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Relative contributions of adiposity in childhood and adulthood to vascular health of young adults

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ABSTRACT

Objective: Vascular damage is suggested to have origins in childhood adiposity, but it is not clear whether this is a direct consequence of being obese in childhood. We aimed to estimate the associations of childhood body size or adiposity with adult vascular health, and to investigate whether these associations were independent of adult body size or adiposity.

Design and methods: Subjects were 2328 participants aged 7–15 years at baseline in 1985 with follow-up during 2004–2006 when aged 26–36 years. Anthropometric measures were taken at both baseline and follow-up. Carotid intima-media thickness (IMT) and three measures of large artery stiffness (LAS) were measured by ultrasound at follow-up.

Results: Childhood body size or adiposity was positively associated with both adult IMT and LAS. Participants who were obese in adulthood had the greatest LAS, particularly those who were normal weight in childhood. Adjustment for adult body size or adiposity eliminated effects of childhood body size or adiposity on LAS. For IMT, adjustment for adult body size or adiposity reduced estimated effects of child height by 44% (male) and 27% (female), of child weight by 46% (male) and 70% (female) and, after adjusting for sex, of child body mass index and body surface area by 60% and 53% respectively.

Conclusions: Whereas IMT appeared to be influenced by body size or adiposity during childhood and early adulthood, LAS depended primarily on current adiposity and magnitude of adiposity gain between childhood and adulthood.

1. Introduction

Vascular damage is suggested to have origins in childhood obesity [1,2], but it is unclear whether this is a direct effect of childhood adiposity as suggested by recent studies [3,4] or an indirect effect arising from tracking of obesity from childhood to adulthood. A key research question is whether childhood adiposity influences adult vascular health independently of adult adiposity. Some measures of vascular health associated with cardiovascular risk include carotid intima-media thickness (IMT) and three measures of large artery stiffness (LAS) including carotid distensibility (CD), stiffness index (SI) and Young's elastic modulus (YEM) [5–7]. Whilst IMT [8–13] and recently CD, SI and YEM [14] have been reported to be associated with childhood body mass index (BMI), it is unclear whether these associations are independent of adult adiposity or indeed whether childhood BMI in this context is an appropriate measure of childhood adiposity [15,16].

This study aimed to investigate the association of childhood body size or adiposity with adult vascular health. We hypothesised childhood body size or adiposity to have positive effects on adult IMT and LAS that are independent of adult body size or adiposity. Clarifying this matter will provide information critical for determining when and how clinical and public health interventions should be undertaken to reduce cardiovascular risk.

Abbreviations: LAS, large artery stiffness; IMT, intima-media thickness; CD, carotid distensibility; SI, stiffness index; YEM, Young's elastic modulus.

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2. Methods

2.1. Study population

This study used data from the Childhood Determinants of Adult Health (CDAH) study, a prospective cohort study with baseline data collected in 1985 on a nationally representative sample of 8498 Australian schoolchildren aged 7–15 years [17]. During 2001–2004, 5170 (60.8%) of them enrolled in the follow-up study (CDAH). Of these, 2410 attended one of 34 study clinics across Australia during May 2004–May 2006 when aged 26–36 years. In this study, analyses were restricted to 2328 non-pregnant subjects (49.4% male) with physical measurements at both time-points (1985, 2004–2006) and vascular ultrasound parameters at follow-up.

2.2. Body size or adiposity

Weight, height, and waist and hip circumference were measured in childhood and adulthood [16]. BMI was calculated as weight (kg)/height (m) [2]. Body surface area was measured as $[\text{weight (kg)} \times \text{height (cm)}/3600]^{0.5}$. Waist-to-hip and waist-to-height ratios were calculated as waist (cm)/hip (cm) and waist (cm)/height (cm) respectively. While skinfolds at four locations in adulthood were measured for all clinic participants, skinfolds in childhood were measured only for those then aged 9, 12 and 15 years [16]. The sum of four skinfolds was used in subsequent analyses.

2.3. Carotid intima-media thickness

B-mode ultrasound studies of carotid IMT were performed using a portable Acuson Cypress (Siemens Medical Solutions USA Inc., Mountainview, CA) ultrasound machine with a 7.0 MHz linear-array transducer by a single technician [18], following previously reported standardised protocol [10]. (Please see Supplemental Methods for more details.)

2.4. Blood pressure (BP) and LAS

Brachial BP was measured supine during the ultrasound study using an Omron M4 Digital Automatic Blood Pressure Monitor (Omron Corporation, Kyoto, Japan) with a mean of two readings used in this study. Electrocardiogram-based end-systolic and end-diastolic diameters, which were maximum and minimum diameters during a cardiac cycle, were taken 10 mm proximal from the carotid bulb. Three measures of LAS were calculated as follows:

$$CD = \left(\left[D_{sbp} - D_{dbp}\right] / D_{dbp}\right) / (SBP - DBP)$$

$$SI = \ln(SBP/DBP) / \left(\left[D_{sbp} - D_{dbp}\right] / D_{dbp}\right)$$

$$YEM = \left([SBP - DBP] \times D_{dbp}\right) / \left(\left[D_{sbp} - D_{dbp}\right] / IMT\right)$$

where D_{sbp} is the end-systolic diameter, D_{dbp} is the end-diastolic diameter, SBP is brachial systolic BP, and DBP is brachial diastolic BP. CD measures passive expansion and contraction of the arterial wall with changes in pressure. SI is a measure of LAS designed to be relatively independent of BP. YEM is an estimate of LAS per mm of IMT.

2.5. Covariates

Covariates included socioeconomic status, smoking, alcohol consumption, female reproductive characteristics and fasting blood biochemistry (Please see Supplemental Methods for details).

2.6. Statistical analyses

Other than for the summary statistics reported in Table 1, all physical measurements, BP, and cardio-metabolic parameters were

Table 1
Participants' characteristics at baseline and follow-up.

	Baseline			Follow-up
	7–9 Years	10–12 Years	13–15 Years	26–36 Years
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Male	341 (46.5%)[a]	408 (49.8%)[a]	401 (51.8%)[a]	1150 (49.4%)[a]
Weight, kg	27.7 (4.7)	37.0 (6.9)	54.1 (10.6)	83.5 (13.8)
Height, cm	131.3 (7.5)	145.7 (7.9)	165.7 (9.7)	179.5 (6.7)
BMI, kg/m^2	16.1 (1.5)	17.3 (2.0)	19.5 (2.4)	25.9 (3.8)
Waist, cm	57.1 (4.3)	62.7 (5.9)	70.8 (6.2)	88.0 (9.7)
Waist-hip ratio	0.86 (0.04)	0.85 (0.04)	0.83 (0.04)	0.84 (0.05)
Waist-height ratio	0.44 (0.03)	0.43 (0.03)	0.43 (0.03)	0.49 (0.06)
Sum of skinfolds,[b] mm	31.0 (9.5)	36.8 (15.8)	35.7 (12.3)	61.7 (25.9)
Intima-media thickness, mm				0.61 (0.10)
Carotid distensibility, %/10 mmHg				1.94 (0.64)
Stiffness index				5.29 (1.82)
Young's elastic modulus, mmHg mm				293.3 (111.4)
Female	393 (53.5%)[a]	412 (50.2%)[a]	373 (48.2%)[a]	1178 (50.6%)[a]
Weight, kg	27.1 (5.0)	37.6 (7.8)	51.2 (8.0)	65.7 (12.9)
Height, cm	129.7 (7.4)	146.4 (8.6)	160.8 (6.2)	165.6 (6.3)
BMI, kg/m^2	16.1 (1.7)	17.5 (2.2)	19.7 (2.4)	23.8 (4.2)
Waist, cm	55.8 (5.0)	61.2 (6.4)	66.6 (6.5)	75.7 (9.6)
Waist-hip ratio	0.84 (0.05)	0.81 (0.05)	0.78 (0.05)	0.74 (0.05)
Waist-height ratio	0.43 (0.03)	0.42 (0.04)	0.42 (0.03)	0.46 (0.06)
Sum of skinfolds,[b] mm	41.1 (15.9)	47.1 (17.6)	59.0 (20.3)	73.4 (30.8)
Intima-media thickness, mm				0.58 (0.08)
Carotid distensibility, %/10 mmHg				2.35 (0.79)
Stiffness index				4.83 (1.68)
Young's elastic modulus, mmHg mm				230.3 (87.4)

[a] Data are number (percentage).
[b] Childhood skinfolds were available for 9, 12 and 15 year-olds only (males $n = 383$, females $n = 403$).