## Letter to the Editor

# Association between Chinese Famine Exposure and the Risk of Overweight/Obesity and Abdominal Obesity in Laterlife: A Cross-sectional Study

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This study aimed to examine the association between famine exposure in different stages of life and the risk of overweight/obesity and abdominal obesity in laterlife. A total of 12,458 participants were categorized into non-exposure and four direct exposures, including fetal, childhood, adolescence, and adult exposure. Only risk of being overweight or obesity in adolescence exposure [odds ratio (*OR*), 1.45; 95% confidence interval (*CI*), 1.08–1.94] was significantly higher than in non-exposure. Childhood (*OR*, 1.27; 95% *CI*, 1.05–1.54) and adolescence (*OR*, 1.53; 95% *CI*, 1.15–2.05) exposures had significantly an increased risk of abdominal obesity compared with non-exposure. Additionally, different famine severity exposures had different influences on the development of overweight/obesity and abdominal obesity. Famine exposure in adolescence, which was a behavior formative period, can increase the risk of overweight/obesity and abdominal obesity in adulthood, specifically in famine severely affect area.

Key words: Famine; Overweight/obesity; Abdominal obesity

The prevalence of overweight people and obesity is increasing worldwide. Based on the report on the Chinese Residents' Chronic Diseases and Nutrition, the overall prevalence of overweight and obesity among Chinese adults was 30.1% and 11.9% in 2012, respectively[1]. Sufficient evidence showed that genetic, diet, and lifestyle are associated with an increased risk of becoming overweight or developing obesity[2]. The Development Origins of Health and Disease hypothesis suggested that fetal malnutrition and early nutrition might increase the risk of common diseases such as hypertension and overweight[3]. Nutritional status during the critical window periods of life might influence health in adulthood. Due to ethical considerations, a study to validate this hypothesis in human beings has not been conducted yet. Famine was considered as a natural exposure.

The Great Chinese Famine that occurred during 1959–1961 is one of the most disastrous catastrophes in human history that significantly affected the residents' health. Several studies regarding the association between famine exposure in early life and the risk of becoming overweight or obese in adulthood have been published, and these studies were based on certain province, but were not conducted nationwide[4]. Liu et al.[5] found that famine during early life was associated with increased risks of abdominal obesity in adulthood. However, it only analyzed overweight and obese people, the exposure group only included fetal and infant exposures, and patients' age was not adjusted in statistical analysis. The China Health and Retirement Longitudinal Study (CHARLS) assessed the effects of undernutrition in early life on becoming overweight, obesity, and abdominal obesity in patients aged 54–56 years to control the effect of age, but the control group was also exposed to famine[6]. Because of the limitations in the previous studies, we used CHARLS in 2011–2012 to determine the association between Chinese famine exposure in different stages and the risk of becoming overweight, obesity, and abdominal obesity in adulthood.

After excluding the participants whose birth date did not meet the inclusion criteria and those with missing information about waist circumference (WC) and body mass index (BMI), 12,458 participants were enrolled in our final analysis. We categorized the participants into the non-exposure group (born from 1962 to 1974) and four famine direct exposure groups: fetal exposure (born from 1959 to 1961), childhood exposure (born from 1949 to 1958), adolescence exposure (born from 1944 to 1948), and adult exposure (born from 1922 to 1943). Additionally, the CHARLS has been approved by the Ethical Review Committee of Peking University.

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We calculated the BMI by measuring the weight in kilograms divided by the measured height in meters squared and categorized it into underweight (BMI < 18.5 kg/m$^2$), normal (BMI < 24.0 kg/m$^2$), and overweight/obesity (BMI ≥ 24.0 kg/m$^2$). According to the World Health Organization recommendations, we defined abdominal obesity as WC ≥ 90 cm in male and WC ≥ 80 cm in female. We classified the provinces into severely affected area and less severely affected area based on the excess death rate of every province and considered the participants' birthplace[7]. Smoking status (ever/never, current) and drinking status (never, less than once per month, more than once per month) were assessed, and sleeping time was categorized into insufficient (sleep time > 8 h/d) and enough (sleep time < 8 h/d). Educational level was categorized into four statuses (illiteracy, primary, junior, high school, and above). Analysis of covariance, multinomial logistic regression, and multivariate logistic regression were performed in the present study. All analyses were performed using the Statistical Analysis System (SAS) version 9.4 (SAS Institute, Inc., Cary, NC, USA).

Out of the total of 12,458 participants, 10,421 had been exposed to Chinese famine. Among these participants, 1,461, 4,809, 1,660, and 2,491 participants were from the fetal, childhood, adolescence, and adult exposures, respectively. The prevalence of overweight and obese people for the non-exposure, fetal, childhood, adolescence, and adult exposures were 49.04%, 48.19%, 41.86%, 39.82%, and 30.03%, respectively. The prevalence of abdominal obesity in non-exposure, fetal, childhood, adolescence, and adult exposures were 55.26%, 53.32%, 51.74%, 52.11%, and 47.71%, respectively (Table 1).

After adjusting the confounding variables, it indicated that only adolescence exposure [odds ratio (*OR*) = 1.45; 95% confidence interval (*CI*): 1.08–1.94] significantly increased the risk of becoming overweight or obese compared with non-exposure, and consistent result was not observed in other famine exposures. It also showed that direct exposure was not associated with underweight ($P$ > 0.05). Stratified analysis evaluating the association between famine severity areas and overweight/obesity showed that only the adolescence exposure (*OR* = 1.65; 95% *CI*: 1.15–2.36) had significantly higher risk of overweight/obesity than the non-exposure in severely affected areas. Association between becoming overweight and obesity and less severely affected areas was not observed, and being underweight was not associated with famine exposure in both affected areas (Table 2).

It has been documented that the risk of abdominal obesity is higher in childhood (*OR* = 1.27; 95% *CI*: 1.05–1.54) and adolescence (*OR* = 1.53; 95% *CI:* 1.15–2.05) exposures than that in the non-exposure after adjusting for the confounding variables. Stratified analysis demonstrated that compared with non-exposure, childhood (*OR* = 1.49; 95% *CI*: 1.07–2.07) and adolescence (*OR* = 1.73; 95% *CI*: 1.05–2.86) exposures increased the risk of abdominal obesity in less severely affected areas. In severely affected areas, the consistent association was only observed in adolescence exposure (*OR* = 1.44; 95% *CI*: 1.01–2.06). Significant association between fetal and adult exposure and abdominal obesity in both famine severity areas was not observed ($P$ > 0.05) (Table 3).

Our results suggested that adolescence is a critical period of physical development and an important period of food preferences, dietary choices, and other dietary behavioral formations. Adolescence exposure to famine might be more likely to form a preference of high-fat, high-energy foods[8-10], increasing the risk of becoming overweight or obese in adulthood. Additionally, besides the severely affected areas by famine in 1959–1961, several areas also experienced another famine, for example, Hunan, Guangdong, and Guangxi experienced the famine called 'Southern Famine' in 1946–1947 and Henan, Shandong, and Anhui experienced the famine called 'Henan Famine' in 1942–1943. The effects of these two famines on the individuals' various metabolic functions in laterlife might be different.

Several limitations should be considered in the present study. First, it classified the famine exposure based on participants' birth date, which could not accurately distinguish the actual famine exposure. However, the Chinese famine lasted more than 3 years; this non-differential error might cause the true correlation effect in an underestimation. Second, there were several independent risk factors (e.g., diet and lifestyle) for becoming overweight or obese and abdominal obesity, and we also had no data on dietary intake, physical activity, and other lifestyle. Therefore, the hypothesis that the higher risk of overweight/obesity and abdominal obesity among adolescents exposed to famine is totally attributed to malnutrition in early life cannot be concluded.

Additionally, this study had no any objective indicators that could evaluate the effect of famine exposure on health outcomes, such as birth weight and body length.

In conclusion, a significant positive association was observed between famine exposure during early life and the risk of becoming overweight or obese and abdominal obesity in laterlife, specifically exposure in adolescence, which is a critical period for behavioral formations. This finding provides

**Table 1.** Characteristics of the study population according to Chinese famine exposure

| Factors | Non-exposure | Direct exposure | | | | *P*-value |
|---|---|---|---|---|---|---|
| | | Fetal | Childhood | Adolescence | Adult | |
| *N* | 2,037 | 1,461 | 4,809 | 1,660 | 2,491 | |
| Age (y), mean ± SD | 46.2 ± 1.8 | 50.3 ± 1.2 | 57.6 ± 2.8 | 64.8 ± 1.4 | 74.1 ± 5.0 | |
| Sex, *n* (%) | | | | | | < 0.0001 |
| Men | 777 (38.18) | 651 (44.56) | 2,301 (47.91) | 832 (50.12) | 1,262 (50.68) | |
| Women | 1,258 (61.82) | 810 (55.44) | 2,502 (52.09) | 828 (49.88) | 1,228 (49.32) | |
| Famine areas, *n* (%) | | | | | | < 0.0001 |
| Severely affected | 759 (37.26) | 579 (39.63) | 1,708 (35.52) | 536 (32.29) | 841 (33.76) | |
| Less severely affected | 1,278 (62.74) | 882 (60.37) | 3,101 (64.48) | 1,124 (67.71) | 1,650 (66.24) | |
| Area, *n* (%) | | | | | | 0.0013 |
| Rural | 795 (39.03) | 562 (38.47) | 1,776 (36.93) | 550 (33.13) | 961 (38.58) | |
| Urban | 1,242 (60.97) | 899 (61.53) | 3,033 (63.07) | 1,110 (66.87) | 1,530 (61.42) | |
| Educational level, *n* (%) | | | | | | < 0.0001 |
| Illiteracy | 548 (26.9) | 426 (29.16) | 2,436 (50.66) | 827 (49.82) | 1,597 (64.11) | |
| Primary | 508 (24.94) | 251 (17.18) | 974 (20.25) | 505 (30.42) | 527 (21.16) | |
| Junior | 714 (35.05) | 441 (30.18) | 933 (19.4) | 221 (13.31) | 212 (8.51) | |
| High school and above | 267 (13.11) | 343 (23.48) | 466 (9.69) | 107 (6.45) | 155 (6.22) | |
| Smoking, *n* (%) | | | | | | < 0.0001 |
| Never | 564 (30.36) | 474 (35.37) | 1,833 (41.14) | 651 (42.44) | 1,011 (43.32) | |
| Current | 1,294 (69.64) | 866 (64.63) | 2,622 (58.86) | 883 (57.56) | 1,323 (56.68) | |
| Alcohol, *n* (%) | | | | | | < 0.0001 |
| Never | 450 (24.22) | 348 (25.97) | 1,153(25.88) | 412 (26.86) | 486 (20.82) | |
| Less than once per month | 153 (8.23) | 125 (9.33) | 364 (8.17) | 99 (6.45) | 143 (6.13) | |
| More than once per month | 1,255 (67.55) | 867 (64.7) | 2,939 (65.96) | 1,023 (66.69) | 1,705 (73.05) | |
| Sleep, *n* (%) | | | | | | < 0.0001 |
| Insufficient | 1,203 (59.06) | 926 (63.38) | 3,152 (65.54) | 1,108 (66.75) | 1,625 (65.23) | |
| Enough | 834 (40.94) | 535 (36.62) | 1,657 (34.46) | 552 (33.25) | 866 (34.77) | |
| BMI, *n* (%) | | | | | | < 0.0001 |
| Underweight | 58 (2.85) | 48 (3.29) | 230 (4.78) | 137 (8.25) | 360 (14.45) | |
| Normal | 980 (48.11) | 709 (48.53) | 2,566 (53.36) | 862 (51.93) | 1,383 (55.52) | |
| Overweight/obese | 999 (49.04) | 704 (48.19) | 2,013 (41.86) | 661 (39.82) | 748 (30.03) | |
| WC, *n* (%) | | | | | | < 0.0001 |
| Normal | 910 (44.74) | 682 (46.68) | 2,318 (48.26) | 795 (47.89) | 1,302 (52.29) | |
| Abdominal obesity | 1,124 (55.26) | 779 (53.32) | 2,485 (51.74) | 865 (52.11) | 1,188 (47.71) | |

***Note***. BMI, Body mass index; WC, Waist circumference.

evidence on the critical period of behavioral formations required to have a well-nourished environment and the importance of adolescent interventions.

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HUANG Li Na analyzed the data and wrote the initial manuscript. WANG Hui Jun and WANG Zhi Hong participated in the revision of the manuscript. DING Gang Qiang critically reviewed the manuscript for important intellectual content.

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**Table 2.** Risk of famine direct exposure and being underweight and overweight/obese in laterlife (normal body mass index as the reference)

| Variables | Non-exposure | Direct exposure | | | |
|---|---|---|---|---|---|
| | | Fetal | Childhood | Adolescence | Adult |
| Underweight | | | | | |
| Total | | | | | |
| Prevalence, *n* (%) | 58 (2.85) | 48 (3.29) | 230 (4.78) | 137 (8.25) | 360 (14.45) |
| Model 1 (*OR*, 95% *CI*) | Ref | 0.93 (0.62, 1.39) | 0.84 (0.58, 1.22) | 1.03 (0.64, 1.67) | 1.02 (0.54, 1.90) |
| Model 2[a] (*OR*, 95% *CI*) | Ref | 1.03 (0.67, 1.59) | 0.90 (0.60, 1.34) | 1.13 (0.68, 1.88) | 1.08 (0.56, 2.10) |
| Stratified by famine severity | | | | | |
| Less severely affected area | | | | | |
| Prevalence, *n* (%) | 27 (3.56) | 24 (4.15) | 86 (5.04) | 44 (8.21) | 137 (16.29) |
| Model 1 (*OR*, 95% *CI*) | Ref | 0.97 (0.54, 1.75) | 0.75 (0.42, 1.34) | 0.82 (0.37, 1.80) | 1.00 (0.36, 2.80) |
| Model 2[b] (*OR*, 95% *CI*) | Ref | 0.99 (0.54, 1.83) | 0.72 (0.39, 1.32) | 0.81 (0.35, 1.85) | 0.97 (0.33, 2.89) |
| Severely affected area | | | | | |
| Prevalence, *n* (%) | 31 (2.43) | 24 (2.72) | 144 (4.64) | 93 (8.27) | 223 (13.52) |
| Model 1 (*OR*, 95% *CI*) | Ref | 0.89 (0.51, 1.54) | 0.92 (0.57, 1.5) | 1.20 (0.65, 2.22) | 1.05 (0.48, 2.32) |
| Model 2[b] (*OR*, 95% *CI*) | Ref | 1.09 (0.59, 2.02) | 1.10 (0.63, 1.89) | 1.43 (0.73, 2.8) | 1.21 (0.52, 2.83) |
| Overweight/obese | | | | | |
| Total | | | | | |
| Prevalence, *n* (%) | 999 (49.04) | 704 (48.19) | 2,013 (41.86) | 661 (39.82) | 748 (30.03) |
| Model 1 (*OR*, 95% *CI*) | Ref | 1.08 (0.93, 1.25) | 1.02 (0.85, 1.22) | 1.19 (0.90, 1.57) | 1.05 (0.72, 1.53) |
| Model 2[a] (*OR*, 95% *CI*) | Ref | 1.13 (0.97, 1.32) | 1.15 (0.95, 1.4) | 1.45 (1.08, 1.94)* | 1.15 (0.77, 1.72) |
| Stratified by famine severity | | | | | |
| Less severely affected area | | | | | |
| Prevalence, *n* (%) | 357 (47.04) | 277 (47.84) | 737 (43.15) | 207 (38.62) | 267 (31.75) |
| Model 1 (*OR*, 95% *CI*) | Ref | 1.10 (0.87, 1.40) | 1.01 (0.74, 1.36) | 0.96 (0.60, 1.54) | 0.91 (0.48, 1.73) |
| Model 2[b] (*OR*, 95% *CI*) | Ref | 1.17 (0.90, 1.52) | 1.12 (0.81, 1.56) | 1.07 (0.65, 1.79) | 0.90 (0.44, 1.81) |
| Severely affected area | | | | | |
| Prevalence, *n* (%) | 642 (50.23) | 427 (48.41) | 1,276 (41.15) | 454 (40.39) | 481 (29.15) |
| Model 1 (*OR*, 95% *CI*) | Ref | 1.06 (0.88, 1.27) | 1.02 (0.81, 1.28) | 1.33 (0.94, 1.87) | 1.13 (0.71, 1.81) |
| Model 2[b] (*OR*, 95% *CI*) | Ref | 1.12 (0.92, 1.36) | 1.16 (0.92, 1.47) | 1.65 (1.15, 2.36)* | 1.32 (0.81, 2.14) |

***Note.*** Model 1: adjusted for age. [a]Model 2: based on Model 1 – adjusted for gender, area, different famine severity areas, educational level, smoking status, alcohol status, and sleeping time. [b]Model 2: based on Model 1 – adjusted for gender, area, educational level, smoking status, alcohol status, and sleeping time. *$P < 0.05$.

**Table 3.** Risk of famine direct exposure and abdominal obesity in latelife

| Variables | Non-exposure | Direct exposure | | | |
|---|---|---|---|---|---|
| | | Fetal | Childhood | Adolescence | Adult |
| Total | | | | | |
| Prevalence, *n* (%) | 1,124 (55.26) | 779 (53.32) | 2,485 (51.74) | 865 (52.11) | 1,188 (47.71) |
| Model 1 (*OR*, 95% *CI*) | Ref | 0.96 (0.83, 1.10) | 0.95 (0.80, 1.12) | 1.02 (0.79, 1.31) | 0.92 (0.65, 1.30) |
| Model 2[a] (*OR*, 95% *CI*) | Ref | 1.08 (0.91, 1.27) | 1.27 (1.05, 1.54)* | 1.53 (1.15, 2.05)* | 1.31 (0.88, 1.95) |
| Stratified by famine severity | | | | | |
| Less severely affected area | | | | | |
| Prevalence, *n* (%) | 407 (53.62) | 282 (48.70) | 902 (52.84) | 278 (51.87) | 398 (47.32) |
| Model 1 (*OR*, 95% *CI*) | Ref | 0.87 (0.69, 1.10) | 1.15 (0.86, 1.53) | 1.23 (0.80, 1.91) | 1.19 (0.65, 2.15) |
| Model 2[b] (*OR*, 95% *CI*) | Ref | 1.01 (0.77, 1.33) | 1.49 (1.07, 2.07)* | 1.73 (1.05, 2.86)* | 1.45 (0.73, 2.89) |
| Severely affected area | | | | | |
| Prevalence, *n* (%) | 717 (56.24) | 497 (56.35) | 1,583 (51.13) | 587 (52.22) | 790 (47.91) |
| Model 1 (*OR*, 95% *CI*) | Ref | 1.02 (0.85, 1.23) | 0.85 (0.69, 1.05) | 0.92 (0.67, 1.25) | 0.8 (0.52, 1.22) |
| Model 2[b] (*OR*, 95% *CI*) | Ref | 1.13 (0.92, 1.40) | 1.17 (0.92, 1.48) | 1.44 (1.01, 2.06)* | 1.25 (0.77, 2.04) |

***Note.*** Model 1: adjusted for age. [a]Model 2: based on Model 1 – adjusted for gender, area, different famine severity areas, educational level, smoking status, alcohol status, and sleeping time. [b]Model 2: based on Model 1 – adjusted for gender, area, educational level, smoking status, alcohol status, and sleeping time. *$P < 0.05$.

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