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A cross-national comparison of lifestyle between China and the United States, using a comprehensive cross-national measurement tool of the healthfulness of lifestyles: the Lifestyle Index

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Abstract

Background. Extensive studies have revealed the importance of a healthy lifestyle and the role of each lifestyle factor in health. However, lifestyle factors have rarely been studied simultaneously. The authors propose an integrated approach to summarize total healthfulness of lifestyles and to enhance understanding of lifestyle patterns across countries.

Methods. The authors created an overall measure of lifestyle called the Lifestyle Index (LI), integrating diet, physical activity, smoking, and alcohol use to provide a global tool of monitoring healthfulness and patterns of lifestyles. Using the LI, the authors conducted a cross-national comparison between China (n = 8352) and the United States (n = 9750).

Results. The LI effectively reflected the healthfulness of lifestyle components in both countries. The mean of the LI scores was slightly higher in China than the US. Scores of diet quality, physical activity, and smoking were higher in China, but scores of alcohol behavior were higher in the US. Similar lifestyle patterns but different unhealthy behaviors were identified in these countries.

Conclusions. An assessment of total healthfulness of lifestyles and a better understanding of lifestyle patterns across countries using the LI can provide practical guidance to developing and targeting public health promotion activities to improve global public health.

Keywords: Alcohol drinking; China; Diet; Index; Life style; Physical fitness; Smoking; United States

Introduction

Extensive clinical and epidemiological evidence points to the importance of a healthy lifestyle—eating a well-balanced diet, being physically active, not smoking, and drinking alcohol in moderation—in reducing chronic conditions [1–6]. Whereas these lifestyle factors have been amply studied individually in relation to chronic health outcomes, only a few studies have considered them simultaneously, including the interrelation with other lifestyle behaviors [7,8] and their clustering in population subgroups [9,10].

Studies that considered multiple risk factors together include the Framingham study, where the risk for cardiovascular diseases was summarized into a single measure that integrated smoking and a set of clinical measures [11]. More recently, the Chronic Disease Risk Index (CDRI), a semi-quantitative composite measure, combined rankings for smoking, alcohol use, body mass index, fat intake, and fruit and vegetable consumption [12]. These composite measures provided an effective way of assessing health risks for chronic disease. In a longitudinal multiethnic cohort, a higher CDRI was associated with a lower risk of chronic diseases and extended longevity [12].

The Lifestyle Index (LI), an overall measure of lifestyle, is created in this study to provide a more comprehensive measure of healthfulness that summarizes total healthfulness of lifestyles, incorporating current recommendations for lifestyle factors related to chronic health outcomes. The LI integrates detailed component indices of lifestyle behaviors—diet, physical activity, smoking, and alcohol consumption—beyond simple dichotomy or ranking, including the composite measure of diet quality, with differential weights. In addition, to address the gap in the literature in similarities and differences in lifestyle behaviors across countries, the LI

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is created specifically for cross-national comparisons and considers constraints of most population surveys. The index is a tool to offer, by the total LI as well as the four component indices, monitoring of healthfulness of lifestyles globally and thus guidance in public health efforts, and further understanding of lifestyle patterns through cross-national comparisons.

This paper describes the construction of the LI and illustrates its use through a cross-national comparison between China and the US, using national, in-depth surveys from these countries.

Methods

Data and subjects

Data used included the 1993 China Health and Nutrition Survey (CHNS) and the 1994–1996 US Continuing Survey of Food Intakes by Individuals (CSFII). The CHNS included approximately 14,000 individuals in eight provinces, whose socioeconomic and other related health, nutritional, and demographic factors vary substantially [13]. The data collection for the CHNS followed human subject-approval procedures approved by the University of North Carolina at Chapel Hill School of Public Health and the Chinese Academy of Preventive Medicine Human Subjects Protection Committees. The CSFII surveyed a representative national probability sample comprised of more than 16,000 individuals in the US [14]. Both data sets have comparable information on the key lifestyle practices. This study included adults (aged 20 or older) who provided lifestyle data and who were not pregnant or lactating. This resulted in a sample size of 8,352 from the CHNS (age 42.93 ± 15.44 y, 51% females) and 9,750 (age 49.93 ± 17.52 y, 48% females) from the CSFII.

In the CHNS, dietary data were collected on three consecutive days by trained nutritionists using the 24-h recall method, during which detailed household food consumption was also assessed. Respondents gave reports of their work-related activity to provide information on physical activity. Information on smoking status and the average number of cigarettes smoked daily was obtained during a physical examination. Alcohol consumption was ascertained by assessing the frequency of intake of beer, wine, and hard liquor of a standard amount per week and from the 24-h dietary recalls.

In the CSFII, interviewers collected individual food intakes for two nonconsecutive days through in-person 24-h recalls. To measure physical activity, the survey posed questions regarding the frequency of vigorous, sweat-producing exercise. Subjects were also asked if they had smoked more than 100 cigarettes during their entire lifetime. Current smokers were further asked for the number of cigarettes smoked per day. Information on alcohol use was provided by the 2-day 24-h recall data. A detailed description of each survey and methods of data collection are described elsewhere [13,14].

Construction of the LI

To emphasize the importance of preventing chronic conditions (such as cardiovascular disease, cancer, diabetes, osteoporosis, obesity, and impaired overall functional capacity), the LI is constructed based on current scientific lifestyle recommendations related to four major lifestyle factors (Table 1) [6,15–28]. The four lifestyle factors are integrated in the LI as a composite measure of diet quality and an individual component index of physical activity, smoking, and alcohol consumption, described in the following sections.

Diet Quality Index-International

The Diet Quality Index-International (DQI-I) is a composite measure of diet quality, designed for international comparisons of diet quality, assessing four important areas of diet: variety, adequacy, moderation, and overall balance [29].

Variety of diet is evaluated in two aspects—overall variety and variety within protein sources—to assess whether intake comes from diverse sources both across and within food groups. Consumption of at least one serving from each of the five food groups daily (meat, poultry, fish, egg; dairy, beans; grains; fruits; and vegetables) defines the maximum overall variety score. A maximum score of dietary protein variety is defined as consumption of at least three different sources of protein (from among meat, poultry, fish, dairy, beans, and eggs) per day. The adequacy category evaluates the intake of fruits, vegetables, grains, protein, iron, calcium, vitamin C, and dietary fiber. Daily consumption of these food and nutrients is compared with the recommended level, and results are displayed on a continuous scale ranging from 0% to 100%. The moderation category evaluates intakes of food and nutrients that can contribute to the development of chronic diseases, and therefore perhaps need restriction. Percentage of energy intake of total fat, saturated fat, and empty calorie foods and the level of cholesterol and sodium intake are evaluated. Lastly, DQI-I examines an overall balance of diet in terms of proportionality in the energy sources and fatty acid composition. The total DQI-I score ranges from 0 (poorest) to 100 (best possible).

Physical Activity Index

The literature consistently indicates that a sedentary lifestyle increases the risk of developing several chronic diseases and conditions, whereas regular physical activity enhances overall health [30]. Physical activity includes any bodily movements produced by skeletal muscles that result in energy expenditure, covering daily activities at work and structured exercise training [31]. Over 30 min of moderate-intensity physical activity on each day of the week [32] is

Table 1
Lifestyle recommendations for the prevention of major chronic health conditions

Health conditions	Lifestyle recommendations			
	Diet	Physical activity	Smoking	Drinking
Cardiovascular diseases [6,15–17]	low in total fat, saturated fat, cholesterol, and sodium; high in fiber and complex carbohydrates; caloric balance	aerobic exercise	no smoking	moderate drinking; avoid heavy drinking
Cancers [18–21]	low in total fat, saturated fat, cholesterol; high in fiber and complex carbohydrates; high in antioxidant nutrients	generally increase physical activity	no smoking	avoid heavy drinking
Osteoporosis [22–24]	high calcium, vitamin D, and protein intake; balance between calcium and phosphorus intake	weight-bearing physical exercise	no smoking	avoid heavy drinking
Type 2 diabetes [25,26]	low in total fat, saturated fat, cholesterol; low in simple sugar; high in fiber and complex carbohydrates	increase physical activity to avoid weight gain and to maintain healthy weight	no smoking	avoid heavy drinking
Obesity [27]	decrease total energy intake, maybe fat intake; maintain energy balance	increase physical activity	smoking decreases body weight, but smoking is not recommended for a weight loss	avoid heavy drinking
Impaired overall functioning [28]	adequate dietary intake; balanced nutrient intake	continuous moderate physical activity	no smoking	avoid heavy drinking

recommended to obtain benefits from physical activity. Relatively short bouts of physical activity can be added in an accumulative manner. Total amount [32] and the level [33] of physical activity (except for light sports activities) show graduated benefits.

Since the more useful data on level, frequency, and duration are lacking in most population surveys, the Physical Activity Index (PAI) categorizes activity levels into five groups: very active, active, moderate, light, and sedentary, and assigns a gradient of scores from 10 (very active) to 0 (sedentary).

Smoking Index

Cigarette smoking is a significant risk factor for chronic diseases, especially lung cancer and cardiovascular diseases [34]. Cessation of smoking seems to restore some of the adverse health effects of smoking [3,35], as former smokers generally have morbidity and mortality risks intermediate to those of never-smokers and current smokers [36].

The Smoking Index (SMI) is based on both the status and amount of smoking. Categories of smoking status include nonsmokers, former smokers, and current smokers. Nonsmokers, who have never smoked, are given the highest score of 10. Current smokers are categorized into four groups based on the number of cigarettes smoked per day, and a descending gradient of scores (from 5 to 0) is given as the smoking amount increases. Smokers are given a score of five at best, because smoking with any intensity significantly elevates the risk of chronic diseases [34]. Since the health benefits of smoking cessation are noticeable, the higher score of 7 points is given to former smokers.

Alcohol Consumption Index

The detrimental health effect of heavy drinking, on blood pressure and triglycerides, for example, is well known [37]. More recently, a protective effect of regular moderate alcohol consumption on cardiovascular health has been fairly well established [38]. Consuming amounts of alcohol comparable to those shown protective, with a different pattern of binge drinking, however, has been linked to adverse cardiovascular effects [39], particularly sudden death [40]. Therefore, the Alcohol Consumption Index (ACI) considers not only the amount but also the pattern of alcohol consumption (regularly moderate or binge) that has commonly been ignored in past studies.

A standard ‘‘drink’’ is defined as an amount of an alcoholic beverage containing about 13 g of pure alcohol. This approximates the amount used in the US Food Pyramid Guide [41], equivalent to about 12 fl oz of beer, 5 fl oz of wine, or 1.5 fl oz of 80-proof distilled spirits. Four or more drinks for women and five or more drinks for men per occasion are considered binge drinking and are given the lowest score of 0. If the subject is not a binge drinker, the number of drinks per week is categorized further. Both abstinence and moderate consumption categories are given the highest score of 10, as the difference in health benefits between them is not distinguishable [38]. A descending gradient of scores is given for the more-than-moderate

Table 2
Comparison of scores of the Lifestyle Index (LI) and its component indices between China and the United States

Component	Score	Scoring criteria	China[a]		US[b]	
			Mean (SE)			
			% Population in subgroups[c]			
Lifestyle Index	0–100 points		**68.2**[d]	**0.19**	**66.1**	**0.25**
Diet Quality Index-International	0–100 points		**60.5**[d]	**0.11**	**59.1**	**0.14**
1. Variety	0–20 points		**11.8**	**0.06**	**15.6**[d]	**0.04**
Various food groups (meat, poultry, fish, eggs; dairy, beans; grain; fruit; vegetable)	0–15 points		**9.2**	**0.04**	**11.4**[d]	**0.04**
		at least 1 serving from each food group per day = 15	2.4		23.3	
		any 1 food group missing = 12	28.8		41.6	
		any 2 food groups missing = 9	43.6		26.9	
		any 3 food groups missing = 6	25		6.9	
		≥4 food groups missing = 3	0.3		1.2	
		none from any food groups = 0	0		0.1	
Within-group variety for protein source (meat, poultry, fish, dairy, beans, eggs)	0–5 points		**2.5**	**0.03**	**4.2**[d]	**0.02**
		≥3 different sources per day = 5	28.1		68.4	
		2 different sources per day = 3	28.6		25.1	
		from 1 source per day = 1	27.0		6.1	
		none = 0	16.3		0.4	
2. Adequacy	0–40 points		**28**	**0.05**	**28.6**[d]	**0.08**
Vegetable group[e]	0–5 points	≥3 to 5 servings = 5, 0 servings = 0	**4.7**[d]	**0.01**	**3.8**	**0.02**
		≥100%	82.2		42.1	
		99–50%	14.7		37.7	
		<50%	3.1		20.2	
Fruit group[e]	0–5 points	≥2 to 4 servings = 5, 0 servings = 0	**0.2**	**0.01**	**2.0**[d]	**0.03**
		≥100%	0.4		19.6	
		99–50%	2.4		23.4	
		<50%	97.2		57.0	
Grain group[e]	0–5 points	≥6, ≥9, ≥11 servings = 5, 0 servings = 0	**5.0**[d]	**0.002**	**3.0**	**0.02**
		≥100%	99.1		9.6	
		99–50%	0.7		59.8	
		<50%	0.2		30.7	
Protein	0–5 points	≥10% of energy = 5, 0% of energy = 0	**4.9**	**0.004**	**5.0**[d]	**0.003**
		≥100%	80.3		95.3	
		99–50%	19.6		4.5	
		<50%	0.1		0.1	
Iron	0–5 points	≥100% RDA (AI) = 5, 0% RDA (AI) = 0	**4.7**[d]	**0.01**	**4.3**	**0.01**
		≥100%	68.3		68.9	
		99–50%	30.4		22.5	
		<50%	1.3		8.7	
Calcium	0–5 points	≥100% AI = 5, 0% AI = 0	**2.4**	**0.02**	**3.1**[d]	**0.02**
		≥100%	2.9		16.0	
		99–50%	36.4		44.9	
		<50%	60.7		39.1	
Vitamin C	0–5 points	≥100% RDA (RNI) = 5, 0% RDA (RNI) = 0	**3.9**[d]	**0.02**	**3.7**	**0.02**
		≥100%	43.3		44.0	
		99–50%	37.1		27.9	
		<50%	19.6		28.1	
Fiber[e]	0–5 points	>20 g, >25 g, >30 g = 5, 0 g = 0	**2.2**	**0.02**	**3.1**[d]	**0.02**
		≥100%	3.9		13.9	
		99–50%	28.7		52.6	
		<50%	67.3		33.5	
3. Moderation	0–30 points		**18.6**[d]	**0.1**	**14.3**	**0.08**
Total fat	0–6 points		**3.0**[d]	**0.04**	**1.2**	**0.03**
		≤20% of total energy = 6	33.7		5.5	
		>20–30% of total energy = 3	31.5		27.4	
		>30% of total energy = 0	34.9		67.1	
Saturated fat	0–6 points		**4.2**[d]	**0.04**	**1.5**	**0.04**
		≤7% of total energy = 6	57.6		11.4	
		>7% to 10% of total energy = 3	24.5		27.2	
		>10% of total energy = 0	18.0		61.4	

(continued on next page)

Table 2 (*continued*)

Component	Score	Scoring criteria	China[a]		US[b]	
			Mean (SE)			
			% Population in subgroups[c]			
Cholesterol	0–6 points		**4.9**[d]	**0.03**	**4.5**	**0.03**
		≤300 mg = 6	77.2		66.4	
		>300 to 400 mg = 3	8.2		14.4	
		>400 mg = 0	14.6		19.2	
Sodium	0–6 points		**0.85**	**0.03**	**2.7**[d]	**0.04**
		≤2400 mg = 6	9.5		30.9	
		>2400 to 3400 mg = 3	9.3		29.9	
		>3400 mg = 0	81.3		39.2	
Empty calorie foods	0–6 points		**5.8**[d]	**0.01**	**4.5**	**0.03**
		≤3% of total energy per day = 6	94.5		63.7	
		>3% to 10% of total energy per day = 3	2.8		22.6	
		>10% of total energy per day = 0	2.7		13.8	
4. Overall balance	0–10 points		**2.1**[d]	**0.04**	**1.1**	**0.02**
CPF ratio (C:P:F)[f]	0–6 points		**1.2**[d]	**0.03**	**0.5**	**0.02**
		55–65:10–15:15–25 = 6	4.8		1.2	
		52–68:9–16:13–27 = 4	14.0		5.1	
		50–70:8–17:12–30 = 2	15.6		9.6	
		otherwise = 0	65.6		84.1	
Fatty acid ratio (PUFA:MUFA:SFA)[g]	0–4 points		**1.0**[d]	**0.02**	**0.6**	**0.02**
		P/S = 1–1.5 and M/S = 1–1.5 = 4	14.5		7.1	
		Else if P/S = 0.8–1.7 and M/S = 0.8–1.7 = 2	19.3		16.2	
		otherwise = 0	66.2		76.7	
Physical Activity Index	0–10 points		**5.5**[d]	**0.04**	**5**	**0.05**
1. Level of physical activity		very active = 10	0.8		26.7	
		active = 8	51.6		21.4	
		moderate = 5	18.2		7.4	
		light = 2	17.1		5.2	
		sedentary = 0	12.4		39.3	
Smoking Index	0–10 points		**7.2**[d]	**0.04**	**7.1**	**0.05**
1. Smoking status	0–10 points	nonsmokers = 10	66.7		47.8	
		former smokers = 7	3		27.2	
		current smokers	30.3		25	
2. Smoking amount (average number of cigarettes smoked per day)		light smokers (1–4 cigarettes/day) = 5	3.3		2.4	
		light-medium smokers (5–9) = 3	3.3		2.3	
		medium smokers (10–19) = 1	9.3		6.6	
		heavy smokers (≥20) = 0	14.4		13.8	
Alcohol Consumption Index	0–10 points		**9**	**0.03**	**9.3**[d]	**0.03**
1. Drinking pattern (number of drinks per occasion)	0–10 points	binge drinkers (F: ≥4; M: ≤5) = 0	2.5		3.8	
		non- or regular drinkers (F: <4; M: <5):	97.5		96.2	
2. Drinking amount (number of drinks per week)		abstinence = 10	67.3		63.7	
		moderate drinking (F: <1 to 7; M: <1 to 14) = 10	19.9		26.6	
		more than moderate drinking:				
		(F: <7 to 14; M: <14 to 21) = 6	3.7		3.7	
		(F: <14 to 21; M: <21 to 28) = 3	1.7		1.6	
		(F: <21 to 28; M: <28 to 35) = 1	1.2		0.5	
		heavy drinking (F: >28; M: >35) = 0	3.7		0.2	

[a] Based on sample size of 8352 (China) and 9750 (US) persons.
[b] Design effect controlled for in China. Mean estimate (SE) values are in boldface.
[c] Adjusted for the CSFII sampling weights for the US. Mean estimate (SE) values are in boldface.
[d] Significantly greater than the counterpart ($P < 0.0001$).
[e] Based on 1700, 2200, and 2700 kcal diet.
[f] CPF ratio: a ratio of energy intake from carbohydrate:protein:fat.
[g] PUFA:MUFA:SFA: a ratio of an intake of polyunsaturated fatty acids–monounsaturated fatty acids–saturated fatty acids.

consumption category as the amount increases. Although the beneficial effect of moderate alcohol consumption may depend on the type of alcoholic beverage (wine, liquor, or beer) [42], the ACI did not distinguish between them due to inconclusive evidence [43].

Overall structure and scoring system

A weighted sum of the four components results in the overall LI score ranging from 0 to 100, with a higher score representing a healthier lifestyle. The four components are weighted according to the degree that they affect long-term

health—based on a comprehensive review of the literature. Ideally, the weights would be best determined by analyzing the lifestyle behaviors against overall longitudinal health outcomes around the world; however, such data are not available. Therefore, information on population attributable risks (PARs) and relative risks (RRs) of each lifestyle factor for chronic diseases and mortality, mainly from the studies of the US, were reviewed and used.

According to the literature, among the four lifestyle factors physical activity and smoking contributed the greatest to the risk of chronic diseases, followed by dietary intake and alcohol use [33,44–48]. Therefore, differential weights based on the literature that distinguish the relative importance of these lifestyle factors are believed to make the LI a more practical and reasonable measurement tool than would arbitrary equal weights. The assigned weights are 0.2 to DQI-I, 0.3 to PAI, 0.3 to SMI, and 0.2 to ACI. The LI is based on applying the weights to the component parts' percent of perfect score.

Calculation of the scores for the component indices of the LI for CHNS and CSFII data

The actual application of the LI to the data sets had to consider slight differences in data availability between the CHNS and the CSFII.

In the DQI-I, the CHNS food intake data were converted into number of servings using the US Food Guide Pyramid serving size definitions [49] to result in comparable serving sizes in both countries. For the evaluation of adequacy, country-specific Dietary Reference Intake (DRI) [50,51] was used.

For China, people were categorized into the five levels of physical activity for the PAI based mainly on work activity. People with very heavy levels of work activity were grouped into 'very active', heavy into 'active', moderate into 'moderate', light into 'light', and very light into 'sedentary'. For the US, the frequency of vigorous exercise was categorized into five groups: daily or five to six times per week as 'very active', two to four times per week as 'active', once per week as 'moderate', one to three times per month as 'light', and rarely or never as 'sedentary'. For people with activity data missing (n = 340, 4.07% of the sample in China; n = 40, 0.41% in the US), the level of physical activity was imputed by regression using related variables available from the surveys (daily caloric intake, area of residence, level of income and education, and occupation for both countries, and physical disability conditions additionally for China).

For the SMI in China, subjects who had never smoked were considered nonsmokers. For the rest of the subjects, current smokers were distinguished from former smokers. Current smokers were categorized into four groups based on the number of cigarettes smoked per day. For the US, if a person had smoked more than 100 cigarettes during their entire lifetime, he or she was excluded from the nonsmoker category. If the person was not currently smoking, he or she was classified as a former smoker. The rest of the subjects were considered as current smokers, and the number of cigarettes smoked per day was examined to group them accordingly.

For the ACI, the pattern of drinking was identified from the three and two days of 24-h recalls for China and the US, respectively. To assess the amount of alcohol intake, for the CHNS, frequency of consumption of beer, wine, and hard liquor of a standard amount per week was converted into the amount of pure alcohol, using the pure alcohol content obtained from the food composition table [52]. The average value (4% for beer, 12% for wine, and 50% for hard liquor) was used as a representative alcohol concentration. For those whose frequency data were missing (n = 173, 2.1% of the sample), alcohol intake in the 24-h recalls were examined alternatively. The daily alcohol intakes were averaged and converted into a weekly consumption amount. For the US, no frequency data were available, so the average amount of pure alcohol from the two 24-h recalls was converted into a measure of quantity consumed.

Statistical analysis

The scores of the LI and its four component indices were descriptively summarized for each country. For the comparison of continuous variables, a t test was used, and of categorical variables, the chi-square test was used. These analyses were performed using SAS statistical software: SAS/STAT Release 8.2 [53]. To determine trends of the mean of some lifestyle behaviors across ordered groups of LI scores, a nonparametric test (nptrend—an extension of the Wilcoxon rank sum test) was conducted [54]. A stringent P value of 0.0001 or smaller was used to denote statistical significance in all analyses to give protection for overall level of significance, since a large number of comparisons were made. The scores of the component indices were dichotomized into good (≥60% of the full score) or poor (<60% of the full score) categories to identify representative lifestyle patterns in both countries. The continuous LI scores were further categorized into quartiles for diverse data analyses. In both data sets, data were collected from multiple members of the same households, whose lifestyles may be correlated. A Huber correction was used to control for correlation of lifestyle behaviors among the same household members. Also, design effects were controlled for the CHNS data using survey commands from the Stata statistical software (Stata 7). For the US, results were adjusted for the CSFII sampling weights, making the results representative of the total US population.

Results

The mean estimates of the scores of the LI component indices (unweighted) and the proportion of the sample in the

component subcategories are summarized for China and the US (Table 2). The mean of the total LI score, a weighted sum of the four component indices, was higher in China than in the US ($P < 0.0001$). Among the scores of the LI component indices, those of the DQI-I, PAI, and SMI were higher in China, whereas those of the ACI were higher in the US. The goal of physical activity was least achieved, whereas that of alcohol consumption behavior was best accomplished in both countries. The largest difference between the countries was found in the weighted scores of the PAI.

The mean of the DQI-I scores reached about 60% of the full score in both countries. Dietary variety was greater in the US diet, whereas moderation and overall balance was superior in China. The higher DQI-I scores in China were mainly derived from higher intakes of food from the vegetable and grain groups and lower intakes of fat compared with those in the US. The adequacy score in both countries was reduced, mainly due to poor compliance with the recommendations for the intakes of fruit, calcium, and fiber, and particularly in the US, of grains. The poor scores of the components in the moderation category except sodium intake resulted in a lower moderation score in the US. The overall balance category was the weakest category in both countries. The most drastic difference in DQI-I scores between China and the US was in the intakes of grain and fruit within the adequacy category, and in the intake of saturated fat within the moderation category. Intake of grain was much higher in China, whereas intake of fruit and saturated fat was significantly higher in the US.

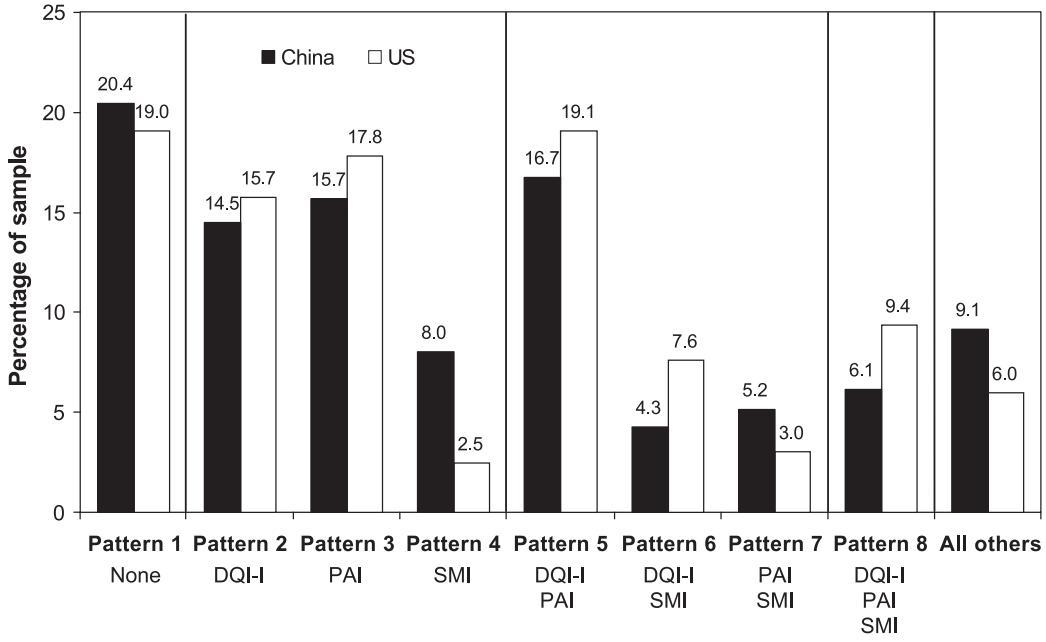
The PAI showed a wide range of scores with great variation among the populations. Whereas the US had a significantly higher proportion of very active people than China (26.7% vs. 0.8%), there was also a much greater proportion of sedentary people in the US than China (39.3% vs. 12.4%). China had more than double the proportion of people engaged in active, moderate, and light levels of activity, compared with those in the US. The mean of the resulting PAI scores was significantly higher in China.

The SMI scores also showed a very different distribution in China from that of the US. In the US, the perfect SMI score was achieved by about one-half of the population. The remaining half of the population was nearly evenly divided into former smokers and current smokers. Among the current smokers, more than half was heavy smokers. China had a greater proportion of current smokers than the US (30.3% vs. 25.0%), and the smokers in China included a slightly greater proportion of heavy smokers than the US (14.4% vs. 13.8%). At the same time, China also had a significantly greater proportion of nonsmokers than the US (66.7% vs. 47.8%), which contributed to the higher total SMI scores in China.

Table 3
Mean values of selected lifestyle behaviors by the LI score category in China and the United States[a]

	LI score category					
	0 to ≤45	>45 to ≤55	>55 to ≤65	>65 to ≤75	>75 to ≤85	>85
China						
No. of subjects in the category	1025	662	1518	1378	1362	2407
LI score[b]	34	49.7	59.8	68.5	79.3	86.6
DQI-I score[b]	11.7	12.0	12.1	12.0	11.7	12.6
PAI score[b]	10.3	13.9	13.1	10.2	18.4	24.1
SMI score[b]	2.8	7.3	15.4	27.5	29.5	30.0
ACI score[b]	9.3	16.4	19.1	18.8	19.7	20.0
Vegetable servings per day[b]	7.2	7.4	7.6	7.1	7.2	8.7
Grain servings per day[b]	19.4	20.6	21.4	18.5	19.3	24.3
% Energy from fat[b]	29.9	28.6	26.2	29.1	28.1	19.8
% ≥ Moderate physical activity[b]	41.2	71.9	55.6	27.7	100.0	100.0
No. of cigarettes smoked per day[b]	16.8	11.9	8.3	0.5	0.007	0.0
No. of drinks per week[b]	27.0	9.9	3.7	3.0	1.1	0.47
United States						
No. of subjects in the category	1322	1286	2511	1021	1605	2005
LI score[b]	32.6	51.5	60.7	69	80.2	90.1
DQI-I score[b]	10.7	11.2	11.6	12.4	11.9	12.8
PAI score[b]	3.0	4.9	8.3	15.2	24.6	27.9
SMI score[b]	3.5	16.9	21.6	24.0	24.3	29.4
ACI score[b]	15.4	18.5	19.2	17.4	19.4	20.0
Vegetable servings per day[b]	3.1	3.2	3.2	3.4	3.6	3.6
Grain servings per day[b]	5.9	6.3	6.0	6.6	6.8	6.9
% Energy from fat[b]	34.4	35.0	33.7	31.4	33.9	31.3
% ≥ Moderate physical activity[b]	10.7	22.5	29.8	61.1	100.0	100.0
No. of cigarettes smoked per day[b]	19.9	4.6	5.2	1.1	0.07	0.0
No. of drinks per week[b]	9.6	3.4	2.0	5.5	2.0	0.97

[a] Based on sample size of 8352 (China) and 9750 (US) persons.
[b] Test for trend significant at $P < 0.0001$ level.



Note: 1) The components of LI listed below the patterns are the areas of unhealthy lifestyle (< 60 % of full score) of the patterns (DQI-I: Diet quality; PAI: Physical activity; SMI: Smoking).
2) Based on 8,352 (China) and 9,750 (US) persons.

Fig. 1. Major pattern distribution of lifestyle behaviors in China and the US.

The mean of the ACI score was higher in the US. Only a small proportion of the population was identified as binge drinkers based on a few days of 24-h recalls, which was greater in the US than in China (3.8% vs. 2.5%). Close to 90% of the population was considered nondrinkers or moderate drinkers in both countries. The fewer alcohol consumers in China included a greater proportion of heavy drinkers than the US (3.7% vs. 0.2%), whereas the US had a greater proportion of moderate drinkers than China (26.6% vs. 19.9%).

Table 3 presents the mean of selected lifestyle characteristics by subgroups of the population, categorized based on the LI score, to examine how the LI scores reflected the variation in the individual components on which the index was based. The increasing trends of the LI component index scores were consistent with the increase of the LI score in

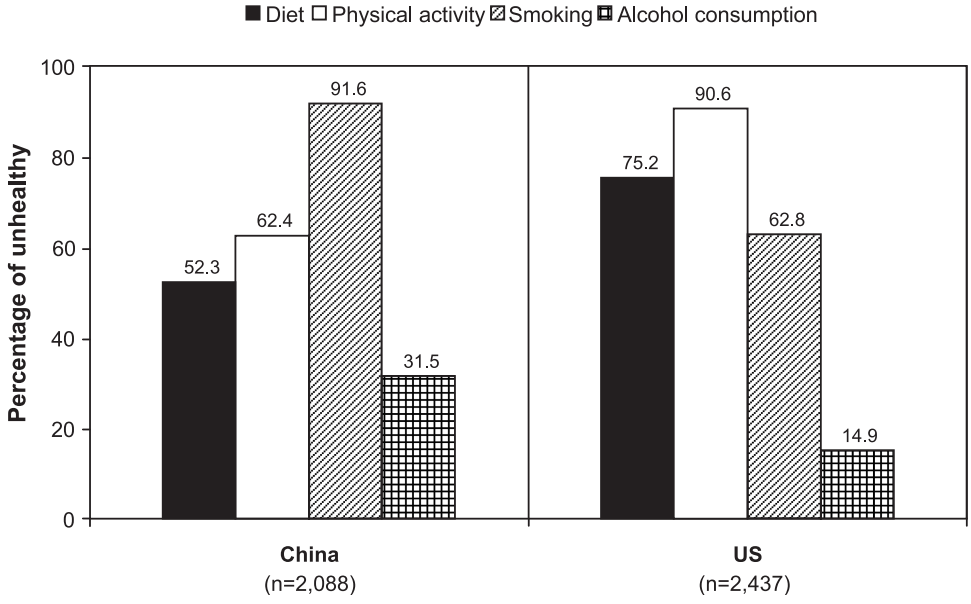


Fig. 2. Percentage of individuals among the lowest LI quartile with poor scores in the four component indices of the LI (<60% of full score) in China and the US.

both countries. Each lifestyle behavior also moved toward a desirable pattern as the LI score increased.

Based on the dichotomization of the scores of the four component indices at the level of 60% of the full scores, some representative lifestyle patterns were identified. Of 16 possible patterns from different combinations of good or poor category of the four components, the most predominant eight patterns are presented in Fig. 1. The most predominant four patterns (Patterns 1, 2, 3, and 5) represented about 70% of the population in both countries. The pattern with none of the four areas rated unhealthy (Pattern 1) was the most predominant pattern in China. The same pattern, and the one with poor diet quality and poor physical activity (Pattern 5), was equally significant in the US.

To identify underlying problems of unhealthy lifestyles in each country, the composition of lifestyles in the lowest LI score quartile group was further examined. Fig. 2 shows the proportions of individuals in the lowest quartile with unhealthy lifestyles (below 60% of the full score) for the four component indices of the LI. Overall, China had higher proportions of people with unhealthy smoking and unhealthy alcohol use than the US, whereas the US had higher proportions of people with poor diet quality and less physical activity than China. Poor smoking behavior was the most predominant problem of the unhealthy lifestyles in China, whereas lack of physical activity followed by poor diet quality prevailed in the unhealthy lifestyles in the US.

Discussion

The introduction of the concept of the LI can be understood as a parallel to the recent trends seen in the area of dietary assessment, where a composite measure of diet is preferred to the index of a single nutrient or food as a measure of diet quality [55]. Composite measures of diet quality have been associated with favorable health outcomes [56,57], more strongly than single index measures have been [58]. The LI, described here, integrates the detailed component indices of important lifestyle factors into a summary measure with differential weights, presenting a promising new way of examining the overall healthfulness of a given lifestyle. The LI can provide a useful evaluation tool of healthfulness of lifestyles, as the index was created solidly based on the principles of healthy lifestyles found in the literature.

Some data suggest that components of lifestyle may act synergistically to elevate or augment the health effect of lifestyle behaviors. For example, combined effects of poor diet and heavy smoking may differ from the simple sum of their individual effects [59]. Biological and epidemiological evidence, however, is not conclusive enough to quantify these synergistic mechanisms into estimates that can be incorporated into the LI. The construction of the LI, therefore, did not include the concept of synergism among the lifestyle factors.

For the LI to be used for a cross-national comparison, only the key aspects of lifestyles were selected as the components of the LI, considering limited information from population surveys. For example, the SMI did not distinguish former smokers according to their past smoking amount. Some of the important aspects of smoking, such as the age of onset, other types of smoking (e.g., pipe smoking), and exposure to environmental smoking, were not included in the SMI. Whereas an inclusion of the detailed information would result in a more precise measure of healthfulness of lifestyle, the LI provides a novel tool that enables a multinational comparative work.

The largest difference in percent of perfect scores between China and the US was shown in the PAI, which were significantly higher in China. As society develops economically, the level of physical activity tends to drop due to the increasing energy-saving resources available. This fact, along with the changing dietary intake toward higher fat and added sugar, may be one of the major causes of overweight [60,61].

Issues related to the comparison of the PAI scores between China and the US are worth addressing. For China, the level of activity was more of a reflection of work activity [62], whereas for the US, it was primarily that of leisure-time activity. Work and leisure-time activities were not assessed together, and the estimate of physical activity may also have been biased, as people who are engaged in vigorous leisure-time physical activity are shown to be less physically active at work [63]. Also, the use of different types of data in the ACI—preferred frequency data [64] for China and two 24-h recalls for the US—may have caused uneven assessment of amount of alcohol consumption between China and the US. Alcohol drinking behaviors are known to depend largely on the day of the week [66]. Since data were not available to measure weekend versus weekday intakes for each individual, estimation of usual alcohol intakes may have been underestimated in the US.

Besides the data comparability issue, there may be a difference in self-reporting of lifestyle behaviors between China and the US. Overreporting of fruit and vegetable intake [65] and physical activity [67], and underreporting of energy and fat intake [68], smoking [69], and alcohol consumption [38] are some of the most common reporting biases found in the literature. The degree and even the direction of bias may differ among individuals with varying level of behaviors [70]. In our cross-national comparison, differential reporting bias between the two countries may have been a more important issue. These under- or overreporting biases can be very culturally sensitive, but the difference between the countries has not been fully explored. Although there is no direct information about under or overreporting of health behaviors comparing Chinese with the US populations, there is evidence that socially desirable behaviors tend to be overreported, whereas culturally less acceptable behaviors tend to be underreported [71,72]. Therefore, differences in norms may best hint

possible differential reporting biases in these countries. Sociodemographic characteristics such as gender may be an important factor that determines reporting of health behaviors especially in China. For example, underreporting of smoking and alcohol consumption by females is very likely in China. On the other hand, underreporting of fat intake may have been greater in the US than in China, as the cultural desirability for reduced fat intake is much stronger in the US than in China. The real difference in fat intakes between the two countries, therefore, may be even greater than what was observed in this study. Whereas physical activity may have been overreported in the US data, it is unlikely in the China data, as the estimates used in this study were derived from work-based activity, and higher physical activity is culturally not considered prestigious in China. Based on this rough estimation, reporting biases may have worked toward more favorable LI scores for the US than China, which may have resulted in an underestimation of the difference in LI scores between the countries.

The way each component index of LI was constructed led to some noticeable results. The ACI scores were best achieved among the components of the LI when examined in percent of perfect score, followed by the SMI scores. The higher population mean of the ACI and SMI scores may be related to the limited amount of information by which we have failed to identify all the negative behaviors. Smaller differences in the DQI-I scores across LI score groups compared to the other component score (Table 3) reflect complexity of relationships among dietary qualities. Among the four main categories of the DQI-I, dietary variety and dietary moderation are negatively correlated [73].

The LI identified some comparable and country-specific lifestyle characteristics. The major patterns of lifestyle defined by different combinations of healthfulness of the four lifestyle factors were similar in China and the US. However, an examination of the scores of each separate component index in addition to the total LI scores revealed some country-specific public health concerns. In general, an improvement of smoking behaviors is most needed in China, whereas an achievement of healthier lifestyles through a better diet quality and an increase in physical activity is desirable in the US. This illustrates the usefulness of the LI; although overall healthfulness of lifestyles may seem similar between countries, a closer examination of the component indices can identify substantial differences in lifestyle patterns and direct areas of lifestyles needing interventions.

It was surprising that the overall LI scores did not differ more between China and the US. The use of the LI allowed us to identify similarities and differences across all lifestyle characteristics, but also illustrated that the overall healthfulness of lifestyles differ less than might have been expected between a developed country such as the US versus a country like China that has undergone more recent economic development and nutrition transition. Possible differential reporting bias between the countries discussed earlier may in part explain the small difference. Also, lifestyle is multidimensional and it is clear in this case that the lifestyles in each country have quite different strengths and weaknesses.

The LI, as illustrated in this study, is a useful means of monitoring healthfulness of lifestyles across countries and improving the information necessary for developing effective interventions. The fact that the LI incorporated modifiable lifestyle behaviors implies that it is a very practical tool to evaluate one's lifestyle for directing changes for improvement. The index can also be used to identify populations at risk that have a clustering of poor diet and other unhealthy lifestyle behaviors in future studies. Using the LI, determinants of overall lifestyles can be explored, which cannot be accomplished by analyzing individual lifestyle components separately. A better understanding of lifestyle behaviors with the use of the LI is believed to provide practical guidance to the development and targeting of public health promotion activities to improve global public health.

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References

[1] Shikany JM, White Jr GL. Dietary guidelines for chronic disease prevention. South Med J 2000;93(12):1138–51.
[2] Lee IM, Paffenbarger Jr RS, Hennekens CH. Physical activity, physical fitness and longevity. Aging 1997;9(1–2):2–11.
[3] Minami J, Ishimitsu T, Matsuoka H. Effects of smoking cessation on blood pressure and heart rate variability in habitual smokers. Hypertension 1999;33(1 Pt. 2):586–90.
[4] Palomaki H, Kaste M. Regular light-to-moderate intake of alcohol and the risk of ischemic stroke. Is there a beneficial effect? Stroke 1993;24(12):1828–32.
[5] Weisburger JH. Prevention of cancer and other chronic diseases worldwide based on sound mechanisms. BioFactors 2000;12(1–4):73–81.
[6] Grundy SM, Balady GJ, Criqui MH, Fletcher G, Greenland P, Hiratzka LF, et al. Guide to primary prevention of cardiovascular diseases. A statement for healthcare professionals from the task force on risk reduction. American Heart Association Science Advisory and Coordinating Committee. Circulation 1997;95(9):2329–31.
[7] Castro FG, Newcomb MD, McCreary C, Baezconde-Garbanati L. Cigarette smokers do more than just smoke cigarettes. Health Psychol 1989;8:107–29.
[8] Norman RM. Studies of the interrelationships amongst health behaviors. Can J Public Health 1985;76:407–10.
[9] Patterson RE, Haines PS, Popkin BM. Health lifestyle patterns of U.S. adults. Prev Med 1994;23:453–60.
[10] Raitakari OT, Leino M, Rakkonen K, Porkka KV, Taimela S, Rasanen L. Clustering of risk habits in young adults. The cardiovascular risk in young finns study. Am J Epidemiol 1995;142:36–44.
[11] Kannel WB, Gordon T, editors. The Framingham Study: An Epide-

miologic Investigation of Disease. Bethesda (MD): National Institute of Health; 1974. p. 74–618. Section 28, DHEW.
[12] Meng L, Maskarinec G, Lee J, Kolonel LN. Lifestyle factors and chronic diseases: application of a composite risk index. Prev Med 1999;29(4):296–304.
[13] The China Health and Nutrition Survey. [version online]. Available from: Carolina Population Center. The University of North Carolina at Chapel Hill (http://www.cpc.unc.edu/projects/china/) (accessed 20 November 2001).
[14] USDA. Design and operation: The Continuing Survey of Food Intakes by Individuals and the Diet and Health Knowledge Survey, 1994–96. NFS Report No. 96-1. May 1998.
[15] Fletcher GF, Balady G, Blair SN, Blumenthal J, Caspersen C, Chaitman B, et al. Statement on exercise: benefits and recommendations for physical activity programs for all Americans: a statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association. Circulation 1996;94:857–62.
[16] Holbrook JH, Grundy SM, Hennekens CH, Kannel WB, Strong JP. Cigarette smoking and cardiovascular diseases: a statement for health professionals by a task force appointed by the steering committee of the American Heart Association. Circulation 1984;70:1114A–7A.
[17] Gaziano JM, Manson JE. Diet and heart disease. The role of fat, alcohol, and antioxidants. Cardiol Clin 1996;14(1):69–83.
[18] Greenwald P, Clifford CK, Milner JA. Diet and cancer prevention. Eur J Cancer 2001;37(8):948–65.
[19] Thune I, Furberg AS. Physical activity and cancer risk: dose–response and cancer, all sites and site-specific. Med Sci Sports Exerc 2001;33(Suppl. 6):S530–50.
[20] Weisburger JH. Worldwide prevention of cancer and other chronic diseases based on knowledge of mechanisms. Mutat Res 1998; 402(1–2):331–7.
[21] Longnecker MP, Enger SM. Epidemiologic data on alcoholic beverage consumption and risk of cancer. Clin Chim Acta 1996;246(1–2): 121–41.
[22] Keen RW. Effects of lifestyle interventions on bone health. Lancet 1999;354(9194):1923–4.
[23] Lunt M, Masaryk P, Scheidt-Nave C, Nijs J, Poor G, Pols H, et al. The effects of lifestyle, dietary dairy intake and diabetes on bone density and vertebral deformity prevalence: the EVOS study. Osteoporos Int 2001;12(8):688–98.
[24] Turner RT. Skeletal response to alcohol. Alcohol Clin Exp Res 2000;24(11):1670–93.
[25] Foreyt JP, Poston II WS. The challenge of diet, exercise and lifestyle modification in the management of the obese diabetic patient. Int J Obes Relat Metab Disord 1999;23(Suppl. 7):S5–11.
[26] Ritz E, Ogata H, Orth SR. Smoking: a factor promoting onset and progression of diabetic nephropathy. Diabetes Metab. 2000; 26(Suppl. 4):54–63.
[27] Martinez JA. Body-weight regulation: causes of obesity. Proc Nutr Soc 2000;59(3):337–45.
[28] Woo J. Relationships among diet, physical activity and other lifestyle factors and debilitating diseases in the elderly. Eur J Clin Nutr 2000;54(Suppl. 3):S143–7.
[29] Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. J Nutr (in press).
[30] Blair SN, Kohl HW, Gordon NF, Paffenbarger Jr RS. How much physical activity is food for health? Ann Rev Public Health 1992;13:99–126.
[31] Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness. Public Health Rep 1985;100:125–31.
[32] Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273:402–7.
[33] Paffenbarger RSJ, Hyde RT, Wing AL, Lee IM, Jung DL, Kampert JB. The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. N Engl J Med 1993;328(Suppl. 3):538–45.
[34] Sleight P. Smoking and hypertension. Clin Exp Hypertens 1993; 15(6):1181–92.
[35] Gourlay SG, Benowitz NL. The benefits of stopping smoking and the role of nicotine replacement therapy in older patients. Drugs Aging 1996;9(1):8–23.
[36] Kaprio J, Koskenvuo M. A prospective study of psychological and socioeconomic characteristics, health behavior and morbidity in cigarette smokers prior to quitting compared to persistent smokers and non-smokers. J Clin Epidemiol 1988;41(2):139–50.
[37] Anderson P, Cremona A, Paton A, Turner C, Wallace P. The risk of alcohol. Addiction 1993;88(11):1493–508.
[38] Hanna EZ, Chou SP, Grant BF. The relationship between drinking and heart disease morbidity in the United States: results from the National Health Interview Survey. Alcohol Clin Exp Res 1997; 21(19):111–8.
[39] Puddey IB, Rakic V, Dimmitt SB, Beilin LJ. Influence of pattern of drinking on cardiovascular disease and cardiovascular risk factors—A review. Addiction 1999;94(5):649–63.
[40] Britton A, McKee M. The relation between alcohol and cardiovascular disease in Eastern Europe: explaining the paradox. J Epidemiol Community Health 2000;54(5):328–32.
[41] USDA. The food guide pyramid. Home and Garden Bulletin, vol. 252. Washington (DC): USDA; 1992.
[42] Wannamethee SG, Shaper AG. Type of alcoholic drink and risk of major coronary heart disease events and all-cause mortality. Am J Public Health 1999;89(5):685–90.
[43] Poikolainen K. Alcohol and overall health outcomes. Ann. Med. 1996;28(5):3381–4.
[44] McGinnis JM, Foege WH. Actual causes of death in the United States. JAMA 1993;270:2207–12.
[45] Kant AK, Schatzkin A, Harris T, Ziegler RG, Block G. Dietary diversity and subsequent mortality in the first National Health and Nutrition Examination Survey Epidemiologic Follow-up Study. Am J Clin Nutr 1993;57:434–40.
[46] Powell KE, Blair SN. The public health burdens of sedentary living habits: theoretical but realistic estimates. Med Sci Sports Exerc 1994;26(7):851–6.
[47] Kant AK, Schatzkin A, Ziegler RG. Dietary diversity and subsequent cause-specific mortality in the NHANES I epidemiologic follow-up study. J Am Coll Nutr 1995;14:233–8.
[48] Paffenbarger RSJ, Kampert JB, Lee IM. Physical activity and health of college men: longitudinal observations. Int J Sports Med 1997; 18(Suppl. 3):S200–3.
[49] USDA. Food Survey Research Group ARS CSFII 1994: Pyramid Servings. 1994 USDA CD-ROM.
[50] Chinese Nutrition Society. Chinese Dietary Reference Intakes. Beijing, China: China Light Industry Publishing House; 2000.
[51] Institute of Medicine. Dietary Reference Intakes: Applications in Dietary Assessment. Washington, DC, USA: National Academy Press; 2001.
[52] Institute of Food and Nutrition Hygiene at Chinese Academy of Preventive Medicine. Food Composition Table. Beijing, China: People's Medical Publishing House; 1991.
[53] SAS Institute, Inc. SAS/STAT Software. Version 8.2. Cary (NC): SAS Institute, Inc.; 2001.
[54] Stata Corporation. Stata Statistical Software: Release 7.0. College Station (TX): Stata; 2001.
[55] Kant AK. Indexes of overall diet quality: a review. J Am Diet Assoc 1996;96:785–91.
[56] McCullough ML, Feskanich D, Stampfer MJ, Giovannucci EL, Rimm EB, Hu FB, et al. Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. Am J Clin Nutr 2002;76:1261–71.

[57] McCullough ML, Feskanich D, Stampfer MJ, Rosner BA, Hu FB, Hunter DJ, et al. Adherence to the Dietary Guidelines for Americans and risk of major chronic disease in women. Am J Clin Nutr 2000;72:1214–22.
[58] Kant AK, Schatzkin A, Ziegler RG. Dietary diversity and subsequent cause-specific mortality in the NHANES I epidemiologic follow-up study. J Am Coll Nutr 1995;14(3):233–8.
[59] Morabia A, Wynder EL. Dietary habits of smokers, people who never smoked, and exsmokers. Am J Clin Nutr 1990;52:933–7.
[60] Schrauwen P, Westerterp KR. The role of high-fat diets and physical activity in the regulation of body weight. Br J Nutr 2000;84(4): 417–27.
[61] Shepard TY, Weil KM, Sharp TA, Grunwald GK, Bell ML, Hill JO. Occasional physical inactivity combined with a high-fat diet may be important in the development and maintenance of obesity in human subjects. Am J Clin Nutr 2001;73(4):703–8.
[62] Paeratakul S, Popkin BM, Keyou G, Adair LS, Stevens J. Changes in diet and physical activity affect the body mass index of Chinese adults. Int J Obes 1998;22:424–31.
[63] Anonymous. Prevalence of leisure-time and occupational physical activity among employed adults—United States, 1990. MMWR Morb Mortal Wkly Rep 2000;49(19):420–4.
[64] Barrett-Connor E. Nutrition epidemiology: how do we know what they ate? Am J Clin Nutr 1991;54(Suppl. 1):182S–7S.
[65] Bogers RP, Dagnelie PC, Westerterp KR, Kester AD, van Klaveren JD, Bast A, et al. Using a correction factor to correct for overreporting in a food-frequency questionnaire does not improve biomarker-assessed validity of estimates for fruit and vegetable consumption. J Nutr 2003;133(4):1213–9.
[66] Haines PS, Hama MY, Guilkey DK, Popkin BM. Weekend eating in the United States is linked with greater energy, fat, and alcohol intake. Obes Res 2003;11(8):945–9.
[67] Rzewnicki R, Vanden Auweele Y, De Bourdeaudhuij I. Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. Public Health Nutr 2003;6(3):299–305.
[68] Lafay L, Mennen L, Basdevant A, Charles MA, Borys JM, Eschwege E, et al. Does energy intake underreporting involve all kinds of food or only specific food items? Results from the Fleurbaix Laventie Ville Sante (FLVS) study. Int J Obes Relat Metab Disord 2000;24(11): 1500–6.
[69] Perez-Stable EJ, Marin BV, Marin G, Brody DJ, Benowitz NL. Apparent underreporting of cigarette consumption among Mexican American smokers. Am J Public Health 1990;80(9):1057–61.
[70] Zhang J, Temme EH, Sasaki S, Kesteloot H. Under- and overreporting of energy intake using urinary cations as biomarkers: relation to body mass index. Am J Epidemiol 2000;152(5):453–62.
[71] Embree BG, Whitehead PC. Validity and reliability of self-reported drinking behavior: dealing with the problem of response bias. J Stud Alcohol 1993;54(3):334–44.
[72] Johansson G, Wikman A, Ahren AM, Hallmans G, Johansson I. Underreporting of energy intake in repeated 24-hour recalls related to gender, age, weight status, day of interview, educational level, reported food intake, smoking habits and area of living. Public Health Nutr 2001;4(4):919–27.
[73] Kim S. A cross-national comparison of relationships between dietary qualities (Abstract). Faseb J 2003;15(5):A1104. Part 2 Suppl.