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RESEARCH ARTICLE

The impact of neonatal parameters and parental factors on body fat level in early childhood

Łukasz Kryst[1*], Magdalena Żegleń[2], Maria Gał[1], Agnieszka Woronkowicz[1] and Małgorzata Kowal[1]

[1]Department of Anthropology, Faculty of Physical Education and Sport, University of Physical Education in Kraków, Poland and [2]Pain Research Group, Institute of Psychology, Jagiellonian University, Kraków, Poland
*Corresponding author. Email: lkryst@poczta.onet.pl

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Abstract

Parental and pregnancy characteristics can affect proportions and tissue composition of the child's body- and thereforecan influence their present and future health, as well as overall wellbeing. The aim of this study was to examine the differences between selected parental and birth-related parameters among pre-school (3-7 years of age) children of varying adiposity status (n=541 girls and n=571 boys).The research was carried out in 20 randomly selected kindergartens in Krakow (Poland). Thickness of 6 skinfolds (biceps, triceps, subscapular, suprailiac, abdominal and calf) was measured. Sum of skinfolds was calculated and participants were divided into low, normal or high body fat groups. Birth-related characteristics were obtained using a questionnaire filled out by the children's parents. Children of mothers who gained the most gestational weight were characterised by high adiposity. Preschoolers with the highest birth weight, body length and head circumference had the greatest adiposity. Children of relatively younger mothers had higher body fat, in comparison to the rest of the study group. Parents of preschoolers in the high adiposity category were characterised by a greater body mass, compared to the parents of children in other body fat groups and that boys with the highest adiposity relatively more often had a close relative with obesity. Children in varying adiposity categories differed in terms of some birth-related factors. Particular attention should be paid to familial and parental characteristics, because they may influence the child's predisposition to excess adiposity deposition later in life.

Keywords: birth parameters; adiposity; skinfold thickness; preschool children

Introduction

It has been shown in a plethora of studies, that birth parameters, such as weight, length of the body, as well as maternal and pregnancy characteristics can affect future size, proportions and tissue composition of the child's body (Mathai *et al.*, 2013; Perenc *et al.*, 2019).

It has been demonstrated, that prematurely born children have an increased risk of obesity in adulthood (Mathai *et al.*, 2013). However, it has also been demonstrated that children born prematurely are likely to have poor adiposity development at the early school age (Perenc *et al.*, 2019). These observations suggest, that there is a need for exploring the relationship between birth characteristics and future body size, proportion and tissue composition of children.

Birth weight is another factor suggested to significantly influence the body weight and adiposity later in life, as children with a low value of this parameter are especially likely to have overweight or obesity (Yajnik, 2004). Additionally, it has been suggested that individuals with low birth weight have an increased risk of having an excess visceral fat ratio by the age of 6 (Ibáñez *et al.*, 2008).

It is also essential to highlight the importance of maternal nutritional status, which also can have a long-term impact on the future metabolic health of the child (Geraghty *et al.*, 2016). Particular mechanisms explaining how the *in-utero* environment influences the development of the fetus mostly remain unknown. However, it has been suggested, that maternal diet can play a major role during this time (Geraghty *et al.*, 2016).

Breastfeeding is another one of the maternal factors that may be crucial for future metabolic health of the child. It has been suggested, that breastfeeding during the first months of life may have a protective effect in respect to excess weight gain in childhood (Arenz *et al.*, 2004). Though, this phenomenon is still not well examined, which further proves the need for studies investigating this issue (Burke *et al.*, 2005).

The aim of this study was to examine the differences between selected parental and birth-related parameters among preschool (3-7 years of age) children of varying adiposity status.

Methods

The study was conducted with the consent of the Bioethics Committee of the Regional Medical Association in Kraków (No 2/KBL/OIL/2018) and with the written consent of the parents/legal guardians, as well as verbal assent from the examined children. The research was carried out in 20 randomly selected kindergartens in Krakow (Poland) located in four traditional residential districts of the city: Śródmieście, Podgórze, Krowodrza and Nowa Huta. The districts are comparable in terms of the socioeconomic status, therefore any possible changes taking place equally affected the entire population of the city.

The calendar age of the subjects ranged from 2.50 to 7.49 years and was calculated as a difference between the date of the survey and the birth date, expressed as a decimal fraction, was a basis for classifying them as one of 5 age groups (for example: 6-year-olds: 5.50 – 6.49).

Skinfold thickness was measured using a Holtain calliper (GPM, Switzerland) with a constant spring pressure of 10 g/mm2 (accuracy 0.5 mm), on the right side of the body, if appropriate (i.e. measurements performed on one side of the body). The triceps skinfold was measured with the arm muscles relaxed, in the middle part of the posterior surface of the upper arm, over the triceps muscle. The biceps skinfold was measured at the same mark as the triceps skinfold, rotated around along the biceps branchi (the arm resting relaxed and supine). The subscapular skinfold was measured below the inferior angle of the scapula, at 45° to the vertical, along the natural crease lines of the skin. The suprailiac skinfold was measured above the iliac crest, posterior to the mid-axillary line and parallel to the cleavage lines of the skin. The abdominal skinfold was measured 5 cm adjacent and 1 cm below the umbilicus. Lastly, the calf skinfold was measured on the side of the calf, at the point of the maximum girth, with the lower limb relaxed (Tanner, 1962).

Described measurements were a basis for calculating the sum of all 6skinfolds. The children were then divided into groups characterized by low (<-1 SD [standard deviation]), normal (±1 SD) or high body fat (>1 SD) (Table 1). Qualification into each group was carried out within the age classes (i.e. means and SDs were calculated for each age class and children within this class were divided into each adiposity category).

Parental and birth-related characteristics were obtained using a questionnaire filled out by the children's parents or legal guardians. They included: gestational weight gain of the mother, birth weight and length, breastfeeding time, mother's age, body mass of both parents and the presence a close relative (parent, grandparent or sibling) with obesity in the family.

Statistical differences of parental and birth-related parameters between the adiposity categories were calculated using one-way ANOVA or Chi^2 test, depending on the analysed variable.

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Table 1. Selected characteristics of the examined group

Characteristics	Girls		Boys	
Number of individuals, N	541		571	
Mean sum (SD; range) of 6 skinfolds within the age categories				
3	43.70 (8.33; 29.50-61.00)		39.03 (7.73; 25.50-57.00)	
4	44.31 (9.76; 27.50-81.50)		39.35 (7.50; 27.50-76.50	
5	43.39 (9.52; 26.90-90.00)		41.51 (12.27; 25.00-99.00)	
6	43.43 (13.26; 25.00-108.50)		40.79 (13.56; 22.00-120.00)	
7	47.97 (16.18; 24.00-104.00)		44.82 (17.01; 24.50-112.00)	
Number of individuals in each adiposity category				
	N	%	N	%
Low	53	9.80	39	6.83
Normal	411	75.97	467	81.79
High	77	14.23	65	11.38

Table 2. Means and standard deviations (SD) of analysed neonatal parameters in each adiposity category (girls)

	Low (<1SD)		Normal (±1 SD)		High (>1 SD)					
Parameter	Mean	SD	Mean	SD	Mean	SD	p-value	p-value (low vs normal)	p-value (normal vs high)	p-value (low vs high)
Gestational weight gain [kg]	13.87	5.32	13.42	5.41	15.45	6.45	0.01	n.s	≤0.05	n.s.
Birth weight [g]	3185.5	525.6	3270.7	509.4	3317.9	544.9	0.35	n.s	n.s	n.s
Birth body length [cm]	53.02	2.68	53.89	3.13	53.96	4.13	0.17	n.s	n.s	n.s
Birth head circumference [cm]	33.33	1.68	33.80	1.82	33.54	1.39	0.13	n.s	n.s	n.s

n.s. – not significant

Results

Children from high adiposity groups had mothers who gained the most weight during pregnancy. On the other hand, girls and boys who had low body fat also had mothers whose weight increased the least. Described differences were statistically significant in both sexes (Table 2, 3).

When taking the birth parameters into consideration, preschoolers with the greatest adiposity had the highest birth weight, however, said differences were not statistically significant. Analogous discrepancies were noted in the case of body length and head circumference at birth (i.e. girls and boys characterised by greater adiposity had the highest values of mentioned parameters, in comparison to their counterparts in other body fat categories). None of the differences in analysed birth parameters was statistically significant (Table 2, 3).

Children in analysed adiposity categories differed also in terms of the breastfeeding time, although the discrepancies were not statistically significant. Additionally, while the girls in the highest body fat category were breastfed for the relatively shortest time, the direction of the

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Table 3. Means and standard deviations (SD) of analysed neonatal parameters in each adiposity category (boys)

Parameter	Low (<1SD)		Normal (±1 SD)		High (>1 SD)		p-value	p-value (low vs normal)	p-value (normal vs high)	p-value (low vs high)
	Mean	SD	Mean	SD	Mean	SD				
Gestational weight gain [kg]	13.27	5.35	14.75	5.61	16.10	6.79	0.04	n.s	n.s	≤0.05
Birth weight [g]	3316.4	437.1	3441.7	488.7	3540.6	596.6	0.09	n.s	n.s	n.s
Birth body length [cm]	53.76	2.25	55.01	3.87	55.26	3.58	0.11	n.s	n.s	n.s
Birth head circumference [cm]	33.82	2.92	34.59	2.24	34.99	3.85	0.08	n.s	n.s	n.s

n.s. – not significant

Table 4. Means and standard deviations (SD) of analysed parental parameters in each adiposity category (girls)

Parameter	Low (<1SD)		Normal (±1 SD)		High (>1 SD)		p-value	p-value (low vs normal)	p-value (normal vs high)	p-value (low vs high)
	Mean	SD	Mean	SD	Mean	SD				
Breastfeeding time [months]	12.89	7.58	10.70	8.11	9.62	6.81	0.07	n.s.	n.s.	n.s.
Mothers age* [years]	31.23	4.08	31.40	4.17	30.95	4.98	0.69	n.s.	n.s.	n.s.
Mother's body mass [kg]	59.61	9.24	62.99	10.29	67.08	14.12	0.0004	n.s.	≤0.01	≤0.001
Father's body mass [kg]	81.27	9.23	84.18	11.89	92.78	15.29	0.0001	n.s.	≤0.001	≤0.001
Presence of a close relative with obesity [%]	17.07	–	30.53	–	29.79	–	0.20	n.s.	n.s.	n.s.

*refers to the age of the mother at the moment of the child's birth; n.s. – not significant

discrepancies in the boys was the opposite (i.e. preschoolers characterised by the lowest adiposity were breastfed the shortest time) (Table 4, 5).

In terms of parental factors, it was noted, that children characterised by higher body fat had relatively younger mothers, in comparison to the rest of the study group. However, those discrepancies were not statistically significant (Table 4, 5).

On the other hand, significant differences were noted in terms of body mass of both parents. Mothers and fathers of preschoolers in the high adiposity category were characterised by a greater body mass, compared to the parents of children in low and average body fat groups (Table 4, 5).

It was also noted, that boys with the highest adiposity significantly more often had a close relative with obesity, in comparison to those in low and average body fat categories. Also among girls, those characterised by low-adiposity group the least often had family history of obesity. However, contrary to what was observed for boys, similar percentages of girls with low and average adiposity had a close relative with obesity. Additionally, differences noted in this sex were not statistically significant (Table 4, 5).

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Table 5. Means and standard deviations (SD) of analysed parental parameters in each adiposity category (boys)

Parameter	Low (<1SD)		Normal (±1 SD)		High (>1 SD)		p-value	p-value (low vs normal)	p-value (normal vs high)	p-value (low vs high)
	Mean	SD	Mean	SD	Mean	SD				
Breastfeeding time [months]	9.34	7.10	10.36	7.21	10.10	7.82	0.70	n.s	n.s	n.s
Mothers age* [years]	32.26	4.70	31.19	4.08	30.32	4.86	0.08	n.s	n.s	n.s
Mother's body mass [kg]	62.68	12.32	62.73	10.64	69.74	15.07	0.0001	n.s	≤0.001	≤0.01
Father's body mass [kg]	80.47	10.68	84.91	12.08	87.64	14.93	0.02	n.s	n.s	≤0.05
Presence of a close relative with obesity [%]	18.18	–	22.68	–	44.90	–	0.002	n.s	0.01	n.s

*refers to the age of the mother at the moment of the child's birth; n.s. – not significant

Discussion

In the current research, children of mothers who gained the most weight during pregnancy were characterised by high adiposity in preschool age. This is consistent with previous research, where new-borns born to women with elevated gestational weight gain had high adiposity at 3 years of age, as measured by skinfold thickness as well as by BMI (Body Mass Index). In the same study, said relationship turned out to be independent of breastfeeding duration as well as parents' BMI (Derraik *et al.*, 2015). It is an important observation, crucial not only for the metabolic as well as the overall health of the mothers, but also present and future wellbeing of their children. It is due to the fact, that high gestational weight has been suggested to be associated with increased the risk of macrosomia as well as greater postpartum weight retention and thus later possibility of excess body weight in the mother (Ananth & Wen, 2002). The association of increased weight gain during pregnancy with high adiposity in children have also been described in another article. There, it has also been suggested, that the gestational weight gain during the first half of pregnancy is an especially strong predictor of excessive neonatal body fat. This, in turn, indicates a direct connection between the early intrauterine environment and subsequent neonatal metabolic health (Davenport *et al.*, 2013).

It should be noted that not only the gestational weight gain but also parental body mass seemed to affect the adiposity in the examined children – those in children in the high adiposity category had parents with greater body mass, compared to the of boys and girls in low and average body fat groups. Similar results, though among newborn children, were obtained in previous studies, where the effect of maternal BMI on child's adiposity has been linked to the mother's BMI (Diaz *et al.*, 2020; Starling *et al.*, 2015). On the other hand, in a recent study carried out in the USA population, it has been suggested that it is maternal adiposity, that mainly contributes to offspring's level of fatness (Diaz *et al.*, 2020).

Moreover, in the present study boys characterised by high adiposity more often had a close relative with obesity, in comparison to those in low and average body fat categories. Similar findings were described in previous research, in which daughters of mothers with obesity had a higher probability of excess body weight (Derraik *et al.*, 2015; Perenc *et al.*, 2019).

Described findings suggest a relationship between parental body mass and adiposity of the offspring. Presence of similar association has been noted in previous research. Also there, it has been suggested that it may be facilitated by familial genetic and environmental risk factors shared by both generations, which may also be the case in the currently analysed population (Fleten *et al.*, 2012).

When taking into consideration the birth parameters, preschoolers with the highest birth weight and length had the greatest adiposity. This tendency, particularly regarding the birth weight, is consistent with previous research, as it has been suggested that the birth weight of the child can significantly influence their fat ratio later in life. Similarly to what was noted in the present research, high birth weight has been linked to greater BMI and increased risk of obesity in adulthood (Curhan, Chertow, *et al.*, 1996; Curhan, Willett, *et al.*, 1996). Interestingly, some authors also suggest, that children with low body mass at birth are also at an increased risk of excess adiposity, particularly central fat deposition and reduced lean body mass in later life (Rogers, 2003). It has also been noted in previous research, that body size at birth, which can differ even among preterm children, can have a significant influence on their future body mass as well as adiposity. It is due to the fact, that newborns small for gestational age tend to have disruptions in signals generated in response to leptin in the accurate nucleus of the hypothalamus. Furthermore, small gestational size has been associated with a reduced number of neurons of the satiety center. Both of those phenomena can promote an increase in the food intake and thus also the risk of excess body weight and adiposity (Yee *et al.*, 2012).

Currently analysed population differed also in terms of the breastfeeding time, although the discrepancies varied between the sexes and were not statistically significant. This is in line with findings of large, randomised controlled trial, where time and exclusivity of breastfeeding was not associated with reduced levels of adiposity or difference in body adiposity at 16 years. Additionally, similar results were noted in the study group at 6.5 and 11.5 years of age (Kramer *et al.*, 2007; Martin *et al.*, 2017). Furthermore, analogous results were obtained in a prospective study, where the authors did not observe significant differences in body composition at 2 years of age, between primarily breastfed children and those, who were formula-fed (Butte *et al.*, 2000).

On the other hand, in some secondary studies, it has also been suggested, that breastfeeding protects against infantile obesity (Harder *et al.*, 2005; Yan *et al.*, 2014). It has been hypothesised, that such association may be facilitated by the lower level of protein in breast milk, in comparison to other types of feeding. This, in turn, can cause a decrease in plasmatic insulin and consequent reduced fat storage in the offspring (Oddy, 2012). Though, as mentioned previously, children in presently analysed adiposity categories study group did not differ in terms of breastfeeding duration. Thus, it can be concluded that in this population other factors may have a more significant influence on the children's body composition.

Socioeconomic characteristics of the examined population also should be considered in terms of presently obtained results. Especially, as it has been noted in the previous study that preschoolers in the high adiposity group had, on average, fewer siblings in comparison to the rest of the study group. Moreover, lifestyle turned out to be one of the crucial factors differing between children of varying adiposity – for example preschoolers in high adiposity group had longer screen time compared to their peers in low and average groups. Parents of the children in high body fat group also usually had lower levels of education and more often worked in manual jobs (blue collar jobs), compared to the children in the low and average adiposity categories (Kryst *et al.*, 2021). Described results suggest additionally, that not only birth and parental factors but also socioeconomic characteristics are crucial for developing a predisposition to excessive body adiposity later in life.

Present study has also some limitations, which should be taken into consideration while analysing and interpreting the results. They mainly include the memory error in reporting gestational weight gain of the mother, as well as biased reporting of body weight by the parents of examined children, which may reduce the accuracy of obtained data. However, there is evidence in the literature that the self-reported data on body weight is accurate and useful in scientific studies (Dekkers *et al.*, 2008; Hodge *et al.*, 2020). It should also be noted, that only children up to 7 years of age were included in the present study, which may be a limitation due to the fact that the results do provide information on how the analysed factors translate into the risk of excess adiposity in the later stages of life (i.e. after the age of 7).

In conclusion, it was observed that children in varying adiposity categories differ in terms of some birth-related factors. Particular attention should be paid to familial and parental characteristics, such as body weight of mother and father as well as the gestational weight gain. Information on how those factors can affect the metabolic health of children is fundamental for their present and future wellbeing. Thus, it can inform professionals and the parents themselves, what intervention and/or preventive measures should be taken to ensure the best possible outcomes for the child as well as the pregnant woman.

Nevertheless, there is still a need for future research exploring the topic of the influence of birth-related factors on metabolic health later in life. Especially well-planned research carried out in large cohorts as well as longitudinal studies will be particularly helpful in this regard.

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Conflicts of Interest. The authors have no conflicts of interest to declare.

Ethical Approval. The study was conducted with the consent of the Bioethics Committee of the Regional Medical Association in Kraków (No. 2/KBL/OIL/2018) and with the written consent of the parents or legal guardians, as well as verbal assent from the children themselves. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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