

Associations of childhood adiposity and changes in adiposity status from childhood to adulthood with pregnancy hypertension

Ye HE, MM, Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia

Jing TIAN, PhD, Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia

Leigh BLIZZARD, PhD, Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia

Wendy H. ODDY, PhD, Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia

Terence DWYER, MD, Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia; The George Institute for Global Health, University of Oxford, Oxford, UK.

Alison J. VENN, PhD, Menzies Institute for Medical Research, University of Tasmania, Hobart, Australia.

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Corresponding Author:

Professor Alison J. Venn

Menzies Institute for Medical Research, University of Tasmania

17 Liverpool Street, Hobart, Tasmania 7000, Australia

Telephone: 61-3-6226-7706

Fax: 61-3-6226-7704

E-mail: Alison.Venn@utas.edu.au

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Condensation: Childhood abdominal obesity was associated with pregnancy hypertension independent of childhood and adult body mass index.

Short Title: Childhood adiposity and pregnancy hypertension

A. Why was the study conducted?

To investigate the associations between different adiposity measures in childhood, and change in adiposity status from childhood to adulthood, with pregnancy hypertension

B. What are the key findings?

Childhood abdominal obesity was associated with pregnancy hypertension independent of childhood and adult body mass index. Women who were persistently overweight/obese or abdominally obese since childhood had the highest risk of pregnancy hypertension.

C. What does this study add to what is already known?

Our article shows the importance of childhood abdominal obesity, in addition to BMI, as an indicator of future cardiometabolic risk including pregnancy hypertension, and the importance of preventing childhood obesity.

Key words: abdominal obesity, body mass index, childhood, pregnancy hypertension, waist-to-height ratio

Abstract

Background: Pregnancy hypertension is a significant cause of maternal morbidity and mortality. Elevated childhood body mass index (BMI) has been identified as a risk factor for pregnancy hypertension, however, no study to date has reported the role of childhood abdominal obesity and change in adiposity status from childhood to adulthood with pregnancy hypertension.

Objective(s): To investigate the associations between different adiposity measures in childhood, and change in adiposity status from childhood to adulthood, with pregnancy hypertension.

Study Design: The study followed-up 985 girls who participated in the 1985 Australian Schools Health and Fitness Survey when aged 9-15 years and were ever pregnant at follow-up in 2004-2006 and/or 2009-2011 when they were aged 26-41 years. Childhood anthropometric measures included height, weight, waist and hip circumferences. At follow-up, pregnancy hypertension was self-reported by questionnaire and defined as having high blood pressure during pregnancy or due to pregnancy. Overweight and obesity in childhood were defined according to age and sex-specific international standard definitions for BMI. Childhood abdominal obesity measures included waist circumference, waist-to-hip ratio and waist-to-height ratio (WHtR) with abdominal obesity defined as $WHtR \geq 0.5$. Generalized estimating equations for log binomial regression were used to estimate relative risks (RRs) and 95% confidence intervals (CIs) adjusting for age, area-level disadvantage in childhood, parity and adult occupation.

Results: Ever having pregnancy hypertension at follow-up was reported by 141 (14.3%) women. Increased childhood BMI was associated with a higher risk of later pregnancy hypertension, but this risk did not persist after adjustment for adult BMI. Childhood

abdominal obesity was associated with a significantly increased risk of pregnancy hypertension independent of both childhood and adult BMI. Girls with one standard deviation higher waist circumference (7.51 cm), waist-to-hip ratio (0.06) and WHtR (0.04) had a 29% (95% CI:1-65%), 20% (95% CI:3-41%) and 24% (95% CI: 6-41%) greater likelihood of pregnancy hypertension, respectively. Compared with girls who were not abdominally obese, those who were had more than twice the risk of having pregnancy hypertension (RR=2.21, 95% CI:1.09-4.48).

The associations of adiposity with pregnancy hypertension were stronger in participants with persistently high adiposity status from childhood to adulthood than those with high adiposity status only in adulthood. Compared with participants with persistently normal BMI or normal WHtR, those who were overweight/obese or abdominally obese only in adulthood had an increased risk of pregnancy hypertension (RR=1.49, 95% CI:1.10-2.02 and RR=1.43, 95% CI:0.92-2.25). Participants who were persistently overweight/obese or abdominally obese from childhood to adulthood had a significantly higher risk of pregnancy hypertension (RR=2.06, 95% CI:1.29-3.29 and RR=3.09, 95% CI:1.54-6.20). All *p*-values<0.05.

Conclusion(s): Childhood abdominal obesity was associated with later pregnancy hypertension independent of childhood and adult BMI. Women who were persistently overweight/obese or abdominally obese since childhood had the highest risk of pregnancy hypertension.

Key words: abdominal obesity, body mass index, childhood, pregnancy hypertension, waist-to-height ratio

Introduction

Hypertension affects an estimated 10% of all pregnancies and is the most frequently identified medical problem during pregnancy. Hypertensive disorders of pregnancy include both pregnancy-induced (gestational hypertension and preeclampsia) and pre-existing (chronic hypertension) conditions and are associated with a higher risk of cardiovascular events later in life.¹

Being overweight or obese puts a woman at risk of developing pregnancy hypertension. The risk of preeclampsia doubles with each 5-7 unit increase in pre-pregnancy body mass index (BMI).² Abdominal obesity has also been associated with pregnancy hypertension. The results from one Australian cohort indicated that every 1cm increase in waist circumference was associated with a 4% increased risk of pregnancy hypertension.³ Another case-control study indicated that waist circumference was a better predictor of pregnancy hypertension than BMI.⁴ Despite the known detrimental effect of adult adiposity on pregnancy hypertension, the relationship with childhood obesity, especially childhood abdominal obesity with pregnancy hypertension is less well understood.

To our knowledge, only two studies have reported a longitudinal relationship between childhood obesity and pregnancy hypertension, and childhood BMI was the only predictor.^{5, 6} The 1958 British birth cohort study included 4,681 girls and reported that being overweight or obese at the age of 7 years increased the risk of self-reported hypertension in pregnancy before age 33, but this risk did not persist after adjustment for adult BMI.⁵ More recently, a report based on 703 participants in the USA Bogalusa Heart Study showed that elevated childhood BMI was a significant risk factor for self-reported pregnancy hypertension without considering adult BMI.

Therefore, the aim of our present study was to examine the association between different adiposity measures in childhood and changes in adiposity status from childhood to adulthood, with pregnancy hypertension.

Materials and Methods

Participants

The Childhood Determinants of Adult Health (CDAH) Study is a follow-up of 8,498 children including 4,191 girls aged 7-15 years who participated in the 1985 Australian Schools Health and Fitness Survey (ASHFS), a nationwide sample of Australian school children.⁷ In 1985, all children had physical assessments and those aged 9, 12 and 15 years had blood pressure measured. During 2002-2004, a total of 3,412 female participants were traced and 2,734 enrolled to participate in the CDAH Study (enrolment) (Figure 1). During 2004-2006, the first follow-up (CDAH-1) of those enrolled was conducted when participants were aged 26-36 years. Of the 1,017 women who reported having ever been pregnant and answered questions about pregnancy hypertension in the questionnaire, 735 attended one of 34 study clinics held around Australia for physical measurements. The second follow-up (CDAH-2) was conducted during 2009-2011 when participants were aged 31-41 years and 901 reported having ever been pregnant women and completed the same questions about pregnancy hypertension. A total of 1,324 women who were ever pregnant and answered the pregnancy hypertension questions at CDAH-1 and/or CDAH-2 were included in the analysis reported here (423 women only participated in CDAH-1, 307 women only participated in CDAH-2 and 594 women participated in both CDAH-1 and CDAH-2).

The study was approved by the Southern Tasmania Health and Medical Human Research Ethics Committee. Written informed consent was obtained at childhood from parents and obtained at each follow-up from participants.

Childhood adiposity measures

BMI, calculated as weight (kg)/height (m)², was derived from measured height and weight with weight status defined using international age- and sex-specific cut-points.⁸ Waist and hip circumference was measured to the nearest 0.1 cm. Waist-to-hip ratio was calculated by dividing waist by hip circumference. Waist-to-height ratio (WHtR) was calculated by dividing waist circumference by height. Abdominal obesity was defined as WHtR \geq 0.5.⁹ Childhood BMI and waist circumference z scores were calculated based on age- and sex-specific standardization of the full childhood cohort.

Adult adiposity measures

At CDAH-1, weight, height, waist circumference and hip circumference were measured at study clinics for most participants. Some participants (n=1,119) also self-reported their weight and height before measurements were taken to assess the accuracy of self-reported values. Participants who did not visit clinics self-reported their weight and height, and a correction factor was applied to adjust for error.¹⁰ BMI (kg/m²) was calculated from height and weight. WHtR was calculated from measured waist circumference and height at clinics.

Weight was self-reported at CDAH-2. Adjusted weight values were calculated using the correction factor applied at CDAH-1. Height was self-reported and adjusted as described above.

Adult BMI was categorized as normal (BMI<25 kg/m²), overweight (25.0 \leq BMI \leq 29.9 kg/m²) or obese (BMI \geq 30 kg/m²).¹¹ Adult abdominal obesity was defined as WHtR \geq 0.5.¹²

Pregnancy hypertension

In CDAH-1 and CDAH-2, women were asked to answer ‘yes’ or ‘no’ to the question ‘Have you ever been told that you have high blood pressure during pregnancy or due to pregnancy?’ Pregnancy hypertension was recorded if they responded ‘yes’.

Covariate measures

Information on sociodemographic characteristics was self-reported in childhood and follow-up including childhood age, parental education, parental smoking and childhood smoking experimentation, both childhood and adult area-level disadvantage¹³, alcohol consumption, physical activity and adult education level, smoking status, occupation and parity.

Statistical analyses

Taking into account the repeated measures of variables over CDAH-1 and CDAH-2, log-binomial models with generalized estimating equations (GEE) were used to estimate relative risk (RR) for associations between childhood adiposity measures and change in adiposity status from childhood to adulthood with pregnancy hypertension. Subsample analysis which considered the effect of adult abdominal obesity on pregnancy hypertension was conducted among those who participated in ASHFS and CDAH-1 clinics.

Covariates remaining in the final model were variables which associated with the exposure and the outcome and resulted in more than 10% change in the coefficient of the study factor.

The following sensitivity analyses were conducted. First, we excluded those who reported ‘yes’ to ever having pregnancy hypertension in CDAH-1 but ‘no’ in CDAH-2. Second, since multiple births and high childhood blood pressure may be associated with increased risk of pregnancy hypertension,^{14, 15} we restricted our sample to women who had singleton pregnancies and those who had measured childhood systolic (SBP) and diastolic blood

pressure (DBP). Third, inverse probability weighting was used to account for missing data at follow-up, with multiple imputation of incomplete baseline data.¹⁶

Finally, to examine if there is a difference in risk of pregnancy hypertension associated with adiposity during different time periods of growth, we repeated the analyses by stratifying childhood age before or after 12 years.

All analyses were performed using STATA software, version 15.0 (Stata Corp., College Station, TX); A p-value <0.05 was considered statistically significant.

Results

Participant characteristics

This study included 1,324 women who had ever been pregnant and completed hypertension questions at follow-ups; 594 of them completed both follow-ups; 423 participated in CDAH-1 only; and 307 women participated in CDAH-2 only. Participants who had missing data on confounders (n=339) were excluded, leaving 985 women for the final analysis.

Characteristics of participants in childhood and adulthood are shown in Table 1. In childhood, 10 (1.0%) girls were obese, 77 (7.8%) were overweight as defined by BMI cutoffs, and 47 (4.8%) had abdominal obesity as defined by WHtR category. The mean age at CDAH-1 was 32.8 years and 37.5 years at CDAH-2. There were 111 (13.8%) and 68 (10.6%) women who reported experiencing pregnancy hypertension in CDAH-1 and CDAH-2. Among them 21 women reported having had pregnancy hypertension in CDAH-1 but not in CDAH-2.

Compared with those who did not participate in CDAH-1 or CDAH-2, those who did participate in CDAH-1 and/or CDAH-2 were older in childhood (12.1 vs 10.5 years;

$P=0.000$), had greater BMI (18.8 vs 18.2 kg/m²; $P=0.000$) and waist circumference (64.1 vs 62.1 cm; $P=0.000$), lower WHtR (0.42 vs 0.44; $P=0.000$) and waist-to-hip ratio (0.80 vs 0.82; $P=0.000$), and were less likely to be obese (1.0% vs 1.8%; $P=0.001$) or abdominally obese (4.8% vs 7.9%; $P=0.001$).

Pregnancy hypertension

As shown in Table 2, after adjustment for age, area-level disadvantage in childhood, parity and occupation in adulthood, childhood BMI and abdominal obesity measures were all associated with an increased risk of pregnancy hypertension (Model 1). To determine whether the observed associations of childhood abdominal obesity measures with pregnancy hypertension were independent of childhood BMI, we further adjusted for childhood BMI (Model 2), the associations between childhood abdominal obesity measures and pregnancy hypertension remained significant. Model 3 included additional adjustment for adult BMI to investigate whether associations with childhood BMI and abdominal obesity measures were independent of adult BMI. Childhood BMI was no longer associated with pregnancy hypertension after adjustment for adult BMI (Model 3). However, associations remained for childhood abdominal obesity. Girls with one standard deviation higher waist circumference (7.51 cm), waist-to-hip ratio (0.06) and WHtR (0.04) reported 29% (95% confidence interval [CI]:1-65%), 20% (95% CI:3-41%) and 24% (95% CI:6-43%) greater likelihood of pregnancy hypertension. Compared with non-abdominally obese girls, those who were abdominally obese in childhood had more than twice the risk of having pregnancy hypertension (RR=2.21, 95% CI:1.09-4.48). In the subsample of participants with measured waist circumference and height at the CDAH-1 clinics (Supplemental Table 1), the associations of childhood abdominal obesity with pregnancy hypertension persisted after adjusting for adult abdominal obesity (RR=2.15, 95% CI:1.10-4.20).

Influence of adiposity change from childhood to adulthood

The relative risk of pregnancy hypertension by BMI and WHtR category change from childhood to adulthood is displayed in Table 3. Compared with participants who had persistently normal BMI in childhood and adulthood, those who became overweight/obese reported a higher risk of pregnancy hypertension with a RR of 1.49 (95% CI 1.10-2.02). The risk was highest for participants who were persistently overweight/obese from childhood into adulthood (RR=2.06; 95% CI 1.29-3.29).

In the subsample of participants who had WHtR data in both childhood and adulthood (N=549), 19 (3.5%) were abdominally obese in both childhood and adulthood and 31.6% of them had pregnancy hypertension (Figure 2). Compared with those who were not abdominally obese in childhood and adulthood (68.3% of the subset, 11.5% with pregnancy hypertension), those who were persistently abdominally obese had a significantly higher risk of pregnancy hypertension (RR=3.09; 95% CI: 1.54-6.20) (Table 3). Subjects who were not abdominally obese in childhood but who developed abdominal obesity in adulthood (27.5%) also had a higher risk of pregnancy hypertension (RR=1.56; 95% CI 1.00-2.43), but the significance of this association was attenuated following adjustment for confounders.

Sensitivity analysis

Similar results were observed after excluding women who reported they had pregnancy hypertension in CDAH-1 but not in CDAH-2 (n=21). When restricting the sample to women with singleton pregnancies, the risk of pregnancy hypertension (RR=2.55, 95% CI 1.28-5.09) remained significantly higher in those who were abdominally obese in childhood. A total of 415 girls aged 9, 12 and 15 years had blood pressure measured in childhood. The mean childhood SBP and DBP were similar in those with and without self-reported pregnancy hypertension in CDAH-1 (SBP: 110.4±14.8 vs 109.0±11.8, $P=0.50$; DBP: 65.4±12.2 vs

66.8±10.8, $P=0.43$) and CDAH-2 (SBP: 112.6±12.7 vs 108.5±11.8, $P=0.06$; DBP: 67.8±11.1 vs 66.1±10.6, $P=0.38$). Further adjustment for childhood SBP and DBP in these participants did not substantially change the main results: the changes in the magnitude of significant estimates were within 17.2% (Supplemental Table 2). Sensitivity analyses to address loss to follow-up by using combined multiple imputation and inverse probability weighting produced similar patterns of results as the unweighted analyses: changes in the magnitude of significant associations ranging from -23.5-58.0% (Supplemental Table 3).

When stratified by age, childhood BMI and BMI z score showed similar associations in 12 to 15 year-olds (RR: 1.07, 95% CI 1.00-1.15; RR:1.21, 95% CI 1.00-1.45) to those younger than 12 years (RR: 1.09, 95% CI 0.99-1.19; RR: 1.20, 95% CI 0.94-1.53). However, the observed statistically significant association in the 12 to 15 year age group did not persist after further adjustment for adult BMI. In a subsample analysis, a stronger association with pregnancy hypertension was found with abdominal obesity before age 12 than age 12-15 years after adjusting for adult abdominal obesity. RR was 1.59 (95% CI 1.28-1.99) for per SD (0.04) increase in WHtR before age 12 and 1.05 (95% CI 0.81-1.37) between 12 to 15 years.

Comment

Main findings

To the best of our knowledge, this is the first study to report the long-term associations of childhood abdominal obesity and change in body composition from childhood to adulthood with pregnancy hypertension. We found that childhood abdominal obesity was associated with an increased risk of pregnancy hypertension. This association was persistent across different abdominal obesity indicators and independent of childhood and adult BMI.

Persistent overweight/obesity and abdominal obesity were associated with the highest risk of pregnancy hypertension.

Meaning of the findings

Our finding that the association of childhood BMI with pregnancy hypertension was not independent of adult BMI was consistent with findings from the 1958 British birth cohort study⁵ and that overweight/obesity that is proximal to pregnancy is especially important for pregnancy hypertension risk. However, a higher risk was found for women who were persistently overweight/obese in childhood and adulthood than those who first became overweight/obese as adults. This result suggests that childhood adiposity is important because of the tendency for obesity to track from childhood into adulthood.

Although childhood abdominal obesity has been observed in several cross-sectional studies to be associated with cardio-metabolic risk in childhood^{12, 17-19}, the current understanding of the long-term effect of abdominal obesity on chronic conditions including pregnancy hypertension remains limited. Most studies from childhood have followed participants into adulthood and collected BMI due to ease of measurement. In our study, one SD of 0.04 unit increase in childhood WHtR was associated with 33% greater likelihood of reporting pregnancy hypertension and was largely unchanged after adjusting for childhood and adulthood BMI. These results indicated a detrimental impact of childhood abdominal obesity on pregnancy hypertension, which was not modified by BMI. It has been suggested that early onset obesity may have higher risks of adverse outcomes in later life.²⁰ Consistent with this we observed stronger associations with childhood abdominal obesity in girls younger than age 12 than in older girls. In the Bogalusa Heart Study, a stronger association of childhood BMI with pregnancy hypertension was reported between ages 12 to 17 than before age 12. In our study, similar associations of childhood BMI with pregnancy hypertension were found in these younger than age 12 and age 12 to 15 after accounting for adult BMI.

The exact mechanism by which childhood abdominal obesity influences risk of pregnancy hypertension remains unclear. Plausible mechanisms include the long-term adverse effects of excess childhood visceral fat on blood pressure, insulin resistance, inflammation upregulation, oxidative stress and endothelial dysfunction.²¹⁻²⁴

Strengths and limitations

Some potential limitations of our study are acknowledged. The first is the measurement of pregnancy hypertension and that self-report may lead to misclassification.^{25,26} However, the prevalence of pregnancy hypertension in our study is similar to global prevalence.¹ Beyond that, two validation studies to investigate the validity of self-reported pregnancy hypertension show good concordance of self-report with clinical records.^{25,27} Second is the loss to follow-up. We applied inverse probability weighting to account for missingness but these did not appreciably change the results. Third is the potential over adjustment of adult BMI and abdominal obesity measures. Our findings were for ever-pregnant women, but we were unable to account for their BMI and abdominal measures immediately prior to pregnancy. Women's weight or waist circumference may increase after pregnancy, however, over adjustment of adult anthropometric measures tend to favor our study results. Lastly, we cannot classify the category of pregnancy hypertension exactly. Preeclampsia is a distinct cause of maternal morbidity and mortality and can lead to further systemic disorders.¹ Future studies that address pre-eclampsia specifically are needed.

The strengths of our study include the following. Foremost, this is the first prospective study to investigate the long-term association between childhood abdominal obesity measures and pregnancy hypertension. Second, we conducted objective measurement of childhood anthropometrics including childhood BMI and abdominal obesity measures. Third, unlike

previous two studies examining childhood BMI and pregnancy hypertension, a range of data on covariates has been collected in our study.

Conclusion

In conclusion, childhood abdominal obesity was associated with pregnancy hypertension independent of childhood and adult BMI. Women with persistently high adiposity from childhood to adulthood had the highest risk of pregnancy hypertension. Childhood abdominal obesity may be considered in addition to BMI, as an indicator of the risk of future cardiometabolic conditions including pregnancy hypertension.

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Table 1. Characteristic of participants in childhood (1985), CDAH-1 (2004-2006) and CDAH-2 (2009-2011), Childhood Determinants of Adult Health study.

Table 2. Associations between adiposity measures in childhood with pregnancy hypertension, Childhood Determinants of Adult Health study.

Table 3. Relative risk of pregnancy hypertension according to adiposity status from childhood to adulthood, Childhood Determinants of Adult Health study.

Figure 1. Selection of participants for the Childhood Determinants of Adult Health (CDAH) Study.

Figure 2. Percentage of ever had pregnancy hypertension across abdominal obesity category from childhood to adulthood, Childhood Determinants of Adult Health Study.

Supplemental Table 1. Associations between abdominal measures in childhood with pregnancy hypertension in CDAH-1 clinic, Childhood Determinants of Adult Health study.

Supplemental Table 2. Associations between adiposity measures in childhood with gestational hypertension, Childhood Determinants of Adult Health study (Considering childhood blood pressure).

Supplemental Table 3. Sensitivity analysis using inverse propensity weighting technique with multiple imputation. Associations between adiposity measures in childhood with pregnancy hypertension, Childhood Determinants of Adult Health Study.

Table1. Characteristic of participants in childhood (1985), CDAH-1 (2004-2006) and CDAH-2 (2009-2011), Childhood Determinants of Adult Health study^a

Characteristics	Childhood (n=985)	CDAH-1 (n=806)	CDAH-2 (n=641)
Age, years, Mean(SD)	12.1(2.0)	32.8(2.0)	37.5(2.0)
BMI, kg/m ² , Mean(SD)	18.8(2.8)	25.0(5.1)	25.2(5.5)
Waist circumference, cm, Mean(SD)	64.1(7.5)	79.3(10.9)	
Waist-to-height ratio, Mean(SD)	0.42(0.04)	0.48(0.07)	
Waist-to-hip ratio, Mean(SD)	0.80(0.06)	0.76(0.06)	
BMI category (%) ^b			
Normal	91.2	60.7	59.9
Overweight	7.8	24.8	22.9
Obese	1.0	14.5	17.2
WHtR category (%)			
<0.5	95.2	69.0	
≥0.5	4.8	31.0	
Area-level disadvantage (%)			
High	26.9	27.3	25.7
Medium-high	28.9	25.0	24.7
Medium-low	38.2	22.5	23.8
Low	6.0	25.2	25.8
Highest parental education (%)			
University education	23.3		
Vocational training	35.0		
High school	41.7		
Childhood smoking experimentation (%)			
None	56.1		
A few puffs	21.7		
<10 cigarettes	8.5		
>10 cigarettes	13.8		
Parental smoking (%)			
None	57.8		
Either parent smoked	26.8		
Both parents smoked	15.4		
Childhood alcohol assumption (%)			
Never	67.6		
Less than once per week	26.3		
More than once per week	6.1		
Physical activity, mins/week, Mean(SD) ^c	406.7(365.7)	784.3(502.0)	819.4(507.0)
Systolic blood pressure, mmHg, Mean(SD)	108.9(12.0)		
Diastolic blood pressure, mmHg, Mean(SD)	66.6(11.0)		
Adulthood smoking status (%)			
Never smoker		49.7	56.1
Ex-smoker		28.0	30.4
Current smoker		22.4	13.5
Highest education attainment (%)			

University education	36.6	46.2
Vocational training	26.8	27.7
High school	36.6	26.1
Adulthood alcohol consumption (%)		
Non-drinkers	23.6	22.6
Light drinkers	56.8	57.8
Moderate drinkers	14.5	14.9
Heavy/very heavy drinkers	5.2	4.7
Occupation (%)		
Professional or manager	38.8	43.7
Nonmanual	28.3	27.6
Manual	5.5	6.1
Not in the labor force	27.4	22.6
Parity, Mean(SD)	1.6(1.0)	2.1(1.0)
Pregnancy hypertension (%)	13.8	10.6

^a Childhood overweight and obesity were defined according to the international cutoffs; the final sample (n=985) included participants who participated in CDAH-1 (n=806) or CDAH-2 (n=641).

^b Sample size in Childhood ranges from 415-985, CDAH-1 ranges from 549-806, CDAH-2 ranges from 596-641 due to missing data on some variables;

^c Childhood physical activity was assessed by Australia Health and Fitness Survey, 1985; CDAH-1 and CDAH-2 physical activity was assessed by International Physical Activity Questionnaire;

Abbreviations: BMI, body mass index; CDAH, Childhood Determinants of Adult Health Study; SD, standard deviation; WHtR, waist-to-height ratio.

Table 2 Associations between adiposity measures in childhood with pregnancy hypertension, Childhood Determinants of Adult Health study.

Body composition	n	Unadjusted model		Model 1		Model 2		Model 3	
		RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
BMI (kg/m ²)	985	1.06	1.01-1.12	1.08	1.02-1.14			1.04	0.97-1.11
BMI z score	985	1.19	1.03-1.38	1.20	1.04-1.40			1.09	0.92-1.30
BMI category									
Normal	898	Ref.	—	Ref.	—			Ref.	—
Overweight	77	1.68	1.06-2.67	1.67	1.06-2.63			1.31	0.79-2.17
Obese	10	1.27	0.30-5.30	1.58	0.41-6.08			1.00	0.29-3.39
Waist circumference (cm)	985	1.03	1.01-1.05	1.04	1.02-1.06	1.04	1.01-1.07	1.03	1.00-1.07
Waist circumference z score	985	1.28	1.11-1.41	1.29	1.12-1.49	1.28	1.01-1.61	1.25	0.99-1.57
Waist circumference, per SD (7.51 cm)	985	1.26	1.10-1.44	1.32	1.14-1.54	1.33	1.04-1.69	1.29	1.01-1.65
Waist-to-hip ratio, per SD (0.06)	985	1.22	1.05-1.42	1.25	1.07-1.47	1.22	1.04-1.43	1.20	1.03-1.41
Waist-to-height ratio, per SD (0.04)	985	1.33	1.17-1.51	1.33	1.15-1.53	1.35	1.09-1.67	1.24	1.06-1.43
WHtR category									
<0.5	938	Ref.	—	Ref.	—	Ref.	—	Ref.	—
≥0.5	47	2.33	1.45-3.74	2.54	1.61-4.01	2.14	1.18-3.87	2.21	1.09-4.48

Model 1: adjusted for age, area-level disadvantage at childhood, parity and occupation at adulthood;

Model 2: adjusted for age, area-level disadvantage and body mass index at childhood, parity and occupation at adulthood;

Model 3: adjusted for age, area-level disadvantage and body mass index at childhood (for abdominal obesity measures only), parity, occupation and body mass index at adulthood;

Abbreviations: BMI, body mass index; CI, confidence interval; RR, risk ratio; SD, standard deviation; WHtR, waist-to-height ratio.

Table 3 Relative risk of pregnancy hypertension according to adiposity status from childhood to adulthood, Childhood Determinants of Adult Health Study.

Body composition from childhood to adulthood		Pregnancy hypertension			
	n (%) ^a	Unadjusted model		Model 1	
		RR	95% CI	RR	95% CI
BMI category (N=985)					
Persistently normal	860(59.4)	Ref.	—	Ref.	—
Normal to overweight/obese	469(32.4)	1.49	1.11-2.01	1.49	1.10-2.02
Overweight/obese to normal	13(0.9)	1.00	0.15-6.53	1.09	0.16-7.29
Persistently overweight/obese	105(7.3)	2.05	1.27-3.29	2.06	1.29-3.29
WHtR category ^b (N=549)					
Persistently not abdominally obese	375(68.3)	Ref.	—	Ref.	—
Not abdominally obese to abdominally obese	151(27.5)	1.56	1.00-2.43	1.43	0.92-2.25
Abdominally obese to not abdominally obese	4(0.7)	2.18	0.39-12.18	2.13	0.40-11.43
Persistently abdominally obese	19(3.5)	2.75	1.34-5.65	3.09	1.54-6.20

Model 1: adjusted for age, area-level disadvantage at childhood, parity and occupation at adulthood;

^a n indicated the total number of observations in each BMI category from childhood to CDAH-1 and/or CDAH-2 and the number of participants in each WHtR category from childhood to CDAH-1;

^b Subgroup analysis which only available in those who participated in 1985 Australian Schools Health and Fitness Survey and CDAH-1 clinics;

Abbreviations: BMI, body mass index; RR, risk ratio; CI, confidence interval; WHtR, waist-height ratio.

Supplemental Table 1 Associations between abdominal measures in childhood with pregnancy hypertension in CDAH-1 clinic, Childhood Determinants of Adult Health study.

Body composition	n	Unadjusted model		Model 1		Model 2	
		RR	95% CI	RR	95% CI	RR	95% CI
Waist circumference (cm)	549	1.03	1.00-1.06	1.04	1.01-1.07	1.03	1.00-1.07
Waist circumference z score	549	1.26	1.03-1.55	1.33	1.08-1.65	1.22	0.96-1.56
Waist circumference, per SD (7.30 cm)	549	1.22	1.01-1.48	1.36	1.09-1.69	1.25	0.97-1.60
Waist-to-hip ratio, per SD (0.06)	549	1.15	0.93-1.42	1.21	0.96-1.52	1.20	0.94-1.52
Waist-to-height ratio, per SD (0.04)	549	1.32	1.10-1.58	1.34	1.11-1.61	1.24	1.01-1.54
WHtR category							
<0.5	526	Ref.	—	Ref.	—	Ref.	—
≥0.5	23	2.29	1.19-4.40	2.55	1.34-4.85	2.15	1.10-4.20

Model 1: adjusted for age, area-level disadvantage at childhood, parity and occupation at adulthood;

Model 2: adjusted for age, area-level disadvantage at childhood, parity, occupation and corresponding abdominal measures at adulthood;

Abbreviations: CI, confidence interval; RR, risk ratio; SD, standard deviation; WHtR, waist-to-height ratio.

Supplemental Table 2 Associations between adiposity measures in childhood with pregnancy hypertension, Childhood Determinants of Adult Health Study (Considering childhood blood pressure).

Body composition	n	Unadjusted model		Model 1		Model 2		Model 3		Model 4	
		RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
BMI (kg/m ²)	415	1.10	1.02-1.18	1.12	1.03-1.21			1.03	0.93-1.15	1.04	0.93-1.16
BMI z score	415	1.29	1.04-1.58	1.31	1.06-1.62			1.06	0.81-1.40	1.09	0.81-1.44
BMI category											
Normal	380	Ref.	—	Ref.	—			Ref.	—	Ref.	—
Overweight/obese	35	2.58	1.50-4.45	2.75	1.60-4.73			1.85	0.95-3.59	1.98	0.91-4.30
Waist circumference (cm)	415	1.04	1.02-1.07	1.05	1.02-1.08	1.05	1.00-1.09	1.04	1.00-1.09	1.04	1.01-1.09
Waist circumference z score	415	1.38	1.14-1.67	1.41	1.17-1.70	1.36	0.99-1.87	1.35	1.00-1.82	1.36	1.03-1.80
Waist circumference, per SD (7.87 cm)	415	1.38	1.15-1.66	1.46	1.20-1.78	1.42	1.01-2.01	1.41	1.04-1.92	1.43	1.07-1.90
Waist-to-hip ratio, per SD (0.06)	415	1.26	1.00-1.58	1.33	1.04-1.70	1.25	0.98-1.60	1.23	0.97-1.57	1.23	0.97-1.56
Waist-to-height ratio, per SD (0.04)	415	1.43	1.20-1.71	1.44	1.22-1.70	1.44	1.09-1.90	1.41	1.10-1.81	1.40	1.09-1.80
WHtR category											
<0.5	395	Ref.	—	Ref.	—	Ref.	—	Ref.	—	Ref.	—
≥0.5	20	3.24	1.81-5.80	3.50	2.01-6.10	2.88	1.25-6.59	2.75	1.11-6.82	3.28	1.56-6.87

Model 1: adjusted for age, area-level disadvantage at childhood, parity and occupation at adulthood;

Model 2: adjusted for age, area-level disadvantage and body mass index at childhood, parity and occupation at adulthood;

Model 3: adjusted for age, area-level disadvantage and body mass index at childhood (for abdominal obesity measures only), parity, occupation and body mass index at adulthood;

Model 4: adjusted for age, area-level disadvantage, body mass index (for abdominal obesity measures only) and systolic and diastolic blood pressure at childhood, parity, occupation and body mass index at adulthood;

Abbreviations: BMI, body mass index; CI, confidence interval; RR, risk ratio; SD, standard deviation; WHtR, waist-to-height ratio.

Supplemental Table 3 Sensitivity analysis using inverse propensity weighting technique with multiple imputation. Associations between adiposity measures in childhood with pregnancy hypertension, Childhood Determinants of Adult Health Study.

Body composition	n	Unadjusted model		Model 1		Model 2		Model 3	
		RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
BMI (kg/m ²)	985	1.06	1.01-1.12	1.07	1.01-1.13			1.02	0.96-1.09
BMI z score	985	1.18	1.01-1.38	1.19	1.02-1.39			1.04	0.87-1.24
BMI category									
Normal	898	Ref.	—	Ref.	—			Ref.	—
Overweight	77	1.72	1.07-2.77	1.76	1.10-2.82			1.22	0.73-2.05
Obese	10	1.22	0.33-4.45	1.26	0.35-4.51			0.50	0.13-1.88
Waist circumference (cm)	985	1.03	1.01-1.05	1.04	1.02-1.06	1.04	1.01-1.07	1.03	1.00-1.07
Waist circumference z score	985	1.28	1.10-1.48	1.28	1.10-1.48	1.28	1.02-1.60	1.21	0.94-1.57
Waist circumference, per SD (7.51 cm)	985	1.26	1.10-1.45	1.31	1.12-1.52	1.32	1.05-1.68	1.26	0.97-1.65
Waist-to-hip ratio, per SD (0.06)	985	1.22	1.04-1.44	1.29	1.09-1.52	1.25	1.05-1.49	1.26	1.05-1.50
Waist-to-height ratio, per SD (0.04)	985	1.33	1.17-1.51	1.33	1.18-1.51	1.43	1.18-1.74	1.40	1.3-1.72
WHtR category									
<0.5	938	Ref.	—	Ref.	—	Ref.	—	Ref.	—
≥0.5	47	2.36	1.46-3.82	2.48	1.54-4.00	2.15	1.13-4.08	2.50	1.43-4.37

Model 1: adjusted for age, area-level disadvantage at childhood, parity and occupation at adulthood;

Model 2: adjusted for age, area-level disadvantage and body mass index at childhood, parity and occupation at adulthood;

Model 3: adjusted for age, area-level disadvantage and body mass index (for abdominal obesity measures only) at childhood, parity, occupation and body mass index at adulthood;

Abbreviations: BMI, body mass index; CI, confidence interval; RR, risk ratio; SD, standard deviation; WHtR, waist-to-height ratio.



