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Racial Differences in Growth Rates and Body Composition of Infants Born Preterm

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Abstract

Objective—To evaluate racial disparities in weight gain velocity and body composition among preterm infants.

Study Design—This observational study analyzed race differences in fat-free mass (FFM), fat mass (FM), percent body fat (%BF), and weight gain at discharge of infants born at 25-32 weeks of gestation.

Results—No racial differences in FFM, FM and %BF measurements were found between black and white preterm infants after adjusting for birth weight, gestational age, and the presence/absence of breastfeeding (n=143). Black infants born preterm had lower birthweights and higher weight gain from birth to discharge in unadjusted and adjusted models (13 ± 3 vs. 11 ± 3 g/kg/day; <0.001).

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Conflict of Interest Disclosures: MJ, PL, and OA have no conflicts of interest to disclose. PCL and AAS have filed a patent application for an instrumented feeding bottle. AAS has received honoraria from the Lockwood Group for participation in advisory board meetings.

Ethics Approval: The UAB Institutional Review Board approved the individual study protocols and the study protocol for this secondary analysis. The study was performed in accordance with the Declaration of Helsinki.

Among black infants born at term, lower amounts of lean mass at birth and higher risk of rapid weight gain are observed. These racial differences in growth outcomes may contribute to disparities in pediatric obesity. There is no clinical evidence that these racial differences exist among infants born preterm. This study compares weight gain and body composition at discharge between black and white preterm infants. In this cohort of 143 infants born preterm, black infants compared with white infants had more rapid weight gain and similar body composition measurements at discharge. These findings highlight the importance of health disparity research in growth outcomes.

Conclusion—Black infants had higher weight gain from birth to discharge, but comparable body composition measurements at discharge. More research is needed to understand contributing factors and long-term implications of this finding.

Introduction

Differences in health outcomes by race have been well documented in infants born at term. Black infants born at term have higher mortality and morbidity rates. Black infants born at term also have lower weights and lower amounts of lean body mass in late gestation and at birth^{1,2}. After birth, black infants born at term often experience more periods of rapid growth than white infants born at term, a known risk factor for obesity³. Limited evidence suggests that these racial differences also exist among black infants born preterm, a vulnerable population that often experience a higher proportion of comorbidities that affect neurodevelopment⁴. Potential explanations of race disparities in clinical outcomes seen in preterm infants, discussed by Burris et al in the context of bronchopulmonary dysplasia, include genetics, social/environmental factors, and differences in care, or potential combinations of all 3⁵. As discussed by Burris et al, black race likely does not represent a specific genetic profile⁵. Social and environmental factors experienced by black mothers are known to affect birth outcomes, including birthweight, which may in turn affect postnatal growth patterns⁶. Differences in clinical practices by race also have the potential to impact postnatal growth. Sigurdson et al summarize the well-known finding of disparities in breast milk feeding that disadvantage black infants. Furthermore, qualitative research suggests that black mothers report receiving limited breastfeeding education and support⁷. These differences in care in maternal breastfeeding support and feeding type in infants may also affect postnatal growth and body composition.

Critical aspects of quality of care in the neonatal intensive care unit (NICU) include delivering optimal nutrition, attaining recommended intrauterine rates of weight gain, and monitoring quality of growth. When weight gain is comprised of higher fat-free mass (FFM) gains during the NICU stay, weight gain is predictive of favorable neurodevelopmental outcomes later in childhood⁸. Growth and body composition of preterm infants are mainly affected by illness severity and nutritional practices⁹, but only nutrition can be effectively controlled and modified by clinicians in the NICU.

Addressing the underlying factors that contribute to disparities in growth in the NICU could minimize the role of social and quality of care factors on health disparities. Therefore, it is crucial to determine if there are racial differences in weight gain and body composition among preterm infants in the NICU. We hypothesized that black preterm infants would have higher weight gain, more fat mass (FM), and less FFM at discharge than white preterm infants.

Subjects and Methods

Participants

In this observational study of preterm infants admitted to the neonatal unit at the University of Alabama at Birmingham (UAB), we analyzed growth and body composition data from

preterm infants born at 25-32 weeks gestational age enrolled in three parent studies^{10, 11, 12} that measured infant body composition at 36 weeks postmenstrual age (PMA). The parent studies were single center, randomized clinical trials examining the effects of dietary interventions on body composition^{10, 12} and the potential benefits of serial assessments of body composition outcomes in preterm infants¹¹. Exclusion criteria for the parent trials included infants with gastrointestinal malformations, central nervous system malformations, or terminal illness needing to limit or withhold support were excluded. One study also excluded infants with a hemodynamically significant patent ductus arteriosus, and necrotizing enterocolitis stage 2 or greater.

Procedure / Protocol

Patient enrollment in the parent studies occurred between September 2016 and October 2019. Body composition was assessed at 36 weeks PMA or prior to discharge (whichever came first). The UAB Institutional Review Board approved the individual study protocols and the study protocol for this secondary analysis. Written, informed consent was provided for each of the individual study protocols.

Measurements

We retrieved body composition data and clinical data (race, birth weight, gestational age at delivery, feeding type, and others) from the central databases of the parent studies. Gestational age at birth was determined by last menstrual period, if available, or first trimester ultrasound. Race was determined according to parent report. Of note, in the context of this analysis we considered race to be a social construct, not a biological variable. Ethnicity was not included in the central databases of the parent studies. Feeding type was coded as either “breastmilk” if the infant received any maternal breast milk at 36 weeks PMA or “formula” if the infant received formula only. Length, typically assessed weekly via tape measure, was obtained from the medical record around the time of body composition measurement. Body composition was estimated by air displacement plethysmography (PeaPod®; Cosmed USA, Concord, CA). The PeaPod® volume chamber and scale were calibrated to account for materials that could not be removed from the infant; typically EKG leads, feeding tube, and tape or bandages. Snug-fitting caps were placed on the infants’ heads if they had visible hair that would affect volume measurement. Infants were weighed nude on the PeaPod® scale and then placed in the volume chamber for 2 minutes. Infant body mass and volume were measured and used to derive fat mass, fat-free mass, and total body percent fat¹³.

Weight-for-age and length-for-age Z scores at birth and at the time of body composition assessment were calculated using Fenton 2013 reference data¹⁴. Following expert recommendations¹⁵, we calculated weight gain velocity from birth to the day of body composition measurement using the Patel exponential method (weight gain velocity = $(1000 \times \ln(W_n/W_1))/(D_n - D_1)$)¹⁶.

Statistical analysis

Preliminary analyses included normality and equal variance tests across the two groups. Chi-square tests were used to compare the distribution of male and female infants, and the

distribution of feeding type at 36 weeks PMA. Independent groups t-tests were used to determine racial differences in birth weight, gestational age at delivery, and age at body composition measurement, and sex differences in weight gain velocity, FM, FFM, and total percent fat. Independent groups t-tests were also used to calculate race differences in weight gain velocity and body composition. When significant differences were detected by a two-tailed T-test, analyses of covariance (ANCOVA) were used to investigate whether these differences were independent of birthweight z-score, GA at birth, feeding type at 36 weeks PMA, and weight gain velocity. The model assessing racial differences in FFM was further adjusted for length, and the model assessing race differences in FM was also adjusted for FFM, to account for overall body size.

Results

Descriptive characteristics of the 143 infants included in this secondary study are shown in Table 1. Gestational age at birth of infants ranged from 25 weeks and 1 day to 32 weeks and 6 days. Black infants, with a mean gestational age of 29 5/7 weeks, were born earlier than white infants, who had a mean gestational age of 30 3/7 weeks ($p=0.028$). Birth weight ranged from 525 to 2210 grams, with white infants having a greater mean birth weight as compared with black infants ($p=0.008$). The mean postnatal age at time of body composition assessment was 42 days (i.e. gestational age of 36 1/7). Body weight at time of assessment ranged from 1450 to 4050 g with a mean of 2276 g. Postnatal age and body weight at assessment did not differ significantly between groups.

Unadjusted comparisons of weight gain and body composition measurements are shown in Table 1. In fully adjusted models, there was no racial difference in FM (mean difference: -20 g [95% CI: -48 to 8 g]; 0.34 kg in black infants [%95 CI: 0.32 to 0.36] vs 0.36 kg in white infants [%95 CI: 0.34 to 0.38]; $p=0.204$), FFM (mean difference: -20 g [95% CI: -75 to 36 g]; 1.92 kg in black infants [%95 CI: 1.88 to 1.96] vs 1.94 kg in white infants [%95 CI: 1.89 to 1.98]; $p=0.546$), or %BF (mean difference: -0.8% [95% CI: -1.8 to 0.3]; 14.6 in black infants [%95 CI: 13.9 to 15.3] vs 15.4 in white infants [95% CI: 14.6 to 16.1]; $p=0.160$). Weight gain velocity (g/kg/day) from birth to time of measurement at 36 weeks PMA differed between groups. After adjusting for birthweight z-score, gestational age at birth, and feeding type at 36 weeks PMA, we found that black infants gained weight more rapidly than white infants (mean difference: $+1.2$ g/kg/day [95% CI: 0.3 to 2.1 g]; 12.8 g/kg/day in black infants [%95 CI: 12.2 to 13.4] vs 11.6 g/kg/day in white infants [%95 CI: 10.9 to 12.2]; $p=0.010$).

Discussion

In this cohort, black infants born preterm exhibited a higher rate of weight gain from birth to discharge compared with white infants born preterm. Despite this difference, there were no racial differences in body composition at discharge. To our knowledge, this is the first comparison of racial differences in early postnatal weight gain velocity and body composition of preterm infants. Given the neurodevelopmental and metabolic implications of weight gain and body composition of preterm infants in the NICU, contributing factors and long-term implications of these findings warrant further consideration.

One potential cause in race disparities in clinical outcomes, highlighted by Burriss et al, includes differences in clinical care by race. A recent systematic review described complex structural, process, and outcome measures that most often disadvantaged infants of color⁷, including several outcomes with the potential to impact nutrition and growth in the NICU. Three studies included in this review found lower rates of breastmilk feeding among black infants at discharge. The review also highlights an important study describing disparities in kangaroo care, with more black mothers being discouraged from skin-to-skin care than white mothers. Additionally, the systematic review found two articles investigating quality of care composite scores and concluded that infants of color are more likely to experience a lower quality NICU care. Considering the growing literature describing disparities in NICUs across the country, nutrition and growth outcomes disparity research in this population is essential to promote optimal neurodevelopmental outcomes in this vulnerable population across all racial groups, reduce the disproportionate rates of obesity seen in black children, and modify early life factors that contribute to this disparity¹⁷.

Our findings of lower birth weight and higher rates of weight gain observed in black infants born preterm (13 g/kg/day) are consistent with results from studies of term infants^{2,3} and fetal growth studies¹⁸. This rate of weight gain is not considered excessive according to the recommended range between 15 and 20 g/kg/day for preterm growth¹⁹. Social and environmental factors experienced by black mothers are known to affect birth outcomes, including birthweight.⁶ Though birthweight z-score (a proxy for fetal growth) was included in the model as a confounder, the lower birthweights observed in black infants could explain the higher rates of weight gain. In this analysis, 12 black infants were born weighing less than 1000 grams compared with 3 white infants weighing 1000 grams. Small size at birth increases the risk of extrauterine growth restriction, a common concern for clinicians in the NICU²⁰. Overall, growth-restricted preterm infants often have higher rates of weight gain than non-growth-restricted preterm infants²¹.

Regardless of the reasons for this disparity, as rapid infant weight gain is known to increase risk for poor cardiometabolic outcomes later in life, future analyses should assess if there are long-term consequences of these different weight gain velocities later in childhood and adulthood. Though feeding type at 36 weeks PMA was adjusted for in the analysis, other nutritional variables such as earlier nutrition practices could have contributed to the differences seen in weight gain. Future research should also collect nutritional and non-nutrition related variables across the NICU stay to comprehensively address known contributors of growth and identify contributors to the differences seen in weight gain so that interventions designed to reduced disparities can be developed as needed. Although consensus statements¹⁵ do not suggest to collect detailed maternal variables (such as pre-pregnancy BMI, gestational weight gain, gestational diabetes status, etc.), some experts consider unacceptable to study infant weight gain and body composition without this information. Future neonatal nutrition research in the NICU should collect more detailed data on maternal characteristics that influence size at birth and postnatal growth and consider re-evaluating consensus in this area.

Despite differences in weight gain velocity, no differences in body mass or body composition were observed between black and white infants at discharge. The consistency

in results across the three measures of body composition (FFM, FM, %BF) is not surprising, with these three measures being correlated. However, the finding of similar body composition prior to discharge when infants are approaching term equivalent age stands in contrast to reports of lower amounts of lean mass seen late in gestation and at birth in black infants born at term^{1,2}. This discrepancy likely reflects differences between intrauterine environment, where black infants experience lower fetal weights compared with white infants as early as 21 weeks¹⁸, and the extrauterine environment, where black infants in this cohort gained weight more rapidly than white infants. Since black and white infants reached similar weights by discharge, black infants may have made up for any expected disparity in FM or FFM at birth during their stay in the NICU, where nutrition practices and weight gain goals should be the same across race.

Our findings support the well-documented pattern of higher %BF and lower FFM among preterm infants²², with 15% mean percent fat at the time of measurement in this cohort, compared with a mean of 8-12% fat in term infants²³. More research is needed to investigate determinants of differences in body composition and weight gain patterns seen across racial groups in preterm infants throughout all infancy stages, including at birth and after discharge from the NICU. In our analysis, adjusting for birthweight z-score did not eliminate the association between race and weight velocity. However, we did not adjust for differences in body composition measurements immediately after birth. If body composition differs between black and white infants at birth, higher rates of accretion of fat and fat-free mass to “catch-up” to their white counterparts could explain the lack of differences in body composition observed at discharge. If that is the case, we will need to determine if black infants continue to experience more disproportionate rapid weight gain after NICU discharge.

This study is limited by several factors. Reporting feeding type at 36 weeks PMA as a dichotomous measure is less informative than describing breastmilk to formula ratios at different periods during the NICU stay. Length was obtained using a tape measure, which is less accurate than using length boards. This approach could have affected our body composition measurements. The exclusion of infants who were too clinically unstable for body composition assessment at 36 weeks PMA affects the generalizability of our results. The analysis of a one-time evaluation of body composition at 36 weeks PMA is also a limitation. This study only compares growth and body composition between black and white infants and fails to address other racial groups. Further, as the parent studies did not include ethnicity in the central database, ethnicity could not be included in the analysis, which is an additional limitation.

Strengths of this study include the relatively large sample size, the equal distribution of race and sex within the cohort, and the use of air displacement plethysmography to assess the body composition of preterm infants. The wide range in gestational age and birthweights of the preterm infants included in this study increases the generalizability of our results.

In conclusion, our analysis suggests that black and white infants born preterm exhibit different rates of weight gain while in the NICU. Further studies are needed to determine the specific periods during which black infants born preterm experience more rapid weight gain

and to determine if these differences in weight gain velocity continue after discharge and have implications for future metabolic health.

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Table 1:

Cohort characteristics *

Characteristic	Overall Cohort (n=143)	Black (n=77)	White (n=66)	P-value
Sex (n)	75	41	34	0.836
Birthweight (kg)	1.37 ± 0.32	1.30 ± 0.32	1.44 ± 0.30	0.008
Birthweight Z-Score	-0.04 ± 0.87	-0.11 ± 0.77	0.05 ± 0.98	0.254
Gestational Age at Birth	30 1/7 weeks ± 12 days	29 5/7 weeks ± 13 days	30 3/7 weeks ± 11 days	0.028
Percent Receiving Breastmilk at 36 Weeks	56	45	68	0.006
Body Weight at Time of Measurement (kg)	2.28 ± 0.40	2.28 ± 0.40	2.27 ± 0.39	0.793
Body Weight Z-Score at Time of Measurement	-0.93 ± 0.87	-0.87 ± 0.92	-1.00 ± 0.81	0.383
Postnatal Age in Days after Birth at Time of Measurement	42 ± 19	44 ± 22	40 ± 15	0.244
Percent Body Fat (%BF)	14.95 ± 3.74	15.19 ± 3.84	14.67 ± 3.61	0.405
Fat-Free Mass (kg)	1.93 ± 0.29	1.93 ± 0.30	1.93 ± 0.29	0.940
Fat Mass (kg)	0.35 ± 0.13	0.35 ± 0.13	0.34 ± 0.13	0.538
Weight Gain Velocity (g/kg/day)	12.22 ± 3.36	13.22 ± 2.97	11.06 ± 3.44	<0.001

* All values are reported as mean ± standard deviation unless stated otherwise