Positive association denotes associations where while SES indicator receives ascending levels, also adiposity indicator receives ascending levels. This category includes studies where there are only statistically significant positive associations or both significant positive and nonsignificant associations in different subgroups or with different adiposity indicators.

[b] Inverse association denotes associations where while SES indicator receives ascending levels, adiposity indicator receives descending levels. This category includes studies where there are only statistically significant negative associations or both significant negative and nonsignificant associations in different subgroups or with different adiposity indicators.

[c] Higher level in SES indicator denotes: Longer education or higher degree, less manual or more expertise-demanding occupation, existing employment or longer working hours, higher income, greater affluence or more properties

[d] All variables in category in question

[e] Excluding composite variables based only on wealth and affluence.

[f] Several variables in the same study in the same indicator group: Significant association acknowledged, and nonsignificant association disregarded.

[g] Variation in definition of OW/OB; cut-off points were based on percentiles or SD 's, or continuous z-BMI score was used.

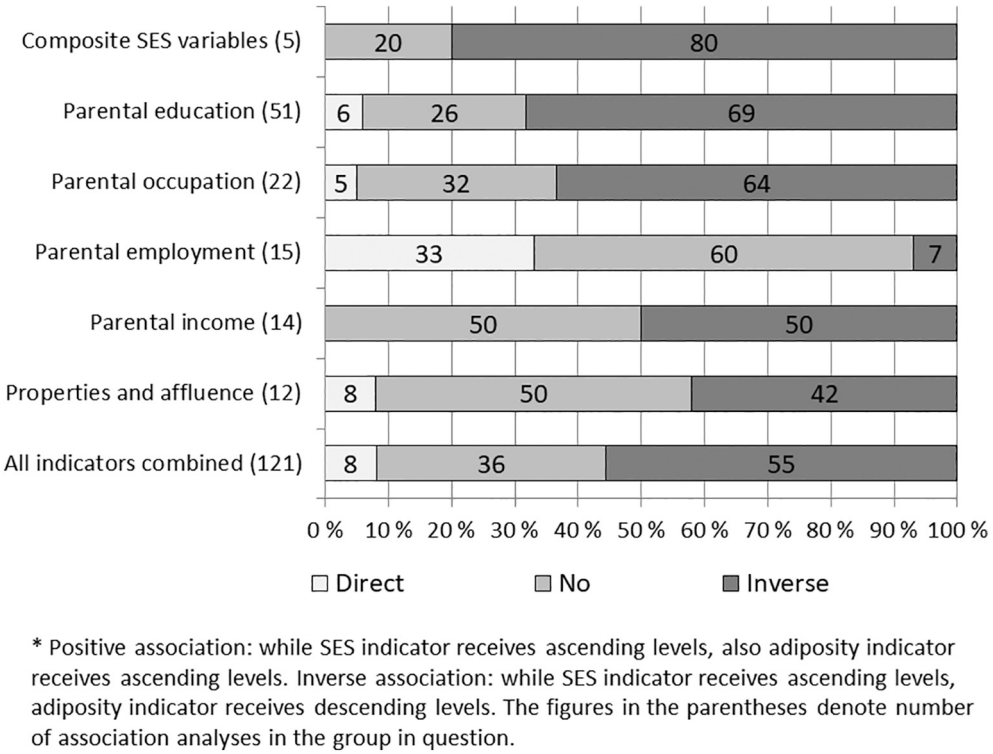

Fig. 1. Proportions (%) of directions of associations* between different SES indicator groups and adiposity.

weight was common in children whose both parents had low education or mother had low education, while father's education seemed to be less related to child's weight. Adiposity was more common among children whose parents had lower occupational status independent of occupation indicator. Composite SES indicators used in the studies included various combinations of variables, most, however, comprising education and occupation, and income or affluence variables. These indicators resulted in mostly aligned inverse associations with outcomes, adiposity being less frequent in children with higher SES.

Previous studies have suggested that mechanisms that explain the inverse associations between SES and adiposity in adults are mostly derived from poorer lifestyle habits (e.g. diet and physical activity) among individuals with low SES (Pampel et al., 2010). According to Pampel et al. (Pampel et al., 2010), the pathways that lead to such poorer lifestyle habits among individuals of poorer SES include for instance, using unhealthy habits as "self-medication" while coping and facing stressors in daily life; not experiencing one would gain advantage from adopting healthy lifestyle habits; lack of knowledge on healthy lifestyle habits and how excess weight gain could be prevented; and lack of self-efficacy or aid to pursue healthier lifestyle habits. Further, one possible explanation is use of lifestyle habits as means of intentional "class distinction" from other SES groups including, especially among women, greater pressures to be thin in higher SES groups (Pampel et al., 2010). Moreover, it is possible that genetic factors or same latent traits (e.g. self-control, intelligence) affect both development of SES and lifestyle behaviors, and thus, obesity (Pampel et al., 2010). The same mechanisms have been regarded to apply to children through their parents' behavioral patterns. Children are directly affected by parents' lifestyle habits (e.g. meal patterns and quality of foods provided to children), but they also learn and adopt the habits of their parents. Indeed, a socioeconomic gradient appears between parental SES and lifestyle habits in childhood and adolescence with poorer habits occurring more frequently in children with lower parental SES (Cameron et al., 2012; Cameron et al., 2015; Hanson and Chen, 2007).

Parental BMI mediates the association between parental SES and childhood adiposity (Mech et al., 2016). Van Vliet et al. (van Vliet et al., 2015) concluded that one important explanation for higher obesity prevalence among children with low SES originates from higher obesity prevalence among parents with low SES, and such parents' tendency to use their own overweight/obesity as reference point to child's weight development and difficulty to categorize own child with excess weight as overweigh/obese. In addition to familial impact, neighborhood,

school, and peers affect adopting lifestyle habits (Hanson and Chen, 2007). It is probable, however, that different SES indicators are associated with adiposity via different mechanisms, and of the SES indicators, education seems to be most strongly associated with lifestyle habits that contribute to risk of obesity (Barriuso et al., 2015).

Indeed, in this review, income and different properties and affluence indicators did not show that explicit gradients with childhood adiposity than education did, but approximately half of the findings were inverse and half non-significant. Previous reviews have drawn aligned conclusion (Shrewsbury and Wardle, 2008; El-Sayed et al., 2012). Drewnowski and Specter (Drewnowski and Specter, 2004) suggested that for individuals with low income, foods with high energy-density may appear appealing due to their inexpensiveness, palatability, and them providing maximum energy per the least cost. The reason, however, for lack of coherent inverse associations, similar to education indicators, may stem from income not being that consistently related to knowledge and values related to healthy lifestyle than education is. It seems that high parental education affects more strongly to development of healthy lifestyle habits than high parental occupation or income do, possibly due to strong association between education and health literacy skills (Stormacq et al., 2019).

Noteworthy was that only one of the reviewed studies (Iguacel et al., 2018) showed an inverse association between parental employment indicators and childhood adiposity, but most of the associations were non-significant and a third of the analyses found a positive association. Of the single indicators, especially mother's employment showed a strong positive gradient in adiposity. However, this may partly be due to two of such studies utilizing data entirely or partly from upper-middle-income economies (Lissner et al., 2016; Yardim et al., 2019) in which the gradient between SES and childhood adiposity tends to be reverse (Buoncristiano et al., 2021; Dinsa et al., 2012; Sobal and Stunkard, 1989). Yet, it is also possible, that parental, and especially mother's employment as such differs from other SES-indicators. While higher parental education and occupational status may decrease the risk of overweight/obesity in children by greater knowledge and emphasis of healthy lifestyles, mother's employment status or longer working hours ensues in shorter time to spend with children and potentially poorer premises for children to learn healthy lifestyle habits to promote normal growth. Moreover, early post-natal return to work may denote shorter breastfeeding period, and use of other feeding practices, which has been shown to increase the risk of excess weight gain in childhood (Verduci et al., 2021; Rito et al., 2019).

SES indicators used in the reviewed studies have a great variety; entirely different indicators may represent different aspects of SES (e.g. parental education, parental occupation, family income), but also different indicators within same indicator groups show variety (e.g. maternal or paternal or the highest parental education, education based on school years or a degree, categorization of e.g. school years). Different SES indicators may yield divergent results, which must be considered when interpreting the results. In this review, lower frequency of use of some SES indicators may also result in higher likelihood of chance in summaries of findings. Use of harmonized and compatible SES indicators would simplify the comparisons between studies and countries. Only three of the reviewed studies utilized SES data that was obtained from registers, while other studies used parents' or participants' self-reported information. More wide-spread use of register-based variables could potentially enable comparisons better. However, variation exists in recording of the SES information between countries.

In the reviewed studies presenting results separately for boys and for girls, in both sexes, non-significant results outnumbered inverse findings. The predominance of non-significant results in these analyses may be due to a chance in smaller number of studies. In a review by Shrewsbury and Wardle (Shrewsbury and Wardle, 2008), a slight majority of sex-stratified studies showed inverse findings in boys and in girls. When looking into associations of individual SES indicators in boys and girls in this review, it, however, seemed that while parental education showed commonly non-significant results in girls, in boys, it was inversely associated with adiposity. It has been suggested that in adults, women experience greater pressures to be normal weight or thin than men do, and those with higher SES experience greater pressures than those with lower SES (Pampel et al., 2010; Sobal and Stunkard, 1989). Presumably, same mechanisms may apply to children and teenagers via their parents' attitudes and peers' influence. Overweight and obesity are more common in underage boys than in girls (WHO European Childhood Obesity Surveillance Initiative (COSI), 2021) and even though boys may not experience that great pressure to be thin, it is possible that in particular among boys, parental education with parents' knowledge and attitudes impacting family lifestyle habits create steeper gradient in obesity prevalence. Conversely, in girls with already lower prevalence of obesity and generally greater pressures to be thin, the obesity prevalence differences between groups may be less notable resulting in non-significant findings. In addition, Van Vliet et al. (van Vliet et al., 2015) suggested that earlier maturation of girls and thus, being less affected by their parents and more by their peers, could be one explanation for the lack of association in girls. On the contrary, a previous review noted that an inverse association between SES and adiposity was more common in girls than in boys (Barriuso et al., 2015).

Summaries of this review suggest that higher SES is more consistently associated with lower risk of adiposity in younger children than in older children and adolescents. Previous reviews have drawn aligned (Shrewsbury and Wardle, 2008) conclusions, but also opposite summations with the inverse association being stronger in older children (Barriuso et al., 2015). In this review, strong inverse gradient between parental education and childhood adiposity seems, however, to persist in later childhood as well, but the association between parental occupation and adiposity appears less coherent. Parental SES being more strongly associated with adiposity in younger children, seems plausible as in smaller children, family lifestyle habits have a greater impact on children's lifestyle and weight development, whereas in older children sources outside family, e.g. peers, begin to have a greater impact on development of lifestyle habits and weight (Hanson and Chen, 2007).

The summarized results according to the IOTF overweight/obesity criteria (Cole et al., 2000) showed more consistent inverse associations compared with the results from the studies using the WHO criteria (de Onis and Lobstein, 2010; de Onis et al., 2007; WHO Multicentre Growth Reference Study Group, 2006). This may be due to the WHO criteria generally yielding higher prevalences of overweight/obesity than the IOTF criteria, which thereby recognizes somewhat more severe forms of overweight and obesity (Rolland-Cachera, 2011). In agreement with this theory, in this study, SES seemed to be more strongly associated with IOTF-defined obesity than with overweight. Also, previous studies have indicated that the inverse association between SES and adiposity appears stronger with more severe forms of obesity as an outcome (Barriuso et al., 2015). As studies using different adiposity indicators and criteria may yield diverse results, use of identical outcomes is preferable.

The number of studies utilizing parents' or participants' self-reported adiposity data was relatively small making it not plausible to compare these summarized results of single indicator groups. When combining all such association analyses, however, the results suggested that inverse association between SES and adiposity is more common when using self-reported adiposity information than when using measured information, which is in line with some previous findings (Barriuso et al., 2015). Chau et al. (Chau et al., 2013) indicated that in teenagers, self-reported BMI is affected by under-reporting and may be unreliable tool to measure excess adiposity in teenagers. Secondly, the same study showed that measured BMI is more often affected by refusal than self-reported BMI, and both under-reporting and refusals are dependent on certain socio-economic, health-related, and behavioral factors. Thus, as has been done in majority of the studies, measured adiposity information should be preferred when possible.

The positive associations between SES and adiposity indicators were mainly found in studies utilizing data from upper middle-income

countries (Lissner et al., 2016; Patel et al., 2018; Yardim et al., 2019) which agrees with findings from other studies from low or middle-income countries (Buoncristiano et al., 2021; Dinsa et al., 2012; Sobal and Stunkard, 1989). Thus, when considering only studies from high-income countries, the frequency of inverse associations grew even stronger. Consistent with this, in an article based on the IDEFICS study, Bammann et al. (Bammann et al., 2013) concluded that divergence in the SES-obesity gradient between European countries is dependent on regional mean income and the country-specific Human development index. Even though majority of the reviewed studies utilized data from high-income countries, these countries cannot be considered equal in terms of being less deprived. Nordic countries have generally more comprehensive welfare systems than many Eastern, Central and Southern Europe countries. For instance, free and wholesome school meals are served in Finland and in Sweden, which may mitigate SES disparities in nutrition and consequently in childhood adiposity. Thus, being poor in different high-income European countries may denote to relatively different degrees of deprivation. Despite these differences the inverse association between parental SES and childhood obesity appeared parallel. Hence, it can be presumed that even though deprivation may reach different distances across Europe, even relative deprivation derived from lower SES predisposes children to higher risk of obesity.

Strengths of this scoping review include examination of associations between SES indicators and childhood adiposity indicators according to several different SES indicators (individual and grouped indicators), corresponding scrutiny in various subpopulations (sex, age groups), and according to different overweight/obesity categorizations and data collection methods.

Some methodological issues that should be considered, however, exist as well. As this review is a scoping but not a systematic review, its purpose was not to create a summary and a meta-analysis of the findings but an overview of which different parental SES or childhood adiposity indicators are used in the literature, whether the associations seem divergent using these indicators, and whether they are divergent in different sub-populations or according to different outcome categorizations. This review summarized results from different study settings and statistical analyses making the overview of results relatively heterogenous. Variety, more specifically, in the adjustment models of the included studies, may cause distortion in the summarized results; part of the studies used comprehensive adjustment for confounding factors while part showed unadjusted results possibly yielding more commonly significant results, and potentially affected by confounding factors. As adjustment models in the reviewed studies showed major diversity, the results were not categorized and summarized according to them in this review. Moreover, this review did not exclude studies according to number of participants. It may be that in larger studies, statistical significance is reached easier. Hence, these methodological differences between included studies should be considered in the interpretation of the results of this review. The results, however, seem plausible compared with previous systematic reviews (Barriuso et al., 2015; Shrewsbury and Wardle, 2008).

This review included only studies on general child populations of the respective European countries including varieties of different ethnicities and did not present results separately for any ethnic/race groups. Thus, the summary results may be affected by proportions on ethnic minorities in the original studies to differing extent, as not in all studies ethnicity/race was adjusted for. In addition to lower SES groups, obesity and unhealthy lifestyle have been shown to be more common in ethnic minorities (Delva et al., 2006). Further, Shrewsbury and Wardle (Shrewsbury and Wardle, 2008) concluded that in black children, no association between SES and adiposity emerged. Both SES and adiposity indicators may distribute differently but also represent different features in different ethnic groups, which should be taken into account.

Finally, this review concentrated only on family-level SES indicators omitting school, neighborhood, area, or country-level indicators. Such area-level indicators have shown mostly aligned inverse associations with adiposity as family-level indicators (El-Sayed et al., 2012). In this study, however, they were omitted due to an aim to concentrate on more personal family-level indicators.

5. Conclusions

Even though in part of the European countries childhood obesity prevalence seems to have plateaued or even decreased (WHO European Childhood Obesity Surveillance Initiative (COSI), 2021), SES inequalities in adiposity persist, and according to part of the studies, continue to widen (Chung et al., 2016). Childhood obesity constitutes a considerable public health problem, as it has been associated with several physical and psychosocial conditions in childhood but also later in adulthood. In childhood, obesity contributes to increased risk of worse general health and health related quality of life, worse psychosocial functioning, weight stigma, and specific physical and mental health disorders such as asthma, cardiovascular dysfunction, attention deficit hyperactivity disorder (ADHD), and depression (Tsiros et al., 2009; Ma et al., 2021; Shan et al., 2020; Halfon et al., 2013; Cote et al., 2013; Rao et al., 2020). Long-term associations of childhood obesity include increased risk of certain elevated adult cardiovascular disease risk factors, diabetes, coronary heart disease, certain cancers, and premature mortality (Umer et al., 2017; Reilly and Kelly, 2011; Llewellyn et al., 2016). Childhood obesity also tends to persist into adulthood (Simmonds et al., 2016). Consequently, childhood obesity remains one of the most notable public health problems, and studies addressing specific determinants of it that could aid in targeting the epidemic, such as parental SES indicators are justified.

Findings of the present review affirmed previous findings on inverse SES inequalities in childhood adiposity in Western and high-income countries and showed that differences exist in associations depending on SES indicator used, on sex and age of the population, and on categorization and measurement method of the outcome variable. As divergence exists in both parental SES indicators and childhood adiposity indicators, findings and conclusions drawn from such analyses may show a relatively heterogenous picture of the study question. Heterogeneity seems considerable especially in used SES indicators, but it exists also in the use of childhood adiposity indicators, albeit not that notably. Different SES indicators represent different aspects of SES, and different adiposity criteria yield divergent prevalences of overweight and obesity. These issues should be considered when interpreting the results. In Europe, harmonization of used indicators would be advisable to enhance comparability of results between countries. As considerable differences exist in e.g. the welfare systems of the European countries, careful consideration, however, is needed to decide whether and how country-specific characteristics related to e.g. income or educational level of each country, should be taken into account in such harmonization.

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CRediT authorship contribution statement

Laura Sares-Jäske: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review

& editing. **Annina Grönqvist:** Data curation, Investigation, Writing – review & editing. **Päivi Mäki:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Hanna Tolonen:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Tiina Laatikainen:** Conceptualization, Methodology, Funding acquisition, Writing – review & editing, Supervision, Project administration.

Declaration of Competing Interest

None.

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