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Low Birth Weight is Associated With Components of the Metabolic Syndrome

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Abstract

Objective—To investigate the association between birth weight and number of metabolic syndrome (MetS) components in an urban Chinese cohort.

Methods—Individuals (n=2,019), who were born between 1921 and 1954 at the Peking Union Medical College Hospital (PUMCH) and who had detailed obstetric records, volunteered to take part and were examined by medical personnel in a clinical setting between May 2003 and April 2005. Data of birth outcome and results on clinic examination in adulthood were analyzed using ANOVA and multivariate ordinal regression to estimate the association between birth weight and MetS. MetS was defined as per the National Cholesterol Education Program (NCEP) Adult Treatment Panel (ATP III).

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Results—The prevalence of MetS was 26.74%, though 55.43% of the subjects had at least two components of MetS. Subjects who presented with all five components of MetS exhibited a significantly lower birth weight and higher age, BMI, and waist circumference at follow-up. Multivariate ordinal regression analysis revealed that, as compared to those with birth weights of 3000-3500 g, subjects who had birth weights of < 2500 g were 66% more likely to develop a greater number of MetS components in adulthood (95%CI: 1.18-2.34, $p=0.004$), whereas those with birth weights between 2500-3000 g were 33% more likely to develop a greater number of MetS components as adults (95%CI: 1.09-1.63, $p=0.005$).

Conclusions—The present study demonstrated the relationship between low birth weight and increased presentation of MetS components in Chinese adults.

Keywords

Metabolic syndrome; low birth weight; obesity; dyslipidemia; hyperglycemia; hypertension

INTRODUCTION

Risk factors of metabolic syndrome (MetS), such as diabetes, coronary heart disease, insulin resistance, and hypertension, cluster in a way that cannot be explained by chance, and have been largely associated with environmental factors such as sedentary lifestyle, diet, and thinness or low weight at birth (1-3). The latter factor is supported by hundreds of epidemiological studies (4), which have given saliency to fetal origin frameworks, such as the thrifty phenotype hypothesis or the Barker Hypothesis, in particular. Briefly, it has been proposed that postnatal survival physiology, structure, and metabolism are altered under conditions of intermittent or poor fetal nutrition, an adaptive response (in concert with other genetic dispositions) (5) that enhances postnatal survival, but portends long-term consequences in function once nutrition becomes more abundant in the postnatal environment (6). Such programmed adaptations result in decreased nephron number, defects in insulin secretion and/or insulin sensitivity, decreased arterial elastin concentrations, and increased activity of the hypothalamic-pituitary adrenal axis (7-10).

Epidemiological studies of MetS, which have characterized MetS as the “small-baby syndrome” (11), are, however, variable in terms of the disparity of cohorts (developing countries versus high-income countries) analyzed and the definitions as well as the validity of those definitions of MetS utilized. We have previously demonstrated low birth weight to be an independent risk factor for adult diabetes or impaired glucose regulation from cohort data from the Peking Union Medical College Hospital (PUMCH) in Beijing (12). More recently, Mi et al. (14) have also investigated the effects of low birth weight in relation to MetS, using the Fetal Origin of Adult Disease (FOAD) cohort of Beijing and working definition of MetS formulated by The National Cholesterol Education Program (NCEP) Adult Treatment Panel (ATP III) (13). The NCEP ATP-III addresses the concurrence of interrelated disorders that define MetS by examining obesity, dyslipidemia, hyperglycemia, and hypertension, and has been routinely used in this field following its inception (15-16).

We hypothesized that low birth weight is associated with greater number of MetS components in adulthood. Thus, the objective of this study was to extend our previous findings in the PUMCH cohort to corroborate the relationship between low birth weight and increased number of MetS components in adulthood.

METHODS

Design and Subjects

As previously described (12), subjects were derived from the PUMCH records (from 1921 to 1954) in Beijing, which provide extensive documentation of obstetric records and data including, weight, length, head circumference at birth, placental weight, gestational weeks, blood pressure at delivery and during pregnancy, and various maternal parameters such as parity, age, and date of last menstrual period. Briefly, during the periods of 1921-1941 and 1948-1954, a total of 6,570 Chinese neonates were born in PUMCH. Using actuarial census projections, we estimated there would be approximately 2,990 survivors at the time of the planned assessment. In 2003-2005, we traced 2,503 subjects through community registries and media announcements with the assistance of the Beijing Population Registry. Among traced subjects, 418 were not included; 175 were deceased, 78 refused to participate, and 165 resided outside Beijing. Thus, of the 2,085 individuals who were traced and agreed to participate, 2,019 had complete MS examinations and were included in this study. Follow-up analysis in May 2003 and April 2005 was conducted. Informed consent from all participants and institutional review board approval was obtained.

Measurements

A team of experienced doctors, nurses, and technicians, all blinded from the obstetric data, performed measurements of the study parameters. Blood samples were collected from the antecubital vein between 0830 and 1230 hours after a 12-h overnight fast and evaluated for HLD-C and TG levels using standard enzymatic methods (17) and fasting plasma glucose (FPG) using a standard oxidase method (18). According to the NCEP ATP III, MetS was defined as the presence of three of five of the following components (14-15): 1) fasting glucose ≥ 110 mg/dL or diagnosed DM; 2) elevated blood pressure (systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85) or history of hypertension; 3) serum HDL concentration < 40 mg/dL for males and < 50 mg/dL for females; 4) serum triglyceride concentration ≥ 150 mg/dL; or 5) a waist circumference of ≥ 102 cm for men and ≥ 88 cm for women, as measured to the nearest 0.1 cm at the level of the navel, using a flexible steel tape.

Statistical Analysis

Differences were assessed by one-way analysis of variance (ANOVA) tests. Multiple comparisons of means were performed using the Student-Newman-Keuls test. Results were presented as mean $\pm$ SD for continuous variables, and as counts and percentages for categorical variables. The correlation between neonatal characteristics and number of metabolic syndrome components presented in adulthood was evaluated using univariate, and when significance was observed, multivariate ordinal regression, adjusted for possible confounding factors in adult life, including gender, age, central obesity, smoking status, alcohol intake, hypertension, dyslipidemia, family history of diabetes, occupational status, current social class, gestational age, and gestational hypertension. All statistical assessments were two-sided, and a P -value < 0.05 was considered statistically significant. Statistical analyses were performed using SPSS 12.0 statistical software (SPSS Inc, Chicago, IL).

RESULTS

Subjects

As shown in Table 1, basic anthropometric, clinical, and biochemical data as well as prevalence of MetS and its defining features of the study participants were analyzed. Of the 2,019 subjects enrolled, 515 (26.74%) fulfilled NCEP ATP-III criteria of MetS ($\geq$ three components), whereas approximately half of the subjects ($n=997$, 49.38%) had at least two

MetS components, and 349 (18.12%) had no MetS components (Table 1). A majority of subjects (67.03%) also had high blood pressure, and 41.59% had elevated serum triglyceride levels.

Birth characteristics and number of metabolic syndrome components in adulthood

Subjects were stratified according to the number of MetS components in adulthood (Table 2). Statistically significant differences were observed in the number of MetS components stratified by weight at birth ($p=0.001$) as well as age, body mass index (BMI), and waist circumference ($p<0.0001$) at follow-up. Specifically, subjects who had all five components of MetS exhibited a significantly lower birth weight (2936 ± 431.2 g), as compared to those with 0-3 MetS components. Subjects with all five MetS components also exhibited significantly higher BMI (29.2 ± 3.8) and waist circumference (100.5 ± 7.7 cm) at follow-up ($p<0.001$), compared to those with 0-4 MetS components.

Birth measurements in relation to adult metabolic syndrome

As shown in Table 3, birth measurements in relation to adult metabolic syndrome were evaluated by univariate and multivariate ordinal regression analysis. After adjusting for possible confounding factors in adult life, including gender, age, central obesity, smoking status, alcohol intake, hypertension, dyslipidemia, family history of diabetes, occupational status, current social class, gestational age, and gestational hypertension, subjects with birth weights < 2500 g were 66% more likely to develop greater number of MetS components (95%CI: 1.18-2.34, $p=0.004$), and 33% more likely when birth weights were between 2500-3000 g (95%CI: 1.09-1.63, $p=0.005$), using individuals with a birth weight of 3000-3500 g as reference. These results confirm that low birth weight is associated with the development of increased number of MetS components in adulthood. No significant association between head circumference and MetS was observed.

DISCUSSION

In this cohort of Chinese adults, the prevalence of MetS was 26.74%, and 55.43% of the subjects had at least two components of MetS. Subjects who presented with all five components of MetS exhibited a significantly lower birth weight and higher age, BMI, and waist circumference. As compared to those with a birth weight of 3000-3500 g, subjects with birth weights of < 2500 g were 66% more likely to develop a greater number of MetS components in adulthood whereas those with birth weights between 2500-3000 g were 33% more likely to develop greater a greater number of MetS components in adulthood; however, low birth weight was not associated with MetS as defined by the NCEP.

At least 224 articles and 5 reviews investigating low body weight and MetS have been published although few have analyzed Chinese cohorts; 31 studies have recently been subjected to meta-analysis by Silveira and Horta (4). Studies using NCEP-ATP III have shown a MetS prevalence ranging from 0.3 to 23%, based on hospital registries or other sources, in high-income countries throughout Europe between the 1920s to the 1980s (19-23). The high prevalence of MetS observed in the present study appears to be consistent with the results of our previous study, which documented a 22.7% prevalence based on FOAD records in Beijing between 1948 and 1954 (12). Adjusted odds ratios of low birth weight and MetS in three studies, which used 2500 g as a cut-off point for low birth weight, Gale et al. (19), Eriksson et al. (20), and Stein et al. (23), were 4.6 (95%CI: 1.02-20.4), 0.99 (95%CI: 0.3-3.3), and 1.92 (95%CI: 0.35-10.6), respectively, which is comparable to the findings of this study. Other large registry-based studies in which birth weight percentiles were used (4,12,14,24), have consistently reported that subjects in the low birth weight ($<$

25th percentile of the total samples) demonstrated a 60% higher MetS prevalence than those in the $\geq 75^{\text{th}}$ percentile.

The prevalence of MetS observed in this study is comparable to those reported for European countries (19-23); however, increased MetS prevalence was observed using waist cut-offs recommended for Asians in the revised AHA-NHLBI definition of MetS (data not shown). Specifically, according to the AHA/NHLBI definition of MetS (waist circumference greater than 90 cm for men and greater than 80 cm for women), 978 (49.5%) of the study participants had MetS as compared to a 26.74% prevalence using the NCEP ATPIII definition, which is similar to another study of MetS prevalence in China (25). Using the ATP III criteria, MetS prevalence was 9.8%; however, MetS prevalence increased to 15.1% upon use of the modified AHA/NHLBI criteria (25). Thus, further studies addressing the most appropriate criteria for analyzing MetS in Asian populations are warranted.

Barker's hypothesis serves to explain what appears to be a universal trend—low birth weight, a marker of intrauterine growth retardation, is associated with development of chronic diseases, including MetS. Fetal growth in late gestation is limited by maternal size and capacity, a condition commonly referred as “maternal constraint” (26). Reproductive outcomes are also predicated upon maternal nutritional status, maternal age, and socioeconomic variables during gestation (27). The weathering hypothesis (health deteriorates as a physical consequence of cumulative socioeconomic disadvantage (28) and the life course approach (health deteriorates as a consequence of the cumulative health impacts of social, biological, and psychological processes from conception to death (29) are often evoked to explain maternal age and other risk factors for low birth weight. Indeed, both hypotheses indicate that the burdens of poverty and social change—phenomena not alien to an epoch marked by political strife in China (1921 to 1954) or to a radically developing metropolis such as Beijing—compromise a woman's health and chances of delivering a healthy infant, perhaps well before conception. Thus, it was not unexpected to observe that low birth weight was associated with subsequent severity of MetS development in adulthood in both univariate and multivariate ordinal regression models.

To conclude, the present study demonstrated the relationship between low birth weight and increased number of MetS components in Chinese adults. Risk factors for MetS, such as tobacco use, dietary intake, and a sedentary lifestyle have, however, modify this relationship (30), suggesting that in addition to improving the nutritional status of Chinese women, promoting healthy lifestyles especially in susceptible individuals remains a priority in public health policy making.

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References

1. Barker M, Robinson S, Osmond C, et al. Birth weight and body fat distribution in adolescent girls. *Arch Dis Child* 1997;77:381–3. [PubMed: 9487954]
2. Huxley R, Neil A, Collins R. Unravelling the fetal origins hypothesis: is there really an inverse association between birthweight and subsequent blood pressure? *Lancet* 2002;360:659–65. [PubMed: 12241871]

3. Laaksonen DE, Lakka HM, Salonen JT, et al. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabetes Care* 2002;25:1612–8. [PubMed: 12196436]
4. Silveira VM, Horta BL. Birth weight and metabolic syndrome in adults: meta-analysis. *Rev Saude Publica* 2008;42:10–8. [PubMed: 18200335]
5. Rinaudo PF, Lamb J. Fetal origins of perinatal morbidity and/or adult disease. *Semin Reprod Med* 2008;26:436–45. Epub 2008 Sep 29. [PubMed: 18825611]
6. Eriksson JG, Lindi V, Uusitupa M, et al. The effects of the Pro12Ala polymorphism of the peroxisome proliferator-activated receptor-2 gene on insulin sensitivity and insulin metabolism interact with size at birth. *Diabetes* 2002;51:2321–4. [PubMed: 12086968]
7. Newsome CA, Shiell AW, Fall CH, et al. Is birth weight related to later glucose and insulin metabolism? A systematic review. *Diabet Med* 2003;20:339–48. [PubMed: 12752481]
8. Ozanne SE, Hales CN. Early programming of glucose-insulin metabolism. *Trends Endocrinol Metab* 2002;13:368–73. [PubMed: 12367817]
9. Yarbrough DE, Barrett-Connor E, Kritz-Silverstein D, et al. Birth weight, adult weight, and girth as predictors of the metabolic syndrome in postmenopausal women: the Rancho Bernardo Study. *Diabetes Care* 1998;21:1652–8. [PubMed: 9773725]
10. Hales CN, Barker DJ. The thrifty phenotype hypothesis. *Br Med Bull* 2001;60:5–20. [PubMed: 11809615]
11. Barker DJ, Hales CN, Fall CH, et al. Type 2 (non-insulindependent) diabetes mellitus, hypertension and hyperlipidaemia (syndrome X): relation to reduced fetal growth. *Diabetologia* 1993;36:62–7. [PubMed: 8436255]
12. Xiao X, Zhang ZX, Cohen HJ, et al. Evidence of a relationship between infant birth weight and later diabetes and impaired glucose regulation in a Chinese population. *Diabetes Care* 2008;31:483–7. Epub 2007 Dec 10. [PubMed: 18070988]
13. Expert Panel on Detection EaToHBCiA. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA* 2001;285:2486–97. [PubMed: 11368702]
14. Mi J, Cheng H, Zhao XY, et al. Developmental origin of metabolic syndrome: interaction of thinness at birth and overweight during adult life in Chinese population. *Obes Rev* 2008;9:91–4. [PubMed: 18307707]
15. Grundy SM. Metabolic Syndrome Scientific Statement by the American Heart Association and the National Heart, Lung, and Blood Institute. *Arterioscler, Thromb, Vasc Biol* 2005;25:2243–4. [PubMed: 16258150]
16. Fall CH, Sachdev HS, Osmond C, et al. Adult metabolic syndrome and impaired glucose tolerance are associated with different patterns of body mass index gain during infancy; Data from the New Delhi birth cohort. *Diabetes Care*. 2008 Oct 3; Epub ahead of print.
17. Kunst, A.; Draeger, B.; Ziegenhorn, J. UV-methods with hexokinase and glucose-6-phosphate dehydrogenase. In: Bergmeyer, HU., editor. *Methods of Enzymatic Analysis*. Verlag Chemie Deerfield: Weinheim; 1983. p. 163-172.
18. Allain CC, Poon LS, Chan CS, et al. Enzymatic determination of total serum cholesterol. *Clin Chem* 1974;20:470–5. [PubMed: 4818200]
19. Gale CR, Martyn CN, Kellingray S, et al. Intrauterine programming of adult body composition. *J Clin Endocrinol Metab* 2001;86:267–72. [PubMed: 11232011]
20. Eriksson JG, Forsen T, Tuomilehto J, et al. Effects of size at birth and childhood growth on the insulin resistance syndrome in elderly individuals. *Diabetologia* 2002;45:342–8. [PubMed: 11914739]
21. Jaquet D, Deghmoun S, Chevenne D, et al. Dynamic change in adiposity from fetal to postnatal life is involved in the metabolic syndrome associated with reduced fetal growth. *Diabetologia* 2005;48:849–55. [PubMed: 15834547]
22. Ramadhani MK, Grobbee DE, Bots ML, et al. Lower birth weight predicts metabolic syndrome in young adults: The Atherosclerosis Risk in Young Adults (ARYA)-study. *Atherosclerosis* 2006;184:21–31. [PubMed: 16326169]

23. tein AD, Conlisk A, Torun B, et al. Cardiovascular disease risk factors are related to adult adiposity but not birth weight in young guatemalan adults. *J Nutr* 2002;132:2208–14. [PubMed: 12163664]
24. Al Salmi I, Hoy WE, Kondalsamy-Chennakesavan S, et al. Relationship Between Low Birth Weight and Disorders of Glucose Regulation. *Diabetes Care* 2008;31:159–64. [PubMed: 17934149]
25. Gu D, Reynolds K, Wu X, et al. Prevalence of the metabolic syndrome and overweight among adults in China. *Lancet* 2005;365:1398–405. [PubMed: 15836888]
26. Thame M, Wilks RJ, McFarlane-Anderson N, et al. Relationship between maternal nutritional status and infant's weight and body proportions at birth. *Eur J Clin Nutr* 1997;51:134–8. [PubMed: 9076402]
27. Elshibly EM, Schmalisch G. The effect of maternal anthropometric characteristics and social factors on gestational age and birth weight in Sudanese newborn infants. *BMC Public Health* 2008;18(8):244. [PubMed: 18638377]
28. Geronimus AT. The weathering hypothesis and the health of African-American women and infants: evidence and speculation. *Ethnicity Dis* 1992;2:207–21.
29. Kuh, D.; Ben-Shlomo, Y. *A Life Course Approach to Chronic Disease Epidemiology*. Oxford: Oxford University Press; 1997.
30. te Velde SJ, Twisk JW, van Mechelen W, et al. A birth-weight questionnaire indicated that life style modifies the birth weight and metabolic syndrome relationship at age 36. *J Clin Epidemiol* 2005;58:1172–9. Epub 2005 Sep 12. [PubMed: 16223661]

Table 1

Patients' basic anthropometric, clinical, and biochemical data and prevalence of metabolic syndrome and its defining features (n=2,019).

	N (%)
Basic anthropometric	
Gender, Male (%)	990 (49.0%)
Measurements at birth	
Birth weight (g)	3111.5±456.0
Birth Length (cm)	49.4±2.4
Head circumference (cm)	31.6±1.7
Ponderal index (kg/m ³)	27.8±3.4
Adult measurements	
Age (y)	59.3±8.1
BMI (kg/m ²)	25.0±3.5
Waist circumference (cm)	89.1±10.7
SBP (mmHg)	130.51±20.66
DBP (mmHg)	79.01±10.91
Maternal Age (y)	27.6±5.6
Clinical and biochemical data	
Fasting glucose (mg/dL)	98.07±29.30
HDL (mg/dL)	56.06±15.01
Triglycerides (mg/dL)	155.13±159.00
Metabolic syndrome, n (%)	515 (26.74%)
Number of metabolic syndrome components presented, n (%)	
0	349 (18.12%)
1	580 (30.11%)
2	482 (25.3%)
3	325 (16.78%)
4	144 (7.48%)
5	46 (2.39%)
Components of the metabolic syndrome, n (%)	
High fasting glucose (≥110 mg/dL)	459 (23.83%)
High blood pressure (≥130/85mm Hg)	1291 (67.03%)
Low HDL (<50 mg/dL women; <40 md/dL men)	210 (10.90%)
High triglycerides (≥ 150)	801 (41.59%)
Waist circumference (≥ 88cm for females and ≥ 102 cm for males)	567 (29.44%)

Table 2
Characteristics of the study sample according to number of metabolic syndrome components

	Number of metabolic syndrome components in adulthood						P-value [^]
	0 n=349	1 n=580	2 n=482	3 n=325	4 n=144	5 n=46	
Measurements at birth							
Birth weight (g)	3148.5±452.8	3140.4±442.6	3098.1±462.4	3114.8±483.7	3001.0±415.3 ^{a,b,d}	2936.9±431.2 ^{a,b,c,d}	0.001 [*]
Birth Length (cm)	49.6±2.4	49.6±2.4	49.3±2.4	49.5±2.4	49.0±2.4	49.0±2.8	0.028
Head circumference (cm)	31.8±1.7	31.6±1.5	31.7±1.8	31.6±1.8	31.3±1.6	31.3±1.4	0.075
Ponderal index (kg/m ³)	25.9±3.6	25.8±3.7	25.9±3.4	25.7±3.0	25.5±2.7	25.0±2.7	0.368
Adult measurements							
Age (y)	56.0±7.2	59.0±8.0 ^a	60.2±8.1 ^a	60.6±8.0 ^a	61.7±8.3 ^{a,b,c}	61.6±8.4 ^{a,b,c}	<0.001 [*]
BMI (kg/m ²)	22.3±2.6	24.1±3.0 ^a	25.5±3.2 ^{a,b}	26.8±3.2 ^{a,b,c}	28.00±3.3 ^{a,b,c,d}	29.2±3.8 ^{a,b,c,d,e}	<0.001 [*]
Waist circumference (cm)	80.2±8.4	86.0±9.2 ^a	91.2±9.00 ^{a,b}	95.3±9.6 ^{a,b,c}	98.3±9.1 ^{a,b,c,d}	100.5±7.7 ^{a,b,c,d,e}	<0.001 [*]
Maternal Age (y)	27.4±5.2	27.4±5.6	27.6±5.6	27.7±5.5	27.8±6.2	28.20±5.8	0.826

^a P-values are based on ANOVA and pair-wise multiple comparisons between groups using the Student-Newman-Keuls test

^{*} P<0.05

^a Significantly different to subjects with 0 MetS components

^b Significantly different to subjects with 1 MetS component

^c Significantly different to subjects with 2 MetS components

^d Significantly different to subjects with 3 MetS components

^e Significantly different to subjects with 4 MetS components

Table 3

Birth measurements, maternal age, and adult metabolic syndrome as evaluated by ordinal regression analysis

	Univariate			Multivariate [†]		
	OR	95% CI	P-value	OR	95% CI	P-value
Maternal age	1.05	1.04-1.06	<0.001*	1.05	1.04-1.06	<0.001*
Gender						
Male	1.00	-		1.00	-	
Female	1.17	1.00-1.38	0.049	1.20	1.02-1.42	0.029*
Neonatal measurements						
Birth weight						
< 2500 g	1.47	1.08-2.01	0.014*	1.66	1.18-2.34	0.004*
2500-3000 g	1.34	1.11-1.62	0.003*	1.33	1.09-1.63	0.005*
3000-3500 g	1.00	-		1.00	-	
> 3500 g	1.00	0.81-1.25	0.982	0.97	0.87-1.23	0.817
Head circumference						
< 31 cm	1.13	0.93-1.37	0.215	0.86	0.70-1.07	0.179
31-33 cm	1.00	-		1.00	-	
> 33 cm	0.91	0.75-1.12	0.378	1.06	0.85-1.32	0.607

* $P < 0.05$

[†] Adjusted for the possible confounding factors in adult life, including gender, age, central obesity, smoking status, alcohol intake, hypertension, dyslipidemia, family history of diabetes, occupational status, current social class, gestational age, and gestational hypertension. OR: Odds ratios; CI: confidence intervals