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Disparities in economic development in Eastern China: impact on nutritional status of adolescents

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Abstract

Objective: To compare the effects of disparities in economic development in urban and rural Eastern China on the nutritional status of adolescents.

Design: A cross-sectional survey consisting of self-completion questionnaires, anthropometry and haemoglobin measurement.

Setting: Twelve middle schools in an urban and a rural area of Zhejiang Province: Hangzhou, the capital, and Chunan, a poor mountainous area.

Subjects: Some 4835 young adolescents (predominant age range 13–16 years).

Results: The mean body mass index (BMI) was significantly higher in urban Hangzhou ($P = 0.01$) Overweight affected 3.6% overall; adjusted odds ratios (ORs) showed male sex (OR 2.1, 95% confidence interval (CI) 1.1–3.4) and urban residence (OR 9.1, 95% CI 3.7–22) to be the most important risk factors. The prevalence of underweight was 18%, with no significant urban–rural difference. Predictors of underweight were male sex (OR 1.5, 95% CI 1.1–2.0) and low household income (OR, 1.3, 95% CI 1.1–1.5). Mean haemoglobin was significantly lower in the rural area. Anaemia was more common in girls, 51% compared with 21% of the boys, but rural residence was not an independent risk factor. Rural students exercised more and had a less varied diet than their urban counterparts. Around one-third of the respondents consumed dietary supplements on a regular basis.

Conclusions: These results suggest that in urban areas of Eastern China a dual picture is emerging with the problems of excess (overweight and obesity) coexisting with underweight and anaemia. In rural areas the problems of relative nutritional deprivation predominate, but the long-term consequences of such marginal underweight and anaemia are not clear.

Keywords
Nutritional status
Adolescence
China
Anaemia
Body mass index
Obesity
Underweight
Food frequency
Diet
Exercise

Average incomes have increased dramatically since the introduction of a market economy in China in the early 1980s. Huge increases in agricultural output and food manufacturing have meant that many parts of China have moved from a situation of food scarcity to a wide choice in diet in less than a generation[1,2]. Between 1982 and 1992 the national consumption of meat and fat/oil increased by 38% and 61%, while the consumption of cereal and tubers decreased by 12% and 47%, respectively[1]. But the changes have been unevenly distributed. The contribution of fat to total energy intake reached an average of 26% in 1992: in poor areas the figure remained at less than 15%, while proportions of over 30% were reported for the big eastern cities, including Beijing, Shanghai and Hangzhou[2]. These changes in diet have contributed to marked changes in body composition. Obesity was very rare in China before the1980s[3] and it remains so in rural China. The 5% increase in overweight (body mass index (BMI)$>25\,kg\,m^{-2}$) in adults in selected cities between 1982 and 1991 has been described as among the most rapid ever documented[4]. However, rates of underweight (BMI$<18.5\,kg\,m^{-2}$) in urban and rural areas fell by just 1% over the same period.

These changes have been mirrored in children and adolescents. Children overall have become heavier and taller but these improvements have not been equitable and an urban–rural gap has developed[5–8]. A large study demonstrated an increasing urban–rural differential in height in pre-school children over the past 20 years[7]. Another study from the early 1990s showed that the mean BMI of urban adolescents is significantly higher than that of their rural counterparts, and that overweight is emerging as a problem of urban adolescents for the first time, with an overall rate of 4%[8].

These studies, however, have mainly consisted of cross-sectional surveys of growth, and little is known about the broader aspects of nutrition in Chinese adolescents.

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Published studies of anaemia have focuses on pre-school children, pregnancy and distinct occupation groups, with virtually nothing on adolescence. Furthermore, there is no work examining nutritional status and the relative contributions of diet and exercise in Chinese adolescents. In the UK, for example, weight gain in children has been attributed more to decreasing levels of physical activity than to increased energy intake[9]. In China, academic pressures and the popularity of indoor pursuits, such as computer games, have led to a more sedentary lifestyle, especially in urban areas[10]. Thus perhaps lowered energy expenditure is the major factor in the higher levels of obesity reported in urban areas.

The aim of this study was to compare different parameters of adolescent nutritional status in rich urban and poor rural settings in Eastern China. Rates of underweight, overweight and anaemia were determined, and their relationship with urban/rural residence, household income and other demographic variables, exercise and diet were explored to establish key determinants.

Subjects and methods

A cross-sectional survey was carried out in middle schools in an urban and a rural area of Zhejiang Province. Zhejiang Province is typical of wealthier eastern coastal provinces, where there has been rapid economic development in the last two decades. The study locations were the capital Hangzhou, one of the boom cities of the east, and Chunan, a poor mountainous area 150 km to the south-west, where the economy is still agriculture-based. The average annual per capita income in 1998 was $US1400 in Hangzhou and $US580 in Chunan, with middle school enrolment of 99% and 96% in the two areas, respectively[11]. The changes in average income over the past 20 years in urban and rural Zhejiang are illustrated in Fig. 1.

In each area, six non-specialist middle schools (predominant age range 13–16 years) were invited to participate. The schools were selected to be representative of all schools in urban and rural Zhejiang on the basis of an 'academic score' or the percentage of students in the school who go on to mainstream higher education. The academic scores of the schools ranged from 20% to 85%, representative of the range for Zhejiang. No school refused to participate. Two randomly selected classes in each year of each school were included.

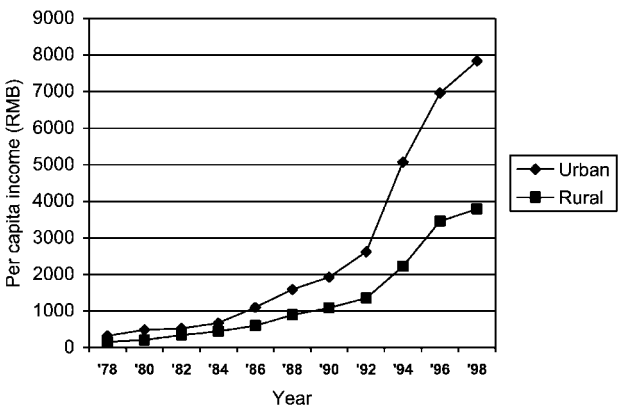

Fig. 1 Annual per capita income in Zhejiang in Chinese RMB, 1978–1998 ($US1 = RMB8) (*source*: National Bureau of Statistics[11])

Two specially trained school nurses with a researcher (QJD) carried out all data collection from September to November 1999. A self-completion questionnaire included questions on sociodemographic indicators, lifestyle, exercise and diet. Food-frequency questionnaires were developed specifically for the study, based on a model that had been used for ethnic Chinese in Singapore[12]. An additional question asked about the use of specific named food supplements.

Anthropometry was carried out by means of a stadiometer with measurement to 0.5 cm and a beam balance scale with measurement to 0.1 kg (subjects lightly clothed in bare feet). Haemoglobin was measured with a Hemocue apparatus, with blood taken by finger prick. One nurse carried out the test, and the other checked and recorded the measurements. Recalibration of the Hemocue was carried out on a daily basis. Haemoglobin results were fed back immediately. All subjects with recordings below 100 $g\,l^{-1}$ were advised to consult a doctor.

Analysis

Body mass index (BMI = weight/height^2) was calculated for each individual. Anthropometric status was assessed by two methods: for underweight using World Health Organization (WHO) standards for adolescents[13] and for overweight using Cole's newly developed international standards for overweight and obesity in adolescents[14]. Both are adjusted for age and gender. Cole's cut-offs were used for overweight and obesity because they have recently been validated specifically for adolescent populations, and because two of the reference populations included ethnic Chinese (Hong Kong and Singapore). Anaemia was defined using the WHO standard of haemoglobin (Hb) less than 120 $g\,l^{-1}$. Age was adjusted as a continuous variable. Other sociodemographic variables were dichotomised: parental education into low (completion of primary education or lower) and high (completion of middle school or higher), household income into low income (<$US100 $month^{-1}$) and middle/high income (>$US100 $month^{-1}$), and family size into only children and those with siblings. Unadjusted odds ratios (ORs) (Pearson Chi-squared with 95% confidence intervals (CIs)) were calculated for undernutrition, overweight and anaemia using demographic variables including age, sex, household income, parental education and family size. Stepwise forward logistic regression was then conducted for those risk factors that were significant in the univariate analysis. Analysis was carried out on SPSS Version 8.

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Results

Characteristics of the study population

Complete questionnaire data were obtained from 4385 respondents in total. Eighty-nine questionnaires were inadequately completed (more than 10% of missing answers across key variables), giving a response rate of 98%. The characteristics of the two study populations are given in Table 1. The huge difference in the proportion of one-child families (91% in Hangzhou and 16% in Chunan) reflects the mode of implementation of family planning policy in Eastern China. This generally allows for two children in rural areas, especially if the first is a girl, and provided there is a five-year gap[15].

Body mass index (BMI)

The mean BMI in urban Hangzhou was significantly higher than in rural Chunan in both sexes. The mean BMI in urban boys was 19.2 (standard deviation (SD) 3.4) $kg\,m^{-2}$ compared with 17.7 (SD 2.0) $kg\,m^{-2}$ for rural boys ($P = 0.006$). Urban girls had a mean BMI of 18.8 (SD 2.8) $kg\,m^{-2}$ and rural girls of 17.5 (SD 2.4) $kg\,m^{-2}$ ($P = 0.01$). The differences in underweight, overweight and obesity by gender, area and income group are shown in Table 2.

Underweight was far more prevalent than overweight, four times as common in boys and six times as common in girls, with differences starker in the rural area. After adjustment for urban/rural residence, age, family size and parental education, the only significant predictors of underweight were male sex (OR 1.5, 95% CI 1.1–2.0) and low household income (OR 1.3, 95% CI 1.1–1.5), although associations were weak with confidence intervals approaching unity in both cases.

The overall rate of *overweight* was 3.6%, but nearly all were urban residents. Only 1.3% of rural boys and 0.7% of rural girls were classified as overweight compared with 8.4% and 4.5%, respectively, of the urban residents. Overweight and obesity were combined for further analysis. After adjusting for age, household income, one-child family and parental education level, the only significant predictors of overweight were male sex (OR 2.1, 95% CI 1.1–3.4) and urban residence (OR 9.1, 95% CI 3.7–22), the latter clearly being very strong.

Table 1 Characteristics of the study population by area

	Urban (Hangzhou)	Rural (Chunan)
Number of subjects	2361	2024
Boys	1160	1103
Girls	1201	921
Mean age (±SD) (years)	13.9±1.1	14.4±1.2
Age range (years)	12–17	12–18
One-child family (%)	91	16
Mean monthly household income ($US)	1600	700
Low-income households (<$US100) (%)	22	69
Literacy rate of parents (%)	98	74

Table 2 Prevalence of underweight, overweight and obesity (%)

	Underweight	Overweight	Obese
All boys	21	4.7	1.0
All girls	16.5*	2.5*	0.5
Urban boys	22	8.4	1.3
Rural boys	21	1.3*	0.5
Urban girls	14.4	4.5	0.9
Rural girls	18.6	0.7*	0
Income			
Low–low middle	23	1.1	
Middle–high	16*	5.3*	

* $P < 0.01$.
See text for definitions of overweight and obesity.

Anaemia

The mean haemoglobin was significantly different in the two areas: 126 $g\,l^{-1}$ in Hangzhou and 122 $g\,l^{-1}$ in Chunan ($P = 0.008$). Taking cut-off points of 100, 110 and 120 $g\,l^{-1}$ for anaemia, the differences in the two areas are shown in Table 3. Over one-third of the respondents were anaemic (Hb<120 $g\,l^{-1}$), and over half of the girls. The only significant associations (after controlling for urban/rural residence, income and parental education level) were female sex (OR 3.8, 95% CI 3.1–4.8) and having siblings (OR 1.22, 95% CI 1.03–1.41). Rural residence ($P = 0.13$) and household income ($P = 0.08$) were not independent risk factors. There also was no significant association between underweight or overweight and anaemia. There was no significant difference in haemoglobin levels between menstruating ($n = 1508$) and non-menstruating ($n = 611$) girls ($P = 0.15$).

Exercise

Levels of exercise in these young people were generally high, but still higher in the rural areas. Fifty-one per cent walked to school and 45% went by bike. Only 3.8% took a bus, 0.1% went by car and 0.2% used a rickshaw. But the mean distance to school was significantly higher in Chunan: 1.6 km compared with 1.1 km in Hangzhou. Students participated in a mean of 2.6 (SD 1.1) hours of sport every week. Students in Chunan did considerably more sport, 3.5 (SD 1.3) hours per week on average, compared with those in Hangzhou who did 1.9 (SD 1.1) hours ($P < 0.001$). Boys averaged a mean of 3.4 hours

Table 3 Low haemoglobin status by sex and area (%)

	Hb ≤ 100 $g\,l^{-1}$	Hb ≤ 110 $g\,l^{-1}$	Hb ≤ 120 $g\,l^{-1}$
All	2.2	10.2	36
Boys	1.0	5.3	21
Girls	3.2*	15*	51*
Urban	1.3	8.1	34
Rural	3.1	12.4*	38
Urban boys	0.8	4.8	20
Rural boys	1.2	4.8	21
Urban girls	1.6	11	48
Rural girls	4.8*	19*	55*

* $P < 0.01$.

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compared with 2.6 hours for the girls ($P < 0.001$). Thirty-five per cent overall, 25% in Hangzhou and 44% in Chunan ($P < 0.001$), claimed to have done some form of physical activity or sport after school on the previous day. In Hangzhou, 21% said they had played computer games the day before (30% of the boys, 11% of the girls) compared with just 6% in Chunan.

However, it seems that much of the sport was of the gentle variety. The mean number of times in the previous week that students had undergone vigorous exercise, i.e. exercised until they were breathless and tachycardic, was 1.6. But rural residents and boys indulged in more vigorous exercise: in Chunan an average of 1.8 times compared with 1.4 in Hangzhou ($P < 0.001$); boys 1.8 times compared with 1.3 times in girls ($P > 0.001$). However, none of these measures of exercise was independently associated with underweight or overweight, so by these measures, the amount of exercise had no bearing on body composition. The exception is an association between playing computer games (the previous day) and overweight in boys (OR 6.3, 95% CI 2.4–12.1; $P < 0.001$).

Diet

The results of the food-frequency questionnaire by urban or rural residence are summarised in Table 4. The data have been simplified by dichotomising to less than twice per week or at least 3–4 times per week, and the table shows just the proportion of respondents stating the higher frequency. All food items were eaten more frequently in the urban area than in the rural, with the exception of rice, pickles, green vegetables and tea. The diet of the urban group is varied: meat, chicken, eggs, milk and tofu being consumed regularly and fruit and vegetables frequently, whereas rural children appear to have a far less varied diet with many food items eaten less than once per week. However, the urban adolescents also consume significantly more convenience food and snacks, such as crisps and biscuits, and are drinking more carbonated sweet drinks. (There are still no low-sugar alternatives of these drinks available in Zhejiang.) The low consumption of fruit in the rural area probably reflects the fact that this study was carried out in the winter, when availability of fruit is limited in the countryside. In urban areas imported fruit is now available all year round. Higher consumption of sweet drinks and cake was associated with overweight (OR 2.04, 95% CI 1.19–3.5 and OR 1.9 95% CI 1.1–3.3, respectively), but no other foods had significant associations. Moreover, there were no significant (biologically plausible) associations between food items and underweight or anaemia.

Students were also asked about regular nutritional supplements, including iron and vitamins, defined as taken at least once weekly (Table 5). Nutritional supplements in China consist mainly of tonics and herbal concoctions reputed to enhance health, increase energy and improve cognition. Urban adolescents were taking significantly more vitamins and nutritional supplements than their rural counterparts, although there was little difference by gender.

Table 4 Percentage of respondents eating the food item at least three times per week

	Urban	Rural
Red meat	93	57*
Chicken	51	24*
Fish	35	5.2*
Eggs	77	27*
Tofu	55	56
Milk	78	6.7*
Yoghurt	21	3*
Rice	96	98
Bread	58	40*
Fruit	94	45*
Green vegetables	83	84
Peas/beans	80	42*
Nuts	40	10*
Pickles	25	28
Potatoes	31	16*
Sweet/carbonated drinks	61	23*
Crisps	39	16*
Cake/biscuits	70	26*
Chocolate sweets	56	24*
Dried fruit snacks	33	5*
Tea	40	51*

* $P < 0.01$.

Discussion

Hangzhou is one of the wealthiest cities in China, while Chunan is classified as middle-income rural and certainly does not represent an extreme by Chinese standards. But Chunan is typical of many rural areas in the richer eastern coastal regions of China. Our results show differences in anthropometry, haemoglobin status, exercise and diet between these two communities in one province. Rural adolescent boys had a lower mean BMI, were less overweight, had the same rates of underweight and anaemia and exercised more than their urban counterparts. Similarly, rural girls had a lower mean BMI, were less overweight and more underweight than urban girls, but had higher rates of anaemia. In the rural area diet was less varied, but there was also less convenience and snack food consumed. Thus our data suggest that a poorer (but

Table 5 Regular (at least once per week) food supplements by gender and area (%), $n = 4032$

	Vitamins	Iron	Other nutritional supplements
All	18	3.0	31
Boys	18	3.9	32
Girls	19	2.2	30
Urban	29	2.8	41
Rural	6.8*	3.2	20*

* $P < 0.001$.

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not very poor) rural lifestyle may actually be beneficial to nutritional health.

Our finding that overweight and obesity are predominantly a problem of male urbanites in this age group has been reported elsewhere[3,8]. Although rates of overweight are low overall in comparison with developed countries, the rapid emergence of this problem in a country where obesity was very rare before the mid-1980s[4] is of concern if these trends continue. This is of particular importance in this age group, since there is evidence from other populations that obesity in childhood persists into adulthood with all the health-related consequences[16,17]. Some local studies have highlighted these trends. In Heilongjiang, Northern China, 5% of urban school students were reported to be overweight in 1991 and this had risen to 15% by 1993[18]. Other surveys in northern coastal provinces suggest that the prevalence of overweight in middle school students had risen to between 6% and 9% in the mid-1990s[19–21].

But this study shows that rates of underweight are still greater even in Hangzhou, and among middle- and high-income groups. Although 10 children in total had forms of chronic disease that could contribute to underweight, the vast majority were healthy. This underweight is probably partly a function of the fact that Chinese have gained more proportionately in height than weight over the past few decades (1.7 cm and $0.9\,kg\,decade^{-1}$ for boys and 2 cm and $0.9\,kg\,decade^{-1}$ for girls over the past three decades)[5], leading to a taller, lean population[5]. This thinness is probably accentuated during the growth spurt of early adolescence and may explain the underweight in the higher income groups. But the health consequences of this underweight, if any, are unknown. The whole question of health-based cut-offs for categorising obesity and underweight in children and adolescents is complex. In adults these definitions are based on known risk ratios for different levels of body mass index[22]. Extrapolating back from these for adolescents and children, as in the WHO and Cole standards, seems a logical approach. But their validity when applied in different countries and ethnic groups is not clear[22]. Cole's standards use reference data from large cohorts in six countries across three continents in an attempt to address this issue. But it is still possible that the high rates of underweight in this and other Asian studies, e.g. 47% in Nepal, 55% in the Philippines and 32% in India[23], may be an artefact of the cut-off points used: they may simply be too sensitive for Asian populations. Longitudinal studies in these populations are necessary to establish appropriate cut-offs for undernutrition based on risk.

Comments about the relative contributions of exercise and energy intake to the differences in BMI can be indicative only, because of the limitations of the data. The food frequency data have all the usual limitations of such data[24,25] and they cannot be converted to units of energy intake, just as the exercise data cannot be extrapolated to energy expenditure, but urban–rural comparisons are valid and hence some conclusions can be drawn.

For most of these students exercise is part of daily activity. In Chinese schools there is compulsory daily morning exercise, plus three or four 45-minute periods of sport every week. The fact that exercise is part of daily routine helps to explain the relatively low prevalence of overweight and the lack of association between exercise and both overweight and underweight. Everyone does exercise irrespective of BMI. Mean BMIs were, however, lower in rural Chunan where all types of exercise were higher. The more sedentary lifestyle resulting from academic pressure and preference for computer games is regarded as more of an urban phenomenon and these data provide some evidence for this supposition[10]. They certainly suggest that the difference between urban and rural exercise levels could contribute to the BMI differences observed.

The food frequency data illustrate the greater variety in diet in urban areas, and the fact that more snack foods are consumed there. Over the last two decades there has been much greater access to a variety of foods in urban areas. However, traditional dietary habits persist. Rice and green vegetables are still the most commonly eaten foods. Together with pickles, these are the only foods eaten more often in the rural area and are the traditional food of the poor. A study carried out amongst adults in Sichuan Province in central China reported similar differences between urban and rural areas, with more than half of the urban respondents reporting a varied diet while rural respondents were eating only rice and green vegetables on a daily basis[26]. Wang also found that increased energy intake in urban adolescents corresponded to slightly higher average BMI than in rural residents. But this study did not report on exercise. In conclusion, it seems likely that diet and exercise play a role in the disparity in BMI between urban and rural areas.

However, the differences in diet are not reflected in differences in anaemia. Anaemia was common, present in 36% across both areas and in 51% of the girls. Rural residence and low household income were not independent risk factors. But it should be noted that the majority (72%) of those classified as anaemic in this study had a haemoglobin level between 110 and $120\,g\,l^{-1}$, and whether such marginal anaemia is of clinical importance is controversial[27,28]. The finding that post-menarcheal girls were not significantly more anaemic than those not yet menstruating suggests that menorrhagia is not highly prevalent in this population. There is clearly some awareness of dietary iron deficiency as evinced by the numbers who take iron as a nutritional supplement. Iron was however the least commonly consumed supplement, most popular were Chinese nutritional/herbal supplements. But the widespread use of these supplements needs to be viewed from the Traditional Chinese Medicine perspective that

there is no sharp distinction between health-enhancing food and medicines[29]. Moreover, the alleged cognitive benefits of supplements are widely advertised and targeted at school children and their parents, explaining the relatively high utilisation by children in a highly competitive educational environment.

The data suggest that in urban areas a dual picture is emerging with the problems of excess (overweight and obesity) coexisting with underweight and anaemia. In rural areas the problems of relative nutritional deprivation still predominate. However, it cannot be assumed that the relative economic deprivation in rural areas is automatically to the detriment of nutritional health. Although the long-term health risks and disadvantages of obesity are clear, the long-term consequences, in terms of adult mortality and morbidity, of marginal underweight and anaemia are not at all clear. More research needs to be done in this area before they can be regarded as public health problems.

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