jcrpe-2018-0157.R2

Original article

Risk factors for childhood overweight and obesity in Ukraine and Germany

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Keywords: obesity, risk factors, childhood, adolescent, overweight

Running title: Childhood obesity in Ukraine and Germany

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What is already known on this topic?
Obesity in children and adolescents has become an increasing and widely-distributed health problem, especially in industrialized countries. Risk factors include both genetic predisposition and socioeconomic factors.

What this study adds?
Only few studies have compared the distribution of socioeconomic risk factors for childhood obesity across different countries. The current study is the first one to analyze the distribution of risk factors for obesity in Ukraine and Germany.

Abstract
Background: Overweight and obesity in childhood and adolescence are rapidly increasing and influenced by genetic, familial, environmental, socioeconomic and cultural factors.
Objective: The aim of the study was to compare risk factors for childhood obesity in Ukraine (UA) and Germany (DE) using comparable investigative tools.
Methods: Two groups of children aged 8 to 18 years in DE (93 children) and UA (95 children) were divided into children with overweight and with obesity. Anthropometric data and detailed medical history were collected.
Results: Risk factors in pregnancy (prematurity, weight gain >20 kg, early contractions) were equally frequent in both groups. Positive correlations of BMI-SDS between children and mothers were seen. The proportion of family members with diabetes mellitus was lower in the UA group. The DE children had obesity more often at the age of 1 year. The DE group became overweight earlier and remained overweight over a longer period of time compared to UA. The mean BMI-SDS of children with obesity was found to be lower in the UA group. In both groups waist circumference to height ratio (WHtR) was >0.5, indicating presence of a cardiometabolic risk factor. About half of the patients in both groups had blood pressure values exceeding the 95th percentile.
Conclusion: Similar risk factors for obesity were observed among two groups of children in UA and DE. Differences were observed regarding the prevalence of specific risk factors for childhood obesity. To our opinion, the population-specific distribution of risk factors has to be considered in order to optimize prevention and treatment strategies.

Introduction

Obesity in children and adolescents has become an increasing and widely-spread health problem, especially in industrialized countries. According to WHO more than 41 million children under the age of 5 suffered from overweight or obesity in 2016 (1). In Germany, according to large national studies (KIGGS and Crescnet), 15-17% of children aged 3 to 17 years were overweight and 6.2-7.6% were obese (2). In Ukraine, the incidence of childhood obesity originally was much lower but showed a significant rise over the last decade increasing from 0.083% among children 0-18 years in 2003, to 1.23% in 2009 and 1.34 in 2016 (3,4).

Numerous risk factors for childhood obesity have been discussed in the literature. Parental overweight is considered to be a particularly important indicator for overweight and obesity among their children (5). Further risk factors refer to the maternal history of pregnancy and the perinatal period. Thus, excessive maternal weight gain during pregnancy and maternal smoking during pregnancy contribute to the development of obesity and its incidence (6). Furthermore, high birth weight constitutes a significant risk factor for the development of childhood obesity (7). Moreover, children with rapid weight gain during the first 4 to 6 months of life have been shown to have an increased risk of developing obesity at the age of 7 years. Breastfeeding over a period of at least 6 months reduces the risk of obesity by 40% (8). Children who have developed overweight by the age of 6 years often remain overweight at the age of 14 years (9).

Since obviously both genetic and socioeconomic factors have an influence on the development of childhood obesity, we investigated similarities and differences regarding these risk factors in two cohorts from two different European countries (Ukraine and Germany).

Methods

The study was conducted at two university children hospital outpatient centers, in Simferopol, Ukraine (2010-2011), and in Heidelberg, Germany (2012-2013). In both centers WHO standards have been used for definition of overweight and obesity Inclusion and exclusion criteria were identical. Comparable questionnaires for risk factors and for both patient and family medical history have been used in both centers.

The study group in Ukraine (UA) consisted of 95 (35 girls and 60 boys) otherwise healthy children aged 10 to 18 years (mean: 13.5 years ± 0.4), divided into an overweight (36 children) and an obesity (59 children) group. The study group in Germany (DE) consisted of 93 (46 girl, 47 boys) otherwise healthy children aged 8 to 18 years (mean: 12.5 years ± 2.9) divided into an overweight (24 children) and an obesity (69 children) group.

The groups were comparable according to sex, Tanner stages and age and did not differ statistically significant. Physical examination in outpatient departments included measurement of height, weight (in underwear), waist and hip circumference, blood pressure, and examination of the skin for acanthosis nigricans. BMI-SDS, waist/hip circumference ratio (WHR), and waist circumference/height ratio (WHtR) were calculated. Standardized anamnesis included pregnancy history (maternal obesity, weight gain of more than 20 kg, arterial hypertension, patients' prematurity, patients' birth after 42nd gestational week, patients' perinatal asphyxia), duration of breastfeeding and family history (overweight or obesity, diabetes mellitus, arterial hypertension in first grade relatives). All risk factors were recorded with regard to their presence or absence. Furthermore, children's history of weight gain was evaluated (reported by parents and according to medical reports).

The study was approved by the Ethics Committee of the medical faculty of the University of Heidelberg (approval number: S-337/2013, approval date: 22/07/2013). Written consent was taken from the parents at the beginning of the study in accordance with the Declaration of Helsinki.

Statistical Analysis

Statistical analysis was performed using SPSS 20.0.0 for Windows (SPSS Inc., Chicago, IL). As part of the descriptive analysis , sample size (s), arithmetic mean (MW), median (M), maximum (Max) and minimum (10), and standard deviation (8) were determined. To test the variables for normality of the distribution, the Kolmogorov-Smirnov test with an error probability of 0.05 was used. The t-test and the Mann-Whitney test (U-test) were used to test for significant differences between groups. Gender differences in categorical variables were tested with the Chi-square test. A statistical parameter of $p < 0.05$ was considered significant.

Results

The risk factors during pregnancy occurred with an approximately equal frequency among the DE and UA groups (Table 1). Premature birth was reported in 8%-12% of all children . In the DE group 21% of mothers of overweight children and 33% of mothers of children with obesity gained more than 20kg during pregnancy. In the UA group the incidence of excessive weight gain during pregnancy among mothers of obese children was 25%. Early contractions were reported by 13%-17% (DE) and 20-28% (UA) of mothers, respectively (Table 1).

The prevalence of obesity was significantly higher in first-degree relatives of children with obesity compared to relatives of children with overweight ($p < 0.05$). A highly positive correlation was found between children's and mothers' BMI-SDS (1.03±1.26 for overweight and 1.96±1.20 for obesity) in the DE group ($r=0.46$, $p<0.0001$). The proportion of family members affected by diabetes mellitus was significantly lower in the UA group (Table 1). We suspect that in the UA group there may be a greater deficit in the diagnosis of DM and arterial hypertension in adults, and the actual frequency is most likely significantly higher. This is indirectly confirmed by the increased incidence of obesity in families in UA group.

The birth weight (3295±474 g in UA group, 3352±517 g in DE group) and birth length (50.6±2.4 cm in UA group, 51.1±2.1 in DE group) as well as their relation to BMI-SDS did not differ among the two groups. In both groups, children affected by obesity were more often obese at the age of 1 year (33.3% in UA group, 27.3% in DE group) compared to overweight children (14.3% in UA group, 17.4% in DE group). On average, the children in the UA group were breastfed

for a longer period of time (6.8±6.7 months for obesity, 7.1±7.2 months for overweight) compared to the children from the DE group (4.6±6.2 months in obesity, 6.1±7.3 months in overweight). The DE group became overweight significantly earlier and therefore remained overweight over a significantly longer period. The mean duration of obesity in the DE group was 7.6±4.3 years (min 1.2, max 18.0), the mean duration of overweight 7.2±5.0 years (min 1.1, max 18.0) compared to 5.7±3.5 years (min 1.0, max 13.7) and 4.71±3.5 years (min 0.8, max 14.0), respectively in the UA group. In both groups, the duration of the overweight period significantly influenced the BMI-SDS. The mean BMI-SDS of children with obesity was lower in the UA group than in the DE group (BMI-SDS (UA) 2.31±0.49 vs BMI-SDS (DE) 2.52±0.55 ($p < 0.05$). There were no significant differences in overweight children. In both groups, the BMI-SDS was significantly influenced by the Tanner stage ($p < 0.05$) (Table 2).

There were significant differences between the DE and UA groups regarding waist/hip circumference ratio and waist circumference/height ratio ($p < 0.05$) (Table 3). The children in the UA group showed no significant differences in the waist/hip circumference ratio according to sex or age compared to the DE group. In DE group the waist circumference/height ratio was significantly influenced by gender ($p < 0.05$). In both groups children showed central trunk obesity (predominantly the girls in the UA group). In children with obesity the waist circumference/height ratio exceeded 0.5. In the DE group 54% of patients with obesity had blood pressure values above the 95th percentile compared to 22% in the UA group (Table 3). Acanthosis nigricans was observed twice as often among patients in the DE group. In both groups, acanthosis nigricans was observed significantly more often in patients with obesity compared to overweight patients (Table 3).

Discussion

The more risk factors identified in mothers during pregnancy, the greater was the likelihood that the child's BMI-SDS would be increased. Mothers with a normal BMI usually gain 11 to 16 kg during pregnancy (11). In the present study we found in both countries that an excessive weight gain of mothers during pregnancy was associated with the risk for childhood obesity (12,13).

The prevalence of birth before 37 or after 42 gestational weeks in the DE study group was within the expected range (14), compared with some higher prevalence in the UA group. Gestational hypertension occurs in 5-10% of all pregnancies (15). The same prevalence was observed in the mothers of overweight children in our study. By contrast, the mothers of children with obesity twice as often developed gestational hypertension (17%), however, only in the DE group. There are no exact data on the prevalence of early contractions with estimates ranging from 5% up to 35% of pregnancies(16). If early contractions are considered as a potential threat of premature birth, the increased incidence can be considered as a relevant risk factor for childhood overweight and obesity. Perinatal asphyxia may be equally considered a risk factor. In our patients, the prevalence of perinatal asphyxia both in the UA group and in the DE group exceeded the one observed in the average population of 0.5-1% (5-10:1000 births) (17).

Several studies have shown that the BMI-SDS of the parents plays an important role influencing the BMI-SDS of a child (18). In the current study, maternal BMI-SDS was significantly higher in children with obesity compared to mothers of children with overweight. A highly significant positive correlation was found between the BMI-SDS of the children and the BMI-SDS of their parents. There was a significant positive correlation between the number of familial risk factors (diabetes mellitus and arterial hypertension) and children's BMI-SDS.

The prevalence of arterial hypertension ranges from 32.3% in developed to 40,8% in developing countries(19). The present study indicates that parents and/or grandparents of children with obesity are having a higher prevalence of arterial hypertension and furthermore are having a significantly higher prevalence of diabetes mellitus. According to the atlas of the International Diabetes Federation from 2015 the prevalence of diabetes in Germany was 10.6%, with a proportion of unknown diabetes of 38.2%. In Ukraine during the same year, the respective numbers were 8% and 43.2% (20).

Currently there are no studies showing the prevalence of obesity in one-year-old children. In the US, the prevalence among children aged 0-2 years was reported as high as 8.1% (21). In our study, the prevalence of overweight at the age of 1 year was much higher with 17-27% in the DE group and with 14-44% for children in UA. The results support the potential importance of BMI in children under 2 years of age to identify an increased risk of later obesity (22). Furthermore, breastfeeding plays an important role in the prevention of obesity. Studies have shown that formula-fed infants have a higher chance to become obese life in life compared to breastfed infants (23).

So far only a small number of studies have investigated the onset of obesity. Most of them identified preschool age of 5-7 years as a risk period (24). In our study, children and parents reported significant weight gain starting from the age of 5-6 years in the DE group and 7-10 years in the UA group. This information might be important to identify the right timing for intervention, investigation and prevention. The longer a child is overweight, the higher is an expected BMI-SDS. Therefore, initiating intervention and therapy as early as possible is important. The children of the UA group had lower BMI-SDS compared to the DE group. To our knowledge this is the first study comparing these two countries.

The data on which parameter is the better one to describe the abdominal fat distribution in children is controversial: while American sources showed that BMI and WHtR did not differ potential to identify children with cardiovascular risk factors, other studies found that waist circumference and WHtR were better predictors of cardiovascular risks compared to BMI (25). Recent research has shown that WHR may not be an informative parameter for cardiometabolic risk. On the other hand, WHtR is associated with cardiometabolic risk compared to BMI-SDS in both adults and children. In both groups children showed trunk obesity. In German children aged 12-18 years WHR was reported as 0.83±0.05 in boys and as 0.78±0.06 in girls (26).

According to studies the normal value for WHtR is below 0.5 (27). In our study, the WHtR was greater 0.5 in children with obesity from the UA group and in children with overweight and with obesity from the DE group which may indirectly interpreted as a cardiometabolic risk factor.

The prevalence of high blood pressure in obesity varies: from 21% -35%, up to 46% in children and 40% in adults (28). According to other studies the prevalence of hypertension in children with overweight increased from 6.6% in boys aged 2-5 years to 13.3% in adolescents 16-19 years; and in girls 4.4% and 16.3% respectively (29). In our study, we found a prevalence of 44.1% in the UA group of patients with obesity; in the DE group the prevalence of hypertension was even higher at 56.1%.

Acanthosis nigricans is associated with diabetes mellitus type 2 and insulin resistance and correlates most strongly with obesity, although it has been described to equally appear in 17% of healthy children (30). Acanthosis nigricans was observed twice as often in the DE patients compared to the UA group with a moderate higher prevalence compared to healthy children. In both groups, acanthosis nigricans was significantly more common in patients with obesity than in patients with overweight.

Study Limitations

The main limitation of our study is that we relied on self-reports of the parents for pregnancy history, and history of weight gain of their children.

Conclusions

The anamnestic risk factors for overweight and obesity in children were very similar in the DE and UA, except for the number of familial risk factors which did not correlate with the BMI-SDS in the UA group. We assume that in the UA group there is a greater deficit in the diagnosis of diabetes mellitus and arterial hypertension in adults and that a substantial fraction of adult cases of diabetes and arterial hypertension remain non-diagnosed in the UA. The actual prevalence of these conditions is likely to be significantly higher. Relevant risk factors for the development of obesity include family and pregnancy history, as well as the neonatal and infant medical history. Further important risk factors include anthropometric parameters. However, not only weight and height alone, but also BMI-SDS, waist circumference/height ratio, blood pressure, and the presence of acanthosis nigricans were found to be relevant in order to identify an elevated risk of child obesity and overweight. The children from the DE group became overweight significantly earlier compared to the UA Group. The DE patients with obesity also had higher BMI SDS.

Conflicts of interest statement: All authors declare that they have no conflict of interest concerning the present study.

Acknowledgements

J Grulich-Henn, M Bettendorf, N Zelinska and V Yakovenko elaborated the study design, were involved in recruiting patients. GF Hoffmann, M Bettendorf and N Zelinska supervised the project and worked on the analysis and manuscript. V Yakovenko collected data in UA and in DE. L Henn was involved in building the data base and performing statistical analyses. G Soloviova helped with literature search and data collection in Ukraine. V Yakovenko and J Grulich-Henn primarily prepared the manuscript. All authors had final approval of the submitted and published version.

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Table 1: Prenatal and familial risk factors

Risk factors	**DE (N_{total} = 93)**		**UA (N_{total} = 95)**	
	N	%	N	%
Overweight				
During pregnancy				
Maternal obesity	5	21%	1	3%
Arterial hypertension	2	8%	1	3%
Early contractions	4	17%	10	28%
Gestational age <37 weeks	2	8%	4	11%
Perinatal Asphyxia	2	8%	1	3%
Family history				
Diabetes mellitus	14	58%	6	17%
Arterial Hypertension	12	50%	14	39%
Obesity	14	58%	14	39%
Obesity				
During pregnancy				
Maternal obesity	22	33%	15	25%
Arterial hypertension	11	17%	4	7%
Early contractions	9	13%	12	20%
Gestational age <37 weeks	7	10%	7	12%
Perinatal Asphyxia	5	8%	2	3%
Family history				
Diabetes mellitus	47	68%	17	29%
Arterial Hypertension	47	68%	28	47%
Obesity	55	80%	37	63%

Table 2: Anthropometric Data

		DE-Group		**UA-Group**	
		Mean	SD	Mean	SD
BMI-SDS	**Overweight**	1.44	0.20	1.42	0.19
	Obesity	2.52*	0.55	2.35*	0.49
Tanner 1-2	**Overweight**	1.41	0.21	1.52	0.11
	Obesity	2.32**	0.27	2.51**	0.49
Tanner 3-5	**Overweight**	1.47	0.19	1.35	0.19
	Obesity	2.62**	0.63	2.19**	0.45

* p<0.05 between DE and UA
** p<0.05 between Tanner stages

Table 3: Risk factors for metabolic syndrome

Prevalence		**DE-Group**		**UA-Group**	
		Mean	SD	Mean	SD
Waist/hip circumference ratio	Overweight	1.09*	±0.13	0.86*	±0.09
	Obesity	1.11*	±0.10	0.84*	±0.08
Waist circumference/height ratio	Overweight	0.51	±0.04	0.48	±0.03
	Obesity	0.58	±0.07	0.55	±0.05
	Overweight	N	%	N	%
Blood pressure > 95th Perc.	Obesity	37	54%	26	22%
	Overweight	8	33%	12	33%
Acanthosis nigricans	Obesity	36	52%	13	22%
	Overweight	2	8%	5	14%

* p<0.05 between DE and UA