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ORIGINAL PAPER

Determinants of obesity in the Ulm Research on Metabolism, Exercise and Lifestyle in Children (URMEL-ICE)

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Abstract We investigated the prevalence of overweight and obesity in German schoolchildren and analyzed determinants of overweight. In the context of a randomized intervention study, a baseline cross-sectional assessment was carried out in 2006. During a physical examination, height, weight, skin fold thickness, and upper arm and waist circumferences were measured according to a standardized protocol among 1.079 children aged 6–9 years. Overweight and obesity were classified according to the definitions of the International Obesity Task Force. Parents completed a questionnaire on potential determinants of overweight. Logistic regression models were calculated for determinants of overweight and obesity. The prevalence of overweight was 16.5% in boys and 17.3% in girls and of obesity 3.5% and 3.6%, respectively. Migration (29.4 %) was correlated with overweight and obesity. In particular, among boys with migration background, overweight (24.0%) and obesity (6.6%) were highly prevalent. Higher obesity prevalence was associated with maternal smoking during pregnancy, parental overweight, and low parental education. Indicators for physical inactivity such as watching television more than 1 h per weekday, participation in club sports less than once a week, consumption of sweetened drinks (≥3 times per week), and skipping breakfast before school were associated with childhood obesity. Our results provide further evidence that parental factors such as migration background and education are strongly associated with body mass of the offspring. Physically inactive children with regular consumption of sweetened drinks and no breakfast were prone to be overweight or obese. Changes of these lifestyle factors as targets of interventions are promising to prevent childhood obesity.

Keywords Overweight · Physical activity · Diet · URMEL-ICE · Children

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Introduction

During the past decades, the population prevalence of childhood obesity has increased in most industrialized countries [8] including Germany [12, 15, 24, 25]. Child-

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hood obesity is associated with psychosocial consequences and a range of health problems, which may last until adult life and cause premature mortality [8, 9, 50, 53]. Even obese children showed profiles of cardiovascular risk factors comparable to those in obese adults [32, 35]. Thus, there is an urgent need for population-based interventions aiming at prevention in childhood obesity.

The body weight and body composition during childhood may be determined by genetic and behavioral factors such as sedentary lifestyle and dietary habits [26]. Important risk factors for overweight and obesity have been identified [50]. Socioeconomic position and migration background were identified as determinants of obesity [15, 18, 42]. Besides parental overweight, not being breastfed, other lifestyle factors, socioeconomic position, and ethnic groups were associated with childhood obesity [50]. Modifiable determinants such as the consumption of foods with high-energy density like fast food and sweetened drinks or sedentary lifestyle are most promising for interventions to prevent childhood obesity [14, 27, 40, 44].

Results from former intervention studies on physical activity or dietary advices suggested only little effects of interventions [46]. However, in many studies, improvement in diet or changes in physical activity habits were recorded. Studies with appropriate design, duration, and intensive interventions may reveal favorable body mass index (BMI) changes [46]. Therefore, the intervention study Ulm Research on Metabolism, Exercise and Lifestyle in Children (URMEL-ICE) has been established. URMEL-ICE focused on intensive motivation of physical activity and reduction of energy dense drinks as an integral part of daily education over a period of one school year (manuscript in preparation).

The purpose of the present analysis was (1) to quantify the prevalence of overweight and obesity at baseline and (2) to explore determinants of overweight and obesity in 6- to 9-year-old schoolchildren.

Materials and methods

Study population

As part of the lifestyle intervention study URMEL-ICE, a baseline cross-sectional assessment was carried out in 2006. All primary schools in Ulm and adjacent regions comprising 5,044 children in 123 schools (232 second-grade classes) were invited to participate in the study. Only schools which did not participate in other health programs were included. Finally, 64 classes in 32 schools (1,427 pupils) agreed to participate prior to randomization. Parents provided signed written informed consent for their children to participate in assessments and clinical investigations, blood and DNA analysis of their children. Informed consent and completed questionnaires (parental and child-specific part) were obtained from 1,120 children (53% boys, 47% girls). All children were invited to a baseline physical examination at which 1,079 (94 %) children in the mean age of 7.6 years (SD=0.4 years) participated and were included in the present analysis.

Anthropometric measurements

During the physical examination in the outpatient clinic of the Ulm Children's Hospital, anthropometric measurements were performed in a standardized manner. Height was measured to the nearest 0.1 cm (Ulm Stadiometer, Busse Design, Ulm, Germany) and weight to the nearest 0.1 kg on a calibrated balance beam scale (Seca, Hamburg, Germany) wearing only underclothes. BMI was calculated as weight (in kilograms)/height (in square meters) and classified using international cut-off points for overweight and obesity, respectively, as recommended by the International Obesity Task Force (IOTF) [4]. The IOTF provides cut-off values based on percentiles passing through BMI 25 or 30 kg/m^2 at age 18 to define overweight and obesity, respectively. In addition, the standard deviation scores (SDS) of BMI were calculated [4, 17]. Upper arm circumference was measured midway between the olecranon and the tip of the acromion process. Waist circumference was measured to the nearest 0.1 cm at umbilicus level. Skin fold thickness measurements were performed by using a Lange skin fold caliper (Santa Cruz, CA). Subscapular skin fold thickness was measured below the tip of the scapula with the fold running at an angle of 45° downwards from the spine; triceps skin fold thickness was measured on the left ram halfway between the inferior border of the olecranon and the tip of the acromion process in a standardized manner by trained medical staff. All anthropometric measurements were done three times by trained personal. Interindividual and intra-individual variations were <5%, respectively.

Data collection

A standardized parental questionnaire was used to collect data on the current parental height and weight of which BMI (in kilograms per square meter) was calculated. Migration background was defined as child's father or mother were born abroad or as father or mother had spoken a foreign language during the child's first years of life. Educational level of the mother and the father was categorized based on the years of schooling in ≤10 and >10 years. Information on maternal smoking during pregnancy was collected (yes, no). Data on birth weight and height were extracted from the children's screening books and classified as <2,500, 2,500–3,999, and ≥4,000 g. Small for gestation was calculated using the reference data of Voigt et al. [48]. Children (N=103) born small for gestation were excluded to calculate the associations of birth weight with overweight and obesity.

The duration of exclusive breastfeeding was classified as <2, 2–4, and >5 months.

The following variables were selected to characterize the children's current lifestyle: time spent watching television (TV) on weekdays (>1 vs. ≤1 h), time spent watching TV on weekends (>1 vs. ≤1 h), playing video games on weekdays (>1 vs. ≤1 h), and playing video games on weekends (>1 vs. ≤1 h). Playing outside ≤5 times a week, club sports (<1 vs. ≥1 time per week), and nonclub sports (<1 vs. ≥1 time per week). Consumption of sweetened drinks (fizzy drinks) was classified ≥3 vs. <3 times per week and of breakfast before school (yes, no).

Statistical analysis

P values were calculated using Fisher's exact test for categorical data and Wilcoxon test for continuous data and *P* values <0.05 from two-sided tests were considered to be statistically significant. Crude logistic regression models were calculated to estimate the odds ratios (OR) and 95% confidence intervals (95%CI) for overweight and obesity [4]. Stratified analyses were performed by sex and migration background. We controlled for sex and age by using the sex- and age-specific BMI percentiles in order to define overweight and obesity. Further adjustments for potential confounders were performed. Due to the low obesity prevalence, the analyses concerning obesity were performed for the entire study sample. All analyses were carried out applying the statistical software package SAS release 9.1 (SAS Institute, Cary, NC, USA).

Results

Table 1 shows the sample characteristics by sex. Among 1,079 children with a median age of 7.6 years (range 6.2–9.2 years) about 30% had a migration background. BMI was statistically significantly higher among boys than among girls, while waist circumference and upper arm circumference did not differ between boys and girls. Skin fold thickness for subscapular and triceps measurements were on average statistically significantly higher among girls than boys.

Among boys, high birth weight (≥4,000 g) was more frequent than among girls (11.8% vs. 7.9%), more boys were born small for gestation (13.3% vs. 11.0%), and after gestation time below 37 weeks compared to girls (7.5% vs. 6.4%), but none reached statistical significance. Breastfeeding patterns differed statistically significantly between boys and girls: boys were more often breastfed than girls 2–4 months. No obvious sex difference was observed for the exposure to tobacco smoking by the mother during pregnancy. Mothers' and fathers' characteristics of mean age, BMI, and education did not differ between boys and girls, except for paternal level of education, which tended to be higher among boys. Concerning lifestyle variables statistically significant sex differences emerged: among boys, playing video games was more prevalent, while girls participated less in club activities than boys and girls omitted breakfast before school. However, no statistically significant sex differences were observed for the consumption of sweetened beverages (≥3 drink per week) and watching TV of more than 1 h per weekday.

Table 2 shows the prevalence of overweight and obesity in the URMEL-ICE study by sex according to the IOTF criteria. The prevalence of overweight was 16.5% in boys and 17.3% in girls. The values for obesity were 3.5% and 3.6%, respectively. Among migrants, overweight was more prevalent in both sexes (boys 25.7% vs. 11.6% and girls 22.3% vs. 14.7%). For obesity, differences by migration background were markedly present in boys (9.5% in migrants vs. 0.8% in nonmigrants), but not in girls (3.6% in migrants vs. 3.4% in nonmigrants)

In Table 3, the crude OR for overweight (by migration status) and obesity (in total) are presented for selected risk factors in the URMEL-ICE baseline assessment. Overall, overweight was associated with maternal smoking during pregnancy (OR=2.36, 95%CI=1.58–3.52), maternal and paternal overweight (OR=2.65, 95%CI=1.91–3.68 and OR=2.07, 95%CI=1.47–2.92, respectively), and maternal and paternal education (OR=1.57, 95%CI=1.05–2.33 and OR=1.79, 95%CI=1.22–2.64, respectively). Overall, stronger associations were observed of these variables with obesity. In particular, the relationship between maternal overweight and obesity of the children was strengthened (OR=7.26, 95%CI=3.40–15.52).

No association was found for birth weight, while breastfeeding over 2 months was inversely associated with overweight. Female sex was related to less overweight in children with migration background. Concerning overweight, the associations were more pronounced for maternal education in migrants (OR=2.76, 95%CI=1.24–6.13) than in nonmigrants (OR=1.14, 95%CI=0.68–1.89).

Table 4 shows the crude OR and 95%CI for overweight (by migration status) and obesity (in total) of selected components of the intervention in the URMEL-ICE baseline assessment. In the crude models, TV consumption more than 1 h on weekdays (OR=1.69, 95%CI=1.22–2.35), TV consumption more than 1 h on weekends (OR=2.02, 95%CI=1.27–3.22), club sports less than once per week (OR=2.22, 95%CI=1.57–3.13), nonclub sports less than once a week (OR=1.70; 95%CI=1.19–2.41), and skipping breakfast before school (OR=1.73, 95%CI=1.13–2.64) were associated with overweight. After further adjustment for migration status (data not shown), watching TV (more than 1 h on weekdays and weekends each) and lack of sports activity both club and

Table 1 Characteristics of boys and girls attending the URMEL-ICE baseline assessment

	Number	Boys	Girls	Total
Participants (*N*)	1,079	577	502	1,079
Age, years [median (range)]	1,078	7.59 (6.54–9.21)	7.56 (6.18–9.18)	7.57 (6.18–9.21)
Migration (%)	989	29.1	29.8	29.4
Anthropometric measures				
BMI, kg/m^2 [mean (SD)]	1,064	16.39 (2.25)*	16.08 (2.16)*	16.24 (2.22)
BMI SDS [mean (SD)]	1,063	0.09 (1.01)*	−0.04 (1.02)*	0.03 (1.02)
Waist circumference, cm [mean (SD)]	1,072	59.75 (6.56)	59.16 (6.63)	59.48 (6.60)
Upper arm circumference, cm [mean (SD)]	1,074	20.22 (2.54)	20.37 (2.57)	20.29 (2.55)
Skin fold thickness				
Subscapular, mm [median (range)]	1,073	6.3 (3.3–38.0)*	7.0 (3.0–32.0)*	7.0 (3.0–38.0)
Triceps, mm [median (range)]	1,073	12.0 (4.0–40.0)*	13.7 (5.7–42.0)*	13.0 (4.0–42.0)
Pregnancy and birth characteristics				
Maternal smoking during pregnancy (%)	1,065	14.4	13.3	13.9
Breastfeeding (%)	973			
<2 months		26.1*	31.5*	28.6
2–4 months		32.7*	23.5*	28.5
≥5 months		41.3*	45.0*	43.0
Birth weight (%)	882			
<2,500 g		5.2	6.0	5.6
2,500–3,999 g		83.1	86.1	84.5
≥4,000 g		11.8	7.9	10.0
Weeks of gestation <37 (%)	873	7.5	6.4	7.0
Small for gestational age (%)	873	13.3	11.0	12.3
Parental characteristics				
Current maternal age, years [mean (SD)]	1,067	37.16 (4.94)	37.26 (4.93)	37.21 (4.93)
Current paternal age, years [mean (SD)]	1,044	40.11 (5.78)	40.36 (5.95)	40.22 (5.86)
Maternal education ≥10 years (%)	1,055	27.2	27.4	27.3
Paternal education ≥10 years (%)	1,020	36.3	31.8	34.2
Maternal BMI, kg/m^2 [mean (SD)]	1,043	24.53(10.34)	24.52 (8.35)	24.53 (9.46)
Paternal BMI, kg/m^2 [mean (SD)]	998	26.03 (3.19)	25.97 (3.38)	26.00 (3.28)
Lifestyle characteristics				
Watching TV ≥1 h on weekdays	1,049	44.7	42.6	43.8
Watching TV ≥1 h on weekends	1,038	78.6	76.4	77.6
Playing video games on weekdays ≥1 h per day	1,040	6.1*	2.3*	4.3
Playing video games on weekends ≥1 h per day	1,042	22.7*	12.3*	17.9
Consumption of soft drinks ≥3 times a week	1,022	26.8	27.3	27.0
No breakfast before school	1,061	11.4*	15.7*	13.4
Playing outside ≤5 times a week	1,057	21.4	21.2	21.3
Club sports <1 time a week	1,017	25.6*	31.4*	28.3
Nonclub sports <1 time a week	964	32.9	30.7	31.9

*$P<0.05$

nonclub remained statistically significantly associated with overweight.

Overall, for obesity, a similar pattern of associations as for overweight was found. Skipping breakfast before school was also related to obesity. The consumption of sweetened drinks was associated with obesity (≥3 vs. less per week: OR=2.65, 95%CI=1.34–5.21). No associations between overweight and obesity were found for consumption of sweetened drinks at school (data not shown). Watching TV more than 1 h (on weekdays) and lack of physical activity in club remained statistically significantly associated with obesity.

Table 2 Overweight and obesity in children attending the URMEL-ICE baseline assessment

	Boys		Girls		Total	
	Number	Percent	Number	Percent	Number	Percent
Total	565		498		1,063[a]	
Overweight	93	16.5	86	17.3	179	16.8
Obesity	20	3.5	18	3.6	38	3.6
Nonmigrants	362		327		689	
Overweight	42	11.6	48	14.7	90	13.1
Obesity	3	0.8*	11	3.4*	14	2.0
Migrants	148		139		287	
Overweight	38	25.7	31	22.3	69	24.0
Obesity	14	9.5	5	3.6	19	6.6

*$P<0.05$

[a] Missing values occurred due to BMI and age

Discussion

Prevalence of overweight and obesity

In the present study, the overall prevalence of overweight was 16.8% and of obesity was 3.6% with no substantial sex difference. Our prevalence rates were higher than previous data from Germany using also the IOTF definitions for overweight and obesity among 6- to 7-year-old children [18, 29, 52] and recent results from the German Health Interview and Examination Survey for Children and Adolescents ("Kinder- und Jugendgesundheitssurvey" [KIGGS]) among children aged 7–10 years using German reference data [17, 19]. Regional differences of overweight in Germany were reported [24, 35]. The KIGGS study aimed to be representative for Germany [19] by randomly selecting local residents with stratification in 1-year age groups in 167 sample points representative for Germany [16]. Differences in the prevalence of obesity may be attributed to regional demographic profiles. Compared with other European countries, our observations for overweight and obesity ranged in the middle position [25].

Among children with migration background, the prevalence of overweight and obesity was higher than among

Table 3 Crude OR for overweight (by migration status) and obesity (in total) are presented for selected risk factors in the URMEL-ICE baseline assessment

	Overweight						Obesity	
	Total		Nonmigrants		Migrants		Total	
	Overweight, *N* (%)	OR (95%CI)	Overweight, *N* (%)	OR (95%CI)	Overweight, *N* (%)	OR (95%CI)	Obese, *N* (%)	OR (95%CI)
Sex (0=boys, 1=girls)	179 (16.8)	1.06 (0.77–1.46)	90 (13.1)	1.31 (0.84–2.04)	69 (24,0)	0.83 (0.48–1.43)	38 (3.6)	1.02 (0.53–1.95)
Migration (yes/no)	159 (16.3)	2.11 (1.49–2.99)	–	–	–	–	33 (3.4)	3.42 (1.69–6.92)
Pregnancy and birth characteristics								
Maternal smoking during pregnancy	178 (16.9)	2.36 (1.58–3.52)	90 (13.1)	2.11 (1.18–3.77)	69 (24.2)	2.19 (1.14–4.18)	38 (3.6)	5.51 (2.83–10.71)
Breastfeeding (%)								
<2 months	63 (22.9)	1.00	30 (17.1)	1.00	24 (34.8)	1.00	17 (6.2)	1.00
2–4 months	45 (16.5)	0.67 (0.44–1.02)	26 (15.0)	0.86 (0.48–1.52)	15 (19.0)	0.44 (0.21–0.93)	7 (2.6)	0.40 (0.16–0.98)
≥5 months	47 (11.4)	0.43 (0.29–0.65)	26 (8.4)	0.45 (0.25–0.78)	18 (22.0)	0.53 (0.26–1.08)	5 (1.2)	0.19 (0.07–0.51)
Birth weight (g)								
<2,500	3 (10.7)	0.64 (0.19–2.15)	2 (10.5)	0.85 (0.19–3.79)	1 (12.5)	0.43 (0.05–3.64)	–	–
2500–3,999	101 (15.9)	1.00	55 (12.1)	1.00	35 (24.8)	1.00	10 (7.1)	1.00
≥4,000	17 (19.8)	1.31 (0.74–2.32)	11 (20.4)	1.85 (0.90–3.80)	5 (18.5)	0.69 (0.24–1.95)	1 (3.7)	0.70 (0.16–3.03)
Parental characteristics								
Maternal overweight BMI ≥25 kg/m²	179 (16.8)	2.65 (1.91–3.68)	90 (13.1)	2.17 (1.38–3.42)	69 (24.0)	2.74 (1.57–4.80)	38 (3.6)	7.26 (3.40–15.52)
Paternal overweight BMI ≥25 kg/m²	179 (16.8)	2.07 (1.47–2.92)	90 (13.1)	2.09 (1.30–3.36)	69 (24.0)	2.15 (1.19–3.88)	38 (3.6)	2.42 (1.16–5.03)
Maternal education ≤10 years	172 (16.5)	1.57 (1.05–2.33)	88 (12.9)	1.14 (0.68–1.89)	66 (23.6)	2.76 (1.24–6.13)	37 (3.6)	4.39 (1.34–14.41)
Paternal education ≤10 years	162 (16.1)	1.79 (1.22–2.64)	83 (12.4)	1.61 (0.98–2.66)	64 (23.5)	1.45 (0.73–2.86)	36 (3.6)	2.22 (0.96–5.11)

Table 4 Crude OR and 95%CI for overweight (by migration status) and obesity (in total) of selected intervention factors in URMEL-ICE baseline assessment

Lifestyle characteristics	Overweight						Obesity	
	Total		Nonmigrants		Migrants		Total	
	Overweight, *N* (%)	OR (95%CI)	Overweight, *N* (%)	OR (95%CI)	Overweight, *N* (%)	OR (95%CI)	Obese, *N* (%)	OR (95%CI)
Watching TV ≥1 h on weekdays	172 (16.6)	1.69 (1.22–2.35)	88 (13.0)	1.34 (0.85–2.11)	65 (23.7)	1.98 (1.09–3.61)	36 (3.5)	2.65 (1.31–5.36)
Watching TV ≥1 h on weekends	170 (16.6)	2.02 (1.27–3.22)	87 (13.0)	1.86 (1.04–3.34)	64 (23.4)	1.67 (0.67–4.21)	35 (3.4)	1.75 (0.67–4.56)
Playing video games on weekdays ≥1 h per day	174 (17.0)	1.84 (0.93–3.63)	88 (13.1)	1.05 (0.31–3.64)	67 (24.6)	2.18 (0.85–5.59)	37 (3.6)	1.26 (0.29–5.39)
Playing video games on weekends ≥1 h per day	171 (16.7)	1.10 (0.72–1.68)	87 (13.0)	0.95 (0.47–1.93)	65 (23.4)	0.84 (0.46–1.55)	36 (3.5)	1.36 (0.61–3.04)
Consumption of soft drinks ≥3 times a week	162 (16.1)	1.04 (0.72–1.52)	85 (12.7)	0.96 (0.55–1.65)	61 (23.0)	1.03 (0.57–1.88)	35 (3.5)	2.65 (1.34–5.21)
No breakfast before school	176 (16.8)	1.73 (1.13–2.64)	89 (13.0)	2.30 (1.18–4.49)	68 (24.1)	0.65 (0.33–1.28)	37 (3.5)	2.50 (1.19–5.29)
Playing outside ≤5 times a week	173 (16.6)	0.93 (0.62–1.39)	89 (13.1)	0.81 (0.45–1.47)	65 (23.3)	1.03 (0.55–1.92)	37 (3.7)	0.71 (0.29–1.72)
Club sports <1 time a week	166 (16.5)	2.22 (1.57–3.13)	87 (13.0)	1.81 (1.06–3.08)	61 (23.9)	1.93 (1.06–3.49)	35 (3.5)	2.17 (1.10–4.28)
Nonclub sports <1 time a week	156 (16.4)	1.70 (1.19–2.41)	84 (13.1)	1.22 (0.74–2.01)	56 (23.2)	2.41 (1.31–4.44)	31 (3.3)	1.38 (0.66–2.88)

children without migration background. In particular, among boys with migration background, higher prevalence of overweight and obesity was observed: for overweight more than twice as high and for obesity ninefold as high as in their counterparts. These observations are in line with other reports among children (5–6 years) in Germany [15, 18, 42]. In the KIGGS study, differences by migration background were remarkably strong among 7- to 10-year-old children [19].

In our data, the proportion of persons with migration background (29.4%) was comparable with other authors [42], but also lower [18, 24] and higher [16] proportions were reported. Differences can be explained by the definition of migration status and the degree of urbanization of the study population. However, for the interpretation of the results, it should be kept in mind that sociodemographic position and migration are time-dependent variables. Cultural attitudes and values are strongly related to behavioral factors, such as physical activity and diet. High prevalence of overweight and obesity was found in children from southern Europe or Turkey [18]. Shorter height in these populations may result in some overestimation of the prevalent obesity among migrants. However, we used the definitions according to the IOTF to achieve a high level of comparability [4].

Mean waist circumference as an indicator for central fatness was, for both sexes, higher than from other reports among children aged 7–8 years from the UK [28], The Netherlands [10], Turkey [11], Australia [7], and Germany (6 years) [6]. Differences can be related to secular changes or ethnic determinants [7, 11].

Our observation of higher measurements for both triceps and subscapular skin fold thickness in girls than in boys is in line with other publications [38, 45]. Mean values in our survey were higher than among children aged 6–8 years in the KIGGS study, which included study centers all across Germany [45]. Regional differences in the prevalence of obesity were reported, which may also apply for body fat composition [24, 35].

Early determinants of overweight and obesity

Consistent with the literature, parental obesity and maternal education status as marker for socioeconomic position were strong determinants of childhood obesity in our study [18, 20, 42]. Associations between socioeconomic position and obesity were also reported from other countries [2, 34, 51]. In children from the low social class, the association between parental overweight and childhood obesity was even more pronounced [22].

In line with previous reports, among children with migration background, the association between maternal education and overweight was markedly stronger [18, 29, 52]. Low maternal education may hamper the adequate knowledge of risk factors of overweight either by language

or foster the adherence to traditional values. Ethnic differences with respect to dietary habits were reported by authors from The Netherlands [2]. Different cultural and social integration may also be linked to leisure time activities [13].

We found no association between birth weight and overweight. However, data on this relationship are conflicting [5, 42]. Research indicates that, rather than birth weight, the growth in the first to second year of life ("catch-up growth") may be predictive for obesity [36]. Consistent with the existing literature, we found an inverse association of breastfeeding with overweight and obesity [37]. However, the protective association of breastfeeding with BMI is thought to be small because of other confounding factors and no substantial association with fat mass [37, 47]. Our observation that maternal smoking during pregnancy is associated with overweight is in line with former publications [23, 39, 42, 49]. Various mechanisms might explain this association such as "programming" by intrauterine nicotine exposure or with other smoking-associated adverse lifestyles of the mother [23].

Among migrants, female sex was associated with less overweight, suggesting that sex matters in the cultural and behavioral pathways. Recent findings indicate that social and biological networks contribute to obesity [3]. Interventions considering these social networks and social gradients may be more successful in practice [3, 30]. In this context, maternal education seems to be an important factor in the prevention of overweight among children with migration background. Further research is needed to understand the trajectories between migration status, SEP, gender, and adiposity.

Lifestyle determinants of overweight and obesity

Time spent watching TV (both weekdays and weekends) as indicator for physical inactivity and sedentary lifestyle was associated with overweight and obesity in our study. This finding was also reported by other authors [1, 18, 42, 43]. Prevalence of daily time spent watching TV was within the range of other reports from Germany [18, 21]. Interestingly, in our study, the strength of association between TV consumption and overweight was related to migration status. In line with others [42], playing video games, which was more prevalent in boys, was, in trend, associated with overweight. Our observation that the lack of physical activity in terms of participation in club sports or nonclub sports was associated with overweight and obesity is consistent with former research [18, 26, 46, 50].

For the consumption of sweetened drinks, we found an association with childhood obesity. This observation is consistent with the results of other studies [18, 33]. Consistent with other publications [41], we found an association of skipping breakfast before school with childhood overweight and obesity. Further adjustment for potential determinants of elevated BMI (migration status, maternal overweight, smoking, maternal education, and breastfeeding) attenuated the relationships between selected lifestyle factors and overweight (data not shown).

Limitations and strengths of the study

Some limitations of our study should be considered when interpreting the results. Concerning dietary and lifestyle factors in overweight individuals, underreporting may have introduced bias and should be considered in the relationships between weight status and lifestyle habits. The cross-sectional study design precludes causal interpretation of our observations. For example, the relationship between obesity and physical activity is bidirectional. Due to low obesity prevalence, no stratified analyses were performed.

BMI is an accepted measure to define obesity in population research, but for the interpretation of the results, it should be acknowledged that BMI does not reflect body fat distribution [31]. Among the strengths of our study are that the anthropometric measurements were performed according to a standardized protocol in one clinic and the population-based approach.

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