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Closing the energy gap to prevent weight gain in China

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Summary

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Introduction

China is one of the most rapidly developing countries in the world. Over the past 20 years, the annual growth rate of the gross domestic product (GDP) has been more than 8% – the highest rate in recent world history (1). Many studies of the nutrition transition in China have documented that the food consumption pattern of Chinese has been shifting away from the traditional pattern – characterized by the consumption of rice, wheat and wheat products – towards high animal food consumption (2–6). At the same time, inactivity (e.g. television use) is increasing (2,7,8). Yet in 2002, 14.3% of pre-school children were still stunted (9), but at the same time, the prevalence of overweight and obesity has risen to a high degree, and reached 22.7% for the overall adult population by 2002 (10,11).

Hill *et al.* (12) have proposed a way to estimate the degree of positive energy balance causing weight gain in a population, and have termed this the *energy gap*. Quantifying the energy gap is useful, because it can provide a quantitative estimate of the degree of behaviour change required to close the energy gap and thus prevent weight gain.

The aim of this study was to use data from a longitudinal survey in China (CHNS) to provide a quantitative goal for the amount of energy balance change required to prevent excessive weight gain in the Chinese population.

Methods

Survey design and study population

The CHNS is a longitudinal survey of health and nutrition in China, conducted jointly by the National Institute of Nutrition and Food Safety, the China Center for Disease Control, and the University of North Carolina at Chapel Hill. The survey began in 1989 and included eight provinces. Follow-up surveys were conducted in 1991, 1993, 1997, 2000 and 2004 in the same eight provinces. In this analysis, we focused on a cohort of 2288 adults (aged 20–45 years in 1989) who had their weight measured in both the 1989 and 2000 surveys.

Calculating the energy gap

The energy gap was estimated according to the method used by Hill *et al.* (12). It was assumed that each kilogram of body-weight gain reflected a body energy accumulation of 7700 kcal. Further, it was assumed that each kilogram of weight was stored in the body with 50% efficiency. By determining the weight change in this cohort from 1989 to 2000, we estimated the energy gap producing weight gain in the sample population.

Results

Participant characteristics

The cohort was composed of 55.6% females and 78.7% lived in rural areas. The age distribution in 1989 was 35.3% between 20 and 30 years, 49.6% between 30 and 40 years, and 15.1% between 40 and 45 years.

Changes in body mass index distribution

The shape of the body mass index (BMI) distribution shifted to the right and the peak value decreased (Fig. 1). The mean BMI increased from 21.6 kg m^{-2}–23.0 kg m^{-2}. At the same time, the BMI distribution increased its spread and flattened. The prevalence of overweight, based on World Health Organization (WHO) criteria (BMI = 25 kg m^{-2}), increased from 9.0% to 23.3%.

The rate of the weight gain and energy accumulation

Cohort body weight significantly increased in this 11-year period ($P < 0.0001$). Average body weight increased from 55.4 to 59.1 kg, so the average weight gain was 3.7 kg. Assuming a linear rate of weight gain during this period, we estimated the median weight gain of the cohort (Fig. 2) to be 0.3 kg year^{-1} and 1.1 kg year^{-1} for the 90th percentile of weight increases.

Using the assumptions described above about the efficiency of storage of excess energy, we calculated the rate of energy accumulation (this is the net or total added energy over this 11-year period because of overweight) in the population. Figure 3 shows the distribution of the daily energy accumulation in this cohort over 11 years – a median daily energy accumulation of 7.0 kcal d^{-1} was estimated with a value of 22.5 kcal d^{-1} for the 90th percentile.

Estimating the energy gap

Energy derived from mixed composition diets is stored with an efficiency of at least 50% (12,13). Therefore, we calculated the energy gap for weight gain in China as 45 kcal d^{-1}. This is the maximum degree of positive energy balance that is producing weight gain in 90% of the population.

Estimation of the energy gap among different body mass index groups

The rate of weight gain differed among different BMI groups. Thus, we classified the participants into underweight (BMI < 18.5 kg m^{-2}), normal (BMI 18.5 kg m^{-2}–24.95 kg m^{-2}), and overweight and obese (BMI ≥ 25 kg m^{-2} and ≥30 kg m^{-2} respectively), according to the cut-off points defined by the WHO. Figures 4 and 5 show BMI distributions for weight gain and energy accumulation in the group that remained in the healthy range and the group that changed from normal weight to

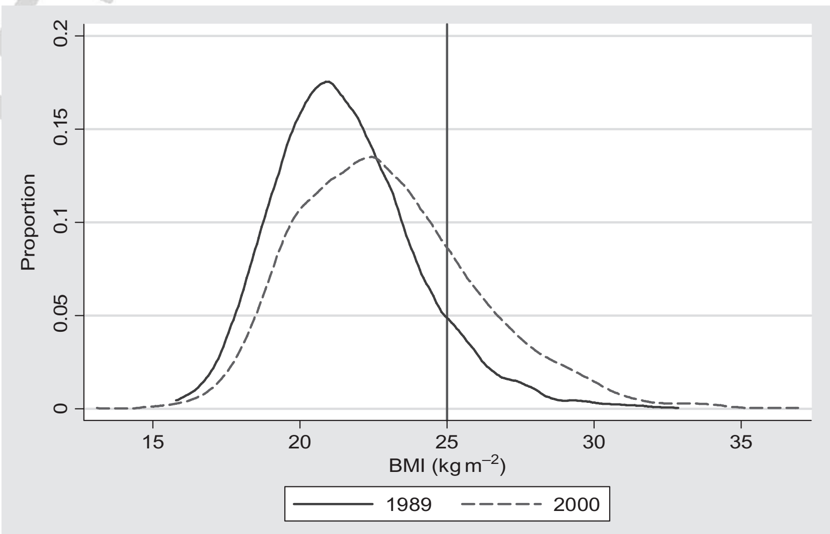

Figure 1 Body mass index (BMI) distributions in 1989 and 2000 for a cohort of Chinese adults aged 20–45 years in 1989 ($N = 2288$).

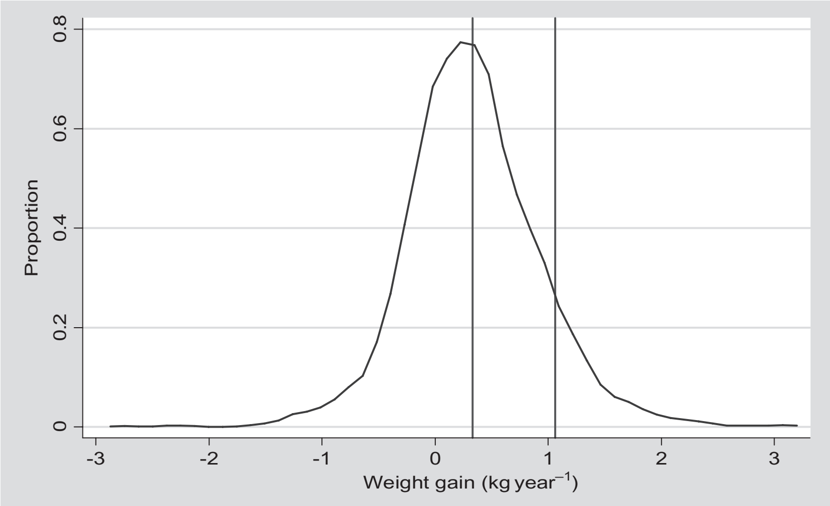

Figure 2 The distribution for Chinese weight gain per year between 1989 and 2000. The vertical lines correspond to the median weight gain and the 90th percentile gain.

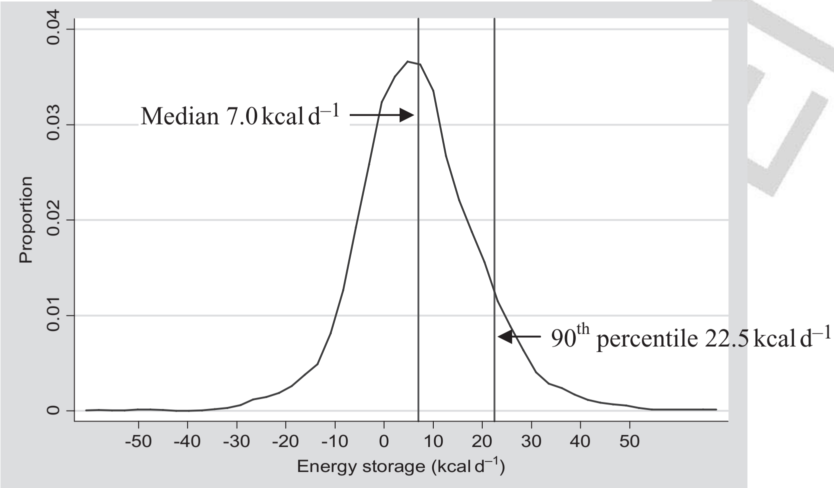

Figure 3 The distribution of daily energy accumulation.

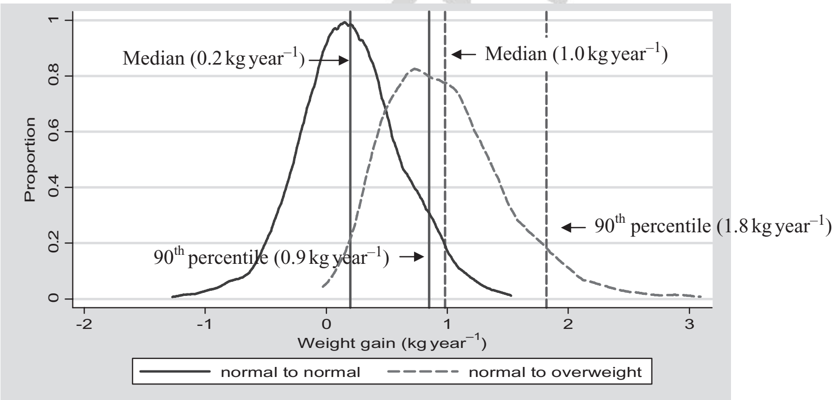

Figure 4 The distribution of Chinese adult weight gain per year in the group remaining within the normal body mass index (BMI) range and in the group transferring from the normal BMI group to the overweight group (1989–2000).

overweight. Table 1 shows the estimate of the energy gap for each of the three BMI groups. The rate of weight gain and energy accumulation was lowest in the group remaining in the healthy weight range. The median weight gain was 0.2 kg year^{-1} and the 90th percentile was 0.9 kg year^{-1}; the 90th percentile of the daily energy accumulation was 18.9 kcal d^{-1}; and the corresponding energy gap was 37.8 kcal d^{-1}.

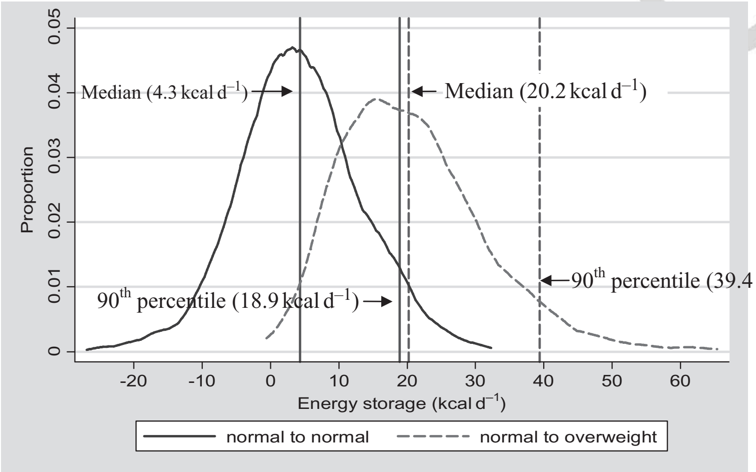

Figure 5 The distribution of Chinese adult daily energy accumulation in the group ($n = 1460$) remaining within the normal body mass index range and the group transferring from normal to overweight (1989–2000).

Table 1 Estimates of the energy gap of different body mass index changes (according to WHO cut-offs)

Group		Number	Median weight gain (kg year^{-1})	Median energy storage (kcal d^{-1})	90th percentile energy storage (kcal d^{-1})	Energy gap* (kcal d^{-1})
Remained within normal range						
	Males	693	0.2	4.3	17.5	35.0
	Females	767	0.2	4.2	15.2	30.4
	Urban	265	0.3	5.8	17.5	35.0
	Rural	1195	0.2	3.7	16.0	32.0
	20–29	459	0.2	5.8	17.5	35.0
	30–39	725	0.2	3.8	14.6	29.2
	40–45	276	0.1	2.5	15.4	30.8
Normal to overweight range change						
	Males	145	1.0	21.1	40.4	80.8
	Females	234	0.8	17.7	30.7	61.4
	Urban	100	0.9	19.2	35.1	70.2
	Rural	279	0.9	19.2	34.6	69.2
	20–29	127	1.1	24	38.4	76.8
	30–39	193	0.9	18.3	32.7	65.4
	40–45	59	0.7	16.1	26.9	53.8
Remained within overweight range						
	Males	53	0.4	8.5	23.1	46.2
	Females	95	0.4	7.7	19.2	38.4
	Urban	46	0.4	8.9	18.3	36.6
	Rural	102	0.3	7.0	21.3	42.6
	20–29	28	0.5	10.1	33.6	67.2
	30–39	66	0.4	8.2	21.3	42.6
	40–45	54	0.3	6.6	18.3	36.6

*Weight gain was significant over time in every group at $P < 0.0001$. Weight gain was not significantly different for men and women.

The fastest rate of weight gain and the highest daily energy accumulation were seen in the group who went from healthy weight to overweight during the 11-year period. The median rate of weight gain in this group was 1.0 kg year^{-1} and the 90th percentile was 1.8 kg year^{-1}. The 90th percentile for daily energy accumulation was 39.4 kcal d^{-1}, and the energy gap was 78.8 kcal d^{-1}.

In the group that remained overweight, the median rate of weight gain was 0.4 kg year^{-1} and the 90th percentile was 1.1 kg year^{-1}. The 90th percentile for daily energy accumulation was 26.7 kcal d^{-1} and the energy gap was 53.4 kcal d^{-1}.

When the BMI classification for Chinese adults (14) is applied to the analysis, using 24 kg m^{-2} as the cut-off for overweight and 28 kg m^{-2} for obesity (Table 2), the average weight gain per year of all the three groups was then similar, but the median of energy storage was all lower than the figures in Table 1, using WHO cut-off

Table 2 Estimates of the energy gap for different body mass index range changes (according to the cut-offs for Chinese adults)

Group	Number	Median of weight gain (kg year^{-1})	Median energy storage (kcal d^{-1})	90th percentile energy storage (kcal d^{-1})	Energy gap* (kcal d^{-1})
Remained within normal range	1221	0.2	3.4	13.8	27.6
Normal to overweight ranges	427	0.8	16.9	27.1	54.2
Remained within overweight range	165	0.2	3.8	12.6	25.0

*Weight gain was significant over time in every group at $P < 0.0001$.

criteria. The energy gap for those remaining within the normal weight range was 27.6 kcal day^{-1}; for people increasing from normal weight into the overweight range, the energy gap was 54 kcal day^{-1} and, perhaps surprisingly, for people who remained overweight, their median energy storage was much lower than the comparable figures in Table 1.

Discussion

Obesity, once present, is difficult to reverse (15,16), and a population strategy based only on treating obesity is not likely to be effective. Preventing the gradual weight gain of the population that is leading to obesity is a more feasible strategy for a population – especially a population such as China – where obesity rates are not yet as high as those in most western countries. This paper provides a theoretical basis for a population strategy of promoting behavioural changes focused on small reductions in energy intake and small increases in physical activity to minimize positive energy balance and prevent weight gain.

Efforts to promote decreased energy intake and increased physical activity may be more effective – if there is a quantitative goal for the degree of change required. Many people attempt dramatic changes in dietary and physical activity patterns; however, such dramatic changes are rarely sustained over the long term. It may be more effective to promote smaller behavioural changes, if such changes are sufficient to prevent weight gain.

Our data suggest that weight gain in China is less than that seen in the United States and in other western countries (12,13). Overall, we estimate that the energy gap for Chinese adults is only 45 kcal d^{-1} as compared with an estimated energy gap in US adults of 100 kcal d^{-1} (15). This means that even smaller degrees of behaviour changes are required to stop the obesity epidemic in China than in other countries. It may be particularly important to begin prevention efforts in China quickly, as the energy gap may increase as the environment further moves towards one that facilitates obesity.

The comparison of the results on the energy gap and energy storage/day between the analyses using WHO and Chinese BMI cut-offs also showed that given the higher disease risk at the same BMI of the Chinese, it is much easier for Chinese adults to move in terms of energy storage from the overweight category into the obesity range. Thus, to keep BMI within the overweight range of 24–27.9 kg m^{-2}, the 90th percentile energy storage for this group of adults was only 12.6 kcal day^{-1} compared with 29–23 kcal day^{-1}, if the WHO cut-off of BMI $\geq$ 30 is applied. This also means that the energy gap required to trigger obesity and its hazards in China was only 25 kcal/day, i.e. about 40% lower than that required to reach the BMI 30 level of Western obesity criteria.

We estimate that modifying diet and/or physical activity to affect energy balance by only 45 kcal d^{-1} would prevent excess weight gain in the population. This can be accomplished with very small changes in diet, in physical activity, or the two in combination. Thus, it should be possible for most people to eat 45 kcal d^{-1} less without changing the types of food they eat or their typical meal patterns. For a typical adult with an energy intake of 2250 kcal d^{-1}, this would mean a reduction of only 2–3% in total daily energy intake. For example, this could be done by eating 40 g less of cooked rice, 25 g less of steamed bread, 2–3 pieces less of Jiaozi (dumplings), or 5 g less of oil each day. Even in those gaining weight at a higher rate and moving from a healthy weight to overweight, the energy gap can be closed with a reduction of only 4–5% in total daily energy intake. This could be accomplished with 70 g less of cooked rice, 40 g less of steamed bread or 10 g less of oil.

Alternatively, the energy gap could be closed entirely with small increases in physical activity and no changes in dietary intake. Most people could close the energy gap with only an additional 10–15 min of brisk walking each day. This would be an additional 1000 m of walking each day or an extra 1200–1500 step. Moreover, this additional walking could be accumulated throughout the day. For those gaining the most weight, closing the energy gap would only require an extra 20–30 min of walking each day – an additional 2000 m more each day or 2400–3000 further steps. It is also possible to combine changes in diet and physical activity that would require even smaller changes in each behaviour.

It is important to point out that our estimate is theoretical and involves several assumptions. While the specific values for the energy gap would change slightly, based on different assumptions, the conclusion would remain that the weight gain that threatens to create an obesity epidemic in China could be prevented with very small lifestyle changes. If lifestyle changes do not occur and the weight gain of the population continues, it may require much larger changes in the future to achieve healthy body weights.

Conflict of Interest Statement

No conflict of interest was declared.

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