Childhood Obesity and Vascular Phenotypes

A Population Study

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Objectives

This study sought to assess the associations of childhood adiposity with vascular phenotype in pre-pubertal children.

Background

The early-life metabolic consequences have consistently been demonstrated in obese children, but the time course and development of any vascular changes remain largely unexplored.

Methods

A total of 6,576 children age 10 to 11 years from the ALSPAC (Avon Longitudinal Study of Parents and Children) were studied. Childhood overweight and obesity were based on body mass index contemporary to vascular measures and supported by other adiposity measures, including fat mass and waist circumference on dual-energy x-ray absorptiometry. Heart rate, blood pressure, flow-mediated dilation in the brachial artery, and carotid to radial pulse wave velocity were measured in all children.

Results

Overweight and obese children had higher heart rates (mean 72.4 ± 11 beats/min and 74.6 ± 12.2 beats/min vs. 71.7 ± 11 beats/min) and systolic blood pressures (mean 106.3 ± 9.1 mm Hg and 108 ± 10.2 mm Hg vs. 103.6 ± 9 mm Hg) compared with normal-weight peers. However, obese children had greater brachial diameters and resting and hyperemic blood flow, marginally increased endothelial function (higher flow-mediated dilation: mean 8.2 ± 3.2% vs. 8.1 ± 3.3%), and lower arterial stiffness (pulse wave velocity: mean 6.99 ± 1.0 m/s vs. 7.05 ± 1.23 m/s) compared with normal-weight children. These findings were not explained by metabolic differences.

Conclusions

Greater childhood adiposity is associated with adverse cardiometabolic risk factors, but with no evidence of vascular damage at age 9 to 11 years. This could represent physiological adaptation to the hyperemic state of adiposity in childhood.

Childhood obesity is common in high-income countries, and its prevalence is also increasing in developing countries (1). One-third of children in the United States are overweight, and many develop dyslipidemia, insulin resistance, and hypertension from as early as their first decade of life (2). Pathological studies have linked obesity with accelerated development of fatty streaks and fibrous plaques in childhood, and large epidemiological studies, such as the Bogalusa Heart Study and the Cardiovascular Risk in Young Finns Study, have demonstrated that childhood obesity is associated with adverse vascular changes in adulthood (3–5). Increased morbidity and mortality have been reported in adults with a history of childhood obesity, and a 5% to 10% increase in the incidence of coronary artery disease in the adult population has been predicted as a result of the current epidemic of childhood obesity (2,6).

The link between adiposity and vascular disease has been extensively explored in adults, but limited information exists on its impact on the vasculature in childhood (6). A number of reports have suggested birth weight and critical periods after birth as key determinants of an adverse cardiovascular (CV) risk factor profile, while others have suggested that the
The development of adiposity between 4 and 7 years of age (“adiposity rebound”) is more important (7,8). However, findings have been inconsistent (9).

Most studies have focused on very obese subjects, and less information is available on the more prevalent “healthy” overweight or obese children. We have previously demonstrated the presence of metabolic disturbances, comparable in magnitude with those seen in adults, in a large population of pre-pubertal overweight and obese children in ALSPAC (Avon Longitudinal Study of Parents and Children), but the relationship among adiposity, metabolic profile, and vascular function and structure was not explored (10). We therefore set out to assess the impact of childhood adiposity patterns with age on arterial phenotype.

Methods

Vascular study population. ALSPAC is a large longitudinal birth cohort study that was set up in 1991. The cohort and study design are described in detail elsewhere (11,12). The cohort of 14,062 live-born children has been followed up, initially with questionnaires through childhood, and at regular annual clinic visits since the age of 7 years. We undertook vascular studies in all term-born ALSPAC children who attended for clinic assessment at the age of 10 to 11 years. Participants who have remained in the cohort over the follow-up to the present analyses have tended to be from more educated and older parents and less likely from minority ethnic groups. Approval for the study was obtained from the ALSPAC ethics and law committee, and written informed consent and assent were obtained from both the parent or guardian and the child.

Anthropometric measurements. ADIPOSEITY MEASUREMENTS. At 10 years, weight, height, and waist circumference were all assessed at the same clinic visit as the vascular measurements. Weight was measured to the nearest 0.1 kg using Tanita scales (Wardworth Ltd, Bolton, United Kingdom). Height was measured to the nearest 0.1 cm using a Harpenden stadiometer (Holtain Ltd, Cymych Pembroke-shire, United Kingdom). Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Overweight and obesity were defined using age- and sex-specific BMI thresholds proposed by the International Obesity Taskforce, which correspond to the adult BMI cutoffs of 25 and 30 kg/m² for adult overweight and obesity (13). Waist circumference was measured using a flexible tape, to the nearest 1 mm, at the midpoint between the lower ribs and the pelvic bone, and the ratio of waist circumference to height was calculated. This has been validated as a measure of central adiposity in children (14).

Fat and lean masses were assessed at an earlier clinic visit, with a median of 9 months (interquartile range: 6 to 11 months) between these assessments and the vascular measurements. This was done using a Lunar Prodigy narrow fan-beam densitometer (GE Healthcare, Bedford, United Kingdom). Body fat mass was expressed as a percentage of the sum of the lean and fat mass. Trunk fat mass was expressed as a percentage of total fat mass, representing central adiposity.

Exposure of adiposity was assessed by identifying children who were overweight or obese from birth and at the specific time points of 2, 6, and 10 years of age. Weight and height measurements were available from birth. Birth weight was obtained from obstetric records, and infant weight was extracted from health visitor records. Trained ALSPAC staff members measured weight and crown-heel length (Harpenden Neonatometer; Holtain Ltd) at birth in 62% of subjects. Additional data were obtained from clinical records and birth notification. Subsequently, weight and height were available from personal child health records until 5 years of age. The accuracy of the data from these clinical records has been confirmed in a subgroup (15). After 5 years, height and weight were measured during regular clinics with the children in light clothing, without shoes. Pubertal status was assessed by validated questionnaire (16).

BLOOD PRESSURE AND HEART RATE. Blood pressure was recorded in the right arm in the seated position using a Dinamap 9301 Vital Signs Monitor (Morton Medical, London, United Kingdom), and the mean of 2 values was used for analysis. Arm circumference was used to choose between a pediatric and a regular adult cuff, using a cutoff of 25 cm. Heart rate was measured as the mean of the last 2 readings, recorded using the same device.

Measurement of metabolic markers. During an earlier visit (interquartile range: 7 to 12 months previously), non-fasting blood samples were taken using standard procedures and immediately spun, then frozen at −80°C. Lipid profile (total cholesterol, high-density lipoprotein cholesterol, triglycerides, apolipoprotein A1, apolipoprotein B), inflammatory markers (C-reactive protein and interleukin-6) and adipocytokines (leptin and adiponectin) were measured as described previously (10).

Vascular measurements. PULSE WAVE VELOCITY (PWV). Pressure-pulse waveforms were recorded transcutaneously using a high-fidelity micromanometer (SPC-301; Millar Instruments, Houston, Texas) from the radial and carotid pulses, using synchronous electrocardiography to provide an R-wave timing reference. Integral software processed the data to calculate the mean time difference between R waves and pressure waves on a beat-to-beat basis over 10 s. PWV was calculated using the mean time difference (in seconds) and arterial path length (in meters) between the 2 recording points (SphygmoCor version 7.1, Scanmed Medical Supplies, Moreton-in-Marsh, United Kingdom).

BRACHIAL ARTERY FLOW-MEDIATED DILATION (FMD). Each child underwent measurement of endothelium-dependent vascular responses of the right brachial artery by high-
resolution ultrasound imaging (Aloka 5500, Hitachi Aloka, Tokyo, Japan; 7-MHz linear probe and automated vessel-diameter measurements, Brachial Tools, Medical Imaging Applications, Coralville, Iowa) in a temperature-controlled room (24°C to 26°C). The children lay supine on a couch, and after 10 min of rest, a straight, nonbranching segment of brachial artery above the antecubital fossa was scanned longitudinally. After depth and gain settings were adjusted, brachial artery diameter was recorded (baseline) for 1 min. A pneumatic cuff was then inflated to 200 mm Hg on the forearm for 5 min. After rapid deflation of the cuff, the segment of brachial artery was recorded continuously for another 5 min. End-diastolic images at 3-second intervals were assessed. Brachial artery diameter was measured offline by an automatic edge detection system. FMD was expressed as both the absolute difference between maximal and resting vessel diameters and as a percentage change of resting diameter. The velocity-time integral of the pulse wave Doppler signal was used to calculate baseline blood flow and reactive hyperemia flow (17). The flow stimulus for FMD was expressed as the difference in blood flow within 15 s of cuff deflation and resting blood flow. FMD corrected for shear stress was obtained by dividing FMD by the hyperemic velocity-time integral (18).

Statistical analysis. All normally distributed variables are expressed as mean ± SD. Data that were not normally distributed (leptin, triglycerides, C-reactive protein, and interleukin-6) were log-transformed to approximate normality before parametric testing and are expressed as median (interquartile range) in descriptive analyses and Tables 1 and 2. Categorical variables are expressed as percentages. Comparisons between metabolic markers and vascular measurements in male and female subjects were performed using independent-sample Student t tests. Univariate relationships between variables are expressed using Pearson’s r coefficients. To assess continuous relationships of adiposity with vascular function, multiple linear regression analysis was used. Adjustment was made for sex and age. Because PWV has been shown to vary with heart rate and blood pressure (19), associations with this variable were further adjusted for these factors. Additional models tested the ability of social class, inflammatory markers, or lipid profiles to influence the associations.

The association of birth weight (converted to age and sex internally standardized z-score) with vascular phenotype at 10 years was explored using linear regression after adjustment had been made for gestational age. Weight gain between birth and 2 weeks and between birth and 2 months was calculated by subtracting birth weight from weight at these ages and converting these differences to age and sex standardized z-scores (20).

Weight and height at different time points from birth to 10 years of age were calculated using a generalized additive model (21). Models for weight and height were fitted for each sex using smoothing cubic splines that describe the age-varying distributions of the data in terms of location (median), scale (coefficient of variation), and shape (skewness and kurtosis). For each individual growth trajectory, outliers were determined and removed after statistical comparison with the immediately preceding and following measures (912 weight estimates [1%] and 906 height estimates [1%]). Weight and height at specific ages were estimated by back transformation of z-scores to natural units. These were converted to BMI for each week since birth for each subject. This growth curve modeling has been described previously (20). Obesity at ages 2, 6, and 10 years was defined using the BMI cutoffs at the same ages from the International Obesity Taskforce (13). Separate groups of children were predefined for exploration: 1) those who were obese at all 3 time points; 2) those who were obese at only 2 time points; and 3) those who were obese at only age 10 years.

Associations of birth weight, weight gain, and different patterns of obesity across the time periods were assessed using multiple linear regression, adjusted for sex. All statistical analyses were performed using Stata version 11 (StataCorp LP, College Station, Texas).

Results

Demographic characteristics. The demographic characteristics of the cohort according to sex are shown in Table 1. Of the 6,592 participants, 80% were normal weight, 16% were overweight, and 4% were obese according to BMI criteria at age 10 years. Pubertal status within 6 months of vascular measurements was available for 51% of subjects, and although girls were more advanced than boys, only a minority of boys (0.6%) and girls (7.7%) had advanced beyond Tanner stage III.

Adiposity and CV risk factors. Overweight and obese children had adverse metabolic and inflammatory biomarkers, with higher total cholesterol, triglycerides, leptin C-reactive protein, and interleukin-6 levels, than normal-weight children (Table 2 and previously reported findings [10]).

Adiposity and vascular measurements. Overweight and obese children had higher heart rates, increased resting and reactive hyperemic blood flow, and larger vessel diameters (assessed at the same age) compared with normal-weight children (Table 2). Valid PWV and FMD measurements were available in 6,293 (95%) and 5,811 (87%) children, respectively. Overweight and obese children had lower PWVs and higher FMD compared with normal-weight children (Table 2). The association was similar in both sexes; was robust to adjustment for age, sex, and social class; and was reproduced when different measures of adiposity (i.e., weight, waist circumference, and dual-energy X-ray absorptiometry) were assessed (Table 3). Associations with PWV did not change significantly after adjustment for blood pressure or heart rate. Further adjustment for inflammatory markers or lipid profile measures did not substantially alter the associations between vascular and adiposity measures.

Exposure to adiposity and vascular measurements. Birth weight and change in weight z-score between birth and the second week and between birth and the second
month of life were not associated with FMD and PWV at 10 years, after adjustment for current vessel size (Table 4). Very few children were consistently classified as obese since birth or between 6 and 10 years according to BMI cutoffs at the same ages from the International Obesity Taskforce. Adiposity in different periods was not associated with vascular phenotype at 10 years (Table 4).

**Discussion**

In the largest reported contemporary cohort of pre-pubertal children, we found that childhood adiposity was not associated with vascular dysfunction, despite associations with higher blood pressure and heart rate and worsened inflammatory and metabolic risk factors. Children who were overweight or obese at 10 years of age had a hyperemic state, with increased systemic blood flow, greater heart rate, and increased blood pressure, but they also had wider brachial artery diameter, increased endothelial function, and reduced arterial stiffness compared with normal-weight children. Although these novel findings require replication, they suggest that children at this age still have compliant arteries able to respond and adapt to metabolic demands.
to some extent to the hemodynamic consequences of adiposity. This adaptation may mitigate some of the deleterious effects of adiposity on the vasculature. These findings have implications for understanding the mechanisms in early atherosclerosis and for the design of interventions to prevent the development of atherosclerotic disease.

The association between adiposity and adult CV disease is well recognized and is becoming increasingly important as a cause of excess morbidity and mortality worldwide in both men and women (22,23). Derangements in metabolic profile, including hypercholesterolemia, insulin resistance, and type 2 diabetes, as well as disturbances in inflammatory markers and adipocytokines, are strongly associated with adiposity (24). A number of studies, including ALSPAC, have demonstrated that adiposity in childhood is associated with a similarly disturbed metabolic profile (10,25,26). This raises major public health concerns as the prevalence and severity of childhood obesity continues to increase substantially (1). The impact of the metabolic disturbances of adiposity on the childhood vasculature is important, as it may affect the initiation and progression of atherosclerosis and its later CV outcomes.

In childhood, assessment of arterial disease relies on the characterization of vascular phenotype, as CV events are extremely rare. Because detectable abnormalities in vascular function typically precede the development of intimal atherosclerotic anatomical changes and plaques, we chose to measure endothelial function and arterial stiffness in ALSPAC children to enable the identification of subtle arterial changes that might result from childhood adiposity (27). We measured FMD in the brachial artery, a technique developed by our group, which has been shown to be accurate, to be reproducible, to correlate with endothelial function in the coronary arteries, and to reflect nitric oxide bioavailability (28–30). Recently, it has also been suggested that microvascular dysfunction may develop early and influence FMD of conduit arteries. The Firefighters and Their Endothelium (FATE) study suggested that this might be of greater prognostic significance (18). In the present study, reactive hyperemic blood flow was greater in overweight children, but adjusting for velocity-time integral did not alter the relationship of FMD to adiposity.

### Table 2  Vascular and Biochemical Measures by BMI Categories

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal Weight (80%)</th>
<th>Overweight (16%)</th>
<th>Obese (4%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMD (%)</td>
<td>8.1 ± 3.3</td>
<td>8.1 ± 3.4</td>
<td>8.2 ± 3.2</td>
</tr>
<tr>
<td>Absolute FMD (mm)</td>
<td>0.21 ± 0.08</td>
<td>0.22 ± 0.09*</td>
<td>0.24 ± 0.09*</td>
</tr>
<tr>
<td>PWV (m/s)</td>
<td>7.65 ± 1.23</td>
<td>7.26 ± 1.15*</td>
<td>6.99 ± 1.01*</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>103.6 ± 9.0</td>
<td>106.3 ± 9.1*</td>
<td>108.0 ± 10.2*</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>59.9 ± 7.9</td>
<td>61.5 ± 8.1*</td>
<td>62.7 ± 8.8*</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>71.7 ± 11.1</td>
<td>72.4 ± 11.0</td>
<td>74.6 ± 12.2*</td>
</tr>
<tr>
<td>Artery diameter (mm)</td>
<td>2.64 ± 0.29</td>
<td>2.80 ± 0.33*</td>
<td>2.93 ± 0.35*</td>
</tr>
<tr>
<td>Blood flow at rest (ml/min)</td>
<td>56 (44-72)†</td>
<td>67 (52-87)*</td>
<td>75 (57-100)*</td>
</tr>
<tr>
<td>Reactive blood flow (ml/min)</td>
<td>323 ± 101</td>
<td>366 ± 115*</td>
<td>396 ± 140*</td>
</tr>
<tr>
<td>Blood flow change (ml/min)</td>
<td>262 ± 86</td>
<td>294 ± 97*</td>
<td>316 ± 115*</td>
</tr>
<tr>
<td>FMD/VTI (%/cm)</td>
<td>0.31 ± 0.15</td>
<td>0.31 ± 0.15</td>
<td>0.33 ± 0.16</td>
</tr>
</tbody>
</table>

**Biochemical measures at age 9 years**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal Weight (80%)</th>
<th>Overweight (16%)</th>
<th>Obese (4%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cholesterol (mmol/l)</td>
<td>4.25 ± 0.65</td>
<td>4.34 ± 0.71†</td>
<td>4.31 ± 0.65</td>
</tr>
<tr>
<td>Triglycerides (mmol/l)</td>
<td>0.96 (0.74–1.30)</td>
<td>1.17 (0.85–1.58)*</td>
<td>1.38 (1.04–1.93)*</td>
</tr>
<tr>
<td>VLDL (mmol/l)</td>
<td>0.44 (0.34–0.59)</td>
<td>0.53 (0.39–0.72)*</td>
<td>0.63 (0.47–0.88)*</td>
</tr>
<tr>
<td>CRP (mg/l)</td>
<td>0.18 (0.10–0.40)</td>
<td>0.52 (0.25–1.07)*</td>
<td>1.24 (0.58–2.35)*</td>
</tr>
<tr>
<td>IL-6 (pg/ml)</td>
<td>0.73 (0.46–1.26)</td>
<td>1.10 (0.71–1.74)*</td>
<td>1.58 (1.09–2.25)*</td>
</tr>
<tr>
<td>Leptin (ng/ml)</td>
<td>4.5 (3.0–7.3)</td>
<td>15.1(10.8–20.9)*</td>
<td>28.5 (21.4–35.2)*</td>
</tr>
<tr>
<td>Adiponectin (µg/ml)</td>
<td>12.7 (9.7–16.5)</td>
<td>10.8 (8.0–14.9)*</td>
<td>10.1 (7.6–13.5)*</td>
</tr>
</tbody>
</table>

Values are mean ± SD or median (interquartile range). p values refer to independent t tests or Wilcoxon rank sum comparisons, as appropriate, of overweight and obese groups with the normal-weight group. *p < 0.0001; †p = 0.004.

**VTI = velocity-time integral; Other abbreviations as in Table 1.**

### Table 3  Associations of Vascular Measures With Adiposity Measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>BMI</th>
<th>Waist/Height Ratio</th>
<th>DEXA Fat</th>
<th>DEXA Trunk Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMD</td>
<td>0.0095</td>
<td>1.52</td>
<td>0.0040</td>
<td>0.021*</td>
</tr>
<tr>
<td>Absolute FMD</td>
<td>0.0032†</td>
<td>0.16†</td>
<td>0.0007†</td>
<td>0.0016†</td>
</tr>
<tr>
<td>PWV</td>
<td>−0.077†</td>
<td>−3.94†</td>
<td>−0.022†</td>
<td>−0.026†</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>0.60†</td>
<td>23.78†</td>
<td>0.17†</td>
<td>0.26†</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>0.36†</td>
<td>18.04†</td>
<td>0.12†</td>
<td>0.17†</td>
</tr>
<tr>
<td>Heart rate</td>
<td>0.10*</td>
<td>16.31†</td>
<td>0.094†</td>
<td>0.040</td>
</tr>
<tr>
<td>Artery diameter</td>
<td>0.039†</td>
<td>1.58†</td>
<td>0.0087†</td>
<td>0.013†</td>
</tr>
<tr>
<td>Blood flow at rest</td>
<td>2.52†</td>
<td>109.49†</td>
<td>0.56†</td>
<td>0.94†</td>
</tr>
<tr>
<td>Reactive blood flow</td>
<td>10.34†</td>
<td>426.38†</td>
<td>2.12†</td>
<td>3.88†</td>
</tr>
<tr>
<td>Blood flow change</td>
<td>7.81†</td>
<td>316.69†</td>
<td>1.56†</td>
<td>2.95†</td>
</tr>
<tr>
<td>FMD/VTI</td>
<td>−0.0001</td>
<td>0.099*</td>
<td>0.00051*</td>
<td>0.0018*</td>
</tr>
</tbody>
</table>

Values are regression coefficients. Blood flow at rest is log transformed. Associations were adjusted for age and sex. *p < 0.05; †p < 0.0001.

**Abbreviations as in Tables 1 and 2.**
We also measured peripheral artery stiffness by using carotid to radial applanation tonometry. This technique has been widely used in studies of children and adults to assess responses to CV risk factors and CV interventions (31,32). Longitudinal studies have consistently reported associations between PWV measured in early life and later progression of atherosclerotic disease (31,33). In our pre-pubertal children, we demonstrated small decreases in PWV and increases in FMD suggesting adaptation of conduit arterial physiology to adiposity. The associations were small in magnitude but remained after adjustment for CV risk factors.

The serial measurements made from birth in the ALSPAC cohort provided the opportunity to assess the association between different patterns of weight gain over time with later vascular outcomes. We did not show a relationship of either birth weight or early weight gain up to 2 months of age with vascular phenotype at 10 years, once adjustment for current vessel size was performed. Consistent with previous publications from this cohort (25,26) on CV risk factors, we confirmed that contemporary levels of adiposity have a greater impact on vascular outcomes than earlier adiposity.

Our study has a number of strengths. It is the largest reported study of children before puberty. We were also able to perform vascular measurements in a large number of children using validated, reproducible techniques (17). The multiple anthropometric measures repeated at regular intervals from birth allowed a robust analysis of early influences of adiposity on the vascular phenotype. Our findings of absence of vascular impairment in the presence of increased CV risk factors at age 10 to 11 years is novel. The higher heart rate, blood pressure, and blood flow are compatible with a higher cardiac output state in overweight children (34,35). This physiological adaptation may result in reduced arterial stiffness and increased measures of endothelial function in the short term, despite increased lipid, glucose, and insulin levels. However, over time, these physiological changes may lead to a series of events, including increased vascular stiffness and resistance and decreased compliance, leading to increasing blood pressure, concentric ventricular hypertrophy, and ultimately to heart failure. The mechanisms underlying these findings remain speculative and require further study. It is possible that vascular damage occurs only with greater duration of exposure to adiposity and older age (36,37). Endogenous repair mechanisms may protect the vasculature before puberty. In other large cohorts, such as the Cardiovascular Risk in Young Finns Study, there was an adverse impact of CV risk factors including adiposity on vascular phenotype in young adults age 30 years (4). This suggests that at some age, the effects of adiposity on the vasculature change from the vascular adaptation observed in our pre-pubertal children. This raises questions as to when and why the adaptive compensation is lost. Adolescence, which is marked by dynamic physiological and hormonal changes in boys and girls, may alter the vascular responses to adiposity, but because the majority of the study population was pre-pubertal, we could not assess the impact of puberty from our data. In addition, ALSPAC, with its serial design, will enable evaluation of the cumulative impact of adiposity as children progress through puberty, and we are currently restudying the vasculature of the cohort at age 17 to 20 years. It is also possible that the attrition of the study population further reduced power and may have introduced bias in the estimation of the effects of adiposity on the vasculature by overrepresentation of a more affluent white population.

Our findings, together with other recent data on CV risk factors, outcomes, and response to weight loss, support the importance of addressing the obesity epidemic in childhood. Improvement in weight status and decrease in body fat are likely to be associated with decreased systolic and diastolic blood pressure, less insulin resistance, and improved lipid status (5,38). Juonala et al. (5), in an analysis of 4 prospective cohorts, demonstrated that people who were overweight or obese during childhood but not as adults had similar outcomes to those who had normal adiposity measures from childhood to adulthood. This suggests that vascular damage is either preventable or reversible by early intervention. This is particularly important, as there is a strong relationship between childhood adiposity and later obesity in adulthood, at which stage it is very hard to treat.
Conclusions

In a large contemporary cohort of children, we have demonstrated that overweight and obesity did not have a measurable adverse impact on vascular function, as assessed by PWV and FMD, by the end of the first decade of life. The mechanisms relating the adverse risk factors associated with adiposity to the development of arterial disease in the young remain to be established. In particular, understanding of the timing of change from our hypothesized “physiological adaptation” to evidence of early arterial disease as a result of adiposity exposure will be important. Our findings suggest that there may be a window of opportunity in early childhood to target and potentially reverse obesity before adverse vascular consequences manifest.

Acknowledgments

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