Extreme Preterm Infant Rates of Overweight and Obesity at School Age in the SUPPORT Neuroimaging and Neurodevelopmental Outcomes Cohort

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Abstract

Objective—To identify rates of overweight (BMI ≥ 85th percentile) and obesity (BMI ≥ 95th percentile) at 6-7 years of age and associated risk factors among extremely preterm infants born at < 28 weeks of gestation.

Study design—Anthropometrics, blood pressure, and active and sedentary activity levels were prospectively assessed. Three groups were compared, those with BMI ≥ 85th percentile (overweight or obese for age, height and sex) and ≥ 95th percentile (obese) versus <85th percentile. Multiple regression analyses estimated the relative risks of BMI ≥ 85th percentile and ≥ 95th percentile associated with perinatal and early childhood factors.

Results—Of 388 children, 22% had a BMI ≥ 85th percentile and 10% were obese. Obese children and overweight children compared with normal weight children had higher body fat (subscapular skinfold and triceps skinfold> 85th percentile), central fat (waist circumference> 90th percentile), spent more time in sedentary activity (20.5 versus 18.2 versus 16.7 hours/week), and had either systolic and/or diastolic hypertension (24% versus 26% versus 14 %) respectively. Post discharge

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weight gain velocities from 36 weeks postmenstrual age (PMA) to 18 months, and 18 months to 6-7 years were independently associated with BMI ≥ 85th percentile whereas weight-gain velocity from 18 months to 6-7 years was associated with obesity.

Conclusions—One in five former extremely preterm infants is overweight or obese and has central obesity at early school age. Post discharge weight gain velocities were associated with overweight and obesity. These findings suggest the obesity epidemic is spreading to the most extremely preterm infants.

Trial registration ClinicalTrials.gov NCT00063063 and NCT0000

Keywords

preterm; overweight; obese; hypertension; sedentary activity; school age

The current epidemic of obesity and associated cardiovascular morbidities in the United States is a significant public health problem,[1–4][4–7] but there have been few longitudinal investigations of very preterm infants to evaluate whether they are at risk for long term effects of overweight and obesity.[7–11] Most studies of older PT infants reported that they are shorter and weigh less than term control infants.[8, 11, 12–18] However, there has been limited evaluation of rates of overweight and obesity among extremely preterm (EPT) children at early school age born in the post-surfactant era.

Findings of elevated body mass index (BMI) in childhood are of concern because obesity is associated with abnormal levels of lipids, insulin and blood pressure (BP)[19, 20] Barker[21, 22] first proposed the "fetal origins" of adult disease hypothesis, demonstrating that alterations in fetal nutrition causing intrauterine growth restriction were associated with developmental adaptations that predispose to adult cardiovascular and metabolic disease. The original concept in growth-restricted term infants[23] has been expanded to concerns about "rapid early catch-up growth" of preterm infants predisposing to increased cardiovascular risk and obesity.[7, 23]

The primary objective of this study was to identify the risk for weight-related outcomes at early school age among EPT children born at < 28 weeks of gestation, including rates of overweight or obesity, obesity, central obesity, and associated high BP and hypertension. The second objective was to determine risk factors associated with BMI ≥ 85th percentile and BMI ≥ 95th percentile, including weight gain velocities from birth to 36 weeks postmenstrual age (PMA), 36 weeks PMA to 18-22 months corrected age (CA), and 18-22 months CA to 6-7 years. Associations of BMI ≥ 85th percentile with maternal and neonatal risk factors and 6-7 year BP and activity levels were examined. It was hypothesized that increased early weight gain velocity would be associated with overweight, obesity and central obesity among EPT.

Methods

The obesity study was a selective secondary to the National Institute of Child Health and Human Development (NICHD) Neonatal Network SUPPORT Neuroimaging and Neurodevelopmental Outcomes (NEURO) school age cohort.[24] The children were originally

enrolled in SUPPORT, a randomized, multicenter trial of ventilation and oxygenation management strategies for infants born at 24-27$^{6/7}$ weeks of gestation (ClinicalTrials.gov: NCT00233324)[25, 26] The subset of children with anthropometric data at 6-7 year follow-up was eligible (N=412). Twenty-four children were excluded for severe growth failure associated with short bowel syndrome (N=2), a congenital syndrome or chromosomal abnormality (N=9), and missing weight (N=4) or height data (N=9) needed to compute BMI percentiles. In the final dataset, 388/412 (94%) children were included. Prenatal and neonatal data from the SUPPORT cohort database including demographics, anthropometrics and BP obtained at 6 years, 4 months to 7 years, 2 months were analyzed.

Measurements at birth, 36 weeks PMA, and 18-22 months CA were retrieved for analyses from the NRN database. Fenton[27] growth charts were used at birth and 36 weeks PMA and the Centers for Disease Control and Prevention growth charts[28, 29] were used at 18 months CA and 6-7 years of age. Standardized methods for measurements were utilized at all sites. [30] Duplicate measurements of weight, height, head circumference, waist circumference, subcutaneous skinfold measurements and BP were obtained at 6-7 years of age.

Overweight or obesity was defined as a BMI >85th percentile and obesity as a BMI >95th percentile. BMI was calculated as Wt (Kg)/height (M^2)/ A waist circumference > 90th percentile was used as an indicator of central adiposity.[31] Skinfolds were categorized as 85th percentile (overweight) and 95th percentile (obese).[32] Measurements obtained to differentiate central adiposity from peripheral adiposity included triceps, subscapular, and abdominal skinfolds which are part of a standard assessment of obesity for children.[33]

Skinfolds were measured with a Lange Skinfold Caliper (Cambridge Scientific Industries, Inc., Cambridge, MD) using standard techniques. All skinfold measurements were taken twice on the right side. If there was > 2 mm difference between measurements, the measurement was taken a 3rd time and the 2 measurements within 2 mm of each other were recorded. Waist circumference was taken horizontally at the level of the narrowest part of the torso with the child standing and relaxed. Head and waist circumferences were measured twice using an inelastic, flexible, retractable metal tape. The head circumference was the largest occipital-frontal measurement obtained with the tape placed superior to the eyebrows. Weight and height were obtained using a standard upright scale. The head was in the Frankfort plane, with subjects fully erect and in stocking feet. Weight gain velocities were calculated as grams/week from birth to 36 weeks PMA, and kg/month from 36 weeks PMA to 18-22 months CA and 18-22 months CA to 6-7 years of age. Site examiners were trained in all measurement techniques.[34] Techniques recommended by the Fourth Task Force on Blood Pressure Control for Children were followed for obtaining BP.[35, 36] Children sat in a quiet room with the right arm fully exposed and resting on a supportive surface at heart level. The American Diagnostic Corporation ADC E Sphygmomanometer automatically measured systolic and diastolic BP, and pulse rate. The appropriate-sized cuff to cover approximately 75% of the upper arm between the top of the shoulder to the olecranon was used. BP was measured twice 2 minutes apart.

BP was classified as normal (average systolic and diastolic BP < 90th percentile), high BP (average systolic or diastolic BP of 90-95th percentile), and high BP or hypertension

(average systolic or diastolic BP   95th percentile) using updated definitions and nomograms for BP by age and sex for height developed by the Fourth Task Force Report on Blood Pressure.[36]

A brief parent questionnaire of physical and sedentary behavior derived from the NICHD study on growth and calcium intake was completed.[37] The activity questionnaire includes questions which reflect either sedentary screen activity (eg, television or computer time) or active physical activity (eg, sports or dance). Parents reported the number of minutes or hours/day for weekdays and weekends that the child participates in these activities. All site examiners received reliability training in study procedures. Institutional review board approval was obtained, and all parents provided informed consent.

Statistical analyses

A power analysis indicated the study would have 91% power to detect differences in means for continuous variables between children who were overweight or obese (BMI   85th percentile, n=89) versus not overweight or obese (BMI <85th percentile, n=310) with an alpha of P = .05, assuming a medium-sized effect (Cohen's d=0.5). Bivariate analyses tested for differences in the characteristics of children with a BMI   85th percentile versus <85th percentile and for BMI   95th percentile versus <85th percentile at 6-7 years, using chi-square tests and t-tests as appropriate. Median tests were used to compare continuous variables with skewed distributions. The association of physical activity and sedentary activity rates with overweight and obesity were also explored. Regression models with generalized estimating equations were conducted to identify antenatal, neonatal, social and demographic factors that predicted BMI   85th percentile and BMI   95th percentile, accounting for clustering by study site. Independent variables associated with cardiovascular sequelae were selected based on the literature. Effects of sex, public insurance, minority race, birth weight, antenatal steroids, and weight gain velocity between birth and 36 weeks PMA, 36 weeks PMA to 18-22 months CA, and 18-22 months CA to 6-7 years were examined in bivariate and regression analyses. Relative risks and 95% confidence intervals were computed to quantify the relationship between the independent variables and BMI. Analyses were conducted using SAS statistical software, which were carried out by the NRN Data Coordinating Center, Research Triangle Institute International.

Results

Among the 388 EPT children with BMI data at 6-7 years, 86 (22%) were either overweight or obese (BMI   85th percentile), of which 39 (10%) were obese (BMI   95th percentile). Maternal and infant characteristics by child BMI categories are shown in Table I. There were no differences between groups in maternal age, race, health insurance, education level, or sex. Cesarean delivery rate was higher in the normal/low weight group. Infant differences identified for those with a BMI   85th percentile were higher birthweight and birth weight z-score, lower rates of intrauterine growth restriction, lower rates of bronchopulmonary dysplasia (BPD), and lower rates of receiving steroids for BPD. Table 2 shows that children with a BMI   85th percentile were heavier and taller at 36 weeks PMA and 18 months CA

and had consistently higher growth velocities from birth to 36 weeks PMA, 36 weeks PMA to 18-22 months CA and 18-22 months CA to 6-7 years of age.

Child anthropometrics and BPs at 6-7 years of age are shown in Table 3. Compared with children with a BMI <85th percentile, children with a BMI 85th percentile and 95th percentile had increased height, waist circumference >90th percentile, waist-height ratio, and abdominal, triceps, and subscapular skinfolds. Overweight and obese EPT children also had higher systolic and diastolic mean BPs, and higher rates of systolic hypertension. In addition, 86/302 (28%) children in the normal/underweight group had weights <10th percentile and 72/388 (19%) had heights <10th percentile. Five percent of children in the overweight group had heights <10th percentile. We compared children with weights <10th percentile to those with weights >10th percentile on the maternal and infant characteristic shown in Table 1 using chi-square tests. Children with weights <10th percentile at 6-7 years of age were significantly less likely to have mothers who received antenatal steroids (p=0.032) and were more likely to have weight <10th percentile at birth (p < 0.001), an adverse finding on an early cranial ultrasound (CUS) (p=0.035) or a late CUS (p=0.050), moderate/severe white matter injury on magnetic resonance imaging (p < 0.001), BPD (p < 0.001), steroids for BPD (p=0.023), and severe retinopathy of prematurity (p < 0.001). Similar comparisons were conducted based on height percentiles. Children with height <10th percentile at 6-7 years of age were significantly less likely to have mothers who received antenatal steroids (p=0.011) and were more likely to be white (p=0.048) and have human milk in first 28 days (p=0.031), adverse findings on early CUS (p=0.008) or late CUS (p=0.016), and moderate/severe white matter injury (p < 0.001).

Rates of physical and sedentary activity are shown in Table 4 (available at www.jpeds.com). There were no differences between groups in active physical activity (<1 hour/week for all groups). However, children with a BMI 95th percentile and BMI 85th percentile versus BMI <85th percentile had a significantly longer duration of mean hours of sedentary activity using electronic devices both during the 5 weekdays and for the total week. Total sedentary activity for screen time for the cohort ranged from 0-40.3 hours per week. Among obese EPT children, 62% had a television and 44% a computer in their bedroom.

The Figure (available at www.jpeds.com) shows the z-scores for weight and height at 6-7 years by BMI <85th percentile versus 85th percentile by sex. In addition to the high scores for weight, all height z-scores for both boys and girls with a BMI 85th percentile were above zero and significantly higher (p<.001) than for those with a BMI <85th percentile. For boys with a BMI 85th percentile versus <85th percentile, the median height z-scores were 0.44 versus −0.67 and for girls were 0.44 versus −0.54, respectively. There were no sex differences.

The regression models to predict BMI 85th percentile and BMI >95th percentile are shown in Table 5. Significant predictors of overweight were weight gain velocities from 36 weeks PMA to 18-22 months CA and from 18-22 months CA to 6-7 years. Only weight gain velocity between 18-22 months and 6-7 years was significantly associated with obesity. Antenatal steroids were protective of overweight and borderline protective of obesity. The risk ratio for obesity contributed by total sedentary activities was 1.03 (0.99 to 1.06)

Discussion

Consistent with our study objective, we identified that 22% of EPT children were overweight or obese and 10% were obese at early school age. In the EPICURE study of EPT infants 25 weeks of gestation from the United Kingdom and Ireland born in 1995, at a median age of 6 years, children had a mean BMI z-score of −0.88±1.3.[38] The BMI z-scores in our cohort at the same age ranged from −0.6 for children with a BMI <85% to 2.0 for the obese children. Our more contemporary cohort was enrolled between February 2005 and 2009 with subsequent follow-up during a period of increasing rates of overweight and obesity in children and adolescents reported worldwide. Hack et al reported that rates of obesity in a cohort of extremely low birth weight (ELBW, birth weights < 1000 grams) born from 1992-1995 increased from 12% at 8 years to 19% at 14 years.[7, 9] A number of studies have reported increased rates of overweight and obesity among preterm children in adolescence and early adulthood.[10, 39] The most recent National Center for Health Statistics obesity rates for the United States (US) are 8.9% for ages 2-5 years and 17.5% for 6-11 years.[2] The preterm children in our cohort had an obesity rate of 10% at a mean age of 6.8 years. The prevalence of obesity in this cohort of EPT children is lower than the prevalence in population data but higher than expected for EPT children. The SUPPORT cohort children were born in 2005-2009 and evaluated in 2012 to 2015. Obesity rates have been increasing in the general pediatric population between 2005 and 2015. We addressed this by comparing the cohort to US population data for obesity trends for 2013-2014.[3] The weighted prevalence obesity rate for 6-11 year old children was 17.5 (15.2-20.1). There were no sex differences. The US data for 2015-2016 indicates the rate is continuing to increase for children and is now 18.4 (6-11) for children 6-11 years. Longer follow-up of anthropometrics is needed to determine the extent of impact as rates of obesity increase with increasing age.

Our findings provide evidence for increased central obesity in the preterm population. At early school age, 27% of the EPT children with a BMI 85th percentile and 39% with a BMI 95th percentile had a waist circumference >90th percentile. In addition, abdominal skinfolds and waist-height ratios were significantly greater in the children who were overweight and obese. This is an important finding because central obesity has been shown to be a better predictor than overall obesity of subsequent risk of type II diabetes, cardiovascular disease, and hypertension.[19,40–42]

The finding of height z-scores above zero (0.44) for both boys and girls with a BMI 85th percentile at 6-7 years of age suggests that a subgroup of preterm survivors is beginning to catchup in height to mean scores for term children by early school age. Our findings are in contrast to those of Doyle et al, who reported that although a cohort of ELBW infants were relatively heavy for their height, their height z-scores were significantly below zero at ages 2, 5, 8, 14, and 20 years.[8] Preterm children who were enrolled in the indomethacin for intracranial hemorrhage prevention trial[39] were shorter and weighed less than term controls at 16 years of age; however, they had a high rate of overweight or obesity (31%) and obesity (16%) at 16 years of age. A recent review[43] of studies reporting adult outcomes of preterm birth confirms that preterm survivors are at increased risk of numerous adverse health outcome including cardiovascular disease and hypertension.

The significant predictor of BMI >85th percentile in our cohort was rapid catch-up growth that began in the hospital and accelerated after discharge from the hospital as reflected by weight gain velocities from 36 weeks PMA to 18-22 months CA and from 18-22 months CA to 6-7 years of age. This is consistent with results from the indomethacin cohort[39] in which weight gain velocity between birth and 36 months significantly predicted obesity at 16 years of age. The Avon longitudinal study in the United Kingdom in a general population also found that increased catch-up growth between birth and 3 years was associated with increased obesity and central obesity at 5 years of age.[23] Hack et al reported that the rate of growth in childhood and maternal BMI rather than perinatal risk factors predicted obesity at 14 years among former ELBW infants.[7] Finally, children in low SES families are known to be at increased risk of obesity.[44, 45] However, in this cohort there were no differences in level of education, race, or health insurance of mothers at the time of enrollment as shown in Table 1.

In addition, children in the SUPPORT cohort with a BMI ≥ 85th percentile were significantly more likely to have higher systolic and diastolic BP and higher rates of systolic hypertension or either systolic or diastolic hypertension (P<0.0001). Evidence of elevated BP has been reported as early as 1 year of age among former preterm infants.[46] The finding in association with overweight and obesity is of particular concern and is consistent with findings of increasing obesity and hypertension in the general US population.[3]

The only maternal characteristic that was protective in our regression model was maternal antenatal steroids. Overweight and obese children also had a higher birth weight z-score, were less like to have BPD, and were less likely to receive postnatal steroids for BPD. We propose that overweight and obese 6 to 7-year-old children may have had a more optimal in-utero environment and had somewhat decreased early neonatal illness severity. In addition, the infants who were growth restricted at birth were less likely to have received ANS, more likely to have had multiple neonatal morbidities, and more likely to have weight <10th percentile at school age. This may account for some of the apparent protective effects of ANS that were identified in our regression analysis to predict overweight and obesity.

In addition, the infants who were growth restricted at birth continued to have evidence of slow growth. They were less likely to receive ANS and more likely to experience neonatal morbidities, which may account for some of the protective effects of ANS on obesity that were identified in our regression analysis. Finally, although extended feeding of human milk has been associated with decreased rates of obesity[47], we only have data on human milk in the first 28 days with rates of 89 and 90% for the children with BMI <85th percentile and ≥ 85th percentile respectively.

Low activity levels and increased screen time have been associated with childhood obesity. [48, 49] In 2015, the American Academy of Pediatrics updated their recommendations to 60 minutes/day of physical activity for children ≥ 6 years of age. We identified that children in our cohort spent an average of <1 hour per week in active physical activity, although sedentary screen activity including television, tablets, smart phones and electronic games was 16.7 hours/week for children with BMI <85th percentile, 18.2 hours/week for children with a BMI ≥ 85th percentile and 20.5 hours/week for obese children. In addition, children

who were overweight or obese spent more time on weekdays participating in sedentary screen activity. As of 10/21/2016 the American Academy of Pediatrics recommends that children ages 2-5 years limit screen use to 1 hour per day of high-quality programs and that for children ages 6 years, parents place consistent limits on the time spent using media. (https://healthychildren.org/English/news/Pages/AAP-Announces-New-Recommendations-for-Childrens-Media-Use.aspx) Some children in our study groups spent up to 40 hours/ week on screen time. Although we are living in the electronic media age, there is increasing evidence that increased screen time has deleterious effects on children including obesity, decreased physical activity, learning problems and absenteeism.[48–51] A recent study of children at 8-10 years of age who were evaluated twice over two years found that higher levels of moderate-to-vigorous physical activity and lower screen time were beneficial to insulin sensitivity in part through their effect on adiposity levels.[49] Studies have shown that young adult former preterm infants spend less leisure time in physical activity.[52] A limitation is that our activity data were obtained by parent report which may be either over or underestimated, rather than an objective assessment such as actigraphy or the 6 minute walk test.[53–55]

Although there is a body of evidence showing a relationship between low socioeconomic status and higher rates of obesity in middle-school-age children, adolescents and adults,[44, 56, 5744, 45] we did not find a significant relationship between Medicaid insurance and risk of overweight or obesity at 6-7 years. However, in our cohort there were no differences in level of education, race, or health insurance of mothers at the time of delivery. There is also evidence that food insecurity and problems associated with food acquisition, preparation and knowledge are associated with overweight.[58] Further evaluation of these aspects of nutritional intake over time is needed. There is moderate evidence that interventions with families and in schools can have beneficial effects on reducing rates of obesity in children and are in fact cost effective.[59, 60] Use of parent mentors is one cost effective approach which has been shown to have benefits.[61] Of equal importance is that the growth outcomes reflect a bell shaped curve in which 22% of the cohort were overweight or obese and an equal 22% were below the 10th percentile for weight at early school age. Current data suggest the percent of preterm infants with poor growth at followup continues to improve.[62]

Strengths of this study are the availability of comprehensive perinatal, neonatal, maternal, and infant data, and longitudinal anthropometric and BP data. Limitations include the lack of a full-term control population and data on maternal pre-pregnancy weight, weight gain in pregnancy, nutrition intake in the NICU and family diet.

In summary, the epidemic of overweight and obesity appears to be spreading to even the most extreme preterm infants. The findings of increased post-discharge weight gain velocities as a predictor of BMI 85th percentile, and the associated low physical activity and increased screen time may in part be related to changes in the US culture. Of particular concern are the findings at early school age of associated central adiposity and elevated BP which are highly associated with subsequent metabolic abnormalities and cardiovascular disease. These findings should be a wake-up call for both pediatricians and the internists who are currently caring for or will be managing these former preterm future adults.

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Acknowledgments

Appendix

List of additional members from the *Eunice Kennedy Shriver* National Institute of Child Health and Development Neonatal Research Network

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Abbreviations

BMI   body mass index

BP	blood pressure
IVH	intraventricular hemorrhage
PVL	periventricular hemorrhage
VLBW	very low birth weight

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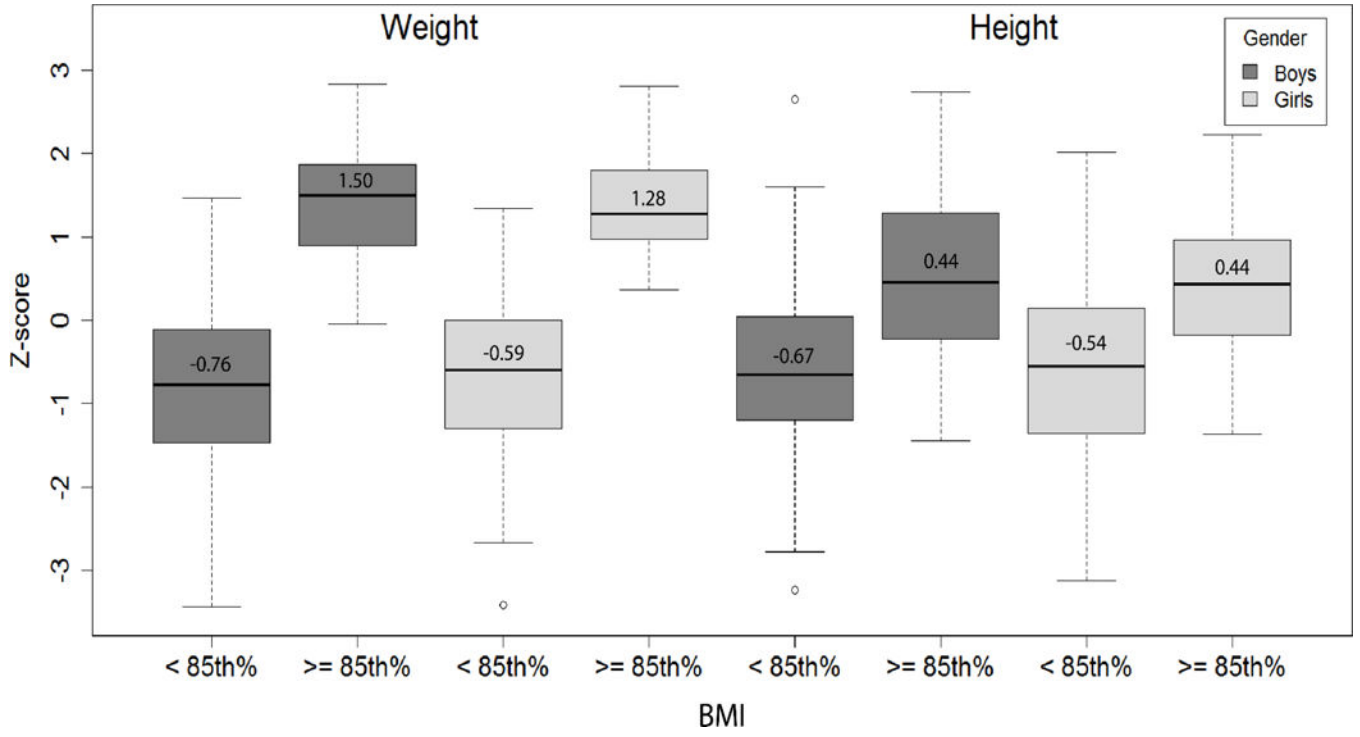
Figure 1. Weight and Height Z-Scores by Gender and BMI - online
Note: Comparisons of BMI < 85th% vs. BMI >= 85th % significant at p < 0.001

Table 1

Maternal and Infant Characteristics by BMI

Characteristic	Normal/Underweight BMI< 85 Percentile	Overweight/Obese BMI 85 Percentile	P value
	N=302	**N=86**	
Male	162 (54)	48 (56)	.721
Female	140 (46)	38 (44)	
Maternal age	27.8 ± 7	28.0 ± 7	.780
Maternal age < 20	38 (13)	9 (10)	.595
Race Black	91 (30)	29 (34)	.089
White	136 (45)	27 (31)	
Hispanic	66 (22)	28 (33)	
Other	9 (3)	2 (2)	
Maternal education			
Less than high school	73 (25)	23 (27)	.654
High school graduate or more	223 (75)	62 (73)	
Hypertension in pregnancy	77 (23)	22 (26)	.987
Diabetes in pregnancy	20 (7)	8 (9)	.397
Antenatal steroids	287 (95)	82 (95)	.905
Cesarean section	207 (69)	48 (56)	.028
Birth weight grams	849 ± 189	904 ± 186	.019
Birth weight below 10th %	26 (9)	2 (2)	.047
Birth weight z score	−0.1 ± 0.9	0.1 ± 0.9	.043
Percent weight loss	12.7 ± 6	12.1 ± 6	.459
Days to regain birth weight	11.5 ± 5	11.5 ± 5	.952
Human milk in first 28 days	269 (89)	77 (90)	.903
Gestation (weeks)	25.9 ± 1	26.0 ± 1	.250
Adverse finding on early ultrasound	28 (9)	8 (9)	1.000
Adverse finding on Late ultrasound	18 (6)	9 (10)	.150
White Matter injury (moderate/severe)	63 (21)	14 (16)	.347
BPD	122 (40)	20 (23)	.004
Steroids for BPD	27 (9)	1 (1)	.014
Late Onset sepsis	92 (30)	25 (29)	.804
Proven NEC	23 (8)	5 (6)	.569
Severe ROP	42 (15)	6 (8)	.104
Days of Hospitalization	102.7 ± 40	95.5 ± 42	.145

Note: N (%) or mean ± SD

Table 2

Child growth characteristics at 36 weeks and 18 months corrected age

Characteristic	Normal/Underweight BMI< 85 Percentile	Overweight/Obese BMI 85 Percentile	P value
	N=302	**N=86**	
Weight			
Weight at 36 weeks (kg)	2.1 ± 0.4	2.2 ± 0.4	.041
Weight % at 36 weeks	10.8 ± 15	14.8 ± 18	.046
Weight z score at 36 weeks	−1.7 ± 1	−1.4 ± 1	.041
Weight at 18 months (kg)	10.5 ± 1	12.3 ± 2	< .001
Weight % at 18 months	16.7 ± 21	49.7 ± 32	< .001
Weight z score at 18 months	−1.6 ± 1	0.0 ± 1	< .001
Height			
Height at 18 months (cm)	81.0 ± 4	83.0 ± 4	< .001
Height % at 18 months	20.6 ± 22	36.0 ± 28	< .001
Height z score at 18 months	−1.2 ± 1	−0.5 ± 1	< .001
Weight gain velocities			
Birth- 36 weeks (g/w)	133.8 ± 32	143.2 ± 38	.032
Time birth wt regained to 36 weeks (g/w)	166.7 ± 47	178.5 ± 49	.063
36 weeks to 18-22 months (kg/yr)	8.0 ± 2	9.9 ± 2	< .001
18-22months to 6-7 years (kg/yr)	2.3 ± .5	3.8 ± .9	< .001

Note: mean ± SD

Table 3

Child Characteristics at 6-7 years

Characteristic	Normal/ Underweight BMI <85 Percentile	Overweight/Obese BMI ≥85 Percentile	Overweight/Obese versus Normal/Underweight	Obese BMI ≥95 Percentile	Obese versus Normal/Underweight
	N=302	N=86	p-value	N=39	p-value
Mean age (years)	6.3 ± .5	6.3 ± .5	.481	6.2 ± 0.4	.121
Mean BMI	14.9 ± 1.2	19.4 ± 1.8	<.001	20.8 ± 1.7	<.001
BMI z score	−0.6 ± 1.0	1.6 ± 0.4	<.001	2.0 ± 0.3	<.001
Health Insurance- Public	174 (58)	47 (55)	.580	21 (54)	.622
Weight (kg)	20.5 ± 3	29.4 ± 4	<.001	31.7 ± 5	<.001
Weight %	30.3 ± 25	88.6 ± 10	<.001	94.3 ± 6	<.001
Weight below 10th%	86 (28)	0 (0)	<.001	0 (0)	<.001
Weight z score	−0.7 ± 1	1.4 ± .6	<.001	1.8 ± 0.6	<.001
Height (cm)	117.2 ± 6	123.0 ± 6	<.001	123.3 ± 6	<.001
Height %	34.6 ± 28	63.0 ± 28	<.001	66.5 ± 29	<.001
Height below 10th%	72 (24)	4 (5)	<.001	2 (5)	.008
Height z score	−0.6 ± 1.1	0.5 ± 1.0	<.001	0.6 ± 1	<.001
Waist circumference (cm)	54.1 ± 4	66.3 ± 8	<.001	68.6 ± 6	<.001
Waist Circumference>90th%	1 (0)	28 (33)	<.001	19 (50)	<.001
Waist-height ratio	0.5 ± 0.0	0.5 ± 0.1	<.001	0.6 ± 0.0	<.001
Triceps skinfold (mm)	8.1 ± 3	14.2 ± 4	<.001	15.6 ± 4	<.001
Triceps skinfold> 85th%	17 (6)	50 (62)	<.001	29 (81)	<.001
Triceps skinfold> 95th%	2 (1)	26 (32)	<.001	18 (50)	<.001
Subscapular skinfold (mm)	5.2 ± 2	10.3 ± 4	<.001	11.4 ± 4	<.001
Subscapular skinfold>85th%	26 (9)	60 (74)	<.001	31 (86)	<.001
Subscapular skinfold>95th%	7 (2)	33 (41)	<.001	19 (53)	<.001
Abdominal skinfold (mm)	6.8 ± 3	13.7 ± 7	<.001	15.8 ± 8	<.001
Systolic blood pressure mm Hg	99.6 ± 8	105.3 ± 9	<.001	105.4 ± 9	<.001
Systolic blood pressure %	64.1 ± 23	71.9 ± 21	.006	72.2 ± 21	.043

Characteristic	Normal/Underweight BMI <85 Percentile	Overweight/Obese BMI ≥85 Percentile	Overweight/Obese versus Normal/Underweight	Obese BMI ≥95 Percentile	Obese versus Normal/Underweight
	N=302	N=86	p-value	N=39	p-value
Systolic prehypertension (≥90%)*	39 (13)	20 (23)	.019	7 (19)	.363
Systolic hypertension (≥95th%)	17 (6)	13 (15)	.004	5 (14)	.079
Diastolic blood pressure mm Hg	62.3 ± 8	64.7 ± 9	.013	65.0 ± 9	.045
Diastolic blood pressure %	68.3 ± 20	70.8 ± 20	.311	71.2 ± 20	.413
Diastolic prehypertension (≥90%)	39 (13)	15 (17)	.285	5 (14)	.985
Diastolic hypertension (≥95%)	17 (6)	9 (10)	.114	4 (11)	.245
Systolic or diastolic prehypertension	63(21%)	26(30%)	.068	9 (24)	.711
Systolic or diastolic hypertension	26(9%)	17(20%)	<.004	34 (87)	.017
Heart rate	81.3 ± 12	81.9 ± 13	.709	84.3 ± 16	.195

Note: N (%) or mean ± SD

*
any blood pressure ≥90th% for age and height

Table 4

Active Physical and sedentary activity rates-online

Characteristic Activity	Normal/ Underweight BMI < 85 Percentile	Overweight/Obese BMI 85 Percentile	Overweight/Obese versus Normal/Underweight	Obese BMI 95 Percentile	Obese versus Normal/Underweight
	N=302	N=86	p-value	N=39	p-value
Physical - 5 week days					
Mean ± SD	0.5 ± 0.9	0.4 ± 0.8	.584	0.4 ± 0.8	.598
Median (IQR)	0.0 (0.0-0.6)	0.0 (0.0-0.6)	.871	0.0 (0.0-0.6)	.869
Range	0.0-5.0	0.0-3.6		0.0-3.6	
Physical - Weekend					
Mean ± SD	0.2 ± 0.3	0.2 ± 0.3	.584	0.2 ± 0.3	.598
Median (IQR)	0.0 (0.0-0.3)	0.0 (0.0-0.3)	.871	0.0 (0.0-0.3)	.869
Range	0.0-2.0	0.0-1.4		0.0-1.4	
Physical- Total					
Mean ± SD	0.7 ± 1.2	0.6 ± 1.1	.584	0.6 ± 1.2	.598
Median (IQR)	0.0 (0.0-0.9)	0.0 (0.0-0.9)	.871	0.0 (0.0-0.9)	.869
Range	0.0-7.0	0.0-5.0		0.0-5.0	
Sedentary -5 week days					
Mean ± SD	10.9 ± 7.7	12.4 ± 7.4	.108	14.0 ± 7.9	.019
Median (IQR)	8.8 (3.8-13.8)	8.8 (8.8-13.8)	.037	13.8 (8.8-18.8)	.011
Range	0.0-28.8	3.8-28.8		3.8-28.8	
Sedentary- Weekend					
Mean ± SD	5.8 ± 3.5	5.7 ± 3.1	.943	6.5 ± 3.1	.203
Median (IQR)	5.5 (3.5-7.5)	5.5 (3.5-7.5)	.285	5.5 (3.5-7.5)	.085
Range	0.0-11.5	0.0-11.5		1.5-11.5	
Sedentary - Total					
Mean ± SD	16.7 ± 10.3	18.2 ± 8.9	.229	20.5 ± 8.7	.026
Median (IQR)	14.3 (7.3-23.3)	17.3 (12.3-21.3)	.009	19.3 (14.3- 23.3)	.002
Range	0.0-40.3	3.8-40.3		5.3-40.3	
TV in bedroom N (%)	160 (53)	50 (58)	.413	24 (62)	.323

Characteristic Activity	Normal/ Underweight BMI < 85 Percentile	Overweight/Obese BMI 85 Percentile	Overweight/Obese versus Normal/Underweight	Obese BMI 95 Percentile	Obese versus Normal/Underweight
	N=302	**N=86**	**p-value**	**N=39**	**p-value**
Computer in bedroom N (%)	93 (31)	31 (36)	.367	17 (44)	.111

Table 5

Regression Analyses to Predict Overweight and Obesity

Variable	Overweight/Obese BMI 85 Percentile		Obese BMI 95 Percentile	
	Risk Ratio (95% CI)	P value	Risk Ratio (95% CI)	P value
Male	0.94 (0.65, 1.35)	.730	1.43 (0.84, 2.43)	.192
Public Insurance	0.89 (0.60, 1.32)	.553	0.65 (0.35, 1.20)	.166
Non-White	1.21 (0.84, 1.73)	.305	1.19 (0.66, 2.13)	.569
Birth weight (g)	1.00 (1.00, 1.00)	.743	1.00 (1.00, 1.00)	.118
Antenatal Steroids	**0.43 (0.23, 0.79)**	**.006**	0.33 (0.09, 1.24)	.100
Sedentary activities @6-7 years (hrs)	1.00 (0.98, 1.02)	.951	1.03 (0.99, 1.06)	.106
Birth- 36 weeks (g/week)	1.00 (0.99, 1.00)	.451	1.00 (0.99, 1.01)	.940
36 weeks to 18-22months (kg/yr)	**1.32 (1.18, 1.48)**	**< .001**	1.23 (0.95, 1.60)	.123
18-22months to 6-7 years (kg/yr)	**2.36 (2.07, 2.70)**	**< .001**	**3.25 (2.48, 4.26)**	**< .001**

Note: Models also control for center