Relationship Between Leg Length and Gestational Diabetes Mellitus in Chinese Pregnant Women

RUN MEI MA, PHD, MD[1]
TERENCE T. LAO, MD[2]
CHUN LING MA, MPHIL[1]
SHU JIE LIAO, MPHIL[1]
YAN FENG LU, MPHIL[1]

MING YU DU, MPHIL[1]
HONG XIAO, BSC[1]
LAN ZHANG, BSC[1]
MING HUI YANG, BSCN[1]
XUE XIAO, MPHIL[1]

The relationship between maternal short stature and gestational diabetes mellitus (GDM) remains controversial. While such an association has been shown in Europeans, South Americans, and Southern Asians (1–5), it was not demonstrated in Hungarians of European origin (6). Apart from ethnic differences, the contribution of the different components of height to overall height could have influenced this association, since leg length rather than trunk length has been correlated with type 2 diabetes in British women (7), and a similar observation in women with GDM has since been reported (5). As Chinese women are generally shorter than their European counterparts because of shorter legs, we have examined the relationship between overall height and components of height with the development of GDM in Chinese women to address this issue.

RESEARCH DESIGN AND METHODS

— This prospective cohort study was conducted in Kunming, China, from August 2004 to March 2005. All the patients were ethnic Chinese. A 75-g oral glucose tolerance test (OGTT) was arranged at booking for women with risk factors for GDM. If the initial results were normal, the OGTT was repeated at 28–32 weeks. All low-risk women received the OGTT at 28–32 weeks. No preliminary challenge test was used. The OGTT results were interpreted by World Health Organization criteria (8), which have been studied in Chinese populations before (9–11).

Maternal demographic data were collected at the first visit. Height and weight at the time of OGTT were recorded, with the weight measurement taken to the nearest 0.1 kg while subjects wore light clothing. Height without shoes was measured with a stadiometer to the nearest 0.5 cm with the subject standing and also while sitting on a stool (5). Trunk length was calculated by deducting the stool height from the measured sitting height. Leg length was calculated by deducting the trunk height from the measured standing height as previously described (5), and the absolute and percentage values were compared between women with and without GDM.

Statistical analysis was performed with SPSS (version 11.5; SPSS, Chicago, IL). Comparison between the GDM and non-GDM groups was performed with Student's *t* test for maternal characteristics and OGTT results, and the multiple stepwise linear regression analysis was performed to examine the independent determinants of GDM.

RESULTS

— Of the 994 women who completed the study, 163 (16.4%) developed GDM (Table 1). This group was older ($P < 0.001$) and had greater weight gain at OGTT ($P = 0.005$), and their overall height tended to be shorter ($P = 0.06$). However, leg length ($P = 0.004$), leg-to-height percentage ($P = 0.018$), and leg-to-trunk ratio ($P = 0.004$) were significantly reduced, while the trunk-to-height ratio ($P = 0.018$) was significantly increased, without any difference in trunk length. Using the receiver operating characteristic curve, trunk-to-height percentage, weight gain, age, and trunk length were found to be significant but weak predictors for GDM, while the height components were correlated with only the OGTT fasting value on partial correlation analysis. Regression analysis, adjusting for age, total height, BMI at OGTT, and parity, indicated that leg-to-trunk ratio ($P = 0.003$) and leg length ($P = 0.004$) were significantly independent determinants of fasting and 2-h values, respectively.

CONCLUSIONS

— In agreement with the study by Moses and Mackay (5), we have demonstrated a significant association between maternal leg length and GDM. Specifically, leg length is an independent determinant of, and inversely correlated with, the OGTT 2-h glucose value. While the design of our study did not allow us to explore the underlying pathophysiological mechanisms, this phenomenon may be related to glucose disposal after ingestion of a glucose load. It has been reported (12) that leg uptake of glucose was significantly stimulated above basal values after an oral glucose ingestion and that 71% of the ingested load was eventually taken up by peripheral tissues, primarily muscles, suggesting that it is the peripheral and not splanchnic tissues that play the predominant role in the disposal of an oral glucose load. It can be envisaged that subjects with shorter legs have fewer peripheral muscles than subjects with longer legs and that their ability to dispose of an orally ingested glucose load would have decreased, thus resulting in a higher 2-h glucose value in the OGTT.

Nevertheless, the leg-to-trunk ratio

●●

Table 1—*Maternal characteristics in subjects with versus without GDM*

	Non-GDM	GDM	P
n	831	163	<0.001
Maternal age (years)	28.4 ± 3.6	29.6 ± 4.0	<0.001
Gestational age at OGTT (weeks)	31.0 ± 3.0	29.9 ± 3.4	NS
Maternal height (cm)	160.0 ± 4.3	159.3 ± 4.7	NS
Weight (kg)			
Prepregnant	51.7 ± 6.5	51.0 ± 6.7	NS
At OGTT	63.8 ± 7.4	64.0 ± 7.8	0.005
Weight gain at OGTT	12.1 ± 4.0	13.1 ± 4.4	NS
BMI (kg/m²)			
Prepregnant	20.2 ± 2.3	20.1 ± 2.4	NS
At OGTT	24.9 ± 2.7	25.2 ± 2.7	0.004
Leg length (cm)	72.2 ± 3.6	71.3 ± 3.3	0.018
Leg-to-height ratio (%)	45.1 ± 1.7	44.8 ± 1.5	NS
Trunk length (cm)	87.8 ± 3.4	88.0 ± 3.3	0.018
Trunk-to-height ratio (%)	54.9 ± 1.7	55.3 ± 1.5	0.004
Leg-to-trunk ratio (%)	81.8 ± 5.6	80.4 ± 4.3	<0.001
OGTT results (mmol/l)			
Fasting	3.7 ± 0.6	4.3 ± 1.0	<0.001
2-h	6.0 ± 1.0	9.0 ± 1.3	<0.001

Data are means ± SD. NS, not significant.

was shown to be an independent determinant of, and again inversely correlated with, the OGTT fasting glucose value in our subjects. As a relatively larger trunk would imply a greater amount of centrally distributed fat cells, an increasing proportion of the trunk relative to overall height could have contributed to the impairment of insulin secretory capacity and increased insulin resistance reported in shorter pregnant and nonpregnant women (2,7). These factors could in turn be responsible for the inverse correlation between leg-to-trunk ratio and fasting glucose values.

Our finding that reduced leg length and the leg-to-height ratio, rather than the overall height itself, was associated with GDM can help explain the controversial observations in the literature. We suspect that leg length plays a greater role than overall height in this regard in ethnic groups that tend to be shorter, such as the Chinese, in whom the difference in overall height between the GDM and non-GDM subjects became reduced. Although short leg length is an independent predictor of GDM in the Chinese, this was less significant than other factors such as age and weight gain, while in the nonpregnant Hong Kong Chinese population,

BMI, waist-to-hip ratio, waist circumference, and waist-to-height ratio are strong predictors of diabetes and hypertension (13). Thus, the additional measurement of leg length in clinical practice is unlikely to enhance the prediction of GDM or type 2 diabetes in the Chinese population, even though these findings may have explained the occasional unexpectedly high postprandial glucose levels in subjects who are short but not obese, as encountered in some of our patients with GDM.

References
1. Jang HC, Min HK, Lee HK, Cho NH, Metzger BE: Short stature in Korean women: a contribution to the multifactorial predisposition to gestational diabetes mellitus. *Diabetologia* 41:778–783, 1998
2. Anastasiou E, Alevizaki M, Grigorakis SJ, Philippou G, Kyprianou M, Souvatzoglou A: Decreased stature in gestational diabetes mellitus. *Diabetologia* 41:997–1001, 1998
3. Kousta E, Lawrence NJ, Penny A, Millauer BA, Robinson S, Johnston DG, McCarthy MI: Women with a history of gestational diabetes of European and South Asian origin are shorter than women with normal glucose tolerance in pregnancy. *Diabet Med* 17:792–797, 2000
4. Branchtein L, Schmidt MI, Matos MCG, Yamashita T, Pousada JMDC, Duncan BB, the Brazilian Gestational Diabetes Study Group: Short stature and gestational diabetes in Brazil. *Diabetologia* 43:848–851, 2000
5. Moses RG, Mackay MT: Gestational diabetes. Is there a relationship between leg length and glucose tolerance? *Diabetes Care* 27:1033–1035, 2004
6. Tabák Á Gy, Kerényi Zs, Nagy E, Bosnyák Zs, Madarász E, Tamás Gy: Height and gestational diabetes. *Diabet Med* 19:344–345, 2002
7. Lawlor DA, Ebrahim S, Davey Smith G: The association between components of adult height and type II diabetes and insulin resistance: British Women's Heart and Health Study. *Diabetologia* 45:1097–1106, 2002
8. Alberti KG, Zimmet PZ, the WHO Consultation: Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus: provisional report of a WHO consultation. *Diabet Med* 15:539–553, 1998
9. Tam W-H, Rogers MS, Yip S-K, Lau TK, Leung TY: Which screening test is the best for gestational impaired glucose tolerance and gestational diabetes mellitus (Letter)? *Diabetes Care* 23:1432, 2000
10. Lao TT, Lee CP: Gestational "impaired glucose tolerance": should the cut-off be raised to 9 mmoll⁻¹? *Diabet Med* 15:25–29, 1998
11. Ma RM, Lao TT: Relationship between maternal mean arterial pressure and oral glucose tolerance test results in normotensive women. *J Reprod Med* 46:747–751, 2001
12. Katz LD, Glickman MG, Rapoport S, Ferrannini E, Defronzo RA: Splanchnic and peripheral disposal of oral glucose in man. *Diabetes* 32:675–679, 1983
13. Ko GT, Chan JC, Cockram CS, Woo J: Prediction of hypertension, diabetes, dyslipidaemia or albuminuria using simple anthropometric indexes in Hong Kong Chinese. *Int J Obes Relat Metab Discord* 23:1136–1142, 1999