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Original Paper

EVALUATION OF PRENATAL AND POSTNATAL RISK FACTORS OF OBESITY IN OBESE AND NORMAL WEIGHT CHILDREN AND ADOLESCENTS

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*Obesity is considered a global epidemic worldwide. During the COVID lockdown, many daily habits changed not only for adults, but also for children. These changes are likely to further increase the prevalence and severity of obesity, which could lead to early health problems and chronic diseases. Therefore, it is important to identify preventable and non-preventable risk factors of obesity, which would be useful in planning long-term obesity prevention programmes in the country. The aim of the study was to investigate the prenatal and postnatal obesity risk factors in obese and normal weight children and adolescents. The prospective study from 2013 to 2018 included 198 children and adolescents — 181 children with obesity and 17 children with normal body weight who attended a paediatric endocrinologist. No statistically significant differences in prenatal risk factors of obesity were found between normal weight and obese children in the study: birth weight (*p *= 0.530), excessive weight gain during pregnancy in mothers (*p *= 0.787), type 2 diabetes mellitus in the family (*p *> 0.999). No statistically significant difference was found for the postnatal risk factor of obesity — duration of exclusive breastfeeding (*p *= 0.120), a statistically significant difference was only observed in parental obesity prevalence between children with normal weight and obesity (p = 0.004). Therefore, it is important to involve all family members to change children's daily habits.*

Keywords: *overweight, type 2 diabetes, diabetes mellitus, breastfeeding.*

INTRODUCTION

Public health research over the last two decades has shown a rapid increase in the prevalence of obesity, not only among adults, but especially among adolescents, and a less increase among young children (WHO, 2017b; 2017c; 2017d). According to the World Health Organisation's (WHO) European Childhood Obesity Surveillance Initiative (COSI) project, the prevalence of overweight and obesity among children aged 6–9 is very high in the European region. Interstate analysis shows that Cyprus, Spain, Greece, and Italy have the highest prevalence of overweight and obesity. According to the COSI project, the lowest prevalence of overweight and obesity is in Tajikistan and Turkmenistan and obesity prevalence are declining in Greece, Italy, Portugal, and Slovenia, with insignificant reductions in Ireland and Spain. Belgium, Czech Republic, and Norway have a constant prevalence of overweight and obesity. However, less informative data are available from Bulgaria, Latvia, and Lithuania. It is possible that there is a growing prevalence of overweight in these countries, especially among Latvian girls and among Bulgarian and Lithuanian boys (WHO 2017a; 2018; Fijałkowska *et al*., 2020). Children are at increased risk of overfeeding due to calorie-rich foods with high levels of fat, sugar, and salt, while nutrition is poor in terms of nutritional value. Children who are obese in pre-school and school age are also at risk of being obese in adulthood (Zhao *et al*., 2011; Sahoo *et al*., 2015).

The COVID-19 pandemic had a negative impact on the whole world and changed many daily habits not only for adults, but also for children. Since March 2020, there have been major changes in children's daily lives, with numerous limitations — studying at school was replaced by on-line learning, reducing time of direct contact with peers, increasing screen time and reducing physical activity time accordingly. The literature shows that during the pandemic, children had a marked increase in body mass index (BMI) compared to pre-pandemic rates (Cushieri *et al*., 2020). BMI was significantly influenced by a sedentary lifestyle, as children spent more time at screens, slept longer, and had limited opportunities to engage in physical activities (Stavridou *et al*., 2021). The pandemic is likely to further increase the prevalence of obesity among children and adolescents, affecting childhood obesity stage, leading to early health problems and chronic diseases. Therefore, early weight management, especially in children, would be important to prevent serious health risks that impair the quality of life and life expectancy (Rundle *et al*., 2020). For this reason, it is important to know the preventable and non-preventable risk factors of obesity in children. This is especially useful when launching long-term obesity prevention programmes in a country, as well as for weight management programme methodology. Integral parts of obesity prevention are not only the promotion of physical activities and healthy eating, including the consumption of fruits and vegetables as important components of weight loss among children and adolescents, but also parental education (Evans *et al*., 2012; Yan *et al*., 2014; Zolotarjeva *et al*., 2018). However, in order to prevent obesity in children, it is important not only to educate parents, but also to educate and involve primary health care professionals (O'Donnell *et al*., 2017). Studies have found that only 25.7% of physicians have reported overweight or excess weight gain in children for parents (Holt *et al*., 2011).

The aim of the study was to investigate the prenatal and postnatal risk factors of obesity in obese and normal weight children and adolescents. The study was performed in the outpatient department of the Children's Clinical University Hospital (CCUH).

MATERIALS AND METHODS

The study, from 2013 to 2018, prospectively included 198 children and adolescents who attended a paediatric endocrinologist and/or had been admitted to a day hospital in CCUH. Anthropometric data of the participants were obtained — weight, height, waist circumference; blood pressure was measured; stretch marks and acanthosis nigricans were evaluated; BMI was calculated and evaluated in BMI percentile charts for children according to age and sex; and a survey of parents or legal representative on prenatal and postnatal risk factors for obesity was conducted.

Anthropometric and blood pressure data from study participants. Weight was determined by weighing the children in lightweight clothing and without shoes (Rice Lake weighing systems) to the accuracy of 0.1 kg. Length was measured to the accuracy of 0.1 cm using a stadiometer (Dr. Keller I). Waist circumference (WC) was measured to the accuracy of 0.1 cm with an elastic tape placed midway between the pelvic bone and the rib cage. During the measurement, the abdomen had to be relaxed and the child had to exhale. Blood pressure in each patient was measured under standard conditions using a calibrated automatic device with the appropriate cuff size.

Calculation and evaluation of BMI for study participants.

BMI for the study participants was calculated according to the formula: body weight (kg) / height (m^2). BMI was then assessed using age and sex BMI percentile (pc) charts approved by the Centre for Disease Prevention and Control:

- underweight if BMI < 5 pc;
- normal weight if BMI ≥ 5 pc and < 85 pc;
- overweight if BMI ≥ 85 pc and < 95 pc;
- obesity if BMI ≥ 95 pc.

Among the children and adolescents enrolled in the study, 181 children had a BMI greater than 95 pc for age and gender, which meets the definition of obesity, and 17 children had a BMI between ≥ 5 pc and < 85 pc, which met the definition of normal weight. None of the children in the study met the criteria for being overweight or underweight.

Taking into account the child's BMI index and age, three study groups were established:

1) children ten years of age and older with obesity – group I (n = 143);
2) children under ten years of age with obesity – group II (n = 38);
3) children with normal weight – control group (n = 17).

This age distribution was chosen according to the definition of metabolic syndrome (MS) by the International Diabetes Federation.

Parent's survey on prenatal and postnatal risk factors of obesity. Parents or legal representatives of children were interviewed about prenatal (birth weight of the child; weight gain during pregnancy in the mother; family history of type 2 diabetes mellitus) and postnatal (duration of exclusive breastfeeding; parental obesity) obesity risk factors. They were asked about:

1) birth weight of the child – they were asked to indicate the weight in grams. Birth weight of 4 kg or more (≥ 4 kg) was considered a risk factor (Kleiser *et al*., 2009);
2) duration of exclusive breastfeeding — they were asked to indicate the duration in months. Duration of exclusive breastfeeding less than 6 months (< 6 months) was con-

sidered a risk factor (Evans *et al*., 2012; Yan *et al*., 2014; Qiao *et al*., 2020);

3) weight gain during pregnancy for the mother — they were asked to indicate the weight gain during pregnancy in kilogrammes. Weight gain during pregnancy of 20 kg or more (≥ 20 kg) was considered a risk factor (Kleiser *et al*., 2009);

4) family history of type 2 diabetes mellitus (T2D) – 1st and/or 2nd degree relatives (Annis *et al*., 2005);

5) parental obesity — no obesity (= normal weight) for both parents or obesity for both parents (mother only, father only) (Reilly *et al*., 2005; Martínez-Villanueva *et al*., 2019).

Statistical analysis. All obtained data were compiled in an Excel database and analysed using RStudio V.1.4.1103. For continuous data, the mean values, the median as the central trend indicator, the interquartile range (IQR), and the difference between the 25th quartile and the 75th quartile as the data set scatter interval were determined. Differences between the two groups were assessed with the Mann–Whitney, Wilcoxon, or T test, and between three and more groups — with the Kruskal–Walli's test. Differences were considered statistically significant if the significance level was $p < 0.05$.

RESULTS

The sex distribution did not differ significantly in the study groups — 49.7% (n = 71) in group I, 50% in group II (n = 19), and 47.1% (n = 8) in the control group were girls. The median age for children in group I and control group was 13.1 years (IQR 11.8; 15.1) and 12.7 years (IQR 11.5; 14.2), respectively. The median age of group II children was 8.1 years (IQR 7.1; 9.1). 1, 9,1). The characteristics of the population of children included in the study are presented in Table 1. The highest BMI in group I was 56.8 kg/m^2, and 21.7% (n = 31) of children exceeded the BMI threshold ≥ 35 kg/m^2, which corresponds to severe obesity. The median BMI of the control group was 1.5 times lower than the median BMI of the children in group I ($p < 0.001$). The median waist circumference in children in the control group was also 1.3 times lower than the median waist circumference in group I children ($p < 0.001$). The median WC and BMI ($p < 0.001$) were significantly higher in group II children compared to control group children. In group II, the highest calculated BMI value reached 43.3 kg/m^2, and 7.9% (n = 3) of children already exceeded the limit of ≥ 35 kg/m^2 at this age, which is considered to be a very severe degree of obesity. The highest blood pressure during the study was observed in group I compared to children in group II and the control group ($p < 0.001$). Children in study group II had statistically significantly lower systolic blood pressure ($p = 0.027$) compared to controls, but no differences in diastolic blood pressure were observed between these groups ($p = 0.761$). No statistically significant differences in prenatal risk factors for obesity were found between the children in the study. The lowest median birth weight was observed in children in the control group — 3.5 kg (IQR 3.0; 4.0), but no statistically significant differences in birth weight were observed between children in the study group ($p = 0.530$). The largest number of children with birth weight ≥ 4 kg were born in study group II – 39.3% (n = 11); in study group I – 29.1% (n = 30) and in the control group 37.5% (n = 3). There was a high proportion of women with excessive weight gain during pregnancy in all study groups ($p = 0.787$). The prevalence of type 2 diabetes in the family also did not differ between the study groups ($p > 0.999$) (Table 2). In the analysis of postnatal risk factors of obesity, the lowest median duration of exclusive breastfeeding was found in study group I, only 4.0 months (IQR 2.0; 8.0); group II — 8.0 months (IQR 3.0; 18.0) and in the control group — 14.0 months (IQR 7.5; 22.0), but no statistically significant differences in lactation duration were found between study groups ($p = 0.120$). Exclusive breastfeeding for ≥ 6 months was received by 40.3% (n = 31) of children in group I, 64.7% (n = 11) of group II, and 66.7% (n = 2) in the control group. Only the postnatal risk factor of obesity – parental obesity – had a statistically significant difference between study groups. Summarising the parents' survey data on weight only between obese or non-obese parents, differences in parental weight existed for all study groups ($p = 0.004$) (Table 3). Parents of both study group I and II children had high rates of obesity ($p = 0.308$). In group I children, obesity of both parents was present in 40.3% of cases, while in the control group only in 11.1% of cases ($p = 0.003$). Maternal obesity was more common in group I children — 24.2% of cases, while paternal obesity was more common in group II children — 29.6%. Only maternal obesity was not detected in the control group chil-

Table 1. Anthropometric parameters and blood pressure of the participants in the study (median with interquartile interval)

Parameter	Group I (n = 143)	Group II (n = 38)	Control group (n = 17)
Height, m	1.7 (1.6; 1.7)	1.4 (1.3; 1.5)	1.7 (1.7; 1.8)
Weight, kg	86.0 (71.0; 100.5)	50.0 (43.0; 58.5)	59.0 (50.0; 65.0)
WC, cm	101.0 (96.0; 110.0)	90.0 (84.2; 94.0)	77.0 (74.8; 82.5)
BMI, kg/m2	30.8 (28.0; 33.9)	25.9 (21.9; 28.2)	19.3 (17.3; 21.0)
SBP, mmHg	123.0 (116.0; 132.0)	105.0 (98.0; 111.8)	115.0 (110.0; 120.0)
DBP, mmHg	78.0 (71.5; 83.0)	65.0 (60.0; 74.0)	70.0 (65.0; 76.0)

n, number of children; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 2. Assessment of prenatal risk factors for obesity in children included in the study

Obesity risk factor	Group I	Group II	Control group
Birth weight, kg	3.6 (3.2; 4.1) * (n = 103)	3.8 (3.5; 4.1) (n = 28)	3.5 (3.0; 4.0) (n = 8)
Weight gain during pregnancy ≥ 20 kg	48.2% (n = 83)	43.5% (n = 23)	33.3% (n = 6)
T2D in family	17.0% (n = 112)	14.8% (n = 27)	11.1% (n = 9)

* Median birth weight with interquartile interval; n – the total number of cases analysed; T2D – Type 2 diabetes mellitus

Table 3. Parental obesity in children included in the study

Study groups	Obesity for parents, %	Normal weight for parents, %
Group I (n = 124)	79.8 %	20.2 %
Group II (n = 27)	63.0 %	37.0 %
Control group (n = 9)	33.3 %	66.7 %

n, the total number of cases analysed.

Table 4. Maternal obesity in children included in the study

Study groups	Obese mothers, %	Normal weight mothers, %
Group I (n = 124)	64.5 %	35.5 %
Group II (n = 27)	33.3 %	66.7 %
Control group (n = 9)	11.1 %	88.9 %

n, the total number of cases analysed.

dren. In addition, the analysis of the study groups according to the maternal weight status — obese or non-obese mother — showed that maternal obesity was found 5.8 times more often of children in group I ($p < 0.001$) compared to control group children, and approximately two times more often compared to study group II children ($p < 0.001$) (Table 4).

DISCUSSION

As the prevalence of obesity in the paediatric population increases worldwide, not only are obesity-related complications studied, but also factors that increase obesity risk, and also early complication risk. Research and awareness of these risks allows for a targeted development of anti-obesity tactics and prevention programmes for children. Many studies provide evidence to support the hypothesis that child's birth weight is associated with disease risk later in life. Such associations are well known, especially with small birth weight and the risk of coronary heart disease, diabetes, hypertension, and stroke in adulthood. Many researchers have reported that a birth weight > 4000 g is associated with a higher risk of obesity compared to a birth weight < 4000 g. The importance of low birth weight, i.e. < 2500 g, in relation to the risk of obesity in children is currently controversial. Several researchers have observed a positive linear relationship between birth weight and obesity. Analysis of subgroups representing different stages of growth and puberty (pre-schoolers, school-age children and adolescents) showed that large birth weight was associated with a higher risk of obesity from childhood to early adulthood (Schellong *et al*., 2012). Research data show, for example, that each increase in birth weight of 100 g is associated with a higher risk of obesity in the future (Zhao *et al*., 2012). However, there are also studies that provide conflicting data on birth weight and the risk of obesity. For example, birth weight has been found to be directly related to the BMI percentile; however, no significant differences in birth weight were found between overweight / obese children and children with normal body weight (Baran *et al*., 2019).

The German Health Interview and Examination Survey for Children and Adolescents (KIGGS) showed that the highest risk of obesity in children was associated with parental obesity, low socioeconomic status, maternal smoking during pregnancy, excessive weight gain during pregnancy, large birth weight, excessive screen time and poor sleep quality. This study found that the children of normal weight mothers who gained ≥ 20 kg during pregnancy were 2.8 times more likely to be overweight or obese (HR 2.81; 95% CI 1.6–5.0). Parental overweight showed the strongest association with childhood obesity risk. In children, the risk of obesity was 11.2 times higher when both parents were obese compared to children whose parents were non-obese (HR 11.24; 95% CI 6.4–19.7) (Kleiser *et al*., 2009). Many other authors described similar observations. Excessive weight gain during pregnancy clearly increased the risk of obesity in children from early age to preschool and school age (Sridhar *et al*., 2014; Baran *et al*., 2020). A study by Shao *et al*. (2016) showed that maternal obesity before pregnancy (HR 2.01; 95% CI 1.53–2.65) and excessive weight gain during pregnancy (HR 1.65; 95% CI: 1.35–2.03) increases the risk of obesity in children, while underweight before childhood is a protective factor for childhood obesity (HR 0.49; 95% CI: 0.39–0.62) (Shao *et al*., 2016). The risk of obesity among children was observed to be the lowest in the group whose mothers were underweight and the differences in the risk of obesity were highest after the age of five and persisted into adolescence (Leonard *et al*., 2017). In addition, if the mother was overweight before pregnancy, the risk of obesity in children aged six to 11 years doubled (Leonard *et al*., 2017).

Short duration of exclusive breastfeeding may also be a risk factor for childhood obesity, while optimal breastfeeding duration may reduce the risk of childhood overweight/obe-

sity. Meta-analyses suggest that breastfeeding longer than 6 months can reduce the risk of obesity by 13–31% (Horta *et al*., 2015). However, although the relationship between the risk of obesity and the duration of breastfeeding in children has long been discussed, unfortunately no agreement has been reached on this issue (Qiao *et al*., 2020). Many studies have identified breastfeeding as a protective factor, while other studies have failed to establish an association between breastfeeding and childhood obesity risk (Yan *et al*., 2014). For example, Toschke *et al*., reported no association between breastfeeding for up to six months and obesity in their study, and other studies have also found no increased risk of obesity in children who have been exclusively breastfed for less than four months (Toschke *et al*., 2007; Huus *et al*., 2008).

A positive family history of T2D has been identified as an important risk factor for chronic disease risk in children. Children with a family history of diabetes are 2–6 times more likely to develop T2D than children without a family history of diabetes. From a comprehensive risk assessment, the use of a family history in children may be crucial in the prevention, early detection and treatment of T2D. At a population level, a family history can help to adapt health promotion intervention to specific population groups (Yoon *et al*., 2003; Annis *et al*., 2005). A family history of positive diabetes is very common in young people with T2D. Many young people with T2D live with an adult family member who also has diabetes and is obese. However, it should be noted that for young people, the consequences of a common diabetes experience in the family can be both positive and negative. Several qualitative studies have addressed this issue (Pulgaron *et al*., 2014). In one study, parents reported a controversial role in the treatment of their child's diabetes: although parents acknowledged the opportunity to provide support and serve as positive examples, they also reported difficulties in setting a good example of healthy lifestyle changes. Family members with T2D can have a negative impact on young people because they accept diabetes-related health complications. If family members have experienced health problems due to chronic hyperglycaemia, such as retinopathy, nephropathy, extremity amputation, and premature death, these complications may be perceived by young people as an inevitable course of diabetes (Jones, 1998; Mulvaney *et al*., 2006).

Several studies have analysed the impact of parental obesity on the risk of childhood obesity and the risk of early complications of obesity. Most studies link parental BMI and overweight/obesity to the risk of obesity in their offspring, both childhood and adulthood (Reilly *et al*., 2005; Martínez-Villanueva *et al*., 2019). The family's predisposition to obesity seems to be particularly important in the development of obesity in preschool children. In studies on children under ten years of age who were obese and normal weight, parental overweight/obesity was an important predictor in the risk of obesity in adulthood. For example, a 1958 British birth cohort study (n = 16794, offspring n = 2908) found that an increased risk of overweight and obesity in offspring was associated with increased parental BMI and rapid parental weight gain in both childhood and adulthood (Li *et al*., 2009; Nielsen *et al*., 2015). Studies linking parental BMI to childhood obesity risk have observed a different effect of maternal and paternal weight: high paternal BMI increases the risk of overweight/obesity in both boys and girls, while increased maternal BMI reduces the risk of obesity in adolescent girls. In contrast, a stronger effect of maternal obesity on the child was found in a small longitudinal study (n = 197) in girls aged five to seven years, as well as in other studies on Native American and Native Pima American children. However, children from families with both obese parents are at highest risk of being overweight/obese (Whitaker *et al*., 2010; Shafaghi *et al*., 2014; Veena *et al*., 2014; Nielsen *et al*., 2015).

When comparing the literature data with the results of our study, the obtained results on the risk factors of obesity in children and adolescents do not overlap in part. Our results show that birth weight does not differ between obese and normal weight children, although a large birth weight was observed in children under 10 years of age. However, all study groups had a high proportion of children with birth weight ≥ 4 kg. The duration of exclusive breastfeeding also did not differ between obese and normal weight children. Children aged 10 years and older who were obese had received exclusive breastfeeding for six months or more in 40.3% of cases, but no statistically significant differences in breastfeeding duration were demonstrated. A positive history of T2D in family and excessive weight gain during pregnancy in mother were equally common in obese and normal weight children. Our study found that only the prevalence of parental obesity differed between obese and normal weight children. Parental obesity was common in 79.8% of obese children and only in 33.3% of normal weight children. Maternal obesity was not observed in children with normal weight.

The study data are limited by inconsistencies in absolute numbers between prenatal and postnatal risk factors of obesity, as they are not always correct or not reported in parents' surveys. These data are presented as non-existent in the study analysis. The small sample of respondents also limits the collection, analysis and interpretation of research data. However, the obtained results allowed us to achieve the research goals and allowed us to compare the data with other studies, which indicate a qualitative research result. Further research is needed, in particular on the interaction between parents and children in obesity and its impact on the risk of chronic diseases, pathogenetic mechanisms, and future complications.

CONCLUSIONS

Our study did not show differences in the prenatal risk factors of obesity in obese and normal weight children. There were also no statistically significant differences in the duration of exclusive breastfeeding between children with normal weight and obesity. However, our study found that the

prevalence of parental obesity differed between obese and normal weight children. Maternal obesity was not common in children with normal weight.

ETHICS

The study was approved by the Ethics Committee of Rīga Stradiņš University.

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PRENATĀLU UN POSTNATĀLU APTAUKOŠANĀS RISKA FAKTORU NOVĒRTĒJUMS BĒRNIEM UN PUSAUDŽIEM AR APTAUKOŠANOS UN NORMĀLU SVARU

Aptaukošanās tiek uzskatīta par globālu epidēmiju visā pasaulē. Covid lokdauna laikā mainījās daudzi ikdienas paradumi ne tikai pieaugušajiem, bet arī bērniem. Iespējams, ka tas vēl vairāk palielinās aptaukošanās izplatību un smaguma pakāpi, kas var izraisīt agrīnas veselības problēmas un hroniskas slimības. Tāpēc ir svarīgi izvērtēt novēršamos un nenovēršamos aptaukošanās riska faktorus, tas būtu noderīgi, plānojot ilgtermiņa aptaukošanās profilakses programmas valstī. Pētījuma mērķis bija izpētīt prenatālus un postnatālus aptaukošanās riska faktorus normāla svara bērniem un bērniem ar aptaukošanos. Prospektīvā pētījumā no 2013. līdz 2018. gadam tika iekļauti 198 bērni un pusaudži — 181 bērns ar aptaukošanos un 17 bērni ar normālu ķermeņa svaru, kuri apmeklēja bērnu endokrinologu. Aptaukošanās prenatālie riska faktori, kā dzimšanas svars (p = 0,530), pārmērīgs svara pieaugums grūtniecības laikā mātei (p = 0,787), pozitīva 2. tipa cukura diabēta anamnēze ģimenē (p > 0,999), statistiski nozīmīgi neatšķirās bērniem ar aptaukošanos un ar normālu ķermeņa svaru. Arī aptaukošanās postnatālam riska faktoram, ekskluzīvās zīdīšanas ilgumam (p = 0,120) netika atrasta statistiski nozīmīga atšķirība starp bērniem ar aptaukošanos un ar normālu svaru. Statistiski nozīmīga atšķirība pētījumā grupās tika novērota tikai postnatālam aptaukošanās riska faktoram — vecāku aptaukošanās faktam (p = 0,004). Tāpēc, apzinoties, ka vecāku aptaukošanās ir nozīmīgs riska faktors liekajam svaram, ir svarīgi iesaistīt visus ģimenes locekļus, lai mainītu bērnu ikdienas paradumus.