

# Effects of body mass index and body fat percentage on gestational complications and outcomes

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## Abstract

**Aim:** The aim of this study was to investigate the correlation between body mass index (BMI), body fat percentage (BFP) and gestational outcomes.

**Material and Methods:** Maternal- and infant-related data of gestation and gestational outcomes of 411 pregnant women were retrospectively analyzed. BMI was used to classify the women as obese, overweight, or normal. BFP was measured by the segmental multi-frequency bioelectrical impedance method. The mothers' blood lipid profiles were assessed by automated chemical analysis. Logistic regression analysis was performed to determine the correlation of BMI and BFP with gestational complications.

**Results:** The rates of gestational diabetes and hypertension were significantly different between mothers who were obese (33.3%, 52.6%), overweight (10.3%, 32.2%) and normal (8.7%, 14.9%) ( $P < 0.001$ ). The Apgar score at 1 min and intensive care unit admissions rate at birth were significantly different between infants born to obese ( $6.14 \pm 0.80$ , 14.0%), overweight ( $6.64 \pm 1.10$ , 8.9%) and normal ( $7.20 \pm 0.78$ , 1.9%) mothers ( $P < 0.01$ ). The Apgar score at 5 min and the birthweights were not significantly different between these three groups ( $P > 0.05$ ). Additionally, the levels of serum total cholesterol (mmol/L), total triglycerides (mmol/L), and leptin (ng/mL) were significantly higher in obese ( $5.87 \pm 2.26$ ,  $2.04 \pm 1.65$ ,  $24.79 \pm 18.38$ ) and overweight ( $5.29 \pm 1.85$ ,  $1.74 \pm 1.05$ ,  $20.79 \pm 15.19$ ) women, compared to normal women ( $4.89 \pm 1.05$ ,  $1.45 \pm 0.77$ ,  $13.35 \pm 6.51$ ) ( $P < 0.05$ ). Furthermore, BFP was more strongly correlated to gestational diabetes ( $r_s = 0.57$  vs  $0.68$ ) and hypertension ( $r_s = 0.31$  vs  $0.43$ ) than BMI.

**Conclusions:** Obesity and overweight are associated with increased adverse maternal and neonatal complications. BFP is a more accurate predictor of gestational outcomes than BMI.

**Key words:** body fat percentage, body mass index, maternal complication, neonatal complication.

## Introduction

Obesity is a worldwide epidemic and is a leading preventable cause of death worldwide, with increasing prevalence in adults and children.<sup>1</sup> Authorities view it as one of the most serious public health problems of the 21st century.<sup>2</sup> One of every five women receiving antenatal care in Scotland was obese, leading to a twofold increase over the past decade.<sup>3</sup> Similar results were also

found in the USA, for which the percentage of women with antenatal care who were classified as obese increased from 16% in 1980 to 36% in 1999.<sup>4</sup>

Obesity during pregnancy may lead to adverse outcomes for both the mother and child, increasing the risk for gestational diabetes, insulin resistance syndrome, and pre-eclampsia. It is also associated with increased risk of recurrent miscarriage; specifically, studies have shown that both obesity and body mass

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index (BMI) can contribute to miscarriage in the first trimester and placental abruption in late pregnancy.<sup>5,6</sup> The precise interplay of obesity-related diseases, such as diabetes, remains to be fully elucidated.

BMI is an accurate reflection of body fat percentage (BFP) in the majority of the adult population. BMI is calculated by dividing an individual's mass by the square of his/her height, which is typically expressed in metric units. Asian individuals, including Chinese, Malays and Japanese, have more body fat than Caucasians at the same BMI values.<sup>7,8</sup> Deurenberg *et al.* suggested differences in body build between Asians and Caucasians, including differences in relative leg-to-trunk length, slenderness and muscularity, as possible reasons for this difference in the BMI–BFP correlation between ethnic groups.<sup>9</sup> Therefore, BFP and BMI are both considered useful criteria to classify Asian individuals as obese, overweight, normal, and underweight.

Leptin is a polypeptide hormone that plays a role in the regulation of bodyweight and energy regulation, and is linked to a variety of reproductive processes. It has been suggested that leptin may play a role in the mechanisms regulating pre-eclampsia, maternal diabetes, and intrauterine growth retardation.<sup>10</sup>

The aim of this study was to investigate the correlation between BMI, BFP and gestational outcomes in patients of the Second Affiliated Hospital of Shaanxi Institute of Traditional Chinese Medicine who delivered between 2010 and 2011.

## Methods

### Study population

Pregnant women consecutively admitted for delivery between 2010 and 2011 ( $n = 411$ ) were included in this retrospective analysis. All patients gave signed consent that permitted the use of collected data for research without disclosure of personal identity. The study protocol was approved by the Research Ethics Committee of the Second Affiliated Hospital of Shaanxi Institute of Traditional Chinese Medicine (Shaanxi, China).

### Exposure variables

BMI was calculated from height and weight measurements taken at admission to the Shaanxi Institute of Traditional Chinese Medicine for delivery (maternal weight in kg/height in m<sup>2</sup>). The World Health Organization (WHO) definitions for Asian populations of

underweight (BMI < 18.5), normal ( $18.5 \leq \text{BMI} < 23$ ), overweight ( $23 \leq \text{BMI} < 25$ ), and obese ( $25 \leq \text{BMI}$ ) were used.<sup>11,12</sup>

BFP was measured by the segmental multifrequency bioelectrical impedance method using the MES-OIS20 system (Maidakang). National Perinatal Information Center definitions for Asian populations of underweight (BFP < 17), normal ( $17 \leq \text{BFP} < 24$ ), overweight ( $24 \leq \text{BFP} < 30$ ), and obese (BFP  $\geq 30$ ) were used.

### Blood lipid measurements

Lipid profiles (serum total cholesterol and total triglycerides) were determined using standard laboratory techniques on a Cobas e601 (Roche). Leptin hormone was measured in the serum of patients using a sandwich enzyme-linked immunosorbent assay (EIA-2395; DRG International).

### Gestational outcomes

The gestational outcomes were collected from the patients' medical records, and included data for both the mother and child. The maternal-related outcomes included weight gained during pregnancy, adverse maternal complications (hypertension and diabetes), gestational length, and delivery mode (vaginal or cesarean). The child-related outcomes included birthweight, condition of newborns (assessed by Apgar score), and incidence of admission to the intensive care unit (ICU).

### Statistical analysis

Independent samples *t*-test was used as a parametric test of significance for comparison between two sample means, after performing Leven's test for quality of variance. The  $\chi^2$ -test was used to assess differences for qualitative variables. The analyses of maternal-related variables were also assessed with adjustment for maternal age. A *P*-value < 0.05 indicated statistical significance. Data are presented as mean  $\pm$  standard deviation, unless otherwise indicated.

## Results

### Study population characteristics

As shown in Table 1, the mean maternal age was  $27.5 \pm 3.7$  years old (range: 20–40) and the mean height was  $161.8 \pm 4.8$  cm. The mean BMI and BFP of the pregnant women were  $22.8 \pm 5.3$  kg/m<sup>2</sup> and  $26.8 \pm 5.1\%$ , respectively. The mean weight gain during pregnancy was  $14.4 \pm 4.2$  kg and the mean length of gestation at delivery was  $39.7 \pm 1.2$  weeks. A total of 215 of the

pregnant women (52.3%) delivered vaginally, while 196 (47.7%) delivered by cesarean section.

### BMI

Due to the fact that, at comparable BMI values, Chinese individuals have more body fat than Caucasians,<sup>7,8,13</sup> BMI was selected as the initial criteria to classify the women as obese ( $n = 57$ ), overweight ( $n = 146$ ), and normal weight ( $n = 208$ ). Obese and overweight women had more adverse maternal complications than normal women, such as gestational hypertension and diabetes. Gestational hypertension was found in 52.6% of obese women and 32.2% of overweight women, respectively, versus 14.9% of normal women ( $P < 0.001$ ). Gestational diabetes was diagnosed in 33.3% of obese women and 10.3% of overweight women, respectively, versus 8.7% of normal women ( $P < 0.001$ ) (Table 2).

**Table 1** Demographic characteristics of the study population

Characteristics	Subject
Maternal age (years)	$27.5 \pm 3.7$
Height (cm)	$161.8 \pm 4.8$
Body mass index (kg/m <sup>2</sup> )	$22.8 \pm 5.3$
Body fat percentage	$26.8 \pm 5.1$
Weight gain during pregnancy (kg)	$14.4 \pm 4.2$
Weeks of gestation at delivery	$39.7 \pm 1.2$
Mode of delivery	
Vaginal delivery	215 (52.3%)
Cesarean section	196 (47.7%)

Data are shown as mean  $\pm$  standard deviation or  $n$  (%).

Infants born to women who were obese or overweight had a significantly lower Apgar score at 1 min than those born to women with normal BMI ( $6.14 \pm 0.08$  and  $6.64 \pm 1.10$  vs  $7.2 \pm 0.78$ ,  $P < 0.01$ ), but there was no statistically significant difference in the Apgar score at 5 min ( $8.84 \pm 0.85$  and  $9.14 \pm 0.99$  vs  $9.28 \pm 0.73$ ,  $P = 0.072$ ). Neonates born to obese and overweight women did not have a statistically significant difference in birthweight, as compared to neonates born to women with normal BMI ( $3.33 \pm 0.40$  and  $3.49 \pm 0.38$  kg vs  $3.51 \pm 0.46$  kg,  $P = 0.061$ ). Birth ICU admissions were significantly increased among neonates born to obese women and overweight women, as compared to those born to women with normal BMI (14.0% and 8.9% vs 1.9%,  $P < 0.001$ ) (Table 3).

Serum leptin concentrations were significantly higher in obese and overweight women, as compared to women with normal BMI ( $24.79 \pm 18.38$  and  $20.79 \pm 15.19$  ng/mL vs  $13.35 \pm 6.51$  ng/mL,  $P < 0.01$ ). Serum cholesterol levels were also significantly higher among obese and overweight women, as compared to those with a normal BMI ( $5.87 \pm 2.26$  and  $5.29 \pm 1.85$  mmol/L vs  $4.89 \pm 1.05$  mmol/L,  $P < 0.05$ ). Finally, obese and overweight women also had significantly higher levels of serum triglycerides than normal women ( $2.04 \pm 1.65$  and  $1.74 \pm 1.05$  mmol/L vs  $1.45 \pm 0.77$  mmol/L,  $P < 0.05$ ) (Table 4).

### BFP

When BFP was used as a criterion to classify the pregnant women as obese ( $n = 72$ ), overweight ( $n = 196$ ) or

**Table 2** Comparison of maternal complications between different BMI groups

Maternal complication	Obese (BMI $\geq 25$ ) $n = 57$	Overweight ( $23 \leq \text{BMI} < 25$ ) $n = 146$	Normal ( $18.5 \leq \text{BMI} < 23$ ) $n = 208$	$P$
Gestational hypertension	30 (52.6)	47 (32.2)	31 (14.9)	$<0.001$
Gestational diabetes	19 (33.3)	15 (10.3)	18 (8.7)	$<0.001$

Data are shown as  $n$  (%). BMI, body mass index.

**Table 3** Comparison of neonatal complications between different BMI groups

Neonatal complication	Obese (BMI $\geq 25$ ) $n = 57$	Overweight ( $23 \leq \text{BMI} < 25$ ) $n = 146$	Normal ( $18.5 \leq \text{BMI} < 23$ ) $n = 208$	$P$
Apgar score at 1 min	$6.14 \pm 0.802$	$6.64 \pm 1.102$	$7.20 \pm 0.782$	$<0.01$
Apgar score at 5 min	$8.84 \pm 0.849$	$9.14 \pm 0.990$	$9.28 \pm 0.730$	0.072
Birth ICU admission	8 (14.0%)	13 (8.9%)	4 (1.9%)	$<0.001$
Birthweight (kg)	$3.33 \pm 0.40$	$3.49 \pm 0.38$	$3.51 \pm 0.46$	0.061

Data are shown as mean  $\pm$  standard deviation or  $n$  (%). BMI, body mass index; ICU, intensive care unit.

**Table 4** Comparison of serum leptin and lipids between different BMI groups

Characteristics	Obese (BMI $\geq 25$ ) <i>n</i> = 57	Overweight (23 $\leq$ BMI < 25) <i>n</i> = 146	Normal (18.5 $\leq$ BMI < 23) <i>n</i> = 208	<i>P</i>
Serum leptin, ng/mL	24.79 $\pm$ 18.38	20.79 $\pm$ 15.19	13.35 $\pm$ 6.51	<0.01
Total cholesterol, mmol/L	5.87 $\pm$ 2.26	5.29 $\pm$ 1.85	4.89 $\pm$ 1.05	<0.05
Total triglycerides, mmol/L	2.04 $\pm$ 1.65	1.74 $\pm$ 1.05	1.45 $\pm$ 0.77	<0.05

Data are shown as mean  $\pm$  standard deviation. BMI, body mass index.

**Table 5** Comparison of maternal complications between different BFP groups

Maternal complication	Obese (BFP $\geq 30$ ) <i>n</i> = 72	Overweight (24 $\leq$ BFP < 30) <i>n</i> = 196	Normal (17 $\leq$ BFP < 24) <i>n</i> = 143	<i>P</i>
Gestational hypertension	46 (63.9)	54 (27.6)	8 (5.6)	<0.001
Gestational diabetes	31 (43.1)	17 (8.7)	4 (2.8)	<0.001

Data are shown as *n* (%). BFP, body fat percentage.

**Table 6** Comparison of neonatal complications between different BFP groups

Neonatal complication	Obese (BFP $\geq 30$ ) <i>n</i> = 72	Overweight (24 $\leq$ BFP < 30) <i>n</i> = 196	Normal (17 $\leq$ BFP < 24) <i>n</i> = 143	<i>P</i>
Apgar score at 1 min	6.20 $\pm$ 0.85	6.66 $\pm$ 0.89	7.31 $\pm$ 0.68	<0.01
Apgar score at 5 min	8.99 $\pm$ 0.81	9.24 $\pm$ 0.90	9.32 $\pm$ 0.71	0.061
Birth ICU admission	11 (15.1%)	12 (6.1%)	2 (1.4%)	<0.001
Birthweight (kg)	3.29 $\pm$ 0.58	3.41 $\pm$ 0.42	3.52 $\pm$ 0.33	0.055

Data are shown as mean  $\pm$  SD or *n* (%). BFP, body fat percentage; ICU, intensive care unit.

normal weight (*n* = 143), gestational hypertension was found in significantly more of the obese and overweight women, as compared to the women with normal BFP (63.9 and 27.6% vs 5.6%, *P* < 0.001). Gestational diabetes was also diagnosed in significantly more of the obese and overweight women, as compared to the women with normal BFP (43.1 and 8.7% vs 2.8%, *P* < 0.001) (Table 5).

Compared to infants born to pregnant women with normal BFP, those born to obese and overweight women had significantly lower Apgar scores at 1 min (7.31  $\pm$  0.68 vs 6.20  $\pm$  0.85 and 6.66  $\pm$  0.89, *P* < 0.01), but there was no statistically significant difference in the Apgar scores at 5 min (9.32  $\pm$  0.71 vs 8.99  $\pm$  0.81 and 9.24  $\pm$  0.90, *P* = 0.061). The differences of birthweights for infants born to women with normal BFP compared to those from obese and overweight women did not reach statistical significance (3.52  $\pm$  0.33 kg vs 3.29  $\pm$  0.58 kg and 3.41  $\pm$  0.42 kg, *P* = 0.055). Birth ICU admissions were significantly higher in the infants born to obese and overweight

women, compared to those born to women with normal BFP (15.1 and 6.1% vs 1.4%, *P* < 0.001) (Table 6).

Serum leptin concentrations were significantly higher in the obese and overweight women, as compared to the women with normal BFP (24.54  $\pm$  17.99 and 20.82  $\pm$  13.73 ng/mL vs 12.55  $\pm$  3.51 ng/mL, *P* < 0.01). Serum total cholesterol levels were also significantly higher among obese and overweight women, as compared to women with normal BFP (5.78  $\pm$  2.32 and 5.23  $\pm$  1.84 mmol/L vs 4.78  $\pm$  1.01 mmol/L, *P* < 0.05). Finally, obese and overweight women had significantly higher levels of serum total triglycerides, as compared to women with a normal BFP (2.01  $\pm$  1.71 and 1.70  $\pm$  1.08 mmol/L vs 1.42  $\pm$  0.69 mmol/L, *P* < 0.05) (Table 7).

### BMI versus BFP

BMI is generally accepted as a measure of body composition. However, there is evidence that BMI may reflect differences in body composition in different

**Table 7** Comparison of serum leptin and lipids between different BFP groups

Characteristics	Obese (BFP $\geq 30$ ) <i>n</i> = 72	Overweight ( $24 \leq \text{BFP} < 30$ ) <i>n</i> = 196	Normal ( $17 \leq \text{BFP} < 24$ ) <i>n</i> = 143	<i>P</i>
Serum leptin, ng/mL	24.54 $\pm$ 17.99	20.82 $\pm$ 13.73	12.55 $\pm$ 3.51	<0.01
Total cholesterol, mmol/L	5.78 $\pm$ 2.32	5.23 $\pm$ 1.84	4.78 $\pm$ 1.01	<0.05
Total triglycerides, mmol/L	2.01 $\pm$ 1.71	1.70 $\pm$ 1.08	1.42 $\pm$ 0.69	<0.05

Data are shown as mean  $\pm$  standard deviation. BFP, body fat percentage.

**Table 8** Correlation between BFP and BMI to gestational hypertension and diabetes

	Gestational hypertension		Gestational diabetes	
	<i>r<sub>s</sub></i>	<i>P</i>	<i>r<sub>s</sub></i>	<i>P</i>
BFP	0.43	0.005	0.68	<0.010
BMI	0.31	0.007	0.57	<0.010

BFP, body fat percentage; BMI, body mass index.

ethnic groups. Deurenberg *et al.* suggested differences in body build between Asians and Caucasians, including differences in relative leg-to-trunk length, slenderness and muscularity, as possible reasons for this difference in the BMI–BFP correlation between ethnic groups. In order to determine which criterion is a more accurate factor to predict gestational outcomes, correlations between BMI and BFP and clinical outcomes were analyzed.

BFP and BMI positively correlated with gestational hypertension ( $r_s = 0.43$  and  $r_s = 0.31$ , respectively) and diabetes ( $r_s = 0.68$  and  $r_s = 0.57$ ) (Table 8). Thus, BFP was more closely correlated to gestational hypertension and diabetes.

## Discussion

This study investigated the correlation between BMI, BFP, and gestational outcomes. In women who were overweight or obese before pregnancy, higher frequencies of gestational diabetes, hypertensive disorder, and neonates with low Apgar scores were observed, which concurred with the results of previous studies. Briese *et al.* previously analyzed German perinatal statistics and also demonstrated higher rates of gestational hypertension and diabetes, as well as of infants with low neonatal Apgar score, in obese women, as compared to women with normal BMI.<sup>14</sup> Similarly, Bhattacharya *et al.* compared 1857 obese pregnant women with 14 076 non-obese pregnant women in the UK and found that the former had significantly higher frequencies of gestational hypertension, emergency

cesarean section, and preterm delivery at less than 33 weeks of gestation.<sup>15</sup> The neonates born to these obese women had an increased risk of admission to the neonatal ICU and birthweight over 4000 g. Finally, a cohort study conducted in Saudi Arabia by El-Gilany and Hammad in 2010 reported similar findings.<sup>16</sup>

In this study, increases in BMI and BFP were proportional to increases in serum leptin levels. These results confirm the results of Erturk *et al.*<sup>17</sup> Other studies have demonstrated that leptin has an inhibitory effect on spontaneous, as well as induced, uterine contractions. Thus, it is believed that leptin may be the cause of dysfunctional labor in obese women, leading to increased cesarean section rates.<sup>18</sup> Our findings, based on BMI and BFP classification of obese and overweight status, support this notion.

BMI  $> 30 \text{ kg/m}^2$  is a globally accepted definition for obesity, while overweight is defined as BMI 25–29.9  $\text{kg/m}^2$ .<sup>19</sup> BFP is considered to be higher in Asian populations, as compared to the European population, at the same level of BMI, and therefore different cut-off levels are recommended for Asians.<sup>20</sup> According to the provisional recommendations for the Asia Pacific Region, published in February 2000 by the WHO Regional Office for the Western Pacific's International Association for the Study of Obesity and the International Obesity Task Force, Asians are overweight at BMI  $> 23$  and obese at BMI  $> 25 \text{ kg/m}^2$ .<sup>11,12</sup> Recently, a large study in the Chinese population utilizing these reference levels was published.<sup>21</sup> It is known that the correlation between BMI and body fat is age- and sex-dependent. Some recent studies indicate that in some populations these differences may reflect differences in body build,<sup>22</sup> as well as differences in energy intake and physical activity.<sup>23</sup> It is important to note that our study population appears to have a generally higher overall incidence of gestational hypertension in obese and overweight women than the previous studies in the literature; however, the other studies are largely based on non-Asian populations and our current results may reflect yet unknown



contributions related to the Asian background, or other hereditary/demographic features, of our particular study population. The correlation between body fat, BMI, and age was different in Chinese individuals compared to Caucasians, showing a lower regression coefficient for BMI and a lower age effect, but with a much larger intercept. Thus, it seems likely that body fat in the Chinese population is overestimated by the prediction formula, especially at lower BMI values, where the impact of the (larger) intercept is greater. When BMI in the Chinese population was corrected for body fat, taking age and sex into account, the Chinese population had a lower BMI for the same amount of body fat.<sup>24,25</sup> Compared with BMI, BFP more accurately reflects the body composition and physical condition. Therefore, BFP is more closely correlated to gestational hypertension and diabetes than BMI in Chinese patients.

In summary, obesity and overweight are associated with increased adverse maternal and neonatal complications. BFP is a more accurate factor to predict the gestational outcomes than BMI.

## Disclosure

None declared.

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