BODY COMPOSITION AND PHYSICAL ACTIVITY IN ADOLESCENTS BORN WITH VERY LOW BIRTH WEIGHT

BY

HOLLY REDMAN

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Approved By:

Patrician Nixon, Ph.D., Advisor

Gary Miller, Ph.D., Chair

Lisa Washburn, MD
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List of Abbreviations

BMI: Body Mass Index
CDC: Center for Disease Control and Prevention
DEXA: Dual Energy Xray Absorptiometry
ELBW: Extremely Low Birth Weight
FMI: Fat Mass Index
FFMI: Fat Free Mass Index
LBW: Low Birth Weight
LTPA: Leisure Time Physical Activity
MAQ: Modifiable Activity Questionnaire
MET: Metabolic Equivalent
MRI: Magnetic Resonance Imaging
NBW: Normal Birth Weight
PA: Physical Activity
TotHrs: average hours of weekly physical activity
VigHrs: average hours of weekly vigorous activity
VLBW: Very Low Birth Weight
WHR: Waist to Height Ratio
Abstract

ASSOCIATIONS OF BIRTH WEIGHT, PHYSICAL ACTIVITY, AND BODY COMPOSITION IN ADOLESCENTS

Thesis under the direction of Patricia A. Nixon, PhD., Professor of Health & Exercise Science and Pediatrics.

PURPOSE: To compare indices of body composition and self-reported physical activity (PA) of very low birth weight (VLBW) and normal birth weight (NBW) adolescents, and to determine if PA is a possible mediator of the relationship between birth weight group and central adiposity. METHODS: Average hours of total PA (TotHrs) and vigorous PA (VigHrs) per week for the past year was assessed via the Modifiable Activity Questionnaire (MAQ). Height, weight, and waist circumference were measured. Waist to height ratio (WHtR) was calculated along with body mass index (BMI) according to CDC age- and sex-specific reference data. Measures of fat and lean tissue were assessed by dual energy x-ray absorptiometry (DEXA). RESULTS: When all VLBW were compared to their NBW peers, VLBW (both males and females) had lower height and weight than their NBW peers. Give numbers. BMI percentiles did not differ by group, and both had % of participants who were either overweight or obese (BMI ≥ 85th percentile). TotHrs and body composition appeared similar. When stratified by sex, differences became apparent. VLBW males were similar to NBW males, but VLBW females displayed several differences from NBW females. VLBW females reported significantly (p<.05) less participation in VigHrs (VLBW: 0.25(5th, 95th percentiles) vs. NBW: 2.1(p<0.01), VLBW females had lower percent body fat (29.5 vs. 32.7%, respectively) and higher percent lean body mass (67% and 63.6% respectively) than NBW females. Central adiposity did not differ between groups so meditational analysis was not performed. Birth weight group and PA were independent predictors of body composition.
CONCLUSION: VLBW was associated with less body fat and greater lean body mass in adolescent females but not males. The high prevalence of overweight/obesity and the low participation in VigHrs may put VLBW females at risk for future development of chronic disease. Continued follow up evaluation is warranted with emphasis on sex effects.
**Introduction**

In 2011, 1.4% of infants were born with very low birth weight (VLBW), weighing under 1,500 grams. Due to technological advances in recent years, the number of survivors of premature birth with low birth weight is increasing. According to the Barker Hypothesis, these individuals undergo physiological adaptations in response to environmental exposure which increases immediate likelihood of survival known as “programming.” Although beneficial in early life, these changes may alter development and persist into adulthood with potentially adverse consequences.

Among others, VLBW has been associated with an increased risk of cardiometabolic disorders including cardiovascular disease, high blood pressure, type 2 diabetes mellitus, and insulin resistance. Accumulation of excess body fat increases risk for these same disorders, especially if concentrated around the abdomen. Rising rates of overweight and obesity may be especially concerning if premature birth and VLBW concurrent with excess adiposity pose additional health risk.

Results of the few studies examining body composition of premature and VLBW individuals are inconsistent. These results are further complicated by variations in methods used to assess body composition which make it difficult to compare the findings of one study to another. Though people born prematurely remain smaller than their peers throughout adolescence and attain comparable BMI’s to their peers in adulthood, the existing research lacks consensus in assessments of body fat percentage and lean mass.
Physical activity (PA) has been shown to decrease adiposity and cardiometabolic risk in normal birth weight populations. Research has found that VLBW adolescents and adults participate in less PA than their normal birth weight (NBW) peers which may further increase their risk for chronic disease.

The primary aim of this study is to compare indices of body composition and self-reported physical activity PA between VLBW and NBW participants, and to determine if PA is a possible mediator of the relationship between birth weight group and central adiposity.
Review of Literature

Epidemiology

According to the National Vital Statistics Report, 11.73% of all babies born in 2011 were preterm with less than 37 completed weeks of gestation. Many were born even sooner, with 1.9% born very preterm at less than 32 weeks gestation. The 0.73% born earliest are termed extremely preterm, entering the world with a maximum of gestational age of 28 weeks. Premature babies are often lighter at birth than their term born peers. Those weighing less than 2,500 grams are termed low birth weight (LBW) and accounted for 8.1% of all births in 2011. That same year, 1.4% of babies were born with very low birth weight (VLBW), weighing under 1,500 grams. The lightest babies can be classified as extremely low birth weight (ELBW), weighing at most 1,000 grams. Gestational age, determined by early ultrasound assessment and the mother's last menstrual period, has been shown to be a better predictor of survival than birth weight. Despite the many risk factors for premature birth including multiple pregnancy, low socioeconomic status, African American heritage, substance misuse, infection, and hypertensive disease during pregnancy, survival rates of premature infants have increased significantly throughout the past few decades due to technological advances. However, complications of prematurity are becoming more common due to the absolute number of survivors.

Consequences of Premature Birth and Low Birth Weight

Both premature birth and VLBW have been associated with neonatal challenges, as well as further consequences during infancy that may persist into childhood, and even adulthood. Neonatal challenges include, but are not limited to, respiratory distress
syndrome, intracranial hemorrhage, and necrotizing enterocolitis\textsuperscript{3,4}. Throughout infancy and childhood greater likelihood of bronchopulmonary dysplasia, retinopathy, growth impairment, and neurodevelopmental limitations have been reported\textsuperscript{3,5}. Chronic neurosensory impairment has been shown to persist into adulthood, with higher rates of vision impairment, hearing loss, and cerebral palsy reported in those born prematurely in comparison to their peers born full term\textsuperscript{6-8}. Some research has shown associations between low birth weight and chronic disease later in life, including increased risk for hypertension, cardiovascular disease, and type 2 diabetes mellitus\textsuperscript{9,10}.

**Barker Hypothesis**

The increased risk for chronic disease may be explained in part by the Barker hypothesis, also referred to as fetal origins hypothesis. The Barker hypothesis, based on the concept of developmental plasticity, states that organisms are sensitive to their environment in early life\textsuperscript{11}. The two fundamental influences on developmental plasticity are variation in energy substrate availability (nutrition) and challenges to survival (stress)\textsuperscript{11}. According to this theory, stimuli encountered in utero or early postnatal life may alter the structure and function of developing organ systems to increase immediate likelihood of survival. The timing of stimulus presentation is also influential and may lead to different alterations based upon the current stage of fetal growth or development. While beneficial in the short term, these alterations known as "programming" may persist throughout the person's lifetime. A mismatch between fetal programming and later surrounding environment however result in adverse health consequences.
Studies of survivors born during in famine-affected areas in World War II provide supporting evidence of the effects of fetal undernutrition on programming. Women residing in areas affected by the Dutch Famine (1944-1945) and the Siege at Leningrad (1941-1945) experienced inadequate food supply early in their pregnancy, and as a result their fetuses were undernourished\textsuperscript{12-14}. Babies born to women affected by the Dutch Famine were programmed with the expectation of low food availability, but many experienced a mismatch between programming and their later environment when ample food became available once the war ended. Consequently, many experienced catch up growth and accumulated more visceral fat than peers not affected by famine in utero. By age 19, young adults whose mothers lived in famine affected areas in early gestation displayed more glucose intolerance, higher mean BMI, waist circumference, and risk of obesity than young adults whose mothers were unaffected by the Dutch famine\textsuperscript{12,13}.

Meanwhile, babies born to mothers affected by the Siege at Leningrad continued to experience famine throughout early childhood\textsuperscript{14}. They experienced similar fetal undernutrition and programming to those affected by the Dutch Famine, however their programming matched that of their later environment in which food was indeed scarce. As a result, they did not experience unexpected nutrient availability or undergo catch up growth like that of the Dutch Famine survivors. Studies comparing survivors of the Siege of Leningrad to peers born outside of famine affected areas showed no differences in glucose intolerance, dyslipidemia, hypertension or cardiovascular disease in adult life\textsuperscript{14}.

These findings indicate that similar fetal programming to those born during the Siege of Leningrad, it was the mismatch in environment “anticipated” by babies born during the Dutch Famine which impacted their subsequent development and increased
their risk of chronic disease in later life. These observations prompted research concluding that in individuals exposed to low nutrient availability in utero, adipocyte development is sacrificed in favor of essential organs\textsuperscript{15}. Catch up visceral fat deposition then occurs if nutrient supplies become more readily available\textsuperscript{16}, consequently increasing risk of visceral obesity\textsuperscript{17}. Excess weight has been associated with increased risk of developing hypertension, atherosclerosis, type 2 diabetes mellitus, dyslipidemia, metabolic syndrome, fatty liver disease, asthma, and cancer in later life\textsuperscript{18} some of which have been observed in persons born prematurely with VLBW\textsuperscript{10,19,20}.

Threats to survival in early life have been shown to program long lasting change to body composition via hormonal influence. Fetal stress may prompt hormonal responses, increasing or decreasing concentrations within the blood stream. Receptors for these hormones may be up- or down-regulated as well, resulting in structural and functional changes in the target organs\textsuperscript{21}. For instance, low birth weight is associated with exaggerated cortisol responses to stress in both children\textsuperscript{22} and adults\textsuperscript{23}. Through interactions among the hypothalamus, pituitary gland, and adrenal gland (HPA axis), cortisol increases insulin levels\textsuperscript{24}. This co-elevation of cortisol and insulin preferentially increases abdominal fat stores, which carries particularly high cardiometabolic risk\textsuperscript{25,26}.

These changes may be passed down to future generations through epigenetic modification, or modifications of gene expression without alterations of DNA sequence occurring in response to developmental environment\textsuperscript{27}. It is believed that the programming is associated with methylation and demethylation of gene base pairs during mitosis of developing organs which ultimately affects its phenotypic expression\textsuperscript{28}. A study of epigenetic changes in survivors of preterm birth identified persistent methylation
differences at ten genomic loci between ELBW and term at 18 years of age, which consequently may be inherited by future offspring\textsuperscript{29}.

**Assessment of Overweight and Obesity**

Due to the ease with which height and weight are measured, body mass index (BMI) is most frequently used to classify overweight and obesity\textsuperscript{30}. Once BMI is obtained, it is then compared to age- and sex-specific data from a reference population\textsuperscript{31}. According to U.S. Centers for Disease Control and Prevention (CDC) growth reference curves, children and adolescents ages 2-19 with BMI between the 85th and 94th percentiles are classified as overweight, while those at or above the 95th percentile are classified as obese\textsuperscript{32}.

**Prematurity and Weight, Height and BMI**

Nine studies were reviewed that compared weight, height, and/or BMI between preterm- and term-born persons during childhood, adolescence and/or adulthood\textsuperscript{33-41}. In general, studies suggest that throughout early life, preterm children remain smaller than their peers\textsuperscript{5,7,9}. Five studies weighing preterm children and their peers demonstrated consensus that preterm children were lighter\textsuperscript{5,33,34,36,37}. Four of these studies found that preterm children were shorter than their peers as well\textsuperscript{5,33,36,37}, but one study did not find a significant difference in height\textsuperscript{34}.

During teenage years, preterm-born teens weighed significantly less in two studies\textsuperscript{5,38}. One of these studies also found that preterm teens were shorter\textsuperscript{5}, but the other
reported no difference in height\textsuperscript{38}. In order to reach their adult heights, preterm -born and VLBW adolescents often experience "catch-up growth" and attain heights comparable to that of their parents. VLBW females seem to have better catch-up growth outcomes than males. Though three studies report that VLBW females remain significantly shorter in adulthood\textsuperscript{36,40,41}, two others report no significant difference in height\textsuperscript{37,39}. Four of these studies reported no differences in adult weight between preterm and term-born females\textsuperscript{36,37,39,40}. The remaining study found that females remained lighter than their peers in adulthood\textsuperscript{41}. In males, four studies report lower adult heights in those born preterm compared to term-born peers\textsuperscript{36,37,40,41}, yet one study did not find a height difference\textsuperscript{39}. Studies examining male weight have less consensus. Two studies reported no difference in weight between preterm adults and their peers\textsuperscript{36,39}, whereas three studies found that preterm adult males remain lighter\textsuperscript{37,40,41}.

Results of studies reporting BMI of preterm/VLBW children, adolescents, and adults show fairly consistent trends, as shown below in Table I. Two studies reported premature children had lower BMI than their term born peers\textsuperscript{33,42}, while a third study found no difference between groups\textsuperscript{20}. Four studies of adolescents report lower BMI in those born preterm compared to their term born peers\textsuperscript{34-36,43}. This difference in BMI seems to be attenuated by adulthood. Seven studies report no differences in BMI between preterm and term-born adult cohorts\textsuperscript{36,38,41,44-46}. However, one study reported lower BMI z-values in preterm males but not preterm females by adulthood. In contrast, another study reported higher BMI in preterm adult males but not adult females compared to term-born peers\textsuperscript{39}. Furthermore, a meta-analysis comparing BMI in preterm vs. term-born
adults (mean age 39.4 y) reported no difference in BMI between groups or when stratified by sex\(^9\).

### Table I. Summary of height, weight, and BMI comparisons

<table>
<thead>
<tr>
<th>Age</th>
<th>(VLBW/Preterm vs. NBW/Term)</th>
<th>Height</th>
<th>Weight</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
<td>↓5,33,36,37 ↔34</td>
<td>↓5,33,34,36,37</td>
<td>↓33,42 ↔20</td>
</tr>
<tr>
<td>Adolescents</td>
<td></td>
<td>↓5 ↔37</td>
<td>↓5,38</td>
<td>↓34-36,43</td>
</tr>
<tr>
<td>Young Adulthood</td>
<td>Females ↓36,40,41 ↔37,39</td>
<td>Females ↔36,37,39,40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males ↓36,37,40,41</td>
<td>Males ↔35,38</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Males ↓37,40,41</td>
<td>↓36,38,41,44-46</td>
<td></td>
</tr>
<tr>
<td>Mid Thirties</td>
<td></td>
<td>↔39</td>
<td>↔39</td>
<td>Males ↑39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Females ↔39</td>
</tr>
</tbody>
</table>

**BMI as an Estimate of Adiposity**

Moderate to strong correlations have been demonstrated between BMI and total body fat, ranging from 0.68 to 0.94 in boys\(^{47-49}\) and 0.67 to 0.90 in girls\(^{47,49}\) ages 3-19. However, the association of BMI with body fatness is complicated by the association of BMI with lean body mass. As children grow, the correlations of BMI with body fat and lean body mass are complicated by variation in growth rate and levels of maturation\(^{50}\).

Studies examining the validity of BMI as an indicator of body fatness and risk among children have found that a BMI for age ≥95\(^{th}\) percentile has a moderately high (70-80%) sensitivity and positive predictive value, along with high specificity (95%).\(^{51}\). However, children whose BMI places them in the “overweight” category (BMI between
85th up to 94th percentile) based on CDC growth charts can be a result of moderate increases in levels of either fat or fat free mass. It is estimated that up to 30% of children classified as overweight based upon BMI have body fatness levels comparable to those of normal weight children\textsuperscript{52}. A recent study found that BMI cutoffs based on CDC growth charts misclassified 11% of overweight and obese children (as determined by measures of actual body fat)\textsuperscript{53}. As a result, other measures such as skinfold thicknesses and waist circumference are recommended for identifying obesity in children\textsuperscript{51}. Differences between study methods of measuring and classifying excess body fat are a source of variability, making it challenging to compare results between studies\textsuperscript{54}.

**Body Composition**

The finding that mean BMI of young adults born preterm is not significantly different from their term born peers\textsuperscript{2,8,55} at first glance implies that they do not have increased risk for excess body fat. Studies comparing measures of body composition of those born prematurely and their peers are fewer and lack consensus thus far, which may be partially explained by the different methods used – dual energy x-ray absorptiometry (DEXA), bioelectrical impedance, skinfold thicknesses. In general, DEXA is currently considered the gold standard for assessing body composition including fat mass, fat-free mass, and bone mass, from which bone-free lean body mass can be determined. It is relatively cheap with barely negligible radiation exposure when compared to peripheral qCT which enables examination of intramuscular fat.

As shown in Table II, three studies have compared body composition in children born pre-term with their term-born peers. Two studies assessed body composition using
DEXA\textsuperscript{20,42}. One found preterm children to have lower body fat percent compared to term-born peers\textsuperscript{42}, whereas the other did not find a difference between groups\textsuperscript{20}. A third study using bioelectrical impedance reported premature children to have significantly lower body fat percent than their peers, but this group difference was not significant when the same children were assessed with skinfold calipers\textsuperscript{33}.

Table II. Summary of percent body fat and percent lean mass comparisons

<table>
<thead>
<tr>
<th>Age</th>
<th>VLBW/Preterm vs. NBW/Term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat</td>
</tr>
<tr>
<td>Children</td>
<td>↓\textsuperscript{42,32}</td>
</tr>
<tr>
<td>Adolescents</td>
<td>↓\textsuperscript{33}</td>
</tr>
<tr>
<td>Young Adulthood</td>
<td>←\textsuperscript{41,46}</td>
</tr>
<tr>
<td>Mid Thirties</td>
<td>↑\textsuperscript{38}</td>
</tr>
</tbody>
</table>

Two studies have examined body composition in preterm adolescents. One study assessed body composition using both with skinfolds and DEXA\textsuperscript{34}. Both measures demonstrated that preterm adolescents had lower body fat percentage than term-born peers\textsuperscript{34}. However, another study using DEXA did not find significant differences between preterm and term-born adolescents\textsuperscript{38}.

Results of three studies that evaluated adults born prematurely and those born at term by DEXA are also inconsistent\textsuperscript{39,41,46}. One study found that preterm adults had
higher body fat percentages than those born full term\textsuperscript{39}, two others found similar body fat percentages between groups\textsuperscript{41,46}. Lastly, a meta-analysis examining body composition of adults born prematurely and those born at term reported no difference in whole body fat percentage\textsuperscript{9}.

Some evidence suggests that lean body mass may also be programmed during early life. Several mechanistic explanations support the programming of decreased lean mass in those born prematurely. Type II muscle fibers normally develop in the last ten weeks of gestation\textsuperscript{56}. Premature birth robs the fetus of the protective environment of the uterus before this development occurs. In addition to providing strength, muscle tissue also actively absorbs glucose in response to insulin. The programming of a smaller proportion of lean tissue therefore slows glucose absorption and metabolism, further predisposing those born prematurely to greater adiposity in later life. They will have a disproportionately high ratio of fat to lean mass if they become overweight\textsuperscript{57}.

Though few studies have assessed adiposity in premature populations, even less research has examined lean mass. Only four studies were found to report comparisons of lean mass between premature participants and their peers born full term\textsuperscript{34,38,41,42}. All assessed lean tissue via DEXA, however none reported whether bone mass was subtracted from lean tissue mass. Though total volume of lean mass was less in those born preterm, differences were nonsignificant after normalization for height in childhood\textsuperscript{42} and adolescence\textsuperscript{34,38}. One study assessing lean mass in adults reported significantly less total lean mass in preterm compared to term adults\textsuperscript{41}. It should be noted however that these results were not normalized for height, and preterm adults were found to be significantly shorter and lighter than their peers in this particular study.
Overall, the results of the few studies examining body composition of premature and/or VLBW individuals are inconsistent, as summarized in Table II. These results are further complicated by variations in methods used to assess body composition which make it difficult to compare the findings of one study to another. Though preterm individuals appear to remain smaller than their peers throughout adolescence and attain comparable BMI’s to their peers in adulthood, the existing research lacks consensus in assessments of body fat percentage and lean mass.

**Body Fat Distribution and Central Adiposity**

While excess whole body adiposity has been correlated with increased risk of chronic disease in the general population, a central pattern of accumulation presents additional risk. Abdominal obesity, or excess of both central subcutaneous and visceral fat, is predictive of metabolic dysfunction and adverse health outcomes including metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease in adulthood. Excess visceral fat has also been linked with increased metabolic and cardiovascular risk factors in children and adolescents.

The few studies examining body fat distribution in preterm populations report inconsistent results as well. This may in part be due to variation in methods of assessing body fat distribution and central adiposity. Initial studies of associations between birth weight and body fat distribution measured central adiposity with anthropometric measurements such as waist circumference and waist-to-hip ratio, both of which fail to differentiate between lean and fat tissue. Other studies have assessed body fat distribution
by examining truncal-to-peripheral skinfold ratios. More recently, researchers have examined trunk fat mass using DEXA and MRI with greater accuracy.

One measure not reported in VLBW studies, but gaining attention in studies of central adiposity in the general population, is waist to height ratio (WHtR). Waist to height ratio has been shown to be more highly correlated with overall body fat percentage, trunk fat percentage, and fat mass index than either BMI or waist circumference in children and adolescents. As WHtR accounts for the growth in both waist circumference and height with increasing age, the measure has been suggested to be an indication of fat distribution. As some studies have reported similar waist circumference and shorter heights in VLBW adolescents when compared to their term born peers, the WHtR calculation may be useful in identifying differences in central adiposity.

As shown in Table III, two studies comparing premature children to their term-born peers found no difference in central adiposity between groups, one via DEXA and the other via MRI. A third study also assessing children with DEXA however reported premature children to have significantly lower fat mass index in limbs, while trunk fat mass was similar between groups. This finding indicates a more central pattern of fat deposition in premature children than their peers. One study evaluated central adiposity of adolescents using skinfolds. Preterm adolescents had lower triceps to subscapular skinfold ratios, again suggesting more truncal deposition of fat. Despite this, waist circumference did not differ between those born at preterm and at term. It should be noted that waist circumference was not normalized for height, and in this particular cohort adolescents born were lighter than terms despite having similar waist
circumference and height. Two studies have examined central adiposity in both preterm and term born adults with DEXA, reporting inconsistent findings. One found preterm adults to have a higher percentage of truncal fat than their peers\textsuperscript{38} while the other found no difference between groups\textsuperscript{46}.

Table III. Summary of central adiposity comparisons

<table>
<thead>
<tr>
<th>Age</th>
<th>VLBW/Preterm vs. NBW/Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>↔\textsuperscript{19,32}</td>
</tr>
<tr>
<td></td>
<td>↑\textsuperscript{41}</td>
</tr>
<tr>
<td>Adolescents</td>
<td>↑\textsuperscript{33}</td>
</tr>
<tr>
<td>Young Adulthood</td>
<td>↔\textsuperscript{45}</td>
</tr>
<tr>
<td>Mid Thirties</td>
<td>↑\textsuperscript{38}</td>
</tr>
</tbody>
</table>

Similar to the inconsistent results of the few studies examining body composition of premature and VLBW individuals, results of studies examining body fat distribution in this population lack consensus. Further examination of truncal or central adiposity may help to explain the elevated risk for developing hyperglycemia and dyslipidemia in those born preterm or VLBW, for which a more central distribution of body fat is a risk factor\textsuperscript{2,66}. 
Associations of Physical Activity and Body Composition

The physiological adaptations that result from PA have the potential to moderate the relationship between prematurity and/or very low birth weight with body composition. A recent study of high school students (not VLBW) found that lower body fat percent was associated with higher amounts of vigorous PA, but not with the amount of moderate PA\(^67\). In addition, a review assessing PA and abdominal obesity in youth found that engaging in high intensity PA was associated with lower waist circumference and less visceral fat, markers of central adiposity\(^68\).

Very Low Birth Weight and Physical Activity

Few studies have compared PA participation in VLBW or ELBW populations to that of their NBW peers. Only two studies have been performed with assessment of PA of VLBW young adults as the main outcome of interest\(^41,69\). Two studies that focused on aerobic capacity in ELBW adolescents have touched upon PA participation\(^70,71\) and two studies assessed overall physical functioning in ELBW young adults\(^35,72\). All assessed participation subjectively through self-report questionnaires, which vary in depth, detail, and length of time prior to the study for which participants were asked to report.

Rogers and colleagues\(^70\) asked ELBW adolescents to report their past sports participation, present sports participation, and frequency of PA as part of a study of aerobic capacity. The responses of 53 ELBW participants (mean age 17.3 years, mean BW = 720g, mean gestation 26 weeks) were compared to those of 31 NBW control participants. ELBW participants reported less past and current participation in sports as well as less frequent current PA than their peers. Only 47% of ELBW participants
reported engaging in PA at least once a week compared to 87% of NBW teens. More than half reported participation in PA less than twice per month (53% ELBW vs. 13% NBW). Though only 34% of ELBW reported current participation in organized sports, 62% reported past participation. Participation in physical education or organized sport is a curricular requirement in the British Columbian school system until age 16, so the drop in participation may be reflective of a lifestyle choice. In comparison, 94% of controls reported past sports participation with 74% currently participating at follow up\textsuperscript{70}.

Clemm and colleagues\textsuperscript{71} asked two cohorts of ELBW children and adolescents (mean ages 10.6 and 16.6 yrs) to report “how often and for how many hours a week they exercise so much that they become out of breath or sweat” as part of a study of aerobic capacity. Both cohorts of ELBW participants reported decreased duration and less frequent participation in leisure time physical activity (LTPA) than their peers. Only 34% of ELBW participants reported PA 2-3 times per week, compared to 72% of NBW participants. In addition, 26% of ELBW participants reported leisure time PA of 2 or more hours per week versus 59% of controls\textsuperscript{71}.

Roberts and colleagues\textsuperscript{72} assessed frequency of PA of ELBW young adults as part of a study of overall health status using the SF-36 questionnaire, which measures physical and mental health across eight domains. Responses of 194 ELBW young adults (mean GA 26.6 weeks, mean BW 887 grams, age 18 at follow up) were compared to those of 148 NBW controls. Physical functioning scores were lower for ELBW (p=0.001). ELBW participants were also less likely to report regular participation in PA in the past six months than NBW (OR (95% CI) = 0.5 (0.3-0.8), p<0.01). Forty percent of ELBW
participants reported regular participation in PA in the past six months versus 56% of controls.\textsuperscript{72}

Saigal and colleagues\textsuperscript{35} also found lower PA participation in ELBW young adults responding to the SF-36 questionnaire as part of a study of overall health status. Responses of 166 ELBW (mean GA 27.1 weeks, mean BW 841 grams, age 23 at follow up) were compared to those of 145 NBW controls. In comparison to NBW, ELBW participants had lower scores in physical self-efficacy and perceived physical ability (p<0.001). Fewer ELBW participants reported regular participation in sports and strenuous activities compared to their peers as well (38% of ELBW vs. 59% of NBW). Furthermore, young adults born ELBW were more likely to attribute lower participation rates to health conditions (22% of ELBW vs. 9% of NBW, p=0.004). However when stratified by sex, only the proportion of males who were unable to participate as a result of health conditions remained significant (p<0.001)\textsuperscript{35}.

In an investigation of different types of PA, Kajantie and colleagues\textsuperscript{41} examined occupational, commuting, and leisure time activity of young adults using a detailed self-report questionnaire. Responses of 163 VLBW participants with no major disabilities (mean age 22.3 years) were compared to those of 188 individuals born at term. Responses to occupational activity questions enabled dichotomization into physically active and physically inactive work. Commuting activity was determined by minutes spent walking, biking or otherwise exercising and dichotomized into low (<30 minutes per day) or high (≥30 minutes per day). Leisure time PA was categorized as either conditioning (activities considered physically stressful and causing substantial perspiration) or non-conditioning (activities similar to gardening, cleaning, and household reparations). Non-conditioning
activity was dichotomized into low (<1 hour per day) or high (≤1 hour per day). Conditioning PA was dichotomized based on responses to questions concerning frequency, duration, and intensity. Participation in occupational, commuting, and non-conditioning leisure time PA did not differ significantly between groups. However, VLBW adults were more likely to report less frequent participation (OR 1.3; 95% CI: 0.74-2.27, p=0.04), participation at a lower intensity (OR 2.81; 95% CI: 1.35-5.84, p<0.0001), and shorter duration (OR 3.07; 95% CI: 1.14-8.24, p<0.0001) of conditioning leisure time activities. VLBW adults were also 1.66 (95% CI: 0.90-3.08) times more likely than NBW adults to report no conditioning leisure time physical activity whatsoever.

Kaseva and colleagues administered a second detailed self-report PA questionnaire to the same cohort of VLBW adults as Kajantie two years later. Responses of 94 unimpaired adults born with VLBW were compared with 101 matched NBW controls (mean age 24.9 years). Time spent in commuting, conditioning, and non-conditioning activity throughout the past year was assessed. Self-reported frequency and duration was used to calculate total time of physical activity. Intensities of activities were transferred into METS and used to calculate total volume. Total volume and weight were multiplied to estimate yearly energy expenditure from PA. No significant differences were reported in yearly frequency, total time, total volume, and energy expenditure of non-conditioning LTPA and commuting PA. However, VLBW participants reported lower frequency [-38.5% (95% CI: -58.9, -7.7)], total time [-47.7% (95% CI: -71.2, -4.1)], total volume [-44.3% (95% CI: -65.8, -9.2)] and energy expenditure [-55.9% (95% CI: -78.6, -9.4)] of conditioning LTPA.
There are several possible explanations for the reports of reduced PA and sports participation in the preterm/VLBW persons. Children may be deterred from participation in sports by their smaller stature and lesser amounts of lean mass than their peers.\textsuperscript{43,73} Overt neurologic limitations such as cerebral palsy will impair participation in PA. Even in children without cerebral palsy, preterm born children exhibit slower motor development and have increased risk for developmental coordination disorders.\textsuperscript{74} Decreased running efficiency, the ability to generate less muscular power, and poorer eyesight than their peers may turn others off to sports participation.\textsuperscript{8,71,75} The parents of VLBW children have also been shown to be more controlling and protective.\textsuperscript{76} Unfortunately, overprotective tendencies may lead parents to steer their children away from PA for fear of injury or health problems.

To date, only one study has considered PA when examining body composition. Parents of VLBW children ages 8-12 were asked to rate their child’s activity in comparison to their peers (less, same, more, or much more active). Activity level was included in a regression model predicting fat mass index from DEXA, and a beta coefficient of 0.14 was found, suggesting that every one unit increase in PA category was associated with a 0.14 increase in FMI (expressed as fat mass in Kg/height in cm squared). Children with lower physical activity levels had significantly higher fat mass index.\textsuperscript{34}

**Inconsistencies of Inclusion and Study Design**

Lack of consensus in study results of preterm and/or VLBW populations may be due in part to variations of inclusion criteria and definitions when categorizing degree of
low birth weight (e.g. VLBW, ELBW) and prematurity. Of the studies identified, several used birth weight cutoff alone as inclusion criteria. Cutoffs for birth weight ranged from ≤ 800 grams to < 1,850 grams. Others included those children below gestational age cutoffs. Gestational age criterion ranged from ≤ 33 weeks to ≤ 37 completed weeks of gestation. These differences in inclusion criteria lead to considerable variation in the mean birth weights of premature cohorts, from the smallest at 719 grams to 1434 grams. As mean gestational age varied from 25.8 weeks to 33.3 weeks completed weeks gestation, participants were born during different critical stages of fetal development.

Further differences in study samples such as age at follow up and participant year of birth may cause additional variation. Mean age at follow up varied from 4.6 years to 35.7 years, with few studies including participants older than young adulthood. Evaluations at different stages of life are essential to determine if associations with preterm birth emerge or become more pronounced with aging. Meanwhile, survival rates have increased dramatically from approximately 40% in the 1960s to almost 90% in developed nations due to medical advances. Many of the studies concerning the effects of premature birth and/or VLBW on body composition and PA stem from retrospective cohorts of older adult participants who were not exposed to newer treatments such as prenatal corticosteroids, surfactant, and high frequency ventilation which have improved survival. Prior to these advances, infants with VLBW were less likely to survive and those that did likely reflect the healthiest. In contrast, infants born in more recent years with access to these advances include smaller, more premature babies whose postnatal
course may be more complicated. Consequently, the findings of older studies are likely influenced by survivor bias with somewhat limited generalizability.

Methods of assessing outcomes and adjustment for potential confounders differed from study to study as well. Skinfolds, DEXA, bioelectrical impedance, and MRI all vary in validity and reliability. The equations from which each calculates estimates of body composition can also vary. Measurement of PA is largely self-report, which may be subject to recall error and bias. Furthermore, while studies commonly adjusted for sex and age, there was substantial variation in adjustment for potential confounders that may have influenced results. Adjustments ranged from none to prematurity, family history of cardiovascular disease, maternal BMI, parental BMI, size for gestational age, sex, age. The lack of uniformity in adjustment has limited evaluation of other potential modifiers of associations between prematurity and body composition thus far.

These variations in study design along with the lack of consensus among findings concerning associations of overweight, obesity, central adiposity, lean mass, and PA warrant further research in these areas.

**Purpose of the Study**

The primary aim of this study is to determine if PA is a possible mediator of prematurity/VLBW on body composition in adolescence. Based on previous literature, we hypothesize that adolescents born prematurely with VLBW will have lower levels of PA and lean body mass, similar BMI and % body fat, but higher central adiposity than
their term-born NBW peers, and that the association between preterm birth and adiposity will be partially mediated by PA level.

**Significance**

If participation in PA is associated with decreased central adiposity and obesity then further research is warranted to examine the role that PA might play in improving body composition and reducing risk for the development of obesity and chronic disease risk in this at risk population. Furthermore, PA and obesity are both associated with risk for chronic diseases such as type II diabetes, hypertension, and coronary heart disease. Consequently, promotion of PA may help to reduce obesity and premature development of chronic disease in this at risk population.
Methods

Participants

Participants were recruited from a neonatal database of infants born with VLBW (≤ 1500 g) at Forsyth Medical Center between 1/01/92 to 6/30/96 who had a follow up visit at one year-corrected age and were currently in their 15th year of life. All were singletons with no major congenital anomaly. A postcard was mailed to each potential study participant in our database containing addresses and phone numbers from when we last had contact with the child, at 12 months corrected age. A letter was mailed to the parents of the child at that address including a post card to be returned. The parent or guardian was asked to fill in a check box indicating whether or not they would be interested in their child participating in the study and the best way to contact them. If the postcard was not returned, telephone calls were placed. In the event a participant could not be located, current telephone numbers and addresses were searched for at anywho.com and peoplefind.com. The study was explained in more detail via telephone to any interested parent and child, and they were then scheduled for the first study visit.

A group of term-born adolescents with normal birth weight (>2500 g) were recruited via word-of-mouth, newspaper advertisements, and signage posted in Wake Forest University Baptist Medical Center. Inclusion criteria were singleton birth at Forsyth Medical Center between 1/01/92 and 6/30/96, and currently in their 15th year of life. They were excluded for prenatal exposure to antenatal steroids, any major congenital anomaly, or history kidney disease. Neonatal information was obtained from the FMC delivery room log.
The study was approved by the Institutional Review Boards of Wake Forest University Health Sciences and Forsyth Medical Center. Upon arrival to the hospital, the study protocol was explained to the adolescent and accompanying parent, and informed assent and consent, respectively, were obtained. Participants were paid $75 for the completion of the visit in which PA data was collected, and $100 for the completion of the DEXA visit. Parents of participants were also given $25 per visit.

**Anthropometric Measurements**

The following measurements were obtained at the Wake Forest University School of Medicine General Clinical Research Center. This facility provides a controlled environment in which to conduct research with human participants.

Height and weight measurements were taken in triplicate. The average of the three measurements was used in statistical analysis. Standing height was measured to the nearest tenth of a centimeter using a wall mounted stadiometer. Measurements were recorded without shoes, during inhalation, with head in a Frankfurt plane position. Weight was measured to the nearest tenth of a kilogram in light clothing using a digital platform scale. Height and weight were then used to calculate body mass index (BMI) (weight [kg] / height [m]²), and age- and sex-specific percentiles and z values were determined from the Centers for Disease Control and Prevention 2000 reference values.\(^3\)

Waist circumference was assessed to the nearest tenth of a centimeter with a flexible measuring tape according to NHANES III Protocol. A nurse positioned at the right of the subject palpated the upper hip bone, locating the right iliac crest. A horizontal
mark was drawn just above the uppermost lateral border, and crossed with a vertical mark on the midaxillary line. The tape was then placed in a horizontal plane around the abdomen at the level of this marked point, parallel to the floor, snug yet not compressing the skin. The measurement was then taken at normal minimal inspiration. Waist to height ratio was calculated as waist circumference (cm) divided by height (cm).63

**Determination of Body Composition**

Body composition was assessed using a Delphi Scanner dual energy X-ray absorptiometer (DEXA) made by Hologic (Bedford, MA). Participants were asked to wear light, metal-free clothing. A negative pregnancy test was obtained from all females prior to the scan. Participants were instructed to lie supine on the DEXA table and remain still during the measurement. Pediatric software was used to obtain measurements of fat mass, fat free body mass, and bone mass from each scan.

Fat mass index was calculated from fat mass in Kg/(height in cm²). Fat free mass index was calculated as fat free mass in Kg/(height in cm²). Lean mass was calculated as (lean mass in kilograms of lean mass)-(kilograms of bone mass), and expressed in Kg as well as a percent of total body mass. Lastly, the percentage of body fat stored in the trunk was calculated as (trunk fat mass in kilograms)/(total body fat mass in kilograms).

**Physical Activity Assessment**

Habitual physical activity over the past year was measured using Kriska's Modifiable Activity Questionnaire (MAQ) (See Appendix). Validity and reliability of the
questionnaire have been determined previously in pediatric populations\textsuperscript{79,80}. The MAQ was administered to participants, with a parent present for consult if needed. Participants were read a list of common leisure activities and asked to indicate the activities in which they had engaged at least 5 times in the past year. The participants could add activities not listed. They were then asked to provide further information on each activity identified, including the number of months performed in the past year, average number of days per month or week, and the average duration for each session. Habitual physical activity was estimated by summing the total hours of activity and dividing by 52 to provide the average hours of activity per week throughout the past year (\textit{TotHrs}). MET intensity levels were assigned for each activity reported by participants\textsuperscript{81,82}. Activities with MET values > 6 were summed and averaged to provide an estimate of time spent in vigorous activity per week for the past year (\textit{VigHrs}). \textit{VigHrs} was stratified into a dichotomous group, with participants falling below or attaining 75 minutes of vigorous activity per week as recommended for adults by the CDC\textsuperscript{83}.

**Statistical Analysis**

Statistical analyses were performed using SPSS 21.0 for Windows. Descriptive statistics were performed to examine measures of central tendency and dispersion. In general, data are presented stratified by sex as other studies of VLBW individuals commonly report sex differences. Mann Whitney \textit{U} tests were performed to compare characteristics of VLBW and NBW participants. Differences in proportions between groups were assessed via Chi square analysis. Log or square root transformations were performed on data lacking a normal distribution. Pearson correlational analysis was used
to determine relationships among variables. Spearman correlational analysis was performed to examine relationships between anthropometric measurements with vigorous hours of activity, as no transformation made the distribution approach normalcy. A p-value <0.05 was considered statistically significant. Multiple linear regression analysis was then performed to determine if physical activity was a partial mediator of the relationship between birth weight and anthropometric measurements.
Results

Participant Characteristics

In all, 193 VLBW participants completed the study. Of these, 172 were able to attend the third visit at which the DEXA measurement was made, and 165 had what was considered valid physical activity data. Exclusions included 5 participants that reported unrealistic over activity, two who had to leave before completing the MAQ, and two with missing DEXA data. Of the NBW participants that responded to recruitment, 52 completed the study. DEXA measurements were obtained for all except one who refused consent fearing radiation exposure, and 47 participants had valid data for both DEXA and PA. Exclusions included three participants who reported unrealistic over activity and one participant with an anterior cruciate ligament injury.
Figure 1. Consort

PEPC 1 Cohort

VLBW
n= 193

20 Do not attend 3rd visit

Attend 3rd visit
n= 172

2 missing DEXA
5 Unreliable report of activity
2 Left early prior to completing MAQ

DEXA measurements & valid PA Data
n=165

NBW
n= 52

Attend 3rd visit
n= 52

1 missing DEXA
3 Unreliable report of activity
1 ACL injury

DEXA measurements & valid PA data
n=47
Neonatal characteristics of the participants with valid PA data are presented in Table IV. All VLBW participants were also born preterm. Control participants were all born full term with NBW (>2500 grams). Gestational age, sex-specific birth weight z-values, sex, and racial distributions did not differ between VLBW and NBW groups.

Table IV. Neonatal Characteristics expressed as median (5th, 95th percentiles) or n (%).

<table>
<thead>
<tr>
<th></th>
<th>VLBW (n=166)</th>
<th>NBW (n=47)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>72 (43.6)</td>
<td>21 (44.6)</td>
</tr>
<tr>
<td>Non white</td>
<td>75 (45.2)</td>
<td>17 (36.2)</td>
</tr>
<tr>
<td>Gestational Age (weeks)</td>
<td>28 (24, 33)</td>
<td>40 (38, 41)</td>
</tr>
<tr>
<td>Birth Weight (g)</td>
<td>1055 (628, 1465)</td>
<td>3430 (2603, 4430)</td>
</tr>
<tr>
<td>Birth Weight z-value</td>
<td>-0.215 (-1.961, 0.995)</td>
<td>0.063 (-1.984, 1.900)</td>
</tr>
</tbody>
</table>

Follow up characteristics are presented in Table V. All participants were in their 15th year of life with median age 14.7 years. VLBW participants were significantly shorter and weighed less than their term peers when expressed in absolute units and as z-values. When examined separately by sex, VLBW females were both significantly shorter and lighter than NBW females. VLBW males were significantly shorter, but did not differ in weight from NBW males.
Table V. Participant characteristics for VLBW and NBW adolescents. Values are expressed as median (5th, 95th percentiles)

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VLBW (n=165)</td>
<td>NBW (n=47)</td>
<td>VLBW (n=72)</td>
</tr>
<tr>
<td>Age at Follow Up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.7 (14.2, 15.0)</td>
<td>14.7 (14.2, 15.0)</td>
<td>14.7 (14.2, 15.0)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>161.8 (144.9, 175.8)</td>
<td>168.3 (154.0, 178.8)</td>
<td>168.1 (147.0, 179.8)</td>
</tr>
<tr>
<td>Height z-value</td>
<td>0.260 (-2.500, 1.308)</td>
<td>0.544 (-1.200, 2.528)</td>
<td>-0.016 (-2.466, 1.456)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>56.0 (39.8, 93.3)</td>
<td>61.6 (47.9, 102.6)</td>
<td>60.9 (39.6, 99.9)</td>
</tr>
<tr>
<td>Weight z-value</td>
<td>0.393 (-1.672, 2.391)</td>
<td>0.736 (-0.536, 2.598)</td>
<td>0.527 (-1.872, 2.708)</td>
</tr>
</tbody>
</table>

a n=164 for preterm, n=92 for preterm females, height unattainable due to high hairstyling  
b VLBW < NBW p<0.05  
c VLBW < NBW, males only, p<0.05  
d VLBW < NBW, females only, p<0.05
Average TotHrs and VigHrs of PA per week for the past year are presented in Table VI. Three VLBW participants reported having cerebral palsy, with one requiring crutches. Exclusion of their data from the analyses did not change the results significantly. No NBW participants reported having cerebral palsy or other disabilities affecting movement. Neither TotHrs nor VigHrs were normally distributed. Participation in TotHrs did not differ between VLBW and NBW males or between VLBW and NBW females. Participation in VigHrs was similar between VLBW and NBW males, with 68.9% and 76.2% attaining 75 minutes respectively ($X^2=0.416, p=0.519$). However, only 33.7% of VLBW females reported participation of at least 75 minutes of vigorous PA compared to 61.5% of NBW females ($X^2= 6.557, p=0.010$).
**Table VI. Self-Reported Physical Activity throughout the Past Year** (Values are expressed as median (5\textsuperscript{th}, 95\textsuperscript{th} percentiles))

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Males</th>
<th>Females</th>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VLBW</td>
<td>NBW</td>
<td>VLBW</td>
<td>NBW</td>
<td>VLBW</td>
<td>NBW</td>
</tr>
<tr>
<td></td>
<td>(n=165)</td>
<td>(n=47)</td>
<td>(n=72)</td>
<td>(n=21)</td>
<td>(n=93)</td>
<td>(n=26)</td>
</tr>
<tr>
<td><strong>TotHrs/wk</strong></td>
<td>8.44</td>
<td>8.48</td>
<td>11.14</td>
<td>11.25</td>
<td>5.45</td>
<td>7.05</td>
</tr>
<tr>
<td></td>
<td>(0.57, 27.00)</td>
<td>(2.29, 22.32)</td>
<td>(0.51, 34.01)</td>
<td>(2.42, 23.54)</td>
<td>(0.55, 22.31)</td>
<td>(2.08, 20.21)</td>
</tr>
<tr>
<td><strong>VigHrs/wk</strong> a,b</td>
<td>0.99</td>
<td>2.48</td>
<td>3.00</td>
<td>2.98</td>
<td>0.25</td>
<td>2.13</td>
</tr>
<tr>
<td></td>
<td>(0, 12.53)</td>
<td>(0.01, 14.28)</td>
<td>(0, 15.39)</td>
<td>(0.05, 16.59)</td>
<td>(0, 3.97)</td>
<td>(0, 11.68)</td>
</tr>
</tbody>
</table>

\textsuperscript{a} VLBW < NBW, \ p<0.05  
\textsuperscript{b} VLBW < NBW females only, \ p<0.05
No significant differences were found between NBW and VLBW groups for BMI z-value, BMI percentile, waist circumference, or WHtR as demonstrated in Table VII. The prevalence of overweight and obesity (based on CDC 2000 reference data) also did not differ between groups. While 12.5% of VLBW participants were overweight (BMI ≥ 85th, <95th percentile), 21.3% of NBW participants were also overweight ($X^2 = 1.62, p = 0.20$). Slightly more VLBW participants were obese, as 21% had BMI at or above the 95th percentile compared to 13% of NBW ($X^2 = 1.87, p = 0.17$). Eighty-one percent of NBW adolescents met the recommendation of waist to height ratio of less than 0.5 compared to only 68% of VLBW. When stratified by sex, fewer of the VLBW males had waist to height ratios < 0.5 than the NBW males (68% vs. 95%, respectively, $p = 0.09$). VLBW females were more similar to their peers, with 64% meeting the recommendation compared to 69% of NBW females.
Table VII. Simple Anthropometrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>All</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VLBW (n=164)</td>
<td>NBW (n=47)</td>
<td>VLBW (n=92)</td>
</tr>
<tr>
<td>BMI z-value&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.437(-1.557, 2.277)</td>
<td>0.721(-0.700, 2.198)</td>
<td>0.453(-2.214, 2.406)</td>
</tr>
<tr>
<td>BMI percentile&lt;sup&gt;a&lt;/sup&gt;</td>
<td>66.9(5.9, 98.9)</td>
<td>76.4(24.3, 98.3)</td>
<td>67.5(1.3, 99.2)</td>
</tr>
<tr>
<td>Waist Circ. (cm)</td>
<td>74.5(62.6, 112.2)</td>
<td>75.0(65.3, 100.6)</td>
<td>74.4(61.8, 115.2)</td>
</tr>
<tr>
<td>WHtR&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.46(0.39, 0.66)</td>
<td>0.44(0.39, 0.58)</td>
<td>0.44(0.38, 0.68)</td>
</tr>
</tbody>
</table>

Values are expressed as median (5<sup>th</sup>, 95<sup>th</sup> percentiles)
<sup>a</sup>n=164 for all VLBW, n=92 for preterm females
WHtR= waist circumference (cm) / height (cm)
The results of the DEXA measurements are displayed in Table VIII. VLBW adolescents had significantly less lean mass than NBW, but no other significant differences were found between VLBW and NBW groups. When split by sex, no differences were seen between VLBW and NBW males. However, in females, total fat mass, trunk fat mass, lean mass, and body fat percent were lower in VLBW than NBW females. Lean body mass percent was higher in VLBW females than NBW.
Table VIII. Body Composition as Measured by DEXA

<table>
<thead>
<tr>
<th></th>
<th>All (n=165)</th>
<th>Males (n=72)</th>
<th>Females (n=93)</th>
<th>NBW (n=47)</th>
<th>NBW (n=21)</th>
<th>NBW (n=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fat Mass (kg)c</td>
<td>13.3 (5.3, 32.4)</td>
<td>9.7 (4.8, 33.3)</td>
<td>16.0 (7.5, 32.8)</td>
<td>16.6 (6.1, 47.5)</td>
<td>10.9 (5.3, 26.1)</td>
<td>22.1 (11.9, 60.8)</td>
</tr>
<tr>
<td>Trunk Fat Mass (kg)c</td>
<td>5.1 (1.7, 16.0)</td>
<td>3.4 (1.3, 16.6)</td>
<td>6.5 (2.5, 15.6)</td>
<td>6.2 (2.0, 19.3)</td>
<td>3.6 (1.9, 10.6)</td>
<td>8.6 (4.2, 26.7)</td>
</tr>
<tr>
<td>Lean Mass (kg)b,c</td>
<td>40.0 (27.8, 61.3)</td>
<td>47.6 (32.2, 64.8)</td>
<td>37.0 (27.3, 50.7)</td>
<td>45.4 (32.7, 59.9)</td>
<td>48.1 (41.1, 59.9)</td>
<td>43.1 (32.1, 59.4)</td>
</tr>
<tr>
<td>Body Fat (%)c</td>
<td>24.7 (11.0, 40.3)</td>
<td>17.3 (9.5, 37.9)</td>
<td>29.5 (18.5, 41.5)</td>
<td>28.0 (11.1, 47.1)</td>
<td>17.9 (9.9, 31.7)</td>
<td>32.7 (20.4, 49.5)</td>
</tr>
<tr>
<td>Trunk Fat (%)</td>
<td>38.2 (28.8, 50.0)</td>
<td>35.0 (26.7, 50.6)</td>
<td>40.2 (31.1, 50.0)</td>
<td>37.4 (30.2, 47.6)</td>
<td>33.5 (29.3, 40.1)</td>
<td>38.9 (31.8, 50.3)</td>
</tr>
<tr>
<td>Lean mass (%)d, e</td>
<td>71.3 (57.3, 85.5)</td>
<td>79.2 (60.1, 87.1)</td>
<td>67.0 (56.2, 77.8)</td>
<td>68.1 (50.5, 85.5)</td>
<td>78.0 (64.9, 86.3)</td>
<td>63.6 (48.1, 75.5)</td>
</tr>
<tr>
<td>Fat Mass Index (kg/m²)a</td>
<td>5.01 (2.04, 12.59)</td>
<td>3.56 (1.78, 12.15)</td>
<td>6.36 (3.23, 12.76)</td>
<td>5.94 (2.19, 16.19)</td>
<td>3.73 (1.91, 8.03)</td>
<td>7.53 (4.32, 21.17)</td>
</tr>
</tbody>
</table>

Values are expressed as median (5th, 95th percentiles)

a=92 for preterm females

b VLBW < NBW, Mann Whitney U test p<0.05
c VLBW < NBW, females only, Mann Whitney U test p<0.05
d VLBW > NBW, females only, Mann Whitney U test p<0.05
e Lean mass = fat free mass – bone mass
Correlational analysis

Pearson correlational analysis was used to examine bivariate associations between TotHrs and anthropometric measures. TotHrs, BMI z-value, FMI, FFMI, and body fat percent were not normally distributed and were subsequently transformed using either log transformation or square root (as indicated in the tables). As shown in Table IX, analyses were run separately for VLBW and NBW groups, and then separated by sex.

Participation in TotHrs was inversely associated with FMI, body fat percent, and the percentage of fat mass stored in the trunk, and directly associated with FFMI and the lean mass percent in VLBW participants. These associations did not reach significance in NBW participants. When stratified by sex, TotHrs was not associated with any anthropometric measure in VLBW males. In NBW males, TotHrs was positively associated with FFMI. In VLBW females, TotHrs was inversely associated with body fat percent and the percentage of fat mass stored in the trunk, and positively associated with lean mass percent. No statistically significant associations were found between TotHrs and any outcome in NBW females.
Table IX. Pearson Correlation Coefficients between TotHrs\(^a\) per week of PA and Anthropometric Measurements

<table>
<thead>
<tr>
<th>Outcome</th>
<th>All</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VLBW</td>
<td>NBW</td>
<td>VLBW</td>
</tr>
<tr>
<td>BMI z(^a)</td>
<td>-.048</td>
<td>-.047</td>
<td>.180</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>-.001</td>
<td>-.094</td>
<td>.070</td>
</tr>
<tr>
<td>WHtR</td>
<td>-.040</td>
<td>-.168</td>
<td>.076</td>
</tr>
<tr>
<td>FMI (kg/m(^2))(^b)</td>
<td>-.181**</td>
<td>-.211</td>
<td>.060</td>
</tr>
<tr>
<td>FFMI (kg/m(^2))(^b)</td>
<td>.176*</td>
<td>.168</td>
<td>.122</td>
</tr>
<tr>
<td>Body Fat (%)(^c)</td>
<td>-.258**</td>
<td>-.242</td>
<td>.032</td>
</tr>
<tr>
<td>Lean (%)</td>
<td>.262**</td>
<td>.254</td>
<td>-.039</td>
</tr>
<tr>
<td>Trunk Fat (%)</td>
<td>-.179*</td>
<td>-.088</td>
<td>.050</td>
</tr>
</tbody>
</table>

\(^a\) log transformed, variable+4
\(^b\) log transformed
\(^c\) square root transformed
* significant p<.05
** significant p<.01
The distribution of VigHrs was not normal and various transformations (e.g. log, square root) did not improve the distribution towards normalcy. Consequently, Spearman correlational analysis was used to examine bivariate associations between VigHrs and anthropometric measures. As shown in Table X, analyses were run separately for VLBW and NBW groups, and then separated by sex. Participation in VigHrs was inversely associated with WHtR, FMI, body fat percent, and the percentage of fat mass stored in the trunk, and directly associated FFMI and lean mass percent in VLBW participants. Participation in VigHrs was inversely associated with BMI z-value, WHtR, FMI, and body fat percent, and directly associated with lean mass percent in NBW participants. When stratified by sex, VigHrs was not associated with any anthropometric measure in males, whether VLBW or NBW. However in VLBW females, VigHrs was inversely associated with body fat percent and positively associated with lean mass percent. In NBW females, only an inverse association between VigHrs and WHtR reached statistical significance.
X. Spearman Correlation Coefficients between VigHrs per week of PA and Anthropometric Measurements

<table>
<thead>
<tr>
<th>Outcome</th>
<th>All</th>
<th></th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VLBW</td>
<td>NBW</td>
<td>VLBW</td>
<td>NBW</td>
<td>VLBW</td>
<td>NBW</td>
</tr>
<tr>
<td>BMI z&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.073</td>
<td>-.293*</td>
<td>-.062</td>
<td>-.113</td>
<td>-.097</td>
<td>-.318</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>-.085</td>
<td>-.339*</td>
<td>-.106</td>
<td>-.362</td>
<td>-.070</td>
<td>-.264</td>
</tr>
<tr>
<td>WHtR</td>
<td>-.198*</td>
<td>-.407**</td>
<td>-.077</td>
<td>-.358</td>
<td>-.114</td>
<td>-.399*</td>
</tr>
<tr>
<td>FMI (kg/m&lt;sup&gt;2&lt;/sup&gt;)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.336**</td>
<td>-.335*</td>
<td>-.129</td>
<td>-.226</td>
<td>-.187</td>
<td>-.292</td>
</tr>
<tr>
<td>FFMI (kg/m&lt;sup&gt;2&lt;/sup&gt;)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.171*</td>
<td>-.056</td>
<td>.010</td>
<td>.319</td>
<td>.009</td>
<td>-.345</td>
</tr>
<tr>
<td>Body Fat (%)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-.418**</td>
<td>-.312*</td>
<td>-.193</td>
<td>-.287</td>
<td>-.230*</td>
<td>-.225</td>
</tr>
<tr>
<td>Lean (%)</td>
<td>.437**</td>
<td>.318*</td>
<td>.198</td>
<td>.270</td>
<td>.235*</td>
<td>.245</td>
</tr>
<tr>
<td>Trunk Fat (%)</td>
<td>-.233**</td>
<td>-.147</td>
<td>-.078</td>
<td>.017</td>
<td>-.170</td>
<td>-.088</td>
</tr>
</tbody>
</table>

* significant p<.05  
** significant p<.01
No difference was shown in TotHrs, VigHrs, or body composition between VLBW and NBW males, including indicators of central adiposity. VLBW females reported lower participation in VigHrs than NBW peers, but did not differ in central adiposity, and had lower body fat percent and a higher lean mass percent than NBW females. As the body composition results are contrary to our hypotheses and not consistent with lower participation in vigorous PA, PA was not tested as a potential mediator of birth weight on body composition.

We did however, perform regression analysis to determine if VigHrs was an independent predictor of body composition in females. As VigHrs was not normally distributed and various transformations did not improve the distribution toward normalcy, VigHrs was coded as a dichotomous variable (< 1.25 hrs vs. ≥ 1.25 hrs per week) and entered into the model. Results of the regression analysis indicated that both VLBW and VigHrs were independent predictors of body fat percent in adolescent females. Birth weight group (VLBW vs. NBW) accounted for 5% of the variance in body fat percent in females, and VigHrs explained an additional 7% of the variance as shown in Table XI.

**Table XI. Birth weight group and body fat percent in females.**

<table>
<thead>
<tr>
<th>Predictors</th>
<th>R square change</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight group</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>VigHrs Group</td>
<td>0.07</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
**Discussion**

To our knowledge, this is the first study to examine the effect of physical activity on the association between birth weight status and measurements of body composition in a cohort of adolescents born with VLBW and compared to their term-born NBW peers. Though we hypothesized that VLBW adolescents would have decreased participation in PA compared to NBW adolescents, VLBW adolescents as a group did not differ in total hours of physical activity. This contradicts the findings of other studies, who observed significantly less participation in physical activity in VLBW adolescents\(^{70,71}\). However, these studies did not examine physical activity participation separately by sex. When we examined males and females separately, it became clear that this difference was attributable to differences in VLBW and NBW females.

Unexpectedly, VLBW males displayed participation similar to NBW males in both total hours of physical activity and the amount of vigorous activity performed. Similar percentages of VLBW and NBW males participated in 420 minutes of weekly PA (75% and 71% respectively), corresponding to the 60 minutes of daily physical activity recommended for adolescents by the CDC to reduce risk of chronic disease\(^{32}\). Males also demonstrated similar participation in vigorous physical activity, with 69% of VLBW and 76% of NBW participating in at least 75 minutes of vigorous activity each week. Although VLBW females also had similar total hours of physical activity to NBW females, VLBW females participated in significantly less vigorous hours of physical activity than NBW females. Only 34% of VLBW females participated in at least 75 minutes of weekly vigorous PA compared to 62% of NBW females. Thirty six percent of VLBW females reported no participation in vigorous activity whatsoever, compared to
only 7% of NBW females. This is particularly concerning given evidence associating physical inactivity and increased risk for chronic disease\textsuperscript{79,84,85}.

Also in contradiction to our hypothesis, significant differences were not observed between VLBW and NBW males in fat mass, lean mass, or indicators of central adiposity. Although waist to height ratio was higher in VLBW than NBW males, the difference did not reach significance (p=0.18). Furthermore, 95% of NBW males met the waist to height ratio recommendation\textsuperscript{63} of less than 0.5, only 73% of VLBW males met the recommendation. Still, the lack of significant differences in both physical activity participation and body composition did not allow us to examine the effect of physical activity as a mediator between birth weight status and body composition in male participants.

While remaining shorter and lighter than their peers, VLBW females attained similar BMI to NBW females and measurements of central adiposity. Trunk fat percentage and fat mass index were similar between groups as well. Despite decreased participation in vigorous activity, VLBW females demonstrated significantly less total fat mass, trunk fat mass, and body fat percent than NBW females, contrary to our hypothesis. As VLBW females had lower body fat percent were not more centrally adipose than NBW females despite decreased participation in vigorous activity, it does not appear that physical activity is a significant mediator of the relationship between VLBW and body composition in females. Still, low participation in vigorous activity was associated with higher body fat percent in VLBW.

We also found that VLBW females had significantly higher lean mass percent than NBW females, however the absolute amount of lean mass was lower associated with
their lower body size. As speculated by others\textsuperscript{43,86}, the smaller stature and lower lean mass and corresponding decreased ability to generate muscular power than their term-born peers may deter them from participation in sports. Consequently, the finding of less lean mass in comparison to peers may partially may have contributed to the decreased participation in vigorous PA that we observed in our cohort of VLBW females compared to NBW females.

To our knowledge, only one other study\textsuperscript{34} has adjusted for physical activity participation when examining the relationship between VLBW and body composition in a cohort of children. Parents of VLBW and NBW children were asked to rate their child's level of physical activity as less than, similar to, or greater than their peers. Though the study did not report whether physical activity differed between VLBW and NBW, when physical activity ranking was entered into their regression analysis it accounted for some of the variance in fat mass index. Fat mass index was higher in children with lower activity ratings (B=0.14)\textsuperscript{34}. This coincides with our results, as we found significant associations between participation in TotHrs and VigHrs to be independently associated with lower FMI in all VLBW, and specifically decreased body fat percent in VLBW females, although it only explained an additional 7\% of the variance in body fat percent (B=0.07).

The results of our study and that by Fewtrell\textsuperscript{34} indicate that much of the variance in body composition remains to be explained by other factors. For instance, accelerated catch up growth, or the upward percentile crossing of 0.67 standard deviations in height or weight before the age of 2\textsuperscript{87}, has been associated with greater risk of obesity at ages ranging from 4 to 20 years\textsuperscript{54}. Additionally, head circumference at birth has been linked to
later obesity risk. In addition, the fetal programming of hormonal responses has been suggested to influence body composition. Changes to the HPA axis affecting stress response has been shown to alter concentrations of ghrelin, leptin, and cortisol. These brain regulated hormones may increase feelings of hunger while decreasing satiety, particularly in times of stress which may further promote adiposity persons born prematurely.

As no other studies stratified participants by sex, simple anthropometric comparisons of our VLBW group to the NBW group were somewhat consistent with other studies assessing VLBW and NBW adolescents. Overall VLBW participants were shorter and lighter than their NBW peers, coinciding with results of other studies. The finding of similar waist circumference between VLBW and NBW is also consistent with others. However, we did not see a difference between VLBW and NBW participants in BMI z score or BMI percentile. This differs from the findings of other studies, which demonstrated lower BMI in VLBW adolescents when compared to their NBW peers.

To our knowledge, only two other studies have examined VLBW and NBW adolescent body composition using DEXA. Fewtrell assessed slightly younger VLBW and NBW participants (mean age 10.6). The findings of this study demonstrated significantly lower body fat percentage and fat mass index when comparing VLBW to NBW, and nonsignificant differences in fat free mass index, in agreement with our findings. Peralta-Carcelen examined body composition of ELBW and NBW 14 year olds. Though the ELBW participants had significantly less lean mass, they demonstrated significantly less fat mass as well. However when body fat percentage and lean mass

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percentage were calculated, ELBW and NBW participants were similar\textsuperscript{38} which agrees with our findings.

Only one study has examined body composition of preterm and term adults after young adulthood. The body composition of preterm (gestational age \(\leq 36\) weeks) and 24 term-born adults were evaluated by DEXA (mean age at follow up 35.7). Results of the study indicated significantly higher body fat percentage in preterm adults when compared to term-born (35.4\% vs. 29.4\% respectively, \(p=0.01\)). Preterm adults also demonstrated a higher percentage of truncal fat than term-born (38.3\% vs. 30.1\% respectively, \(p<0.01\)). Thirty nine percent of preterm adults were obese (BMI \(\geq 30\) kg/m\(^2\)) compared to 14\% of their term-born peers. This indicates that significant changes in adiposity of those born VLBW may appear with increases in maturation and age. Although our VLBW and NBW groups did not differ in amount of overweight (\(X^2= 1.62, p=0.20\)) or obese (\(X^2= 1.87, p=0.17\)) participants, a third of our participants were overweight or obese based on comparisons to age and sex specific reference data (CDC 2000). This along with decreased participation in vigorous physical activity may put VLBW females at a higher risk for developing chronic disease and warrants continued follow up in this population, with emphasis on examining males and females separately.

Limitations of the study include the potential for misrepresentation of physical activity participation associated with self-report and lack of adjustment for potential confounding or mediating variables. Estimates of physical activity participation as measured through self report questionnaires may be influenced by recall error or perhaps recall bias\textsuperscript{89}. The use of accelerometers in recording physical activity would provide an objective measure of PA that would eliminate error in PA measurement attributable to
self report. We also did not adjust for other variables such as preeclampsia\textsuperscript{90}, exposure to and duration of breastfeeding \textsuperscript{91}, extent and timing of early catch up growth\textsuperscript{92}, and current diet of participants that may lead to future alterations in body composition. Consideration of these potential confounders and mediators is warranted in future studies.

Future study should also investigate neurohormonal regulators of body composition and adiposity that may affected by fetal programming. Finally, based on the differences observed between sexes in our study, we recommend future research emphasize separate comparisons of males and females in continued follow up and evaluation.
**Conclusion**

Though only lean mass significantly differed when VLBW adolescents were compared to NBW adolescents as measured by DEXA, we observed several unexpected, sex-specific differences between VLBW and NBW participants when males and females were examined separately. VLBW and NBW males were similar in PA participation, body composition, and central adiposity. Females born at VLBW were also similar in central adiposity, but had lower body fat percent and higher percent lean mass despite less participation in vigorous PA when compared to NBW females. Contrary to our hypothesis, PA was not a mediator of the relationship between VLBW and body composition, but rather VLBW and PA were independent predictors of body composition in adolescence. Though less adipose than their peers at 14 years of age, high prevalence of obesity and particularly low participation in vigorous PA may put VLBW females at greater risk for future development of chronic disease. As differences in body composition may appear with maturity, continued follow up evaluation is warranted in the VLBW population with particular emphasis on examining each sex separately.
References


49. Mei Z, Grummer-Strawn LM, Pietrobelli A, Goulding A, Goran MI, Dietz WH. Validity of body mass index compared with other body-composition screening


### Appendix 1

**Title:** Breukhoven 2012, Fat mass and lipid profile in young adults born preterm.

**Purpose:** Assess the long term effect of premature birth on lipid levels and fat mass in early adulthood.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): Preterm birth</th>
<th>Dependent variable(s):</th>
<th>Results (In comparison to terms, AGA preterms had significantly...)</th>
</tr>
</thead>
</table>
| Cohort: PREMS | N= preterms  
N= 288 terms | GA <36 wks  
SGA: BW below -2 sds | Height measured with stadiometer.  
BMI calculated (no reference to standards).  
Body composition assessed via DEXA  
- total fat mass (kg)  
- trunk fat mass (kg)  
- limb fat mass (kg)  
- lean body mass (kg)  
*Note did not calculate percentages! Also did not define LBM.  
“By adding adult weight SDS to the multiple linear regression model, we investigated the association between GA and fat mass, whereas adult weight SDS was assumed constant, thus indirectly demonstrating the association between GA and fat percentage” | - More limb fat mass (8.8 vs 7.2, P<0.05)  
- More lean body mass (53.8 vs 46.6, P<0.01)  
NS  
- total fat mass  
- trunk fat mass  
- BMI SDS (0.2 vs -0.1)  
SGA birth had NS effects on body composition. |

<table>
<thead>
<tr>
<th>Year of Birth: Missing</th>
<th>Participation rate =79.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at follow up: 18-24, Mean 21.0</td>
<td></td>
</tr>
<tr>
<td>Ethnicity: Dutch Caucasians</td>
<td></td>
</tr>
</tbody>
</table>

| Exclusions: | | Adjustments |
|-------------|--------------------------|
| - serious neonatal complication  
- endocrine/metabolic disorder  
- chromosomal defect  
- conditions known to interfere with growth  
- steroids | Body comp: age, gender, SES, birth length SDS, birth weight SDS, adult height SDS. Lipid levels: all previous plus fat mass and LBM. |

Purpose: Evaluate insulin resistance and body composition in preterm children born AGA or SGA and relations with IGF-1, IGFBP-3 axis.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent Variable(s): Premature birth, birth weight</th>
<th>Dependent variable(s): BMI, IGF-I, IGFBP3, IGFBP1, Leptin, Glucose, Insulin, HOMA-IR, Total fat, Truncal Fat</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Unnamed</td>
<td>N=93 premature children born ≤37 weeks GA in the Istanbul Neonatology Unit</td>
<td>GA determined by mother's last menstrual period and/or antenatal ultrasound examination, and if not conclusive by Ballard assessment (?)</td>
<td>BMI expressed as SDS but no reference for how derived</td>
<td>Sig. diff. (Preterm SGA v. Term SGA):</td>
</tr>
<tr>
<td>Mean GA: 32.5 weeks</td>
<td>N=86 children born at term “recruited from a parallel study”</td>
<td></td>
<td>After overnight fast, serum samples drawn for glucose, insulin, IGF-1, IGFBP-3, IGFBP-1, free T4, thyrotropin (TSH), leptin and lipid levels including cholesterol, triglyceride, LDL and HDL fractions.</td>
<td>- Higher IGFBP-1 (90.4 vs 33.1, p=0.005)</td>
</tr>
<tr>
<td>Mean BW (SGA): -1.9 SDS</td>
<td>SGA= BW or birth length &lt;10th percentile</td>
<td></td>
<td>HOMA-IR (homeostasis model assessment for insulin resistance)= [insulin (microU/ml) x glucose (mmol/l)]/22.5</td>
<td>- Lower insulin (5.0 vs 23.7, p=0.001)</td>
</tr>
<tr>
<td>Mean BW (AGA): -0.3 SDS</td>
<td>Preterm SGA N=43 Term SGA N=42 Preterm AGA N=63 Term AGA N=44</td>
<td></td>
<td>Body composition DEXA</td>
<td>- Lower HOMA-IR (0.1 vs 0.7, p&lt;0.001)</td>
</tr>
<tr>
<td>Year of Birth: Missing</td>
<td>*Included 11 pairs of twins and 1 triplet</td>
<td></td>
<td>- whole body fat (kg)</td>
<td>NS diff in BMI, fat mass, leptin, or body composition. Body composition values not reported.</td>
</tr>
<tr>
<td>Age at follow up: 4.6 years</td>
<td>Exclusions: neurological impairment, severe systemic disease, malformations</td>
<td></td>
<td>- lean body mass (kg, does not say whether this included bone content)</td>
<td>In discussion, reports that DEXA unable to distinguish subcutaneous fat from intraabdominal fat, and truncal fat measured on DEXA not the same as abdominal fat.</td>
</tr>
<tr>
<td>Ethnicity: Turkish</td>
<td></td>
<td></td>
<td>- trunk fat (from chin to obtuse lines passing through femoral necks)</td>
<td>Main finding of the study:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- FMI - FFMI</td>
<td>- Preterm children have similar insulin resistance compared to term children, provided they reach an appropriate height for their target height and have normal BMI.</td>
</tr>
</tbody>
</table>

Adjustments

Not clear, possibly parental education
Title: Euser 2005. Associations between prenatal and infancy weight gain and BMI, fat mass, and fat distribution in young adulthood: a prospective cohort study in males and females born very preterm.
Purpose: Study the association between prenatal, postnatal and late infancy weight gain and body mass index, fat mass, and fat distribution in young adulthood.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): Preterm birth, early postnatal and late infancy weight gain</th>
<th>Dependent variable(s): Weight, height, BMI SD scores, fat free mass, fat mass, body fat percentage, and fat distribution</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>POPS cohort</td>
<td>Males and females born &lt;32 weeks of gestation</td>
<td>Weight and length measured by physicians and nurses, expressed as SD scores with Dutch reference values.</td>
<td>Standing height and weight measured on a balance scale and with a stadiometer.</td>
<td>Birth weight SD scores were positively associated (P &lt;0.05) with</td>
</tr>
<tr>
<td>Mean GA:</td>
<td>Inclusions: Those without congenital malformations leading to changes in body proportions or body composition</td>
<td>BMI calculated.</td>
<td>- Height (B=.336)</td>
<td>- Height (B=.336)</td>
</tr>
<tr>
<td>29.7 weeks</td>
<td>Response rate: 62%</td>
<td>Waist circumference measured at umbilicus after full expiration.</td>
<td>- Weight (B=.369)</td>
<td>- Weight (B=.369)</td>
</tr>
<tr>
<td>Mean BW:</td>
<td>Exclusions - 8 wheelchair bound</td>
<td>Skinfolds taken on left side of body at triceps, biceps, subscapular and iliac.</td>
<td>- BMI SD scores (B=.152)</td>
<td>- BMI SD scores (B=.152)</td>
</tr>
<tr>
<td>1316 grams</td>
<td>- 4 medication</td>
<td>Fat mass and fat free mass calculated using Durnin and Rahaman equations. Subscapular to triceps skinfold thickness calculated as index of truncal to peripheral adiposity.</td>
<td>- Fat free mass (B=.811)</td>
<td>- Fat free mass (B=.811)</td>
</tr>
<tr>
<td>Year of Birth:</td>
<td>1983</td>
<td></td>
<td></td>
<td>NS associations:</td>
</tr>
<tr>
<td>Age at follow up:</td>
<td>19 years</td>
<td></td>
<td></td>
<td>- fat mass</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td></td>
<td></td>
<td></td>
<td>- % body fat</td>
</tr>
<tr>
<td>Dutch</td>
<td></td>
<td></td>
<td></td>
<td>- subscapular to triceps ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- waist circumference</td>
</tr>
</tbody>
</table>

Adjustments

Race, SES, PA
Title: Fewtrell 2004, Prematurity and reduced body fatness at 8-12 years of age.

Purpose: Test the hypothesis that both fat mass and fat free mass are proportionately lower in children born preterm than in children born at term.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): Preterm birth</th>
<th>Dependent variable(s): Fat mass, fat free mass</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unnamed</td>
<td>N=497 preterms</td>
<td>Height and weight digital scales and stadiometer.</td>
<td>BMI: lower 17.5 vs 18.2 (p&lt;0.05)</td>
<td></td>
</tr>
<tr>
<td>Mean GA:</td>
<td>N=95 terms</td>
<td>MUAC and waist circumference assessed with paper measuring tape.</td>
<td>Waist circumference: NS, not a ratio or modified for body size, not a good indicator of adiposity...</td>
<td></td>
</tr>
<tr>
<td>31 weeks</td>
<td>Inclusions: Infants recruited from 5 neonatal units in Cambridge, Leicester, &amp; Nottingham</td>
<td>Biceps, triceps, subscapular and suprailiac skinfold thicknesses measured twice using skinfold calipers.</td>
<td>Skinfolds:</td>
<td></td>
</tr>
<tr>
<td>Mean BW:</td>
<td>Birth wt &lt;1830 g.</td>
<td>PA: parents were asked to rate child less, same, more, or much more active than peers.</td>
<td>1. Slaughter equations: lower body fat % (18.4 vs 20.5, p&lt;0.001)</td>
<td></td>
</tr>
<tr>
<td>1377 grams</td>
<td>Exclusions: - Congenital Malformations - Severe brain damage - If breastfed past hospital discharge - If over 100 days old at time of discharge</td>
<td>DEXA performed on 200 preterm children in light clothing and all term children.</td>
<td>- lower FMI (3.34 vs 3.93, p&lt;0.005)</td>
<td></td>
</tr>
<tr>
<td>Year of</td>
<td></td>
<td>Slaughter and Deurenberg equations used to calculate body FM and FFM from skinfolds.</td>
<td>2. Deurenberg equations: lower body fat % (18.8 vs 20.5, p&lt;0.005)</td>
<td></td>
</tr>
<tr>
<td>Birth:</td>
<td></td>
<td>Arm muscle area and arm fat area calculated from triceps skinfold.</td>
<td>- lower FMI (3.89 vs 3.83, p&lt;0.01)</td>
<td></td>
</tr>
<tr>
<td>1993-1995</td>
<td></td>
<td>FMI and FFMI calculated from FM and FFM to normalize for height. Bone mineral content subtracted from lean mass.</td>
<td>- lower ratio of triceps to subscapular thickness, sug. more truncal fat deposition</td>
<td></td>
</tr>
<tr>
<td>Age at</td>
<td></td>
<td></td>
<td>DEXA</td>
<td></td>
</tr>
<tr>
<td>follow up:</td>
<td></td>
<td></td>
<td>- lower body fat % (20.1 vs 23.3, p&lt;0.005)</td>
<td></td>
</tr>
<tr>
<td>8-12 years</td>
<td></td>
<td></td>
<td>- lower FMI (1.45 vs 1.81, p&lt;0.01)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity:</td>
<td></td>
<td></td>
<td>- FFM NS</td>
<td></td>
</tr>
<tr>
<td>English</td>
<td></td>
<td></td>
<td>PA:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regression of DEXA FMI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Female B=-.44</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Activity B= 0.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Preterm to term B=0.22</td>
<td></td>
</tr>
</tbody>
</table>

Adjustments:
- Sex, activity rating, premature vs term birth, tanner stage, age
Title: Gianni 2007, Regional fat distribution in children born preterm evaluated at school age.

Purpose: To assess total body fat mass and body fat distribution in a cohort of former preterm infants and age matched children born at term.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s):</th>
<th>Dependent variable(s):</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Unnamed</td>
<td>N= 51 preterms</td>
<td>Premature birth</td>
<td>BMI, FM, LM, limb fat mass, trunk fat mass, FMI, LMI, trunk fat index, and limb fat index</td>
<td>Lower BMI (15.5 vs 16.8, p&lt;0.05)</td>
</tr>
<tr>
<td>Mean GA: 30.5 weeks</td>
<td>N= 40 terms</td>
<td></td>
<td></td>
<td>Lower total fat mass (3.5 vs 4.8, p&lt;0.05)</td>
</tr>
<tr>
<td>Mean BW: 1410 grams</td>
<td>59 eligible children born at the NICU of the authors' institution Milan Italy, parents of 8 refused to take part in the study.</td>
<td></td>
<td></td>
<td>Lower fat mass index (2.76 vs 3.76, p&lt;0.05)</td>
</tr>
<tr>
<td>Year of Birth: 2001-2002</td>
<td>GA &lt;34 weeks</td>
<td></td>
<td></td>
<td>Lower limb fat mass (1.8 vs 2.5, p&lt;0.005)</td>
</tr>
<tr>
<td>Age at follow up: 4.8-6.6, mean 5.6</td>
<td>Obtained from follow up records.</td>
<td></td>
<td></td>
<td>Lower limb fat index (1.3 vs 1.9, p&lt;0.05)</td>
</tr>
<tr>
<td>Ethnicity: Italian</td>
<td>GA based on last menstrual period and first trimester ultrasonogram.</td>
<td></td>
<td></td>
<td>No significant difference in</td>
</tr>
<tr>
<td>ISM= BW &lt;10th percentile</td>
<td>SGA= BW</td>
<td></td>
<td>- Lean mass</td>
<td>SGA positively correlated with trunk fat mass content (r=0.37, p&lt;0.05)</td>
</tr>
<tr>
<td></td>
<td>Volume</td>
<td></td>
<td>- Lean mass index</td>
<td>“Children born preterm showed a pattern of fat deposits favoring the trunk relative to the extremities because the lack of adipose tissue was limited to limbs, whereas trunk fat was not different compared with children born at term”</td>
</tr>
</tbody>
</table>

“Terms matched for age and sex, with weight bw 10th and 90th percentiles according to North Italian growth charts recruited from an ongoing study in healthy children”

Adjustments

Age
**Title:** Hack 2003, Growth of Very Low Birth Weight Infants to Age 20 Years  
**Purpose:** Examine gender-specific changes in growth from birth to 20 years old and identify the correlates of growth attainment at 20 years old.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample Characteristics</th>
<th>Independent variable: Birth weight</th>
<th>Dependent variable(s): Weight, height, BMI</th>
<th>Results</th>
</tr>
</thead>
</table>
| **Cohort:** Unnamed | VLBW infants born 1977-1979 and treated in Cleveland, Ohio. | Weight and length measured supine. | Measured with an electric scale and stadiometer.  
BMI calculated using age and sex specific growth data from CDC using z scores. | **At 8:**  
- VLBW males had significantly lower  
  - mean weight (z-score -0.78 (-1.10, -0.46) p<0.001  
  - height (z-score -0.46 (-0.74, -0.18) p<0.01  
  - BMI (z-score -0.72 (-1.03, -0.42) p<0.001  
- Gender difference: Females significantly different in mean weight and BMI but not height.  
  - Mean weight (z score -0.39 (-0.71, -0.07) p<0.05  
  - BMI (z score -0.41 (-0.72, -0.11) p<0.01 |
| **Mean GA:** 29.8 week | N = 195 preterms, 103 male 92 female |  |  | **At 20:**  
- VLBW males had significantly lower  
  - mean weight (z-score -0.86 (-1.19, -0.54) p<0.001  
  - height (z-score -0.44 (-0.72, -0.15) p<0.01  
  - BMI (z-score -0.75 (-1.08, -0.43) p<0.001  
- VLBW females did not differ in mean weight, height, or BMI anymore  
  - Sig. more SGA (wt <-2 SD for GA) than AGA VLBW males remain ed <-2 SD in weight and height.  
- SGA females did not differ significantly from AGA  
- *Females have better growth outcomes than males, makes sense |
| **Mean BW:** 1189 grams | Original sample 312, 64% survival rate. |  |  | **Adjustments**  
Maternal education, age |
| **Year of Birth:** 1977-1979 | Response rate: 68% |  |  |  |
| **Age at follow up:** 8 and 20 | Exclusions:  
- neurosensory impairments (25)  
- Liddles syndrome (1)  
- pregnancy (12)  
- missing growth measurements (9) |  |  |  |
| **Ethnicity:** American, 50% black | Compared to 101 male and 107 NBW controls selected at 8 years old, born with >37 weeks GA. |  |  |  |
Title: Huke 2013. Prematurity is not associated with intra-abdominal adiposity in 5 to 7 year old children.

Purpose: To compare body composition and abdominal fat partitioning between 5-7 year old children born preterm and born at term.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>I variable:</th>
<th>Dependent variable(s):</th>
<th>Results (In reference to terms, preterms had…)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort:</td>
<td>Preterm children of or below 33 weeks GA.</td>
<td>Premature birth</td>
<td>BMI, Waist to Hip ratio, waist circumference, FMI, %FM, %IAAT</td>
<td>Preterms vs terms</td>
</tr>
<tr>
<td>Unnamed</td>
<td>German children that showed up for mandatory health exam required to enter school system and those that responded to mailings from pediatric offices and newspaper advertisements.</td>
<td>≤33 weeks GA, from hospital records</td>
<td>Weight and height measured, BMI calculated using references of Kromeyer-Hausschild.</td>
<td>BMI 5% lower (15.1 vs 15.9 kg/m², p=0.003)</td>
</tr>
<tr>
<td>Mean GA:</td>
<td>29.8 weeks</td>
<td></td>
<td>W/H: Waist and Hip circumferences measured, calculation reported elsewhere.</td>
<td>BIA assessments:</td>
</tr>
<tr>
<td>Meant BW:</td>
<td>1434 grams</td>
<td></td>
<td>Body fat</td>
<td>- %BF lower (18% vs 21%, p=.0022).</td>
</tr>
<tr>
<td>Year of Birth:</td>
<td>Missing</td>
<td></td>
<td>- Bioelectrical impedance analysis measured after fast</td>
<td>- FMI lower (2.82 vs 3.36, p=0.0028)</td>
</tr>
<tr>
<td>Age at follow up:</td>
<td>5-7 years</td>
<td></td>
<td>- Skinfold calipers of biceps, triceps, suprailiac, and subscapular. Fat calculated from triceps and subscapular thicknesses using Slaughter equation.</td>
<td>Skinfold assessments:</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>German</td>
<td></td>
<td>Fat mass index (FMI):</td>
<td>- NS diff in body fat percentage (18% vs 19%, p=0.21)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- fat mass (kg)/height (m²)</td>
<td>- NS diff in FMI (2.82 vs 3.14, p=0.10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- from BIA and skinfold measurements</td>
<td>MRI:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>%IAAT (intra-abdominal adipose tissue)</td>
<td>- Total abdominal adipose tissue lower</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Assessed by MRI</td>
<td>(p=0.04)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- IAAT = Total abdominal adipose tissue volume (TAAT) minus volume of subcutaneous adipose tissue</td>
<td>- NS diff in %IAAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- %IAAT = IAAT/TAAT</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exclusions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 16 refusal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 60 insufficient cooperation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 6 metal implants</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MRI N=68 preterm, 85 term</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exclusions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 16 refusal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 60 insufficient cooperation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 6 metal implants</td>
<td></td>
</tr>
</tbody>
</table>

Adjustments

Prematurity, family history of CVD, maternal BMI, parental BMI, SGA, sex, age
Title: Kajantie 2010. Adults born at VLBW exercise less than their peers born at term.

Purpose: To study the effects of VLBW on PA, an important protective and modifiable factor.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s):</th>
<th>Dependent variable(s):</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Helsinki (Note! Same cohort as Kaseva)</td>
<td>n=163 VLBW n=188 term</td>
<td>BW &lt;1,500 grams</td>
<td>Standard anthropometry Hologic Discovery A DEXA</td>
<td>No difference in BMI or percent body fat for either men or women. No whole group analysis. Both men and women were significantly shorter and lighter. Lean mass was significantly different, but not reported as a percent of body composition or as an index. - Women: 22.2 vs 22.7 kg, p &lt;0.0001 - Men: 34.6 vs 61.1 kg, p &lt;0.0001</td>
</tr>
<tr>
<td>Mean GA: 29.3 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean BW: 1141 grams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of Birth: 1978-1985</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at follow up: 22.3 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity: Dutch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adjustments

Height, parental education, lean body mass, percent body fat
Title: Mathai 2013, Increased adiposity in adults born preterm and their children.

Purpose: Examine body composition and CVD risk factors in adults born preterm and their children.

| Population: Cohort: Offspring of mothers from the Auckland Steroid Trial | Sample | Independent variable(s): BMI | Dependent variable(s): GA ≤ 36 weeks | Results (In comparison to term, preterm…)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean GA: 33.3 weeks</td>
<td>534 survivors of trial contacted at 30 year follow up, of these 127 lived in Auckland. 98 were contactable, 27 declined participation. 19 excluded due to chronic illness. Of these, 31 were preterm and 21 term.</td>
<td>Height and weight recorded, and transformed into SDS for GA (Swedish reference standards).</td>
<td>BMI - Whole group NS diff, women NS diff - Men sig greater (34.2 vs 28.4, p=0.021)</td>
<td></td>
</tr>
<tr>
<td>Mean BW: -0.24 SDS</td>
<td>N= 31 preterm adults and their 37 termborn children (mean age 8)</td>
<td>Body composition - DEXA.</td>
<td>Significant differences in adults: - Higher body fat% (35.4 vs 29.4, p=0.011) - Higher % truncal fat (33.3 vs 30.1, p=0.006) - Higher android fat to glyndroid fat ratio (1.09 vs 0.93, 0=0.004) - 39% preterm obese vs 14% term (BMI ≥30 kg/m2)</td>
<td></td>
</tr>
<tr>
<td>Year of Birth: 1969-1974</td>
<td>N=22 term adults and their 24 termborn children *Very small percentage of original cohort studied!</td>
<td>Physical activity - Assessed by questionnaire (no report of validity) - Weekly frequency, duration, and intensity of exercise. - Graded: 0 = &lt;30 min at least 4 days/wk 1 = 30-60 min at least 4 days/wk 2 = &gt;60 mins at least 4 days/wk</td>
<td>NS diff in PA level or mean caloric intake.</td>
<td></td>
</tr>
<tr>
<td>Age at follow up: 35.7 years</td>
<td>Children excluded having entered puberty, if preterm, if SGA, and for having a 1st degree relative with diabetes.</td>
<td>Food diaries collected for two working days and one weekend day.</td>
<td>Sig. diff in children of preterms vs children of terms - Higher % truncal fat (15.8 vs 12.3, p=0.048) - Higher android fat to glyndroid fat ratio (0.71 vs 0.60, p=0.009) - NS diff in BMI, total body fat %</td>
<td></td>
</tr>
<tr>
<td>Ethnicity: New Zealand European</td>
<td></td>
<td></td>
<td>PA and diet data not shown.</td>
<td></td>
</tr>
</tbody>
</table>

Overall indicates that adverse outcomes associated with preterm birth may extend to the next generation.

Adjustments

Ethnicity, steroid exposure, age, gender, BMI
Title: Peralta-Carcelen 2000, Growth of adolescents who were born at ELBW without major disability.

Purpose: Compare growth between adolescents born at ELBW (≤1000g) and adolescents who were born at NBW (≥2,500g).

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent v.:</th>
<th>Dependent variable(s):</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort:</td>
<td>Cross sectional design, 53 ELBW (≤1000g) matched by sex, race, age, and SES to 53 NBW (≥2,500g) adolescents.</td>
<td>ELBW</td>
<td>BMI, body fat, lean soft tissue mass, bone mineral mass, bone mineral density</td>
<td>No significant differences between ELBW and NBW in any outcome.</td>
</tr>
<tr>
<td>Newborn</td>
<td>ELBW participants were born in Jefferson county hospitals, 55% survived without major disability and eligible. Of the 93 eligible, 69 were contacted, 53 completed study. 57% participation of eligible. NBW recruited from U Alabama Adolescent Clinic, Children’s Hospital of AL Volunteer Program, and Camp Birmingham Summer Program.</td>
<td>BW≤1000g extracted from Newborn Follow Up Program database. GA derived from last maternal menstrual period, clinical history, physician examination, and ultrasound fetal measurements. SGA if BW &gt;10th percentile</td>
<td>Physician blind to BW performed assessments. Height and weight obtained 3 times, with data recorded when 2 equal measures obtained. Z scores calculated with ANTHRO software from CDC. Reference population provided by National Center for Health Statistics Growth Charts.</td>
<td>SGA did not make a difference.</td>
</tr>
<tr>
<td>Follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean GA:</td>
<td>28.2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean BW:</td>
<td>849g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of Birth:</td>
<td>1978-1984</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at follow up:</td>
<td>14.85 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>56.6% white - 43.4% black</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adjustments:
- Sex, race, sexual maturation rating
## Appendix 2

**Title:** Clemm 2012. Aerobic capacity and exercise performance in young people born extremely preterm.

**Purpose:** Compare aerobic capacity and exercise performance of children and adolescents born extremely preterm and at term, and relate findings to medical history and lifestyle factors.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): GA or BW</th>
<th>Dependent variable(s): Level of LTPA</th>
<th>Results (Compared to controls, preterms...)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Western Norway</td>
<td>n= 75 preterms, n= 75 controls&lt;br&gt;Two population based cohorts born in western Norway.</td>
<td>GA ≤ 28 weeks or BW ≤ 1000 grams</td>
<td>Two validated questions&lt;br&gt;1) Apart from at school, how often do you usually exercise so much that you get out of breath or sweat?&lt;br&gt;2) Apart from at school, how many hours a week do you usually exercise so much that you get out of breath of sweat?&lt;br&gt;Parental answers used for youngest cohort.&lt;br&gt;Participation handled as ordinal categorical variables.</td>
<td>- More likely to report LTPA of 2-3x/wk or more (34% of preterms vs 72% of controls, p&lt;0.001)&lt;br&gt;- More likely to report LTPA of 2-3 hours/wk or more (36% of preterms vs 59% of controls, p =0.004).</td>
</tr>
<tr>
<td>GA: 25.8-28.3 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW: 851-1170 grams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at follow up: 10.6 and 16.6</td>
<td>46 from the 1982-1985 cohort, 35 from the 1991-1992 cohort.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity: Norwegian (white)</td>
<td>Exclusions: - unable to run (5) - submax test effort (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 3 Number of Times Per Week With Extracurricular Physical Activity</th>
<th>Pretend Subjects, Control Subjects, No. (%)</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>9 (16)</td>
<td>3 (4)</td>
</tr>
<tr>
<td>Less than 1 h</td>
<td>14 (19)</td>
<td>14 (19)</td>
</tr>
<tr>
<td>1 h</td>
<td>13 (16)</td>
<td>13 (16)</td>
</tr>
<tr>
<td>2-3 h</td>
<td>15 (18)</td>
<td>16 (20)</td>
</tr>
<tr>
<td>4-6 h</td>
<td>13 (16)</td>
<td>14 (18)</td>
</tr>
<tr>
<td>6 h or more</td>
<td>14 (15)</td>
<td>12 (15)</td>
</tr>
</tbody>
</table>

* n = 25; data missing for 2 subjects.

<table>
<thead>
<tr>
<th>TABLE 4 Number of Hours Per Week With Extracurricular Physical Activity</th>
<th>Pretend Subjects, Control Subjects, No. (%)</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 h</td>
<td>10 (20)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>1 h</td>
<td>10 (20)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>2-3 h</td>
<td>11 (22)</td>
<td>11 (22)</td>
</tr>
<tr>
<td>4-6 h</td>
<td>12 (24)</td>
<td>13 (26)</td>
</tr>
<tr>
<td>6 h or more</td>
<td>9 (18)</td>
<td>10 (20)</td>
</tr>
</tbody>
</table>

Exercise more than 1 hour per week was reported by 27 pretend subjects (54%) and 34 control subjects (56%; p<0.001)

n = 25
Title: Kajantie 2010. Adults born at VLBW exercise less than their peers born at term.

Purpose: To study the effects of VLBW on PA, an important protective and modifiable factor.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s):</th>
<th>Dependent variable(s):</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Helsinki (Note! Same cohort as Kaseva)</td>
<td>n=163 VLBW n= 188 term</td>
<td>BW &lt;1,500 grams</td>
<td>Occupational, commuting, leisure time non conditioning, and leisure time conditioning PA</td>
<td>Conditioning LTPA</td>
</tr>
<tr>
<td>Mean GA: 29.3 weeks</td>
<td>73.7% response rate from VLBW and 60.5% response rate from term</td>
<td></td>
<td>Self report questionnaire</td>
<td>- lower frequency (OR: 1.3 (0.74-2.27), p=0.04)</td>
</tr>
<tr>
<td>Mean BW: 1141 grams</td>
<td>Exclusions: cerebral palsy (18) blindness (3) developmental delay (7) severe hearing deficit (1)</td>
<td></td>
<td>Occupational PA dichotomized, physically inactive and physically active work.</td>
<td>- lower intensity (OR: 2.81 (1.35-5.84) p&lt;0.0001)</td>
</tr>
<tr>
<td>Year of Birth: 1978-1985</td>
<td>Commuting assessed in minutes spent walking, biking, or otherwise exercising and dichotomized: low (&lt;30 min/day) or high (≥30 mins/day).</td>
<td></td>
<td>Leisure time non conditioning assessed in mins spent gardening, cleaning, household repair or similar activities and dichotomized: low (&lt;1 hour) or high (≥1 hour).</td>
<td>- short session duration (OR: 3.07 (1.14-8.24), p&lt;0.0001)</td>
</tr>
<tr>
<td>Age at follow up: 22.3 years</td>
<td></td>
<td></td>
<td>Leisure time conditioning assessed with questions:</td>
<td>Low frequency (&lt;1/wk)</td>
</tr>
<tr>
<td>Ethnicity: Dutch</td>
<td></td>
<td></td>
<td>- How much do you exercise and stress yourself physically in your leisure time? 4 response options, leading to categorization as physically active or inactive.</td>
<td>Low intensity (walking)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- How often do you engage in sports or other forms of exercise? 7 response options dichotomized at once a week or less.</td>
<td>Short session duration (&lt;30min)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Asked to rate leisure time exercise intensity as comparable to walking, intermittent walking and light running, light running, or brisk walking, dichotomized as walking or other alternatives.</td>
<td>No difference in occupational, commuting, or nonconditioning LTPA.</td>
</tr>
</tbody>
</table>

Adjustments

Height, parental education, lean body mass, percent body fat, smoking
Title: Kaseva 2012. Lower conditioning LTPA in young adults born preterm at VLBW.
Purpose: Assess PA in healthy young adults born preterm at VLBW compared with term-born controls.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): BW</th>
<th>Dependent variable(s): Yearly frequency, total time, total volume, and energy expenditure of conditioning, non conditioning, and commuting PA</th>
<th>Results (Compared to NBW, VLBW...)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Helsinki</td>
<td>n= 94 VLBW n= 101 NBW</td>
<td></td>
<td></td>
<td>Conditioning LTPA*:</td>
</tr>
<tr>
<td>Mean GA: 29.5 weeks</td>
<td>Controls matched for age, sex, and birth hospital.</td>
<td></td>
<td>- less frequent participation (-38.3% (-58.9, -7.7) p&lt;0.05)</td>
<td></td>
</tr>
<tr>
<td>Mean BW: 1157 grams</td>
<td>Original cohort 335 VLBW and 373 NBW, 255 VLBW and 314 NBW living in area and invited.</td>
<td></td>
<td>- less total time (-47.4% (-71.2, -.4.1) p&lt;0.05)</td>
<td></td>
</tr>
<tr>
<td>Year of Birth: 1978-1985</td>
<td>166 VLBW and 172 NBW attend V1</td>
<td></td>
<td>- lower total volume (-44.3% (-65.8, -9.2) p&lt;0.05)</td>
<td></td>
</tr>
<tr>
<td>Age at follow up: 21-29, mean 24.9 years</td>
<td>Exclusions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity: Finnish</td>
<td>- developmental delay (25)</td>
<td></td>
<td>- less energy expenditure (-55.9% (-78.6, -9.4) p&lt;0.05)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- refusal for further contact (4)</td>
<td></td>
<td>*Adjusting for lean body mass instead of BMI attenuated all differences!</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- abroad (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- untraced (2)</td>
<td></td>
<td>No differences in non-conditioning LTPA or commuting PA.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- pregnancy, medication, type 1 diabetes (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Invited 159 VLBW and 154 NBW to V2. 113 (71.1%) VLBW and 105 (68.2%) NBW participate.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exclusions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- No PA data (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cerebral palsy or mobility disability (8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Final analysis 94 VLBW and 101 NBW.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Energy expenditure = (total time)(MET)(weight). Vigorous PA ≥5 METS.

Adjustments

Age, sex, BMI, smoking, highest level of parental education, personality traits.
Title: Roberts 2013. Quality of life at age 18 years after extremely preterm birth in the post-surfactant era.
Purpose: Assess the self-reported quality of life, health status, self-esteem, and functional outcomes at age 18 years of extremely preterm or ELBW adolescents compared with NBW controls, and assess whether these outcomes are related to GA or BW.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): GA or BW</th>
<th>Dependent variable(s): Physical functioning, role limitations owing to physical health problems, self-esteem</th>
<th>Results (Compared to NBW, EP/ELBW...)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: Victoria Australia</td>
<td>n=194 extremely preterm/elbw</td>
<td>GA &lt;28 wks or BW &lt;1000g</td>
<td>SF-36 “well validated 36-item questionnaire measures physical and mental health across 8 domains”</td>
<td>- Lower total physical functioning scores (p=0.001)</td>
</tr>
<tr>
<td>Mean GA: 26.6 weeks</td>
<td>n=148 controls</td>
<td></td>
<td></td>
<td>- Less regular PA over the previous 6 months (OR:0.5 (0.3-0.8), p&lt;0.01) [40% of EP/ELBW vs 56% of controls]</td>
</tr>
<tr>
<td>Mean BW: 887 grams</td>
<td>Controls recruited at birth and matched for age, sex, and social status. BW &gt;2490g.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at follow up: 18</td>
<td>Exclusions: - major disability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity: Australian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cooperamith Self-esteem Inventory**
“25 forced choice items with good construct validity and test-retest validity”

| Adjustments |
Title: Rogers 2005. Aerobic capacity, strength, flexibility, and activity level in unimpaired ELBW survivors at 17 years compared with term born.
Purpose: To compare aerobic capacity, strength, flexibility and activity level in ELBW adolescents at 17 years of age with term born controls.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s):</th>
<th>Dependent variable(s): Level of past and present sports participation, occurrence of musculoskeletal pain past and present, frequency of activity, enjoyment of activity, happiness with fitness level</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort: unnamed</td>
<td></td>
<td>n= 53 ELBW</td>
<td>BW ≤ 800 grams</td>
<td>(Compared to controls, ELBW...)</td>
</tr>
<tr>
<td>Mean GA: 25.8 weeks</td>
<td></td>
<td>n= 31 controls</td>
<td>“Questionnaire by physiotherapist”</td>
<td></td>
</tr>
<tr>
<td>Mean BW: 719g</td>
<td></td>
<td>Exclusions:</td>
<td>Did not report results well.</td>
<td></td>
</tr>
<tr>
<td>Year of Birth:</td>
<td></td>
<td>- mental retardation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- nonambulatory cerebral</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>palsy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- visual impairment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>worse than 20/200 with</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>correction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- hearing loss with</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hearing aids requiring</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>educational adaptation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>79 eligible, 53 consented</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(67%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 3. Participation in physical activity in ELBW versus controls.
Title: Saigal 2006. Comparisons of current health, functional limitations, and health care use of young adults who were born with ELBW and NBW
Purpose: Compare current health status, physical ability, functional limitations and health care use of ELBW and NBW young adults.

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>Independent variable(s): Birth weight</th>
<th>Dependent variable(s): Physical self efficacy, regular participation in sports and strenuous activities, physical self presentation confidence</th>
<th>Results (In comparison to NBW, ELBW...)</th>
</tr>
</thead>
</table>
| Cohort: Central-west Ontario | n= 166 ELBW survivors (301-1000g) | BW 501-1000g | SF-36  "well validated 36-item questionnaire measures physical and mental health in the previous 4 weeks across 8 domains" | - lower total scores in physical self-efficacy (p<0.001) *  
- lower scores in perceived physical ability (p=0.001) *  
- less regular participation in sports and strenuous activities (p=0.001)  
[38% of ELBW vs 59% of NBW]  
- more likely to attribute lower participation rates to health conditions (p=0.004)  
[22% of ELBW vs 9% of NBW] |
| Mean GA: 27.1 weeks | Of 397 live births, 179 survived hospital discharge, 13 subsequently passed away | Exclusions: - 9 who were lost - 8 refused | 166 available, outcomes reported for 149 (90%) including 7 with severe neurosensory impairment | Gender difference! When stratified by gender no sig. difference in proportion of female individuals who participated and those unable to participate as a result of health conditions. Sig. differences observed among males (p<0.001). |
| Mean BW: 841grams | | Term subjects: 145 available, 5 lost to follow up, 7 refused. 133 evaluated (92%) | | *differences persisted even when individuals with neurosensory impairment were excluded |
| Year of Birth: 1977-1982 | | | | Adjustments |
| Age at follow up: 23 yr | | | | Birth weight group, gender |
| Ethnicity: 94% white | | | | |

*No measure of PA reported.
Appendix 3

Wake Forest University Health Sciences
Department of Pediatrics

Patient Assent Form

Antenatal Steroids and Blood Pressure in Childhood

Principal Investigator: Lisa Washburn, MD
Co-Investigators: T. Michael O’Shea, MD, MPH; Patricia A. Nixon, PhD; Ronald Smith, MD; Leon Lenchik, MD; Paula Sisk, PhD

Why am I here?

We want to tell you about a research study about children who were born early. We want to see if you would like to be in this research study. Dr. Washburn and some other people at this medical center are doing this study.

Why is this study being done?

By doing this study you will help us learn more about the medicines we give to help premature babies and about how blood pressure changes as tiny babies grow up.

What will happen to me?
This study is made up of three visits. You do not have to do everything in the study to participate. Only if you want to be in the study, the following things will happen:

**This is what will happen on every visit:**

1. We want to know how much you've grown! We will weigh you, see how tall you are, and measure your arm muscle.
2. We will check your blood pressure while you are sitting down. To take your blood pressure we will put a band around your arm that gets a little tight for a second or two but it doesn't hurt.
3. We will ask you some questions about your health, habits, and activities. We will also ask you to look at some drawings of the stages of puberty and ask you to circle the pictures that look the most like your body looks now. So that you won't be too embarrassed you will do this in private and put the form in a sealed envelope and it won't even have your name on it.

**This is what will happen on your first visit:**

1. We will ask you to pee in a cup. You can do this all by yourself in the bathroom. So, if you need to use the bathroom when you get here let us know! We will save the sample until you have time to decide if you want to do the study. This urine sample will be sent to the lab to check how your kidneys are working.
2. We will collect some of your spit! We will ask you to chew a piece of sugarless gum and then spit into a container. We will ask you to do this 2 times.
3. We will check your blood pressure after we put a bag of ice on your forehead! How your blood pressure changes when you get the cold feeling on your head will tell us more about how your blood pressure may be when you get older. You will be asked to lie on a bed and we will take your blood pressure. Then we will put a bag of ice on your forehead. This will last for 1 minute.
We will take the bag of ice off your forehead and then we will take your blood pressure three more times while you lie on the bed. You will have 3 sticky pads called electrodes attached to your chest so we can see how fast your heart beats during the test. You will also have a strap around your stomach so we can see how fast you are breathing. The bag of ice will feel very cold, probably like an ice pack you may have put on your head when you bumped your head! You can stop the test at any time.

4. We want to know what you’ve been eating. We want you to keep a record of what you eat for three days. A nutritionist will show you how to do this. We may move this part to your second or third visit.

5. We will ask you to pee in a cup at home on the morning of a next visit. You will be given supplies and instructions. You will bring this urine to the GCRC.

This is what will happen on your second visit:

1. You will collect your urine (pee) in the morning and bring it to the GCRC.

2. We will ask you to pee in a cup when you get to the GCRC. You can do this by yourself in a bathroom. We will send this urine to the lab to check how your kidneys are working.

3. We will also ask you to chew gum and spit in a tube.

4. We will do some breathing tests. We will also ask you to lie on a bed while we monitor your heart rate and breathing. For the breathing tests, you will be asked to blow into a mouthpiece with nose clips on your nose. You will have to take deep breaths in and blow out hard and fast.

5. We will ask you to do the exercise test. For the exercise test, you will also have to blow into a mouthpiece and wear nose clips while you ride an exercise bicycle. You will have sticky pads called electrodes attached to your chest so we can see how fast your heart beats during the test. You will have a strap around your stomach to see how fast you are breathing. A plastic clip with a red light will be loosely attached to your finger so we can see how much oxygen is in
your blood while you exercise. Your ride on the bike will start out very easy like riding on flat
ground. Every minute it will get harder and harder, like going up a steeper and steeper hill. It
is important that you give your best effort and we will cheer you on. The bike ride will only
take 5 to 10 minutes. You may feel tired or short of breath or may even cough or wheeze during
or after the test. You can stop the test at any time.

6. After the exercise test, we will ask you to lie on a bed while we monitor your heart rate and
breathing. Next you will do some more breathing tests while sitting in a chair. We will ask you
to breathe in some medicine called a bronchodilator or Albuterol. You may have breathed in
this medicine as part of testing you have had in the past or may even use this medicine at home.
Several minutes later, you will do the breathing tests one more time to see if the medicine made
a difference in your breathing. This medicine sometimes causes people to have a fast heartbeat
or feel jittery. If this happens it usually only lasts 4 to 6 hours.

7. During the breathing test and exercise test, you may also feel short of breath, tired, lightheaded,
or it may make you wheeze or cough. However, the doctor will be nearby and all of the people
involved have done many of these tests and know how to take care of these problems quickly.

8. We will ask you to chew gum and spit into a container again.

This is what will happen on your third visit:

(You will need to collect and bring a morning urine sample IF you did not do this at
Visit 2.)

1. We will ask you to pee in a cup. You can do this all by yourself in the bathroom. This urine
sample will be sent to the lab to check how your kidneys are working. (If you are a female, we
will need to do a pregnancy test on your urine sample before you have the DXA scan on this visit.)

2. We will measure around your waist with a measuring tape and measure the thickness of your skin on your arm, below your shoulder blade, and at your hip bone.

3. We will ask you to do some game-like tasks like throwing and catching a ball, walking on a line, balancing on one leg on a low (2 ½ inch high) balance beam, and copying a square. These tasks will take about 15 minutes to do.

4. We will ask you to have a DXA scan which is a good way for measuring your body composition – or how much of your body is made of bones, muscle, and fat. For the scan, you lie very still on a table while a metal x-ray arm passes above you from your head to your toes. Your feet may be held in place with tape to help you lie still. You will not feel any pain or discomfort, and the scan only lasts about 5 minutes.

5. For young women we are required to do a urine pregnancy test before the DXA scan. Even though the radiation from the DXA scan is very low, it might be harmful to an unborn baby if you were pregnant. Prior to the DXA scan we will ask you to provide a urine sample in a cup. If the test is positive (meaning you are pregnant), you will not be able to do the DXA scan. We also will not tell anyone, including your parents, that you are pregnant, but we will be happy to help you tell them if you wish.

6. We will get a sample of blood. First we can put some numbing cream on the inside of your arm at the elbow (the best place for getting to the vein) so you won't feel the needle stick so much. Then we will place a small needle into a vein in your arm and take out about 2 Tablespoons of blood. This may hurt and you may have a small amount of bleeding and a bruise where the needle goes in. We will hold pressure on the spot until it stops bleeding and you will be given a band aid. If you have any tenderness, pain or redness in that spot that is getting worse instead of better- let your parent know!
7. We will measure your blood pressure when you are at home or doing your regular activities. We will give you a special blood pressure cuff to wear for 24 hours (all day and all night). It is connected to a small box that you will wear on a strap or on your belt. This monitor will measure your blood pressure every 20 minutes during the day and every 30 minutes during the night. We understand that wearing this monitor all day and all night may bother you some but it will give us very important information about your blood pressure.

**Will the study hurt?**

The stick from the needle will hurt but the hurt will go away after a while. The bag of ice on your forehead will feel cold but will only be on for 1 minute and we will remove it sooner if you ask us to. The exercise test may cause you to have sore muscles for 1 to 2 days. You may be tired after the exercise testing. The exercise testing may cause you to breathe harder. You will be given a medicine through an inhaler to help you breathe easier. This medicine may make you feel jittery and cause your heart to beat faster. There will be a doctor nearby if you have any problems.

**Will I get better if I am in the study?**

This study is not being done because you are sick. But the doctors might find out if you are having certain health problems. The doctors hope to find out something that will help other children like you in the future.

**What if I have questions?**

You can ask questions any time. You can ask questions now, or later. You can talk to the doctors or others helping with the study. You can also talk with your parents or other adults about being in the study if you want to.
Do I have to be in the study?

You do not have to be in the study. No one will be mad at you or unhappy if you don’t want to do this. If you don’t want to be in this study, you just have to tell the study doctor or study nurse. And if you want to be in the study, just let the study doctor or study nurse know. You can decide that you want to leave out part of this study. For example, you may not want to give a sample of blood or wear the blood pressure monitor all day and all night. You can say yes now and change your mind later. It’s up to you.

__________________________  _______  ____________
Signature of Subject        Age        Date

_________________________
Person Obtaining Assent

Date
**ANTENATAL STEROIDS AND BLOOD PRESSURE IN CHILDHOOD**

Principal Investigator:  Lisa Washburn, MD  
Co-Investigators: T. Michael O'Shea MD, MPH; Patricia Nixon, PhD; Ronald Smith, MD; Leon Lenchik, MD; Paula Sisk, PhD

**INTRODUCTION**

Your child is being invited to be in a research study. Research studies are designed to gain scientific knowledge that may help other people in the future. Your child may or may not receive any benefit from being part of the study. There may also be risks associated with being part of research studies. Your child is being asked to take part in this study because of being born prematurely. Your participation is voluntary. Please take your time to make your decision, and ask your study doctor or the study staff to explain any words or information that you do not understand. You may also discuss the study with your friends and family.

**WHY IS THIS STUDY BEING DONE?**

The purpose of this research is to study the long term effects of antenatal steroids (a steroid shot given to pregnant mothers to help the baby's lungs mature) on blood pressure during childhood.

**HOW MANY PEOPLE WILL TAKE PART IN THE STUDY?**

About 200 children will take part in this study. This study is being done at Wake Forest University Health Sciences.
WHAT IS INVOLVED IN THE STUDY?

This study involves 3 visits during a 12 month period.

Each visit will begin in the General Clinical Research Center and will include the following:

1. Your child's arm circumference (the measured distance around the arm), height and weight will be measured.
2. Your child's blood pressure will be measured multiple times while seated in a chair.
3. You will be asked to complete questionnaires.
4. Your child will be asked to complete questionnaires.
5. Your child will be asked to complete a form with pictures of the different stages of puberty to identify the stage of sexual development that he or she is in. This will be done in private and placed in a sealed envelope to avoid any embarrassment.

The visits will last about 1/2 day and are outlined as follows:

Visit 1

1. Your child will be asked to provide a sample of urine during the visit. If your child needs to use the restroom prior to obtaining consent from you and assent from your child, we will collect the urine but hold it until you consent and your child assents to participate in the study.

2. A sample of saliva (spit) will be obtained by asking your child to chew a piece of sugarless gum and then spit into a container.

3. Then we will ask your child to lie on a bed and we will monitor his/her heart rate. Your child's blood pressure will be taken while lying down on a bed. Next, a plastic bag of ice and water will be placed on your child's forehead for one minute. Your child's blood pressure will be taken again several times until it returns to the resting level. While measuring your child's blood pressure change in response to the cold, we will also monitor his/her heart rate with an EKG and monitor the respiratory rate with a strap around your child’s stomach. (The way a person's blood pressure responds to the cold sensation may be predictive of their blood pressure in later life.)

4. Another sample of saliva (spit) will be obtained in the same way.

5. You and your child will meet with a nutritionist in the General Clinical Research Center to learn how to keep the 3 day food record. (This may be moved to the second or third visit if necessary.)
6. At the end of Visit 1, we will give your child supplies and instructions for collecting their first morning urine. Your child will collect this urine in the morning of a subsequent study visit and bring this urine sample to that appointment.

**Visit 2**

1. Your child will collect their first morning urine and bring this sample with them to Visit 2.

2. Your child will be asked to provide a sample of urine during the visit.

3. A sample of saliva (spit) will be obtained by asking your child to chew a piece of sugarless gum and then spit into a container.

4. Your child will be escorted to the lab where the exercise test will take place. Prior to the exercise test we will obtain baseline lung function or breathing tests. We will ask your child to lie on a bed while we monitor heart rate with an EKG and breathing with a strap around your child’s stomach. Your child will then perform the exercise test on a stationary bicycle. The test will start out very easy like riding on level ground. Each minute the test will get progressively harder, like riding up a steeper and steeper hill. Your child will be encouraged to give a maximal or best effort. During the test you child will breath through a mouthpiece and wear noseclips so that we will measure the air your child breathes out. Your child’s heart rate will be monitored with an EKG and oxygen levels in the blood will also be monitored using a pulse oximeter, which is a plastic clip with a red light that sees through the skin on the finger. (No blood is drawn.)

5. After the exercise test is over, your child will lie on a bed while we monitor their heart rate. Next we will have your child repeat the breathing tests. We will give your child a breathing treatment with a bronchodilator, Albuterol, a medicine that opens airways. This will treat any bronchoconstriction (tightening of the airways) that may have occurred with exercise.

6. We will repeat the breathing tests to make sure they return to the baseline levels.

7. Another sample of saliva (spit) will be obtained in the same way.

**Visit 3**

{Your child will need to collect a first morning urine sample and bring it with them to the Visit 3 appointment **IF this was not done at Visit 2.**}
1. Your child will be asked to provide a sample of urine at the beginning of the visit. If your child is female, she will be required to provide a urine sample before the DXA scan (described below) to rule out pregnancy. Even though the radiation is very small, it may be harmful to an unborn baby. The results of the pregnancy test that is performed on your child will be kept confidential and you will not be told the results unless your child agrees to share this information with you, unless there is a medical problem for which we need to receive parental consent to treat, or if medical care is needed from another physician.

2. Your child will have measurements made of skin thickness with calipers and a measurement of the waist with a tape measure.

3. Your child will be asked to perform several game-like tasks assessing coordination such as throwing and catching a ball, walking on line, balancing on one leg on a low (2 ½ inch high) balance beam, and copying a square. These tasks will take about 15 minutes to complete.

4. Your child’s body composition will also be measured by a dual energy x-ray absorptiometry (DXA) scan. You will be escorted to the Sticht Center (a 5 minute indoor walk) for this test. During the DXA scan, your child will be asked to lie very still on a table for approximately 5 minutes while the machine makes an image of your child’s total body. The scan exposes your child to a very small amount of radiation, similar to the radiation from playing outside on a couple of sunny days.

5. Your child will have approximately 2 Tablespoons of blood withdrawn from a vein at this visit. To decrease the pain often felt with a needle stick, a numbing cream will be applied 30 minutes prior to the needle stick. Your child can still participate in the study if he/she doesn’t want to participate in the blood sampling part.

6. Some people have elevated blood pressure when they are in the doctor's office or clinic but normal blood pressure at home. This is called "White Coat" hypertension. To check your child's blood pressure during normal activities your child will be fitted with an ambulatory blood pressure monitor. This monitor will be worn home and kept on for 24 hours (all day and all night) if possible. It consists of a blood pressure cuff and a small box that is worn on a strap like a purse or clipped onto the belt. The cuff will inflate every 20 minutes during the day and every 30 minutes at night. We will ask you and your child to keep a record of the activities your child participates in while wearing the monitor. The ambulatory blood pressure monitor will have to be returned to the GCRC after use. You may pull your car into a special drop off area that we will point out to you or if you live outside of Winston-Salem you may mail it back.

The records surrounding the child's birth (mother and child) will be reviewed to obtain information about the pregnancy and your child’s nursery stay.
FUTURE USE OF BLOOD AND URINE SAMPLES

If you agree, your child’s leftover blood and urine will be kept and may be used in future research to learn more about hypertension and other diseases. The blood and urine will be stored by the Hypertension Core Laboratory at Wake Forest University Health Sciences. An Institutional Review Board (IRB) must also approve any research study using your child’s blood and urine. Sometimes blood and urine samples are used for genetic research that may provide information about diseases that are passed on in families. Even if your child’s blood and urine is used for this kind of research, the results will not be told to you or members of your family and will not be put in your health records. The choice to let your child’s blood and urine be kept for future research is up to you. No matter what you decide to do, it will not affect your child’s participation in this study. If you decide now that your child’s blood and urine can be kept for research, you can change your mind at any time. Just contact Dr. Washburn and let her know that you do not want your child’s blood and urine kept. Otherwise, the blood and urine may be kept until it is used up or until it is destroyed.

I agree that my child’s blood and urine samples and health records may be kept for use in future research to learn about, detect, prevent, treat, or cure high blood pressure and other health problems.

____________________________________  ________________________
Signature of parent or legal guardian    Date of signature
signature

HOW LONG WILL I BE IN THE STUDY?

Each study visit will last about half of a day. There will be three visits scheduled within 1 year. You will be asked to keep a 3 day food record of what your child eats. The ambulatory blood pressure monitor is worn for 24 hours and you must drop it off at the GCRC or put it in the mail the next day. Your child will be asked to record his/her activities during the ambulatory blood pressure monitoring. You or your child may decide to stop participating at any time.

In the future we may wish to invite our study participants to return for a follow-up assessment.

Your signature on the line below indicates that you give permission for us to contact you about
any opportunities for follow-up evaluations.

______________________________________________  _______________________
Signature of parent or legal guardian                Date of signature
signature

**WHAT ARE THE RISKS OF THE STUDY?**

Being in this study involves some risk to your child. You should discuss the risk of being in this study with the study staff. Risks and side effects related to the study include:

**Visit 1**

The bag of ice placed on the forehead will feel very cold and uncomfortable but similar to what you would feel when placing an ice pack on a minor injury.

**Visit 2**

Your child may experience wheezing, shortness of breath, tightening of the airways (bronchoconstriction), muscle soreness, and fatigue from the exercise testing. A bronchodilator will be administered to reverse any exercise induced airway tightening. A possible side effect of the bronchodilator, Albuterol, is a rapid or irregular heart rate and tremor that may last for 4 to 6 hours. Your child will be monitored closely during the tests. Trained personnel will be present in the unlikely event that any medical emergency arises. Your child may have sore muscles 1 to 2 days from the exercise test.

**Visit 3**

The DXA scan involves exposure to radiation. The risk of the DXA procedures is small and is similar to that received from a clinical x-ray or nuclear medicine study. The scan exposes your child to a very small amount of radiation, similar to the radiation from playing outside on a couple of sunny days. The amount of radiation exposure that your child will receive from this procedure is equivalent to a uniform whole body exposure of 0.7 millirem. This is equal to 0.23%
of the amount of background radiation that the average person in the United States receives each year. In the United States, the background radiation is 300 millirem per year.

When having their blood sample taken, your child may experience discomfort, bruising and/or bleeding where the needle is inserted. Occasionally some people become dizzy, lightheaded or feel faint. Infection may occur on rare occasions.

The ambulatory blood pressure monitoring may be inconvenient.

**All Visits**

One of the study questionnaires involves asking your child about his/her stage of puberty or sexual development. This may cause embarrassment to some children but this will be minimized by picture identification done in private and placed in a sealed envelope.

Taking part in this research study may involve providing information that you consider confidential or private. Efforts, such as coding research records, keeping research records secure and allowing only authorized people to have access to research records, will be made to keep your information safe.

A Data Safety and Monitoring Committee, an independent group of experts, will be reviewing the data from this research throughout the study.

**ARE THERE BENEFITS TO TAKING PART IN THE STUDY?**

If your child agrees to take part in this study, there may or may not be direct benefit to him/her. We hope the information learned from this study will benefit other premature babies in the future. The benefits of participating in this study may be: Identification of elevated blood pressure.

**WHAT OTHER CHOICES ARE THERE?**

This is not a treatment study. Your alternative is to not participate in this study.

**WHAT ABOUT THE USE, DISCLOSURE AND CONFIDENTIALITY OF**
HEALTH INFORMATION?

By taking part in this research study, you and your child's personal health information, as well as information that directly identifies you and your child, may be used and disclosed. Information that identifies you and your child includes, but is not limited to, such things as your name, address, telephone number, and date of birth. You and your child's personal health information includes all information about you and your child which is collected or created during the study for research purposes. It also includes you and your child's personal health information that is related to this study and that is maintained in your medical records at this institution and at other places such as other hospitals and clinics where you may have received medical care. Examples of your personal health information include your health history, your family health history, how you respond to study activities or procedures, laboratory and other test results, medical images, and information from study visits, phone calls, surveys, and physical examinations.

You and your child's personal health information and information that identifies you (“your health information”) may be given to others during and after the study. This is for reasons such as to carry out the study, to determine the results of the study, to make sure the study is being done correctly, to provide required reports and to get approval for new products.
Some of the people, agencies and businesses that may receive and use your health information are the Institutional Review Board; representatives of Wake Forest University Health Sciences and North Carolina Baptist Hospital; representatives from government agencies.

Some of these people, agencies and businesses may further disclose your health information. If disclosed by them, your health information may no longer be covered by federal or state privacy regulations. Your health information may be disclosed if required by law. Your health information may be used to create information that does not directly identify you. This information may be used by other researchers. You and your child will not be directly identified in any publication or presentation that may result from this study.

A North Carolina Baptist Hospital (NCBH) medical record will be created for all study participants. As a participant in this study, a copy of this signed informed consent will be placed in the NCBH medical record, along with any routine medical test results that were obtained at NCBH as part of this study.

If this research study involves the treatment or diagnosis of a medical condition, then information collected or created as part of the study may be placed in your child's medical record and discussed with individuals caring for your child who are not part of the study. This will help in providing you with appropriate medical care. In addition, all or part of your child's research related health information may be used or disclosed for treatment, payment, or healthcare operations purposes related to providing you with medical care.

Laboratory test results and other medical reports created as a result of your child's participation in the research study may be entered into the computer systems of Wake Forest University Health Sciences and North Carolina Baptist Hospital. These will be kept secure, with access to this information limited to individuals with proper authority, but who may not be directly involved with this research study.

When you sign this consent and authorization form you authorize or give permission for the use of your health information as described in the consent form. This authorization does not have an expiration date. You can revoke or take away your authorization to use and disclose your health information at any time. You do this by sending a written notice to the investigator in charge of the study at the following address:

Lisa Washburn, MD
Medical Center Blvd.
Winston-Salem, NC 27104
If you withdraw your authorization you will not be able to be in this study. If you withdraw your authorization, no new health information that identifies you will be gathered after that date. Your health information that has already been gathered may still be used and disclosed to others. This would be done if it were necessary for the research to be reliable. You will not have access to your health information that is included in the research study records until the end of the study.

**WHAT ARE THE COSTS?**

There are no costs to you for taking part in this study.

**WILL YOU BE PAID FOR PARTICIPATING?**

Your child will receive $50 for participating in Visit 1, $75 for participating in Visit 2 and $100 for participating in Visit 3. If your child participates in all three visits he/she will get a total of $225. In addition, you will receive $25 for participation in each visit, a total of $75 for participating in all three visits. To receive payment you must provide yours and your child's social security number, name and address so that we can comply with IRS (Internal Revenue Service) reporting requirements. When payments are reported to the IRS we do not let them know what the payment is for, only that you and your child has been paid. If you do not wish to provide this information you can still take part in this study but you and your child will not be paid.

**WHO IS SPONSORING THIS STUDY?**

This study is being sponsored by National Institutes of Health.

**WHAT HAPPENS IF YOU EXPERIENCE AN INJURY OR ILLNESS AS A RESULT OF PARTICIPATING IN THIS STUDY?**

Should your child experience a physical injury or illness as a direct result of your participation in this study, Wake Forest University School of Medicine maintains limited research insurance coverage for the usual and customary medical fees for reasonable and necessary treatment of such injuries or illnesses. To the extent research insurance coverage is available under this policy the reasonable costs of these necessary medical services will be paid, up to a maximum of $25,000. Wake Forest University Baptist Medical Center holds the insurance policy for this coverage. It
provides a maximum of $25,000 coverage for each claim and is limited to a total of $250,000 for all claims in any one year. The Wake Forest University School of Medicine, and the North Carolina Baptist Hospitals, Incorporated do not assume responsibility to pay for these medical services or to provide any other compensation for such injury or illness. Additional information may be obtained from the Medical Center’s Director of Risk and Insurance Management, at (336) 716-3467.

You do not give up any legal rights as a research participant by signing this consent form. For more information on medical treatment for research related injuries or to report a study related illness, adverse event, or injury you should call Lisa Washburn at 336-716-5987. If there is no answer or a problem arises in the evening, please call the hospital operator at 336-716-2011 and ask for Dr. Washburn in Neonatology to be paged.

**WHAT ARE MY RIGHTS AS A RESEARCH STUDY PARTICIPANT?**

Taking part in this study is voluntary. You may choose not to take part or you may leave the study at any time. Refusing to participate or leaving the study will not result in any penalty or loss of benefits to which you are entitled. If you decide to stop participating in the study we encourage you to talk to the investigators or study staff first to learn about any potential health or safety consequences. The investigators also have the right to stop your participation in the study at any time. This could be because new information becomes available or because the entire study has been stopped.

You will be given any new information we become aware of that would affect your willingness to continue to participate in the study.

**WHOM DO I CALL IF I HAVE QUESTIONS OR PROBLEMS?**

For questions about the study or in the event of a research-related injury, contact the study investigator, Lisa Washburn, MD at 336-716-5987. If there is no answer or a problem arises in the evening, please call the hospital operator at 336-716-2011 and ask for Dr. Washburn in Neonatology to be paged.

The Institutional Review Board (IRB) is a group of people who review the research to protect your rights. If you have a question about your rights as a research participant, you should contact the Chairman of the IRB at (336) 716-4542.
You will be given a signed copy of this consent form.

We can send copies of your test results to your personal physician. Even if you do not wish to have any of your medical information sent to your physician, you can still participate in this research study.

Do you request that we sent important medical findings from our child’s study to your child’s personal physician?

[ ] Yes  [ ] No  __Initials

**SIGNATURES**

I agree to let my child take part in this study. I authorize the use and disclosure of my child's health information as described in this consent and authorization form. If I have not already received a copy of the Privacy Notice, I may request one or one will be made available to me.

I have had a chance to ask questions about my child's participation in this study and have those
questions answered. By signing this consent and authorization form, I am not releasing or agreeing to release the investigator, the sponsor, the institution or its agents from liability for negligence.

Subject Name (Printed)

Legally Authorized Representative Name (Printed)

The above named Legally Authorized Representative has legal authority to act for the research subject based upon (specify: parent, legal guardian, health care power of attorney, etc.):

Legally Authorized Representative (Signature)  Date  Time

Person Obtaining Consent  Date  Time
Appendix 5

PHYSICAL ACTIVITY QUESTIONNAIRE (MAQ)

Interviewer ________

Name ____________________________________________  Date ______________

What time does your school day start? __________  end?_____________

How many weeks per school year do you have gym class? ______

How many times per week do you have gym class? ______

During the past 12 months (from ____ to ____), how many team or individual sports or
activities did you participated in on a competitive level, such as varsity, JV, intramurals,
little league, club, out-of-school programs? __________

What were the activities? __________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

Excluding gym class, please tell me any sports or leisure time activities you did in the
past week (from __ to ___ yesterday):

<table>
<thead>
<tr>
<th>Activity</th>
<th>Times per week</th>
<th>Minutes per time</th>
<th>Hard, mod, light</th>
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(Hard = breathe hard and heart beats fast, eg. Basketball, jogging; moderate = not breathe
hard, etc., eg. Walking, slow bicycling)

Was this a normal week?
PAST YEAR LEISURE-TIME PHYSICAL ACTIVITY

I am going to read you a list of activities kids your age might do. Please let me know any that you have done at least 5 or more times in the past year (from _mon_ to _mon_). Do not include activities that you did in school phys ed or gym class.

Aerobics
Band/Drill Team
Baseball
Basketball
Bicycling
Bowling
Cheerleading
Dance Class
Football
Garden/yard work
Gymnastics
Hiking
Ice Skating
Roller Skating/Blading
Running for Exerices
Skateboarding
Snow skiing
Snow boarding
Soccer
Softball
Street Hockey
Swimming (Laps)
Swimming (Play)

Tennis
Trampoline Jumping
Volleyball
Walking
Water Skiing
Weight Training
Wrestling
Others:

__________________
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<table>
<thead>
<tr>
<th>Activity</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Months per Year</th>
<th>Days per Wk or mon</th>
<th>Minutes per Day</th>
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WAKE FOREST UNIVERSITY SEDENTARY BEHAVIOR QUESTIONNAIRE (WFU SBQ)

“The next questions I am going to ask you are about sedentary activities, like watching TV. I am going to ask you to tell me how much time you spend doing these activities during a typical school week. I am going to ask you separately for schooldays (mon-fri), and then for weekend days (sat and Sunday). I am interested in the time you spend doing these activities outside of school, i.e. before or after school.”

For first activity ask, “How much time do you spend during a typical school week on schooldays [activity]:

Record number of minutes per day X number of days, or total for weekdays (and weekend days).

Ask same for weekend.

Repeat for each activity.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Weekday Minutes</th>
<th>Weekend Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watching television or movies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using the computer (playing video games, surfing the net, etc.)</td>
<td></td>
<td></td>
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<tr>
<td>Doing homework</td>
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<tr>
<td>Reading (aside from homework)</td>
<td></td>
<td></td>
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<tr>
<td>Listening to music (not doing any other mentioned already)</td>
<td></td>
<td></td>
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<tr>
<td>Playing a musical instrument</td>
<td></td>
<td></td>
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<tr>
<td>Talking on the telephone</td>
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<td></td>
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<tr>
<td>Hanging out with friends (not doing any other activity listed here on the Physical Activity recall)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On a typical school night, what time do you go to bed? _______ Wake up? _______

On a Friday night, what time do you go to bed? _______ Wake up? _______
Scholastic Vitae

Holly Redman
436 Olde Harbour Trail
Rochester, NY 14612
Phone: (585) 683-0518
Hredman1@gmail.com

EDUCATION

Wake Forest University, Winston-Salem, NC
Masters in Health and Exercise Science
May 2014

The College at Brockport, Brockport, NY
Bachelors in Exercise Physiology & Psychology with Honors
Minor in Biology
May 2012

CERTIFICATIONS

ACSM Clinical Exercise Specialist
04/2014- Present

ACSM Health Fitness Specialist
01/2012- Present

American Heart Association BLS, CPR, AED
08/2012- Present

EXPERIENCE

Research Assistant, Prenatal Events Postnatal Consequences II
Wake Forest University, Winston-Salem, NC
08/2012- 05/2014

Teaching Coordinator, HES 101: Exercise for Health
Wake Forest University, Winston-Salem, NC
05/2013-05/2014

Intern, Healthy Exercise and Lifestyle Programs
Wake Forest University, Winston-Salem, NC
08/2012-09/2013

Research Assistant, Nitrate Supplementation in Hypertensive Older Adults
Wake Forest Baptist Health, Winston-Salem, NC
05/2013- 09/2013

Teaching Assistant, HES 101: Exercise for Health
Wake Forest University, Winston-Salem, NC
08/2012-05/2013

Intern, Biomechanics Lab
The College at Brockport, Brockport, NY
01/2012-05/2012

Research Assistant, Multi-joint Isokinetic Power Training
The College at Brockport, Brockport, NY
08/2011- 01/2012

Student Researcher, Treatment Adherence to Physical Therapy
The College at Brockport, Brockport, NY
08/2009 -05/2012

Research Assistant, Department of Clinical Psychology
University of Rochester, Rochester, NY
08/2008-01/2009