

The Impact of Familial, Behavioural and Psychosocial Factors on the SES Gradient for Childhood Overweight in Europe

A Longitudinal Study

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Karin Bammann, Wencke Gwozdz, Claudia Pischke, Gabriele Eiben, Juan M. Fernandez-Alvira, Stefaan De Henauw, Lauren Lissner, Luis A. Moreno, Yannis Pitsiladis, Lucia A. Reisch, Toomas Veidebaum, and Iris Pigeot

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1 **The impact of familial, behavioural and psychosocial factors on the SES gradient for**
2 **childhood overweight in Europe. A longitudinal study.**

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4
5 Karin Bammann^{1,2}, Wencke Gwozdz³, Claudia Pischke², Gabriele Eiben⁴, Juan Miguel
6 Fernandez-Alvira⁵, Stefaan De Henauw⁶, Lauren Lissner⁴, Luis A Moreno⁵, Yannis Pitsiladis⁷,
7 Lucia Reisch³, Toomas Veidebaum⁸, Iris Pigeot^{2,9}, on behalf of the IDEFICS Consortium

8
9 ¹Institute for Public Health and Nursing Research (ipp), Faculty of Human and Health Sciences, University of
10 Bremen, Germany

11 ²Leibniz Institute for Epidemiology and Prevention Research and Epidemiology – BIPS, Bremen, Germany

12 ³Department of Intercultural Communication and Management, Copenhagen Business School, Frederiksberg,
13 Denmark

14 ⁴Department of Public Health and Community Medicine, University of Gothenburg, Gothenburg, Sweden

15 ⁵Growth, Exercise, Nutrition and Development (GENUD) Research Group, University of Zaragoza, Spain

16 ⁶Department of Public Health, Ghent University, Ghent, Belgium

17 ⁷College of Medicine, Veterinary & Life Sciences, Institute of Cardiovascular & Medical Sciences, University of
18 Glasgow, Glasgow, United Kingdom

19 ⁸Department of Chronic Diseases, National Institute for Health Development, Tallinn, Estonia

20 ⁹Institute of Statistics, Faculty of Mathematics and Computer Science, University of Bremen, Germany

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29 Address for correspondence

30 Karin Bammann

31 Universität Bremen / FB 11

32 Grazer Strasse 2a

33 D-28359 Bremen, Germany

34 Tel: +49 (0)421 218-66873

35 Fax: +49 (0)421 218-66881

36 bammann@uni-bremen.de

37

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41

42 **Abstract**

43 BACKGROUND: In highly developed countries, childhood overweight as well as many
44 overweight-related risk factors is negatively associated with socioeconomic status (SES).

45 OBJECTIVE: To investigate the longitudinal association between parental SES and childhood
46 overweight, and to clarify whether familial, psychosocial or behavioural factors can explain
47 any SES gradient.

48 METHODS: The IDEFICS baseline and follow-up surveys are used to investigate the
49 longitudinal association between socioeconomic status (SES), familial, psychosocial and
50 behavioural factors, and the prevalence of childhood overweight. 5 819 children (50.5 %
51 boys, 49.5 % girls) were included.

52 RESULTS: The risk for being overweight after two years at follow-up in children that were
53 non-overweight at baseline rises with a lower SES. For children who were initially overweight
54 a lower parental SES carries a lower probability for a non-overweight weight status at follow-
55 up. The effect of parental SES is only moderately attenuated by single familial, psychosocial
56 or behavioural factors; however, it can be fully explained by their concerted effect. Most
57 influential of the investigated risk factors were feeding / eating practices, parental BMI,
58 physical activity behaviour, and proportion of sedentary activity.

59 CONCLUSION: Prevention strategies for childhood overweight should focus on actual
60 behaviours while acknowledging that these behaviours are more prevalent in lower SES
61 families.

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66 INTRODUCTION

67 Childhood overweight and obesity is associated with several somatic and psychosocial
68 health-related factors later in life including higher prevalence of comorbidities ¹⁻⁵, higher
69 mortality rates ⁵, lower educational attainment ⁶, and developmental delays ⁷. In highly
70 developed countries, childhood overweight and obesity is negatively associated with
71 parental socio-economic status, i.e. overweight and obesity are more prevalent in children
72 from families with low socioeconomic status ^{8, 9}. This negative SES gradient of childhood
73 obesity indicates SES differences in energy-related behaviours and other psychosocial and
74 familial risk factors, and it is often suggested that, where such a gradient is present,
75 prevention measures should be specifically targeted at low social classes¹⁰. Parental SES is
76 not directly influencing a child's weight status. A multitude of behavioural factors within the
77 family context has been explored. This is especially true for food-related behaviours¹¹⁻¹³, but
78 also physical activity, sleep, media consumption^{14, 15}, and, albeit much rarer, psychosocial
79 factors like e.g. lack of social networks have been shown to be associated with childhood
80 obesity¹⁶. Although familial clustering of overweight and obesity is well established¹⁷, the
81 underlying causes are unknown. They might be driven by genetics, a shared environment,
82 social role modelling, or a combination thereof. Concise research on intermediate factors
83 truly trying to explain the SES-obesity association of childhood obesity is scarce. One of the
84 first attempts is the study of Goisis and colleagues who found that smoking during
85 pregnancy, breastfeeding, early physical activity and dietary factors attenuates the income
86 gradient of childhood overweight and obesity in a UK nationally representative cohort
87 study.¹⁸ However, more studies are needed to substantiate and further investigate these
88 findings.

89 In a previous study, we analysed the cross-sectional association between socioeconomic
90 status and overweight in the baseline survey of the IDEFICS study, a multi-centre European
91 cohort study on diet- and lifestyle-related diseases in children ¹⁹. We found a negative SES
92 gradient in five of the eight IDEFICS survey centres (Belgium, Germany, Sweden, Estonia,
93 Spain) and a zero association for the other three centres (Cyprus, Hungary, Italy), and we
94 were able to link the presence and direction of the SES gradient to the degree of human
95 development in the survey centres ¹⁹. For the present paper, we will be investigating data of
96 Belgium, Germany, Sweden, Estonia and Spain, since these five centres were shown to be
97 homogenous with regard to their cross-sectional SES-overweight association, allowing
98 pooling of the data.

99 The aim of the paper is two-fold: Firstly, we would like to investigate the impact of SES at
100 baseline on childhood overweight / obesity at follow-up, and secondly, we would like to
101 clarify whether familial, psychosocial and behavioural factors can explain any observed SES
102 gradient.

103

104 **METHODS**

105 The IDEFICS study is a multi-centre population-based intervention study on childhood
106 obesity that was carried out in selected regions of eight European countries comprising
107 Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden ^{20, 21}. The study was
108 set up in pre- and primary school settings in control and intervention regions in each of
109 these countries. Two major surveys (baseline (T0) and follow-up (T1)) were conducted in
110 pre-schools and primary school classes (1st and 2nd grades at baseline). The baseline survey
111 (September 2007 - May 2008) reached an overall response proportion of 51% (ranging from
112 41% to 66% in the single countries) and included 16.220 children aged 2 to 9 years. The

113 follow-up survey (September 2009 - May 2010) was conducted two years later, and follow-
114 up was organised such that the schools were visited in the exact same month as they were
115 visited in the baseline survey. The follow-up survey at T1 reached an overall response
116 proportion of 68% (ranging from 49% to 84% in the single countries) and included 11.038
117 children aged 4 to 11 years. The general design of the IDEFICS study has been described
118 elsewhere^{20, 21}.

119

120 The present study only includes children from the centres in which a social gradient for
121 overweight and obesity was established previously¹⁹ i.e. from Belgium, Germany, Sweden,
122 Estonia and Spain (N=6,497 children), for whom full information on the socioeconomic
123 factors is available. This was the case for 5 819 children (50.5 % boys, 49.5 % girls).

124 In both surveys, self-administered questionnaires have been filled in by the parents to
125 gather information on the children's behaviours, parental attitudes and on the social
126 environment of the children. The questionnaire was developed in English, translated to the
127 respective languages and back translated to English to minimize any heterogeneity due to
128 translation problems. Different language versions were available in the centres, and help
129 was offered to those parents who felt they were not able to fill in the questionnaire by
130 themselves.

131 Anthropometric indicators in the children were assessed in the framework of a physical
132 examination. Weight was determined using a TANITA BC 420 SMA with the children being in
133 a fasting status and wearing only underwear. Standing height was measured with the
134 children's head in a Frankfort plane using a stadiometer SECA 225. As in the weight
135 measurement, the children were wearing only underwear, all hair ornaments were removed.

136 Within both surveys, in random subsamples of participating children additional
137 measurements have been carried out ²⁰. In the baseline survey, accelerometer
138 measurements are available for 46% of the children. 24 hour dietary recalls have been done
139 in 67.5% of the children. The methodology of these measurements is described below.

140

141 ***Variables included in this study***

142 **Familial factors**

143 For assessing the **socioeconomic status (SES)** of the children, we employed an additive SES
144 indicator comprising a) equivalized household income (net income of the household
145 equivalized to the number of household members using the OECD square root scale²² and
146 adjusted for median equivalized income of the respective country), b) parental educational
147 level (maximum ISCED level of the parents²³), and c) parental level of occupational position
148 (maximum level of the parents using the European Socioeconomic Classification (ESeC), a
149 modified Erikson-Goldthorpe-Portocarero Schema²⁴). Cronbach's alpha for the three
150 indicators was 0.67. We scaled the indicators to the interval [1,5] and summed them up. The
151 SES score ranges from 3 (lowest SES) to 15 (highest SES). The construction of the indicator is
152 described in detail in our previous work ¹⁹. Baseline descriptive data of the SES indicator and
153 its components in the five countries can be found in Supplementary Table A1.

154

155 The **familial clustering** of overweight and obesity was assessed using self-reported parental
156 BMI. This was assessed in the questionnaire by the question "What is your height and
157 weight? Please give information of parents with whom the child is living." Any numbers
158 could be given as answers. The parental BMI was calculated as weight (kg) / squared height
159 (m²).

160 **Parental feeding practices** were assessed using an abridged version of the Pre-schooler
161 Feeding Questionnaire (PFQ) developed by Baughcum and colleagues²⁵. Items with highest
162 factor loadings were selected relating to the five constructs that were hypothetically related
163 to childhood overweight: *difficulty in child feeding* (it is a struggle to get child to eat, child
164 has poor appetite; Cronbach's alpha 0.79), *concern about child overeating or being*
165 *overweight* (have to stop child from eating too much, think about putting child on a diet to
166 keep him/her from becoming overweight, worried child is eating too much; Cronbach's
167 alpha 0.82), *pushing the child to eat more* (make child eat all the food on the plate, use food
168 child likes as a way to get child to eat healthy; Cronbach's alpha 0.39), *structure during*
169 *feeding interaction* (child watches TV at meals (reversed item), parent sits down with child
170 during mealtime; Cronbach's alpha 0.43), and *age-inappropriate feeding* (parent feeds child
171 her-/himself if child does not eat enough).

172

173 **Psychological factors**

174 **Child's strength and difficulties** were assessed using the Strength and Difficulties
175 Questionnaire (SDQ)²⁶. We assessed four of the five constructs of this questionnaire, namely
176 *emotional difficulties* (Cronbach's alpha 0.63), *behavioural difficulties* (Cronbach's alpha
177 0.51), *difficulties with peers* (Cronbach's alpha 0.54) and *pro-social behaviour* (Cronbach's
178 alpha 0.58).

179

180 **Behavioural factors**

181 The assessment of the child's **dietary behaviour** was based on parental report using one
182 computer-assisted 24-hour dietary recall combined with assessment of all school meals of
183 the particular day. Energy intake per day was calculated using country-specific information.

184 We excluded under- and over-reporters from the data by using adapted Goldberg cut-offs,
185 were Goldberg cutoff values²⁷ were recalculated for application in children using age- and
186 sex-specific reference values²⁸. For our analyses, we adjusted intake by dividing energy
187 intake in calories by body mass in kg. Further details on the 24-hour dietary recall method
188 employed in the IDEFICS study can be found elsewhere²⁹.

189 Child's **physical activity** behaviour was assessed by two different methods. In the parental
190 questionnaire, the Outdoor Playtime Checklist (OPC) was employed³⁰. From the OPC, we
191 derived the typical outdoor playtime in hours per week of the child. This measure had high
192 rank correlation with accelerometer measurements in a study in pre-school children in the
193 U.S.³⁰. Moreover, we asked for the time, the child typically spends in a sports club per week.
194 This questionnaire information was complemented in a subsample of children by
195 accelerometer measurements. The accelerometer device (ActiGraph, Pensacola, FL, USA)
196 was placed on the right hip for three days (two weekdays, one weekend day) during waking
197 hours. The sampling interval (epoch) was set at 15 seconds. Accelerometer measurements
198 were considered to be valid if at least 3-day measurements with a minimum of 6 hours daily
199 wearing time were available. Periods of 20 minutes or more consecutive zero counts were
200 replaced by missing data before further analysis. For the analyses, we used an averaged
201 count per minute, and time spent in moderate or vigorous physical activity using the cut-offs
202 of Evenson³¹. Additionally, the accelerometer data were used to calculate the percentage of
203 time spend in sedentary activities of total accelerometer wear time. Child's **sedentary**
204 **behaviour** was assessed via parental questionnaire. The hours per week the child typically
205 spends using audio-visual media was assessed for weekdays and weekends separately and
206 averaged over the week. As a second indicator, the number of different media devices in the
207 child's bedroom was assessed using a closed question for the presence of five different types

208 of media devices (TV, Computer, Internet connection, Video / DVD player and
209 PlayStation / Game console).

210

211 ***Statistical methods***

212 Body mass index (BMI) was calculated by dividing body mass in kilograms by squared body
213 height in meters. BMI of children was categorized into International Obesity Task Force
214 (IOTF) categories. For this, we interpolated the given categories for continuous age as
215 proposed by Cole et al.^{32, 33} by using cubic splines, and categorized each child according to
216 his / her continuous age (measurement day-birthday) . For this paper, we built two
217 categories for weight status: a) IOTF underweight and IOTF normal weight and b) IOTF
218 overweight and IOTF obese.

219 To analyse the cross-sectional association of SES on the prevalence of overweight including
220 obesity, age-, and study centre-adjusted prevalence odds ratios (OR) were calculated using
221 logistic regression models.

222 For longitudinal effects, we analysed the impact of a putative risk factor at T0 on the change
223 of weight status from T0 to T1. For this, hazard ratios (HR) were calculated employing Cox
224 proportional hazard models with age at T1 as time-dependent covariate stratified by weight
225 status at T0. We included the study centres as random effects. Thus, for each weight status
226 we modelled the proportional effects of a factor on the risk of a change of this weight status
227 at any given age independent of study centre. By this approach, we also eliminated country
228 effects and possible intervention / control group effects. Using the same method, we
229 estimated the HR for familial, psychosocial and behavioural factors on a change from IOTF
230 underweight / IOTF normal weight at T0 to IOTF overweight / IOTF obesity at T1. We
231 adjusted the proportional hazard models by SES to explore whether any SES gradients can be

232 explained by the analysed risk factors. In a last step, we analysed the interplay of risk factors
233 on change of weight status in a multivariate model (model I). To ensure that our results were
234 not influenced by the choice of subsamples for accelerometer measurements and / or 24-
235 hour dietary recall, we analysed a second multivariate model where these variable were
236 excluded beforehand (model II). The model building for the two latter models was done
237 using best subset selection to eliminate any possible bias introduced by automated model
238 building procedures³⁴. We reported the Wald statistics to judge the relative importance of
239 the single factors³⁵. Statistical significances are reported based on a significance level of
240 $\alpha=0.05$.

241 All statistical analyses were done with SAS 9.2 (SAS Institute, Cary (NC), USA). The code is
242 available from the authors upon request.

243

244 ***Ethical issues***

245 All parents or legal guardians of the participating children gave written informed consent to
246 data collection, examinations, collection of samples, subsequent analysis and storage of
247 personal data and collected samples. Additionally, each child gave oral consent after being
248 orally informed about the modules by a study nurse immediately before every examination
249 using a simplified text. Study participants and their parents / legal guardians could consent
250 to single components of the study while abstaining from others. All procedures were
251 approved by the relevant local or national ethics committees by each of the five study
252 centres, namely from the Ethics Committee of the University Hospital Ghent (Belgium), the
253 Tallinn Medical Research Ethics Committee of the National Institutes for Health
254 Development (Estonia), the Ethics Committee of the University Bremen (Germany), the

255 Ethics Committee for Clinical Research of Aragon (Spain), and the Regional Ethical Review
256 Board of Gothenburg (Sweden).

257

258

259 **RESULTS**

260 Basic characteristics of the 5,819 included children (2,931 boys, 2,888 girls) can be found in
261 Table 1. The sample is well balanced regarding sex and country (ranging from 17.6% children
262 from Germany to 24.2% children from Sweden). At T0, the prevalence of overweight and
263 obese children was 12.3% (N=712). Two years later, at T1, this prevalence was 15.4%
264 (N=896). The proportion of children with a change of weight status from T0 to T1 was 5.5%
265 for underweight / normal weight at T0 to overweight / obesity at T1 (N=320; 6.3% of all
266 underweight / normal weight children at T0) and 2.4% for a change from overweight /
267 obesity at T0 to underweight / normal weight at T1 (N=140; 19.7% of all overweight / obese
268 children at T0).

269

270 >>>> Include Table 1 about here

271

272 Table 2 shows the influence of SES on the weight status and on the change of weight status
273 over time. Within the cross-sectional surveys, SES is associated with overweight / obesity at
274 both time points. The higher the socio-economic status, the lower the prevalence of
275 overweight / obesity. The SES gradient is slightly steeper at T1 (POR: 0.903 95%CI: 0.882-
276 0.925) than at T0 (POR: 0.919 95%CI: 0.896-0.944). SES is also protective against a change
277 from underweight / normal weight at T0 to overweight / obesity at T1 (HR: 0.938; 95% CI:

278 0.905-0.974) and bears a higher chance for a change from overweight / obesity at T0 to
279 underweight / normal weight at T1 (HR: 1.108; 95% CI 1.040-1.180).

280

281 >>>> Include Table 2 about here

282

283 The impact of single familial, psychosocial and behavioural factors on a change from IOTF
284 underweight / IOTF normal weight at T0 to IOTF overweight / IOTF obesity at T1 and on the
285 SES gradient of this change is displayed in Table 3. Statistically significant factors bearing a
286 higher risk of changing to overweight / obesity are parental BMI (maternal BMI: HR: 1.104;
287 95% CI: 1.080-1.127; paternal BMI: HR: 1.108; 95% CI: 1.073-1.143), child's difficulties with
288 peers (HR: 1.091; 95% CI: 1.015-1.173), parental concern for overweight or overeating (HR:
289 1.397; 95% CI: 1.281-1.523), age-inappropriate feeding (HR: 1.107; 95% CI: 1.041-1.178) and
290 percentage of sedentary activity (HR: 1.065; 95% CI: 1.030-1.102). Statistically significant
291 protective against such a weight change are reported difficulties in feeding (HR: 0.899; 95%
292 CI: 0.839-0.962), pushing the child to eat more (HR: 0.917; 95% CI: 0.847-0.994), physical
293 activity as expressed in average accelerometer counts per minute (HR: 0.999; 95% CI: 0.998-
294 1.000), daily MVPA in minutes (HR: 0.980; 95% CI: 0.972-0.987) or time spent in a sports club
295 (HR: 0.805; 95% CI: 0.744-0.871). These results hold also after adjustment by SES, which only
296 explains a small part of the observed single effects (data not shown).

297 The SES gradient (Raw HR for SES score: 0.938; 95% CI: 0.905-0.974) was most strongly
298 attenuated (change towards the 1) by maternal BMI (Adjusted HR for SES score: 0.960; 95%
299 CI: 0.924-0.998), followed by the physical activity behaviour of the child and the child's
300 strengths and difficulties.

301

302 >>>> Include Table 3 about here

303

304 The results of the multivariate models are displayed in Table 4. In model I, which contains all
305 investigated variables, three variables are protective to weight status change from T0 to T1.
306 This concerns difficulties in feeding (HR: 0.842; 95% CI: 0.755-0.940) daily MVPA (HR: 0.976;
307 95% CI: 0.958-0.955) and time spent in a sports club (HR: 0.847; 95% CI: 0.758-0.946). A
308 higher risk for weight status change from T0 to T1 carry parental BMI, age-inappropriate
309 feeding (HR: 1.295; 95% CI: 1.172-1.430) and time spent in sedentary activities (HR: 1.125;
310 95% CI: 1.018-1.244). The hazard rate for accelerometer average count per minute, which
311 was below 1 in the bivariate model (Table 3), is at 1.006 (95% CI: 1.003-1.009) in the
312 multivariate model.

313 Similar results were obtained in model II that does not include the variables that are only
314 available in subsamples (accelerometer, 24-hour dietary recall). Here, pro-social behaviour
315 as a further protective factor was included in the model (HR: 0.900; 95% CI: 0.824-0.984).
316 The HRs for SES were closer to unity and no longer statistically significant in both
317 multivariate models (model I: HR for SES: 0.987; 95% CI: 0.930-1.048; model II: HR for SES:
318 0.997; 95% CI: 0.954-1.023).

319

320 >>>> Include Table 4 about here

321

322

323 **DISCUSSION**

324 This paper investigated the longitudinal association of familial, psychosocial and behavioural
325 factors with childhood overweight and their interplay with socio-economic status. In our

326 study, a low parental SES in non-overweight children is a risk factor for the development of
327 overweight or obesity two years later. This effect of parental SES is only moderately
328 attenuated by single familial, psychosocial or behavioural factors; however, it can be fully
329 explained by the concerted effect of such factors. Most influential factors for the
330 development of overweight or obesity were feeding / eating practices, parental BMI, the
331 child's physical activity behaviour, and time spent with audio-visual media, which was
332 surprisingly protective in our study. For the child's strengths and difficulties single effects
333 were found which were no longer significant in multivariate models. We also found that, vice
334 versa, for children who were initially overweight a lower parental SES carried a lower
335 probability to change back to a non-overweight weight status. For this case, the effect of
336 most behavioural factors was simply reversed (see supplementary table A3).

337 The findings from our study confirm the results from the literature regarding the high and
338 independent impact of parental BMI on the risk for overweight of the offspring ³⁶. Our
339 results regarding the association of parental feeding practices with overweight in children
340 differ from the result obtained in the original study by Baughcum and colleagues ²⁵. In their
341 cross-sectional study surprisingly only two of the five investigated factors were associated
342 with childhood overweight. In our study, we found a longitudinal effect of four factors on
343 the risk of a non-overweight child to develop overweight or obesity in one of the
344 multivariate models. Two of the investigated factors, pushing the child to eat more as well as
345 difficulties in child feeding, were not risk-elevating factors as hypothesized by Baughcum et
346 al ²⁵, but were protective. However, other longitudinal studies also found overeating to be
347 positively and picky eating to be negatively associated with BMI ³⁸. Moreover, it is likely that
348 the child's BMI is influencing parental feeding practice, thus confounding any cross-sectional
349 associations ³⁹. Previous studies have linked children's strengths and difficulties with

350 childhood overweight^{40, 41}. However, effects have been found to be rather small. A
351 longitudinal study showed that the effect of weight status on later Strength and Difficulties
352 Questionnaire (SDQ) score might be larger than the effect of SDQ score on weight change⁴².
353 In our study, a higher score on the SDQ subscale peer problems in non-overweight children
354 was statistically significant related to the risk of developing overweight at T1. Previous cross-
355 sectional studies have repeatedly shown associations between objectively measured
356 physical activity with weight status in children^{43, 44}. However, the rare longitudinal studies
357 show ambiguous results⁴⁵⁻⁴⁷, and association might be bidirectional⁴⁸. In our study, both
358 average counts per minute (cpm) and daily MVPA in minutes contributed to the hazard of
359 becoming overweight at T1 in children that were non-overweight at T0, and these variables
360 were also able to explain part of the SES gradient of the overweight risk, albeit the hazard
361 ratio for average cpm was a risk factor in the multivariate model. A possible explanation
362 could be non-linearity in either the MVPA-obesity association or proportion of sedentary
363 activities-obesity association, or even both. We also included questionnaire data on physical
364 activity in our models Time spent in a sports club showed a protective effect in addition to
365 the accelerometer-derived data. This variable was the one with the second highest influence
366 in the model without accelerometer data indicating that this information might be valuable
367 in studies where collection of objective physical activity data is not feasible. We found no
368 effect of time spent outdoors on weight status. The proportion of sedentary activity derived
369 from accelerometer data was a risk factor for obesity in the bivariate as well as the
370 multivariate model. This is very similar to the results of Mitchell and colleagues⁴⁹, however
371 the raw effect (Table 3) does not disappear when adjusted by physical activity and other
372 confounders (Table 4).

373 The current study has several limitations. First of all, the data of the study stems from a
374 multi-centre intervention study⁵⁰ which could have potentially influenced weight status at
375 follow-up. For the sake of statistical power, we decided to include the intervention regions in
376 our study, and we statistically controlled for a possible effect by including study centre as
377 random effect. Secondly, we cannot rule out selection bias due to nonresponse. In the
378 IDEFICS study, we observed selection with regard to weight status at baseline⁵¹. This should
379 not influence our results, since we restricted ourselves to underweight and normal weight
380 children. A further selection bias can have been introduced within this paper due to the
381 number of missing values, and measurements only performed in sub-samples. This holds
382 especially for the multivariate models presented in Table 4. Although the subsamples were
383 selected randomly, the parents could refuse any single procedure of the surveys. We found
384 only little differences in SES scores of the children included in Model 1 (mean SES score =
385 10.61) versus Model II (mean SES score = 10.70), compared to a mean SES score of 10.46 in
386 the overall sample.

387 With the exception of the accelerometer measurements all of the investigated familial,
388 psychosocial and behavioural factors including the social indicators of the study were
389 gathered by parental self-report, which might have influenced the results. Most of the
390 derived variables stem from well-known validated instruments^{25, 30, 52-54}, however the
391 reliability as measured by Cronbach's alpha for some of the sub-scales is very low. We only
392 included multi-scales that had similar Cronbach's alpha values with our data as those
393 published by the scale authors or by other previous papers. Nevertheless, especially two of
394 the feeding / eating practices (pushing the child to eat more, structure during meals) have
395 extremely low values and should be interpreted with caution. Both sub-scales did not enter
396 the multivariate models. While SES is often used as a putative confounder in validation

397 studies, the validity of self-reported social indicators themselves is largely understudied. The
398 energy intake of the child assessed by 24-hour dietary recall is only derived from a single day
399 of reporting. Although the validity of the instrument in general appears to be high ⁵⁵, the
400 restriction to a single day of reporting implies that the variable we used, energy intake, is
401 only valid on group level, but not necessarily on individual level ⁵⁶. This very well might
402 explain the lack of association between energy intake and risk of overweight in our study.

403 A particular strength of the study is the fact that the data was gathered in a standardized
404 way in all participating centres. The BMI measurement followed a strictly standardized
405 procedure and was taken with the children being in a fasting status. Children not in fasting
406 status were generally excluded from the database, and we had only 70 (1.2%) documented
407 cases where very small amounts (like e.g. a cookie) had been eaten in the last 8 hours prior to
408 the examination. Quality control procedures, like e.g. central trainings and external site
409 visits, ensured comparability of measurements across centres. Height and weight
410 measurements in the IDEFICS survey centres have an intra- and inter-observer reliability of
411 more than 99% in each of the study centres ⁵⁷. Moreover, the questionnaire data on physical
412 activity behaviour is supplemented by objective data from accelerometer measurements in a
413 subsample of children. In a separate validation study, the accelerometer measurements
414 (counts per minutes) in small children show a high correlation with energy expenditure
415 derived by doubly labelled water measurements ⁵⁸.

416 Another advantage of our study is the strict longitudinal approach. We are able to
417 disentangle cause and effect and rule out any reverse causation that might otherwise have
418 biased the results.

419 In our study, the association of SES and childhood overweight was fully explained by familial,
420 psychological and behavioural factors. This result suggests that prevention measures do not

421 inevitably have to target specific social groups. Although, it is true that obesity-prone
422 behaviour is more prevalent in low SES groups and that it takes tailored efforts in terms of
423 communication and measures to be successful in these groups^{59,60}, it has to be kept in mind
424 that there is not a one-to-one association between the here investigated factors and SES
425 group. Moreover, specific attention to one group might lead to stigmatization and thus may
426 have unwanted side-effects⁶¹. An alternative intervention approach would be targeting
427 specific behaviours, e.g. age-inappropriate feeding, in the total population working with a
428 broad choice of culturally sensitive measures through different channels.

429

430 **CONFLICT OF INTERESTS**

431 We certify that there is no conflict of interest with any financial organisation regarding the
432 material discussed in the manuscript.

433

434

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