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Risk factors in newborns for large waist to height ratio at 1, 2 and 3 year follow up

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Abstract

Objective: To establish if waist to height ratio at age 1, 2 or 3 years are dependent of prematurity, small for gestational age, large for gestational age or heritage for metabolic syndrome.

Method: A population-based longitudinal birth cohort study with 2666 children recruited from 2007 to 2008 in south-western Sweden. At visits to the child health centre, parents were asked to complete a questionnaire. Measurements of weight, height, head and waist circumference were recorded using a standard procedure. Children were followed up at 1, 2 and 3 years of age. Risk factors were analyzed with multivariate logistic regression.

Results: Prematurely born children had a significantly increased risk of larger waist to height ratio at 1 year of age (OR 1.80), but not at 2 or 3 years. Children born large for gestational age had a nearly significantly increased risk (OR 1.58) of a large waist to height ratio at the age of 3. Mothers body mass index (BMI) nearly significantly (p=0.064) increased the risk (OR 1.024 per step in BMI) of a large waist to height ratio at the age of 1.

Conclusion: Both factors related to the child and to the mother predicted a larger waist to height ratio at follow up. In order to find children at risk for future overweight or obesity, it is important to take factors such as prematurity, size for gestational age and mother's BMI into consideration.

Keywords

Waist circumference, waist to height ratio, Overweight, Obesity, Children, Insulin resistance, Heritage for metabolic syndrome, Small for gestational age, SGA, Large for gestational age LGA. Premature,

Introduction/background

Overweight and obesity

The prevalence of overweight and obesity is increasing and since 1980 worldwide obesity has more than doubled. In the world overweight and obesity is the fifth leading global risk for death. The fundamental cause of overweight and obesity is an imbalance in consumed and expanded calories. This is due to an increased intake of energy-dense foods together with that change of work, transportation and increasing urbanization leads to a decrease in physical activity(1).

Also among children and adolescents an increasing percentage are overweight and obese. This has reached epidemic proportions in most industrialized countries and is associated with an increased risk of adult obesity, which is a major risk factor for chronic disease and premature mortality(2-3).

Children and overweight

Prevalence of overweight and obesity among children and adolescence ranges from 5% to over 25% in some countries. The problem continues to increase in more than half of the countries in spite of awareness of the problem. In most countries a greater proportion of boys than girls are overweight. Today children are more frequently subject to many obesity-related health conditions once confined to adults(2).

In Swedish school children aged 7 to 9 years overweight were found in 17 % including 3 % being obese. Areas with low socioeconomic status have a higher risk for overweight and obesity(4). In ten-year old children in Malmö 2004 – 2005 overweight varied between 9% and 25% and obesity between 0% and 11%. The big difference is explained by differences in socioeconomic status. A low socioeconomic status increases the risk of overweight and obesity(5). In 4- year old pre-school children in Västerbotten, 16.7% of the boys were overweight and 3.1% obese, and in girls 22.1% were overweight and 6.0% obese. There was a pattern with higher prevalence of overweight and obesity in municipalities with a low socioeconomic level(6). The STOPP-study (Stockholm Obesity Prevention Project) in Stockholm shows that overweight and obesity has increased from 8% to 20% since 1989(7). A study in Umeå on children 6 to 11 years the prevalence of overweight doubled over 15 years from 1986 to 2001and obesity has increased five times during the same period(8). In a cross-sectional study 2006 in preschool children in Halland 15% of the 2-5 years old were overweight and 2.5% obese(9).

Metabolic syndrome

The World Health Organization criteria for the metabolic syndrome requires diabetes mellitus or insulin resistance together with two of the following: high blood pressure, dyslipidemia, central obesity and microalbuminuria. The most important risk factor for the metabolic syndrome and type 2 diabetes mellitus is overweight together with inactivity and smoking. Each component of the metabolic syndrome increases the risk for cardiovascular disease. The metabolic syndrome is a disease that develops over time, often decades, and is persistent often ten years before hyperglycemia occur(10).

Predictors for overweight and obesity

Childhood obesity is an important predictor of adult obesity. A high BMI in adolescence predicts elevated adult mortality and cardiovascular disease rates, even if the excess body weight is lost(2). The probability of being obese as a young adult increased with the age of the obese child and was higher at all ages for the group of very obese children(11).

Children with an obese mother or father had a significantly greater risk of adulthood obesity, and it did not matter if the subject was obese or nonobese as a child. The risk with an obese parent was most pronounced among children under ten years of age. For children under three years of age the predictor of obesity in adulthood was depending in the parents´ obesity status and not the child(11).

I adults waist circumference is a better predictor for accumulation of visceral fat than body mass index. Visceral fat accumulation is a better predictor for adult morbidity than obesity itself. Waist circumference is a good predictor in children to detect cardiovascular disease risk factors such as high blood pressure, lipids and lipoproteins(12).

Prematurely born children and children born in term, but small for gestational age (SGA) has a reduction in insulin sensitivity and a compensatory increase in acute insulin release. This may be a risk factor for type 2 diabetes mellitus(13).

Children born large for gestational age (LGA) by mothers with diabetes mellitus are heavier and have a lager waist circumference than control children, and 38 % had a BMI in the .90th percentile at age of 7. LGA children born by a non-diabetic mother remain larger than controls but with a harmonic body composition, but the mothers are significantly taller(14).

Children born SGA they have a significantly higher fat mass percentage at age 6 to 10 compared with controls. Children born LGA remain lager at age 8 compared with appropriate for gestational age (AGA) children, but with a similar body fat and adiposity distribution and no signs of excess body fat deposition or impaired metabolic adaptation(15).

In adults BMI is used to determine overweight and obesity. In pre-pubertal children several reports indicate a less strong correlation between BMI and metabolic risk and BMI is a suboptimal marker of total body fat percentage(12, 16). There are several studies where body composition and fat mass distribution correlate with waist circumference(17-18). There is no studies today about adiposity and fat mass distribution compared to waist circumference in younger children between the age 1 and 3. There are new reference values for waist circumference and waist to height ratio for Swedish preschool children(9). They might enable future identification of new risk populations for childhood obesity but there are still no correlating cutoffs with metabolic data. If children at risk for overweight and adiposity could be detected at an early age, interventions could be made to prevent adult obesity and metabolic syndrome in these children.

Aim

The aim was to study if waist to height ratio at one, two and three years of age was predicted by premature birth, being large for gestational age (LGA), small for gestational age (SGA) or having a heritage for metabolic syndrome in a birth cohort followed over time.

Methods

Study design

This project is a part of a larger ongoing population-based longitudinal birth cohort study. Subjects recruited where infants born between October 1, 2007 and December 31, 2008 in the County of Halland, in south-western Sweden. The families were recruited at their first visit to Children's health center (CHC), at age 1 to 2 weeks. The children were followed up at age 1, 3, 6, 12 and 18 months and at age 2, 3, 4, and 5 years.

Subjects

The total births in Halland during the period where 3860. 2666 choose to participate (69.1%), 376 parents chose actively not to participate (9.7%) and 818 parents did not respond (21.2%). At the initial clinical visit parents were asked to complete a questionnaire with detailed mapping of social and medical factor. At the follow-up appointments parents were asked to fill out questionnaire about the child. At their first visit at CHC the parents filled out a questionnaire with detailed mapping of social and medical factors. In this study we asked the mothers' age, length, weight before pregnancy and at delivery. We also asked about the mothers' medical condition regarding cardiovascular disease, diabetes, gestational diabetes, high blood pressure and preeclampsia. The fathers were asked about age, length and weight and medical condition regarding diabetes, cardiovascular disease and high blood pressure. Both parents were asked about smoking habits, education and medical condition in the family regarding diabetes, cardiovascular disease and overweight, and if father and mother lived together.

Measurements

The children were measured as newborn, age 3, 6, 12 and 18 months and at age 2, 3, 4, and 5 years. In this study measurements as newborn and at age 1, 2 and 3 years were used. Until 2 years of age, height was measured with stadiometer in the supine position, after which standing height was measured. Until they reached a weight of 15 kg, infants were weighed on baby scales in the supine position, while older children were weighed on mechanical or electronic step scales. Children were weighed without clothing or, in the case of older children, wearing only underpants. Waist circumference was measured by a flexible tape midway between the lowest rib and the top of the iliac crest at the end of a gentle expiration. The circumference was measured without clothing.

Data management

As a part of my work I have studied the quality of the data. I have localized missing data in length, weight, waist circumference, head circumference, visiting date at CHC, gestational age, length at birth and weight at birth. I have localized all data outside 2 standard deviations of length, weight, waist circumference and head circumference. When questionnaires were filled out more than two months before or after the ideal age, more exact data was asked for at CHC. All posts were compared to data in the collected questionnaire to look for wrong scanned data or missing data that was present in the questionnaire. The fairness of all data outside 2 standard deviations was studied. CHC were asked about all data that not was reasonable and all missing data. The total amount of reviewed data was 2543 and the total data asked for at CHC was 761.

Data analysis

Data was analyzed with statistical package IBM SPSS 20. It was decided to calculate waist to height ratio for the children and use that instead of waist circumference. Dividing waist with height provides a measurement more independent of length. Waist to height ratio was calculated as waist (cm)/ height (cm). The children were divided in to two groups. Large waist to height ratio was defined as the upper 25th percentile and the rest were defined as the reference population. Gestational age (full weeks), birth weight (gram) and length (cm) were reported by the parents in the newborn questionnaire. LGA was defined as weight or height at birth > 2 SD according to gestational age, AGA as weight or height at birth -2 to +2 SD and SGA as weight or height <-2SD. Gestational age <37 weeks was defined as prematurely born and gestational age ≥37 as term. To determine overweight in parents we calculated BMI, weight in kg/(length in cm)^2. Overweight was defined as BMI >25 and obesity as BMI >30. Possible predictors for waist to height ratio were analyzed in cross tables with chi-square tests. Factors that showed statistically significant ($p<0.05$) associations with the outcome were stepwise introduced into multivariate logistic regression models for each follow up time (1, 2 and 3 years). It was decided to introduce BMI as a continuous variable in order to use the full potential of the data. Children born before week 32 (n=20) were omitted from the logistic regressions, due to that they could be suspected to have special circumstances that we not were able to control for. The statistical power varied in the different chi-square analyzes due to that group sizes in some cases were very small, for example mothers cardiovascular disease. In order to show group differences of 10% with a significant level of 0.05 the power varied between 17% (worst case) to 99.9% (best case).

Ethical consideration

The study is part of a larger project and is approved by the Regional Ethical Review Boards, Lund University. Signed informed consent was obtained from parents to the participants. The current analyzes of already collected material is not believed to incur any additional ethical considerations.

Results

Children

At baseline 2666 children participated (1349 (50.6%) boys and 1317 (49.4%) girls). At 1 year follow up 2308 children participated (87%). At 2 year follow up 2169 children participated (81%), and at 3 year follow up 1869 participated (70%).

Ninety-three (3.5%) of the children were small for gestational age (SGA), 2319 (89.9%) were appropriate for gestational age (AGA) and 167 (6.3%) were large for gestational age (LGA). Premature children, born before week 37, were 126 (4.7%) (table 1).

Parents

Mothers and fathers were cohabitant in 95.9%. Mother's mean age at birth was 31(range 15 to 46). Father's mean age was 34 (range 17 to 75). Mother's mean length was 167 cm. Father's mean length was 181 cm (table 2). Mother's mean BMI was 23.6, and 25.0% were overweight including 7.6% obese. Father's mean BMI was 25.4, and 43.3% were overweight including 7.1% obese. For parental medical condition and heritage for metabolic syndrome see table 3. Among the parents 42.3% of the overweight mothers and 22.3% of the overweight fathers had heritage for overweight. And in obese parents 61.4% of the obese mothers and 42.7% of the obese fathers had heritage for overweight.

Predictors of large waist to height ratio

Possible predictors besides prematurity and gestational age were first analyzed univariate with regard to waist to height ratio at 1, 2 and 3 years. Mother having a higher BMI was nearly significantly associated with larger waist to height ratio at 1 year (p=0.064), but not at 2 or 3 year follow up. There were no significant associations with regard to fathers BMI. Mother’s or father´s family history of overweight was not associated to larger waist to height ratio at any follow up. This was also the case for family history of cardiovascular disease, high blood pressure or diabetes. Mother’s history of pre-eclampsia did not show any significant associations to the outcome. Mother’s own history of cardiovascular disease was significantly (p=0.034) associated to waist to height ratio at 2 years, with only 4.8% of the children in the upper quartile compared to 24.8% for cardiovascular healthy mothers. At 3 years there was still a difference (7.1% vs 25.1%; p=0.122), though not statistically significant.

Factors that were significant in the univariate analyses were stepwise introduced into multiple logistic regression models with waist to height ratio at 1, 2 and 3 years as outcome. A final model with prematurity, size for gestational age and parental BMI emerged. Although only mothers BMI were significantly associated, fathers BMI were also introduced into the models due to the research question.

Prematurely born children had a risk of larger waist to height ratio at 1 year of age (OR 1.80), but not at 2 or 3 years, compared to children born term. Children born LGA had a nearly significantly increased risk (OR 1.58) of a large waist to height ratio at the age of 3. Children born SGA had no increased risk of larger waist to height ratio at any age. Mothers BMI nearly significant (p=0.064) increased the risk (OR 1.024 per step in BMI) of a large waist to height ratio at the age of 1 (table 4).

Discussion

Prematurely born children had a risk of larger waist to height ratio at 1 year of age, but not at 2 or 3 years, compared to children born term. Children born SGA had no increased risk of larger waist to height ratio at any age. Children born LGA had an increased waist to length ratio at 3 years. Children at 1 year of age showed a nearly statistical significant increased risk of large waist to length ratio with regard to a higher mothers BMI, not longer visible at age 2 and 3.

In our study prematurely born children have an increased risk of larger waist to height ratio at 1 year of age. This is not longer visible at age 2 and 3. Children born prematurely before 32 weeks of gestational age are found to be insulin resistant during childhood(13). They present lean with a smaller total fat mass and a predominantly central distribution measured with magnetic resonance imaging at term(19) and this situation is preserved into young adulthood as measured with indirect methods(20). Body composistion in children born moderately preterm (GA 32-37 weeks) has not been extensively studied. In our study we excluded children born extremely preterm since the recruitement procedures through CHC rendered a not representative number of extremely premature children, still the moderately premature children in our study had an increased risk of a large waist to height ratio at 1 year of age. This may point to different body composition in infancy. Children born moderately preterm may have a extrauterine growth retardation due to the premature birth but severe illness is often not present.

The result of several other studies shows that both children born with a low birth weight and SGA children with a rapid catch up in weight have an increased risk of large waist circumference. In a study with Spanish children the SGA children had largely completed their catch-up growth and weight gain at age 2. In spite of that SGA children progressively gained more body fat and abdominal fat mass than AGA children between ages 2 and 4(21). The ALSPAC cohort (the avon longitudinal study of parents and children) in England showed that a small size at birth and by rapid early postnatal weight gain was a risk factor for increased body fat mass and central fat distribution at 5 years of age(22) In a study of a Netherland cohort showed that rapid weight gain relative to height growth the first three months of life was associated with an increased waist circumference later in life(23). The studies above have also showed that going from a small size at birth to a larger size at childhood is a risk factor for developing insulin resistance. That could at adulthood indicate an increased risk for diabetes mellitus type 2 and metabolic syndrome.

In this study we found an increased waist to height ratio in children born LGA at the age of three years-An American study showed that LGA children remain larger during childhood, but they retain a harmonic body composition. The same study saw that diabetic mothers more often got LGA children. Those children had a larger waist circumference during childhood(14). We couldn't show any relationship between diabetes and LGA in our study. It could depend on the low number of diabetic mothers in our study (only 37). In a large study among Swedish mothers and their firstborn offspring they discovered that mothers born LGA had an increased risk for overweight and obesity, especially severe obesity, in adulthood. The rates of LGA offspring was also larger in women born LGA compared with mothers with lower birth weight for gestational age. The largest risk of having a LGA offspring had overweight and obese mothers born SGA. This is likely to further accelerate the obesity epidemic and increase fetal growth in the next generation(24).

Many studies have shown that a heritage for overweight and obese is a predictor for adult overweight(11, 25). Among the parents in our study a large proportion of the parents with overweight and obesity had heritage for overweight. That indicates that one of the predictors for adult overweight and obesity are heritage. We also discovered a risk in increased waist to height ratio for each step in BMI of the mothers at age 1. That may be due to a heritage influence on the children. A Swedish study reported that rates of overweight and obesity increased with mothers' birth weight and birth weight for gestational age, and were generally increased among mothers with low education, smokers, and among mothers with short stature(24). This study indicated the same as our study, that mothers with an increased BMI were likely to have larger children with an increased risk of future overweight and obesity.

Some studies have shown a connection between low socioeconomic status and overweight among children(4-6, 24-25). In our study we have looked at parental education as a marker of socioeconomic status but we have no results indicating a larger waist to height ratio among our children with low educated parents. Adding smoking as a marker socioeconomic status did not change the result.

We have not found any relationship that mothers smoking during pregnancy more often get premature children or children born SGA. There are other studies that show that children to smokers have lower birth weight and more often have SGA children or give birth preterm(25-26). The only reasonable explanation we have to children at age 2 whose mothers have a cardiovascular disease have a lower waist to height ratio is failure to thrive. There is no relationship between cardiovascular disease in the father and waist to height ratio in the child.

Strengths and limitations

The strength of this study is that it is based on a large cohort of children prospectively followed since birth. This study was carried out in a CHC setting and children were measured at their normal visit. 98.9% of the preschool children in the area visit the CHC and all data of length, weight, waist circumference and head circumference were collected by trained CHC nurses. Confirmations of these results should be possible in another cohort of children.

The study population was measured at their normal visit to the CHC, which rendered a broader range of exact ages of the study population when measured at 1, 2 and 3 years of age. Premature children where measured at chronological age and not corrected age. This may confound the results, so that the odds of having a greater waist to height ratio are underestimated. This may specially influence the results in the younger age group since most premature children have achieved their full catch up growth at 2 years of age. This problem could in further studies be overcome by transforming data to SDS according to existing growth charts

Since the study children were included at their first CHC visit most extremely prematurely born or sick newborns that required more than 4 weeks of neonatal care were maybe not eligible for the newborn questionnaire.

Limitations of this study are also that the questionnaires were filled out by the parents. There are data missing and answers are estimations. There is also a dropout from the study. We didn’t have all questionnaires among 3 year old children. In some analyzes lack of power could be a reason for not showing any differences, though this is true only for factors that are uncommon in the population and thus would need a much larger sample.

Conclusions

Both factors related to the child and to the mother predicted a larger waist to height ratio at follow up. In order to find children at risk for future overweight or obesity, it is important to take factors such as prematurity, size for gestational age and mother’s BMI into consideration.

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Tables

Table 1
Size for gestational age and prematurity

	N	Percent
Size		
SGA	93	3.5
AGA	2319	89.9
LGA	167	6.3
Missing	87	3.3
Total	2666	100
Age		
< 37 weeks	126	4.7
≥ 37 weeks	2505	94.0
Missing	35	1.3
Total	2666	100

SGA=Small for gestational age; AGA=Appropriate for gestational age; LGA=Large for gestational age.

Table 2
Parental data

	N	Minimum	Maximum	Mean	Std deviation
Mother					
Age	2627	15	46	31.1	4.9
Length	2620	134	186	167.1	6.2
Weight	2580	40	142	65.8	12.3
BMI	2566	14.9	46.8	23.6	4.1
Father					
Age	2497	17	75	33.7	5.8
Length	2434	150	203	181.0	6.5
Weight	2356	48	145	83.4	11.8
BMI	2335	14.9	40.3	25.4	3.2

Table 3
Parental BMI and risk factors

	Mother		Father	
	N	**Percent**	**Number**	**Percent**
BMI				
Underweight <18.5	78	2.9	12	0.5
Normal weight 18.5 – 24.9	1816	68.1	1169	43.8
Overweight 25.0 – 29.9	465	17.4	965	36.2
Obese >30	202	7.6	188	7.1
Missing	105	3.9	332	12.5
Total	2666	100	2666	100
Parental risk factors				
Overweight	667	25.0	1153	49.4
Diabetes	13+31[1]	0.5+1.7[1]	29	1.2
Cardiovascular disease	24	0.9	23	0.9
High bloodpressure	48	2.5	34	1.4
Preklampsia	73	3.2		
Smoking	144	5.5	240	9.7
Hereditary risk factors				
Overweight	617	24.6	398	16.6
Diabetes	546	21.5	433	17.9
Cardiovascular disease	617	24.4	520	21.7

[1]Gestational diabetes

Table 4
Waist to height ratio at follow up year 1, 2 and 3 depending on prematurity, size for gestational age and parental BMI

		No	**OR**	**95% CI**	**p**
Age 1 year					
Premature	No	1840	1.0		
	Yes	76	**1.80**	**1.12-2.92**	**0.016**
Size for gestational age	Appropriate	1732	1.0		
	Small	69	0.97	0.55-1.69	0.903
	Large	115	1.27	0.84-1.93	0.259
BMI mother		1916	**1.02**	**1.00-1.05**	**0.064**
BMI father		1916	1.02	0.99-1.06	0.227
Age 2 years					
Premature	No	1703	1.0		
	Yes	69	1.15	0.67-1.98	0.612
Size for gestational age	Appropriate	1603	1.0		
	Small	62	1.05	0.59-1.88	0.864
	Large	107	0.85	0.53-1.36	0.486
BMI mother		1772	1.02	0.99-1.05	0.177
BMI father		1772	1.01	0.97-1.04	0.623
Age 3 years					
Premature	No	1493	1.0		
	Yes	71	0.87	0.50-1.57	0.678
Size for gestational age	Appropriate	1414			
	Small	54	0.61	0.30-1.27	0.184
	Large	96	**1.58**	**1.00-2.41**	**0.052**
BMI mother		1564	1.02	0.99-1.04	0.278
BMI father		1564	1.01	0.97-1.05	0.613