Association between parity and obesity patterns in a middle-aged and older Chinese population: a cross-sectional analysis in the Tongji-Dongfeng cohort study

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Abstract

Background: Higher parity has been implicated as a risk factor for obesity of women. The objective of the study was to examine whether parity was associated with general obesity or abdominal obesity, or both, among middle-aged and older Chinese women.

Methods: A total of 12,829 Chinese women (mean age: 64.8 years) with at least one live birth were selected from the Dongfeng–Tongji Cohort Study (phase II). We used body mass index to assess general obesity, and waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and waist circumference (WC) to assess abdominal obesity. We used multivariate linear and logistic regression models to investigate the association between parity and obesity.

Results: The values of all four obesity measures increased with the greater number of live births (P for trend <0.001). After adjustment for potential confounders, women with four or more children had 1.72 times (95% confidence interval [CI], 1.41–2.10) higher risk of general obesity, and 1.93 (95% CI, 1.57–2.37), 2.09 (95% CI, 1.65–3.64) and 1.58 (95% CI, 1.28–1.94) times risk of abdominal obesity assessed by WHR, WHtR and WC, respectively. Furthermore, we observed an ascending gradient between parity and the three abdominal obesity measures.

Conclusions: Parity was positively associated with risk of obesity, especially abdominal obesity, in the long term among Chinese women.

Keywords: General obesity, Abdominal obesity, Parity, Childbirth, Chinese

Background

Obesity has been increasing globally, and the World Health Organization (WHO) reported that in 2014, 39% of adults aged 18 years and older were overweight. As a fast-developing country, China is facing an upsurge in obesity [1]. Between 2004 and 2009, a nationwide study found that more than two in five middle-aged Chinese women were overweight or obese (body mass index [BMI] ≥24.0 kg/m², Chinese criteria), suggesting an urgent need to better understand the causes of obesity [2].

Pregnancy involves physiological and psychological changes, and may induce insulin resistance in peripheral tissues [3], weight gain or obesity, and postpartum weight retention [4]. Although multiple studies have reported a positive association between parity and obesity, there is controversy with the type of obesity (general or abdominal), the level of parity (primiparous or multiparous), and the strength, trigger time and length of time of the association. A study of Chilean women concluded that parity moderately influenced BMI, but was unrelated to abdominal obesity [5]. Other studies have indicated that...
abdominal obesity, but not BMI, is significantly related to increased parities [6, 7].

In some prospective studies, increased BMI was only observed after the first childbirth and not after later childbirths [8, 9], whereas other studies have suggested a positive gradient with consecutive pregnancies [5, 7]. A 7-year follow-up study found that childbearing might not increase the incidence of obesity among parous young women in the USA [10]. Additionally, a meta-analysis investigation reported a U-shaped secular trend of postpartum weight retention for women who gained excess weight during pregnancy, indicating that in addition to short-term obesity, women were also at greater risk of obesity over the long term [11]. However, contrary to this finding, a nationwide cohort study in the USA observed significant parity-related weight gain in a 10-year follow-up, but not after 25 years [8], suggesting that long-term correlation requires further confirmation.

Studies have revealed that most Asians (Chinese, Indonesians and Thais) have a higher percentage of body fat for a given BMI than Europeans [12]. In addition, Asians are genetically more susceptible to morbidities that include the accumulation of visceral fat (e.g. metabolic syndrome, coronary heart disease, and diabetes) [13]. Therefore, evaluation of abdominal obesity, rather than other forms of obesity, would be more meaningful among an Asian population [14]. Current evidence suggests that the parity-obesity association varies among different cultures [15], ethnic groups [6, 8, 9, 11] and levels of country development [16]. There has been no previous research on the relationship between obesity and number of children among Chinese population. We aimed to examine whether parity was associated with general obesity or abdominal obesity, or both, among middle-aged and older Chinese women.

**Methods**

**Study population**

This analysis used data from the Dongfeng–Tongji cohort study (phase II), which was launched in 2013 among retirees of the Dongfeng Motor Corporation (DMC) in Shiyan, Hubei Province, China. Details of the Dongfeng–Tongji cohort design, fundamentals, and methods have been previously described [17]. A total of 38,295 retired DMC employees agreed to participate in the Dongfeng–Tongji cohort study (phase II). Each participant was required to complete a standard questionnaire via a face-to-face interview, undergo a medical examination, and provide a blood sample. Exclusion criteria included all men, women with missing data for parity or obesity measurements (weight, height, waist circumference and hip circumference), and nulliparous women. The final study population included 12,829 participants (mean age: 64.8 ± 7.6 years). Written informed consent was obtained from all participants, and the Medical Ethics Committee of the School of Public Health, Tongji Medical College and Dongfeng General Hospital approved the study.

**Parity**

We defined parity as the self-reported total number of live births, which we classified into four categories: one, two, three, and four or more live births.

**Anthropometric measurements**

All anthropometric measurements, including weight, height, waist and hip circumference, were carried out with standard apparatus by trained medical staff at hospitals affiliated to DMC. BMI was calculated by dividing weight (kg) by height squared (m²). Waist-to-hip ratio (WHR) and waist-to-height ratio (WtHR) were calculated by dividing waist circumference (WC), respectively, by hip circumference and height, and measured both in the same units. In the current study, general obesity was defined as BMI ≥24.0 kg/m² (including 24.0–27.9 kg/m² for overweight and ≥28.0 kg/m² for obesity) using the Chinese cut-off as recommended by the Working Group on Obesity in China [18]. Abdominal obesity was defined as WC ≥80.0 cm as recommended by the Working Group on Obesity in China, or WHR ≥0.85 as recommended by WHO [19] or WtHR ≥0.5 as based on previous studies [20].

**Assessment of covariates**

Sociodemographic characteristics including sex, age, education (primary school or below, junior high school, senior high school, college or above), and marital status (married, unmarried, widowed or divorced) were collected from the questionnaire replies. We also obtained lifestyle characteristics including physical activity, smoking and alcohol drinking status from the questionnaires. We obtained reproductive data including menopause status, abortion, the use of contraceptives, and the use of hormone replacement therapy, which were self-reported from the questionnaires. Peripheral venous blood samples were collected after overnight fasting, and plasma glucose levels were measured with Aeroset automatic analyzer (by glucose oxidase method; Abbott Laboratories. Abbott Park, Illinois, USA). We defined diabetes mellitus as fasting plasma glucose ≥7.0 mmol/L, self-reported physician diagnosis of diabetes mellitus, or current use of antidiabetic medications. Similarly, hypertension was defined as a self-reported previous diagnosis of hypertension, taking antihypertensive treatment, or systolic blood pressure >140 mmHg or diastolic blood pressure >90 mmHg.

**Statistical analysis**

We summarized numerical data as means ± standard deviation (SD) and presented categorical variables as percentages. We used analysis of variance (ANOVA) or
χ² test to test the difference among parity groups. We used four hierarchical models to estimate the effect and the risk of increased parity on obesity in both linear and logistic regression. Model 1 examined the relationship between parity and obesity without adjustment for any covariates. Model 2 included age plus parity. Model 3 included the variables in Model 2 plus diabetes and hypertension. Model 4 included the variables in Model 3 plus education level, marital status, physical activity, smoking status (current or passive smoker), current alcohol drinker and current tea drinker, use of contraceptives, hormone replacement therapy, menopause status and abortion. In general linear regression, we calculated the variance inflation factor (VIF) to detect possible multi-collinearity during modeling. We carried out statistical analysis of the data using SPSS statistical software (version 18.0, IBM, Inc.).

Results
Table 1 presents the descriptive characteristics of the study population. Women with higher parity were more likely to be older, less educated, doing less physical exercise, married or widowed, and current or previous smokers. We also found prevalence of diabetes mellitus, hypertension or menopause to increase with parity. Multiparous women tended to show a lower prevalence of abortion, passive smoking, having a habit of drinking alcohol or tea, or having used contraceptives or hormone replacement therapy.

The age-adjusted mean values of the four obesity measurements according to parity are shown in Table 2. The mean values of BMI, WC, WHtR and WHR showed an increasing trend with higher parities (P for trend <0.001). The obesity measurements all showed that the prevalence of obesity increased with parity before or after

Table 1 The descriptive characteristics of 12,829 retired Chinese women of The DFTJ Cohort, by number of parity

| Variable                              | Parity     | χ²/F       | P for trend |
|---------------------------------------|------------|------------|-------------|
|                                       | 1          | 2          | 3           | ≥4          |             |
|                                       | (n = 4362) | (n = 4410) | (n = 2543)  | (n = 1514)  |             |
| Age (years) (mean ± SD)               | 58.61 ± 4.69 | 64.84 ± 5.46 | 69.88 ± 6.01 | 74.36 ± 5.97 | 4252.18**   | <0.001      |
| Education level                       |            |            |             |             | 2561.64**   | <0.001      |
| Primary school or illiteracy (%)      | 415 (9.6)  | 1184 (27.0) | 1116 (44.2) | 1022 (68.1) |             |             |
| Middle school (%)                     | 1742 (40.1)| 1858 (42.3) | 973 (38.5)  | 378 (25.2)  |             |             |
| High school (%)                       | 1767 (40.7)| 1049 (23.9) | 362 (14.3)  | 77 (5.1)    |             |             |
| College or higher (%)                 | 416 (9.6)  | 298 (6.8)   | 73 (2.9)    | 23 (1.5)    |             |             |
| Marital status                        |            |            |             |             | 828.61**    | <0.001      |
| Single (%)                            | 6 (0.1)    | 3 (0.1)    | 3 (0.1)     | 1 (0.1)     |             |             |
| Married or Remarried (%)              | 3892 (89.7)| 3692 (84.0)| 1988 (78.6) | 990 (65.6)  |             |             |
| Divorced (%)                          | 169 (3.9)  | 108 (2.5)  | 22 (0.9)    | 4 (0.3)     |             |             |
| Widowed (%)                           | 274 (6.3)  | 593 (13.5) | 515 (20.4)  | 515 (34.1)  |             |             |
| Physical activity (%)                 | 3918 (89.8)| 3925 (89.0)| 2221 (87.3)| 1226 (81.0)| 89.25**     | <0.001      |
| Current/Former smoker (%)             | 61 (1.4)   | 105 (2.4)  | 115 (4.5)   | 121 (8.0)   | 184.87**    | <0.001      |
| Passive smoking (%)                   | 1500 (35.0)| 1193 (27.6)| 587 (23.6)  | 333 (22.4)  | 146.58**    | <0.001      |
| Current/Former alcohol drinker (%)    | 548 (12.6) | 479 (10.9) | 251 (9.9)   | 124 (8.2)   | 26.87**     | <0.001      |
| Current tea drinker (%)               | 1841 (42.2)| 1603 (36.4)| 824 (32.4)  | 403 (26.6)  | 144.00**    | <0.001      |
| Diabetes Mellitus (%)                 | 406 (9.3)  | 662 (15.1) | 523 (20.7)  | 344 (22.8)  | 222.34**    | <0.001      |
| Hypertension (%)                      | 1337 (30.7)| 1966 (44.6)| 1368 (53.9)| 888 (58.7)  | 553.88**    | <0.001      |
| Ever used Contraceptives (%)          | 845 (19.5) | 885 (20.2) | 434 (17.2)  | 153 (10.2)  | 83.26**     | <0.001      |
| Hormone replacement therapy (%)       | 160 (3.7)  | 113 (2.6)  | 52 (2.1)    | 13 (0.9)    | 40.64**     | <0.001      |
| Menopause (%)                         | 4090 (93.8)| 4333 (98.3)| 2523 (99.3)| 1495 (98.7)| 238.61**    | <0.001      |
| Abortion frequency                    |            |            |             |             | 519.00**    | <0.001      |
| 0 time (%)                            | 1033 (24.3)| 1497 (35.1)| 1033 (42.1) | 772 (53.1)  |             |             |
| 1 time (%)                            | 1434 (33.7)| 1328 (31.1)| 764 (31.1)  | 364 (25.0)  |             |             |
| 2 or more times (%)                   | 1786 (42.0)| 1441 (33.8)| 658 (26.8)  | 318 (21.9)  |             |             |

Numerical data are presented as mean ± SD and tested with F test; Categorical data are presented with percentage in parentheses after the numbers and tested with χ² test

**P < 0.001
adjusting for all potential variables (Fig. 1). BMI-delimited obesity had generally lower prevalence rates with or without adjustment, while WHtR predicted the highest obesity prevalence rates.

Table 3 presents the results of linear regression from the four models, in which parity was considered as a continuous variable. The VIF was introduced to detect possible multi-collinearity during modeling. The two variables with the highest VIF values in Model 4 were parity (VIF = 2.18) and age (VIF = 2.13). However, neither surpassed the threshold of 10, suggesting a less likely multi-collinearity in our modeling [21]. Regression coefficients for parity calculated as explanatory variables were added into the four models successively. The results showed that after adjustment for the potential confounders, all four measurements of obesity were significantly associated with parity (all \( P < 0.05 \)). The fully adjusted \( \beta \)-coefficient of parity for BMI, WC, WHtR and WHR were 0.34, 0.97, 0.0063 and 0.0050, respectively.

The crude and adjusted odds ratios (ORs) with 95% confidence intervals (CI) for different measurements of obesity according to number of parity are shown in Table 4. In the crude model, parity was significantly associated with risk of all obesity measurements, with abdominal obesity measurements (WC, WHtR and WHR) showing greater OR than general obesity measurements (BMI). In Model 2, OR values of all three abdominal obesity measurements decreased, whereas that of general obesity measurements increased among all three parity groups. In Model 3 and Model 4, all ORs attenuated but remained statistically significant. For women who had four or more children, the obesity rate was 1.72 times higher by BMI, 1.93 times higher by WC, 2.09 times higher by WHtR and 1.58 times higher by WHR than those of monoparous women. From Model 1 to Model 4, we observed a consistent gradient in WC, WHtR and WHR through modeling, but the gradient of BMI receded in the highest parity group, although the general trend was significant.

**Discussion**

We found a positive correlation between higher parity and the risk of both general and abdominal obesity in middle-aged and older Chinese women. Furthermore, we observed an ascending gradient between parity and the three abdominal obesity measures.

Most existing studies have reported a positive association between parity and weight gain or BMI [5, 7–9, 16, 22, 23]. However, a few studies have incorporated abdominal measurements and their results have been inconsistent. Mansour et al. [7] reported that higher parity was significantly associated with BMI and all three abdominal obesity measurements among a middle-aged Iraqi population, which was consistent with our study. Another study from Finland concurred with most of our results [23]. They reported a general positive association between parity and BMI and WC, and found that abdominal obesity was more prevalent among multiparous women.
than with other groups. A prospective study also indicated that childbearing might increase visceral adipose tissue independent of overall increase in body fat [24].

Two studies have partially investigated the relationship between parity and obesity among Chinese middle and older-aged women. Wen et al. [25] reported that weight gain was associated with increasing parity in Shanghai, China, and the study in Guangzhou, China, reported a positive correlation between number of parity and obesity as measured by BMI and WHR [26]. These two studies supported our finding that parity was associated with both general and abdominal obesity among a Chinese population. In addition, abdominal obesity has already been regarded as an important risk factor for metabolic syndrome. Our present data also demonstrated that higher parity was associated with increased risk of obesity related diseases, such as diabetes (see Additional file 1: Table S1). This analysis from the same data supported our findings of association between parity and obesity.

The mechanisms underlying the association between parity and obesity are complicated and remain unknown.

### Table 3 β-coefficients (95 % CI) for parity and different measurements of obesity

| Measurement     | Parity | Model 1      | Model 2      | Model 3      | Model 4      |
|-----------------|--------|--------------|--------------|--------------|--------------|
| BMI             |        |              |              |              |              |
| ≥24.0 kg/m²     | 1      | 0.38 (0.35, 0.41) | 0.48 (0.44, 0.52) | 0.45 (0.41, 0.49) | 0.34 (0.29, 0.39) |
| 2               | 1.77 (1.69, 1.85) | 1.40 (1.29, 1.51) | 1.32 (1.21, 1.43) | 0.97 (0.85, 1.09) |
| WC              |        |              |              |              |              |
| ≥80 cm          | 1.54 (1.49, 1.59) | 1.01 (0.93, 1.09) | 0.96 (0.89, 1.03) | 0.63 (0.55, 0.71) |
| WHtRa           | 1.18 (1.13, 1.23) | 0.76 (0.69, 0.83) | 0.72 (0.65, 0.79) | 0.50 (0.42, 0.58) |
| VIF for parity  |        |              |              |              |              |
| 1.00            | 1.91   | 1.92         |              |              | 2.18         |

Abbreviations: BMI body mass index, WC waist circumference, WHtR waist-to-height ratio, WHR waist-to-hip ratio, VIF variance inflation factor

*: β-coefficient amplified by 100

Model 1: unadjusted; Model 2: adjusted for age; Model 3: adjusted for covariate in Model 2 plus DM and hypertension; Model 4: adjusted for covariates in Model 3 plus education level, marital status, physical activity, smoking status (current smoker, passive smoker), current alcohol drinker, current tea drinker, ever used contraceptives, hormone replacement therapy, menopause status and abortion frequency

### Table 4 ORs (95 % CI) for parity and different measurements of obesity

| Measurement     | Parity | Model 1      | Model 2      | Model 3      | Model 4      |
|-----------------|--------|--------------|--------------|--------------|--------------|
| BMI ≥24.0 kg/m² |        |              |              |              |              |
| 1               | 1.00   |              |              |              |              |
| 2               | 4.11 (3.81, 3.46) | 1.52 (1.36, 1.69) | 1.47 (1.32, 1.64) | 1.39 (1.24, 1.56) |
| 3               | 1.83 (1.63, 2.05) | 2.09 (1.82, 2.42) | 2.00 (1.73, 2.32) | 1.79 (1.54, 2.08) |
| ≥4              | 1.77 (1.54, 2.03) | 2.14 (1.78, 2.56) | 2.09 (1.74, 2.52) | 1.72 (1.41, 2.10) |
| P for trend     | <0.001 |              |              |              |              |
| WC ≥80 cm       |        |              |              |              |              |
| 1               | 1.00   |              |              |              |              |
| 2               | 1.69 (1.53, 1.86) | 1.55 (1.39, 1.73) | 1.51 (1.35, 1.69) | 1.41 (1.26, 1.58) |
| 3               | 2.44 (2.17, 2.74) | 2.11 (1.83, 2.44) | 2.03 (1.75, 2.35) | 1.76 (1.51, 2.05) |
| ≥4              | 3.04 (2.62, 3.33) | 2.49 (2.06, 3.01) | 2.45 (2.02, 2.97) | 1.93 (1.57, 2.37) |
| P for trend     | <0.001 |              |              |              |              |
| WHtR ≥0.5       |        |              |              |              |              |
| 1               | 1.00   |              |              |              |              |
| 2               | 1.89 (1.71, 2.09) | 1.60 (1.43, 1.80) | 1.57 (1.40, 1.76) | 1.41 (1.25, 1.58) |
| 3               | 3.19 (2.80, 3.63) | 2.39 (2.04, 2.80) | 2.31 (1.97, 2.72) | 1.88 (1.59, 2.23) |
| ≥4              | 4.36 (3.66, 5.21) | 2.92 (2.35, 3.64) | 2.90 (2.32, 3.62) | 2.09 (1.65, 3.64) |
| P for trend     | <0.001 |              |              |              |              |
| WHR ≥0.85       |        |              |              |              |              |
| 1               | 1.00   |              |              |              |              |
| 2               | 1.70 (1.54, 1.88) | 1.47 (1.32, 1.64) | 1.43 (1.28, 1.60) | 1.34 (1.19, 1.50) |
| 3               | 2.30 (2.04, 2.59) | 1.78 (1.53, 2.06) | 1.70 (1.46, 1.97) | 1.48 (1.27, 1.73) |
| ≥4              | 2.92 (2.51, 3.40) | 2.04 (1.68, 2.48) | 2.00 (1.64, 2.43) | 1.58 (1.28, 1.94) |
| P for trend     | <0.001 |              |              |              |              |

Abbreviations: BMI body mass index, WC waist circumference, WHR waist-to-hip ratio

Model 1: unadjusted; Model 2: adjusted for age; Model 3: adjusted for covariates in Model 2 plus DM and hypertension; Model 4: adjusted for covariates in Model 3 plus education level, marital status, physical activity, smoking status (current smoker, passive smoker), current alcohol drinker, current tea drinker, ever used contraceptives, hormone replacement therapy, menopause status and abortion frequency
with three or more childbirths had a higher risk of a lower risk of BMI-delimited obesity, while women [23] found that women with one or two childbirths had... mechanisms [27]. Therefore, the incorporation of nulliparity into the analysis without prior examination can result in a paradox. For example, Luoto et al. [23] found that women with one or two childbirths had a lower risk of BMI-delimited obesity, while women with three or more childbirths had a higher risk of...switch the fertile mother’s lifestyle forever. However, Lawlor et al. [35] reported that parity was positively associated with BMI in both sexes, but only influenced WHR among women. This finding suggests that higher parity might induce general obesity in a non-biological manner. This may partly explain why abdominal obesity measurements remained strongly associated with childbirth after adjusting for multiple lifestyle factors as observed in our study.

We excluded nulliparity women from the study for several reasons. First, findings in other populations have generally indicated that parous women compared with nulliparous women have different physiological and pathological characteristics [36]. Childlessness among Chinese women is mainly caused by polycystic ovary disease [37], which may lead to a decrease in ovulatory cycles, alter female hormone levels, and cause an increase in BMI and obesity [38]. Second, pre-existing obesity could induce infertility through an already elucidated mechanism [27]. Therefore, the incorporation of nulliparity into the analysis without prior examination can result in a paradox. For example, Luoto et al. [23] found that women with one or two childbirths had a lower risk of BMI-delimited obesity, while women with three or more childbirths had a higher risk of...diabetes and hypertension. Table S2. Means (95% CI) of BMI/WC/WHR/WHR difference between multiparous individuals and monoparous individuals, pair-matched by age. Mean differences were calculated...
Abbreviations
ANOVA: Analysis of variance; BMI: Body mass index; DMC: Dongfeng motor corporation; SD: Standard deviation; VIF: Variance inflation factor; WC: Waist circumference; WHO: World Health Organization; WHR: Waist-to-hip ratio; WHR: Waist-to-height ratio

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Authors' contributions
YJW designed the study. WDL and YW performed the study and wrote the manuscript. WDL conducted statistical analysis. YJW, LJS, LLS, HL, BQL and JY revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
The study protocol was approved by the Medical Ethics Committee of the School of Public Health, Tongji Medical College and Dongfeng General Hospital. Written informed consent was obtained from all participants.

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References
1. Malik VS, Willett WC, Hu FB. Global obesity: trends, risk factors and policy implications. Nat Rev Endocrinol. 2013;9:13–27.
2. Wang L, Lyu J, Guo Y, Bian Z, Yu C, Zhou H, et al. Regional specific differences in prevalence of overweight/obesity in China: findings from China Kadoorie Biobank study in 10 areas in China. Zhonghua Liu Xing Bing Xue Za Zhi. 2015;36:1190–4.
3. Dahlgren J. Pregnancy and insulin resistance. Metab Syndr Relat Disord. 2006;4:149–52.
4. Linne Y, Barkeling B, Rossner S. Long-term weight development after pregnancy. Obes Rev. 2002;3:75–83.
5. Koch E, Bogado M, Araya F, Romero T, Díaz C, Manníquez L, et al. Impact of parity on anthropometric measures of obesity controlling by multiple confounders: a cross-sectional study in Chilean women. J Epidemiol Community Health. 2008;62:461–70.
6. Martínez ME, Pond E, Wertheim BC, Nodora JN, Jacobs ET, Bondy M, et al. Association between parity and obesity in Mexican and Mexican-American women: findings from the Ella binational breast cancer study. J Immigr Minor Health. 2013;15:234–43.
7. Mansour AA, Ajeel NA. Parity is associated with increased waist circumference and other anthropometric indices of obesity. Est Weight Disord. 2009;14:e50-5.
8. Abrams B, Heggesseth B, Rehkopf D, Davis E. Parity and body mass index in US women: a prospective 25-year study. Obesity (Silver Spring). 2013;21:1514–8.
9. Lee SK, Sobal J, Frongillo EA, Olston CM, Wolfe WS. Parity and body weight in the United States: differences by race and size of place of residence. Obes Res. 2005;13:1263–9.
10. Robinson WR, Cheng MM, Hoggatt KJ, Sumner T, Siega-Riz AM. Childbearing is not associated with young women’s long-term obesity risk. Obesity (Silver Spring). 2014;22:1126–32.
11. Mannan M, Doi SA, Mamun AA. Association between weight gain during pregnancy and postpartum weight retention and obesity: a bias-adjusted meta-analysis. Nutr Rev. 2013;71:343–52.
12. Deurenberg P, Yap M, Van Staveren WA. Body mass index and percent body fat: a meta-analysis among different ethnic groups. Int J Obes Relat Metab Disord. 1998;22:1164–71.
13. Heber D. An integrative view of obesity. Am J Clin Nutr. 2010;91:280S–9.
14. Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, Connerford P, et al. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case–control study. Lancet. 2005;366:1640–9.
15. Kopelman PG. Obesity as a medical problem. Nature. 2000;403:433–43.
16. Kim SA, Yount MK, Ramakrishnan U, Martorell R. The relationship between parity and overweight varies with household wealth and national development. Int J Epidemiol. 2007;36:93–101.
17. Wang F, Zhu J, Yao P, Li X, He M, Liu Y, et al. Cohort Profile: the Dongfeng-Tongji cohort study of retired workers. Int J Epidemiol. 2013;42:731–40.
18. Ministry Of Health, Bureau of Disease Control. Guideline for overweight and obesity control of Chinese adults. Beijing: People’s Health Publishing House; 2006.
19. World Health Organization. Waist Circumference and Waist-to-Hip Ratio: Report of a WHO Expert Consultation, Geneva, 8–11 December 2008. http://apps.who.int/iris/bitstream/10665/44583/1/9789241501491_eng.pdf. Accessed 25 Oct 2016.
20. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value. Nutr Res Rev. 2010;23:247–69.
21. Hadi AS, Chatterjee S. Regression analysis by example. 5th ed. Hoboken: Wiley; 2012.
22. Hajian-Tilaki KO, Heidari B. Prevalence of obesity, central obesity and the relationship between parity and overweight varies with household wealth and national development. Int J Epidemiol. 2007;36:93–101.
23. Luoto R, Mannisto S, Raitanen J. Ten-year change in the association between obesity and parity: results from the National FINRISK Population Development Study. Int J Epidemiol. 2007;36:399–406.
24. Gundersen EP, Sternfeld B, Wellsom MF, Whitmer RA, Chiang V, Quesenberry CJ, et al. Childbearing may increase visceral adipose tissue independent of overall increase in body fat. Obesity (Silver Spring). 2008;16:1078–84.
25. Wen W, Gao YT, Shu XO, Yang G, Li HL, Jin F, et al. Sociodemographic, behavioral, and reproductive factors associated with weight gain in Chinese women. Int J Obes Relat Metab Disord. 2003;27:933–40.
26. Lao XQ, Thomas GN, Mildon CJ, et al. Childbearing may increase visceral adipose tissue independent of overall increase in body fat. Obesity (Silver Spring). 2008;16:1078–84.
27. Parihar M. Obesity and infertility. Rev Gynaecol Pract. 2003;3:120–1.
30. Pasquali R, Vicennati V, Cacciari M, Pagotto U. The hypothalamic-pituitary-adrenal axis activity in obesity and the metabolic syndrome. Ann N Y Acad Sci. 2006;1083:111–28.
31. Bjorntorp P. Neuroendocrine factors in obesity. J Endocrinol. 1997;155:193–5.
32. Bjorntorp P. Visceral obesity: a civilization syndrome? Obes Res. 1999;1:206–22.
33. Diamanti-Kandarakis E, Economou F. Stress in women: metabolic syndrome and polycystic ovary syndrome. Ann N Y Acad Sci. 2006;1083:54–62.
34. Despres JP, Lemieux I. Abdominal obesity and metabolic syndrome. Nature. 2006;444:881–7.
35. Lawlor DA, Emberson JR, Ebrahim S, Whincup PH, Wannamethee SG, Walker M, et al. Is the association between parity and coronary heart disease due to biological effects of pregnancy or adverse lifestyle risk factors associated with child-rearing? Findings from the British Women's Heart and Health Study and the British Regional Heart Study. Circulation. 2003;107:1260–4.
36. Gleicher N. Why are reproductive cancers more common in nulliparous women? Reprod Biomed Online. 2013;26:416–9.
37. Liu J, Larsen U, Wyshak G. Prevalence of primary infertility in China: in-depth analysis of infertility differentials in three minority province/autonomous regions. J Biosoc Sci. 2005;37:55–74.
38. Rossner S. Pregnancy, weight cycling and weight gain in obesity. Int J Obes Relat Metab Disord. 1992;16:145–7.
39. Ouyang X, Lou Q, Gu L, Ko GT, Mo Y, Wu H, et al. Anthropometric parameters and their associations with cardio-metabolic risk in Chinese working population. Diabetol Metab Syndr. 2015;7:37.
40. Schneider HJ, Friedrich N, Klotsche J, Pieper L, Nauck M, John U, et al. The predictive value of different measures of obesity for incident cardiovascular events and mortality. J Clin Endocrinol Metab. 2010;95:1777–85.
41. Cheng CH, Ho CC, Yang CF, Huang YC, Lai CH, Liaw YP. Waist-to-hip ratio is a better anthropometric index than body mass index for predicting the risk of type 2 diabetes in Taiwanese population. Nutr Res. 2010;30:585–93.
42. Ding QJ, Hesketh T. Family size, fertility preferences, and sex ratio in China in the era of the one child family policy: results from national family planning and reproductive health survey. BMJ. 2006;333:371–3.