Influence of dietary pattern on the development of overweight in a Chinese population

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Running title: Dietary pattern and obesity

Abstract

Objective

To examine dietary factors predisposing to overweight and obesity, taking into account age, gender, education level, and physical activity.

Design

Longitudinal population study.

Setting

Community living subjects in Hong Kong

Subjects

1,010 Chinese subjects participating in a territory wide dietary and cardiovascular risk factor prevalence survey in 1995–6 were followed up for 5–9 years.

Measurements

Body Mass Index (BMI) was measured. Information was collected on factors predisposing to development of overweight and obesity (age, gender, education level, physical activity, macronutrient intake, Mediterranean diet score, and food variety), and the predisposing dietary factors examined, adjusted for other confounding factors, using logistic regression.

Results

The 5–9 year incidence of overweight is 22.6% (BMI ≥ 23kg/m^2, 95% CI=15.0%–30.1%) or 11.5% (BMI ≥ 25kg/m^2, 95% CI=7.3%–15.7%), and for obesity (BMI ≥ 30kg/m^2) is 0.6%

(95% CI=-0.2%–1.4%). The corresponding figures for women were 14.1% (95% CI=8.8%–19.5%), 9.7% (95% CI=6.0%–13.4%) and 3% (95% CI=1.3%–4.8%). After adjusting for confounding factors (age, sex, education and physical activity), increased variety of snack consumption was associated with increased risk of developing overweight (BMI ≥ 23kg/m^2) in the Hong Kong Chinese population over a 5–9 year period.

Conclusion

Increased variety of snack consumption may predispose to weight gain over a 5–9 year period.

Sponsorship

Research Grants Council and Health Services Research Fund, Hong Kong Government

Key words

Food variety, Mediterranean diet

Introduction

Much attention has been drawn to the obesity epidemic in Western populations (http://www.iotf.org/globalepidemic.asp, accessed 21 Feb 2006). While the prevalence of obesity among Chinese populations in China is lower (http://www.iotf.org/database/globaladultsaugust2005.asp, accessed 21 Feb 2006), the rising trend (Popkin BM, 2001), reflected in the rapid rise in obesity related diseases such diabetes (Zimmet P, 2001), represents a major public health challenge. Preventive measures are needed, yet there is little data regarding lifestyle factors predisposing to development of overweight and obesity, due to the paucity of longitudinal population studies. There are few studies among Chinese populations examining the role of dietary intake taking into account other confounding factors such as age, physical activity, gender and educational attainment. Other than the effect of total energy and macronutrient intake (Halkjaer J et al., 2006) on development of overweight and obesity, recent studies have highlighted the role of dietary patterns in terms of meal frequency and timing, and types of food consumed (Howard BV et al., 2006; Sichieri R, 2002; Kelishadi R et al., 2003; Ghosh A et al., 2003; Kirk TR, 2000; Nicklas TA et al., 2003; Hubert HB et al., 2005; Waller CE et al., 2003; Francis LA et al., 2003; Bazzano LA et al., 2005). For example, patterns predisposing to overweight and obesity include a "Westernized" pattern compared with a "traditional" pattern for the population studied (Sichieri R, 2002; Ghosh A et al., 2003; Hubert HB et al., 2005) and

snacks consumption (Hubert HB et al., 2005; Francis LA et al., 2003; Sothern MS, 2004; Fu FH & Hao X, 2002).

Of particular interest is the Mediterranean diet, which has received much interest in view of its many health benefits with respect to cardiovascular health, prevention of cancer, as well as longevity (Karger et al., 2000). The main features of the diet are: high consumption of fruits, vegetables, legumes and grains; foods with high mono to saturated fats ratio; moderate consumption of dairy products and wine; and low consumption of meat and meat products. Recent studies have addressed concerns that non-adherence to the Mediterranean diet may predispose to the development of overweight and obesity in view of the rising prevalence in Mediterranean countries. (Serra-Majem L et al., 2003; Schroder H et al., 2004; Moreno LA et al., 2002; Notarbartolo A & Barbagallo CM, 2001; Wahlqvist ML et al., 1999; Trichopoulou A et al., 2005). The traditional Chinese diet has many similarities with the Mediterranean diet, such that the Mediterranean diet score when applied to Chinese dietary patterns is comparable to the score from Mediterranean populations (Woo J et al., 2001). Furthermore, it is increasingly considered that the Mediterranean-type diet is transposable to non-Mediterranean regions (Speed, 2004). Therefore it would be of particular interest to examine this pattern as a predisposing factor to overweight and obesity in the population.

Studies have also highlighted the role of food variety in body fat accumulation (McCrory MA et al., 1999; Sea MMM et al., 2004). In the Hong Kong Chinese population, a

food variety ratio derived from varieties of snacks, grain and meat was a stronger predictor of body fat compared with dietary fat (Sea MMM et al., 2004). However, these were cross sectional studies and cause-effect relationship could not be addressed. In a 5–9 year follow up of subjects recruited in a territory wide Cardiovascular Risk Factor Prevalence Survey carried out in 1995–6, where detailed dietary information was also collected from a sub sample, we examined dietary factors predisposing to overweight and obesity, taking into account potential confounding factors such as age, gender, education level, and physical activity.

Subjects and Method

A dietary survey was carried out from October 1995 – May 1996 as part of a territory wide cardiovascular risk factor study in ethnic Chinese. Subjects were contacted by a random telephone survey, and invited to have a physical examination and blood tests. Dietary assessment was carried out consecutively on the attendees until 100 subjects in each age and sex groups from ≤ 34 years to ≥ 55 years were recruited. The response rate from the telephone survey was 78%, and of those, 37% attended for the physical examination. No significant difference was observed between subjects with and without the examination, and with the general population of Hong Kong (Janus ED, 1997). 2 900 subjects aged 25–74 years attended for physical examination, of which 1 010 subjects underwent dietary assessment. The mean age of the dietary study subjects was 45.6 ± 11.7 years.

Dietary assessment was carried out using a food frequency questionnaire, the validity of which had been examined elsewhere (Woo J et al., 1997). This consisted of items in the following seven categories; Bread/pasta/rice (16 items); vegetables (63 items); fruits (26 items); meat (39 items)/fish (31 items)/eggs (5 items); beverages (37 items); dimsum/snacks (39 items); soups (10 items); and oil/salt/sauces. Wherever possible, subjects were told prior to the visit that a survey on a week's diet would be carried out and were advised to make a brief record at home to help the interview. On the day of the interview, each subject was asked to complete the questionnaire: the food item, the size of each portion, the frequency of

consumption on a daily and weekly basis. Portion size was explained to subjects using a catalogue of pictures of individual food portions. Data were cross checked by examining the dietary pattern (for example, if meals were skipped) to see if it corresponded to the number of times staple foods such as rice or noodles were consumed over a one week period. In case of discrepancies, the questionnaire was rechecked with the subject. The amount of cooking oil was estimated according to the method of preparing different foods: 0.2 tablespoon for steaming fish or stir frying half a portion of vegetables or one portion of meat. The type of oil used was also documented to allow estimated of the quantity of fat used in cooking. Quantitation of nutrients was carried out using food tables for Hong Kong compiled from McCance and Widdowson (Holland B et al., 1992) and food tables used in China (Institute of Health, 1992). Level of physical activity was assessed by asking subjects how many times in the past month did they carry out exercise/sports activities for ≥ 30 mins. Activity level was graded into four categories: none (sedentary), 1–7 episodes (light), 8–15 episodes (moderate), and > 15 episodes (vigorous). Height was measured to the nearest 0.5cm and weight to the nearest 0.1kg, with subjects in light clothing and without shoes.

Between 2000 and 2004, the original cohort was invited to re-attend for a repeat physical examination. 732 of the original 1 010 subjects returned (72.4%). There were slightly more men and more subjects in the two extreme age groups among those lost to follow up. The number of subjects with normal BMI (<23 kg/m^2) in 1995, whose BMI

increased to ≥ 23 kg/m^2, ≥ 25 kg/m^2, and ≥ 30kg/m^2 respectively on follow up, was calculated. These figures represent the "Asian" criteria for overweight (≥ 23 kg/m^2) (Ko GTC et al., 1999), and the current WHO criteria for overweight (≥ 25 kg/m^2) and obesity (≥ 30 kg/m^2) (World Health Organization, 1998). The 5-9 year incidence of overweight (for both BMI criteria) and obesity was calculated by dividing the number of subjects with normal BMI at baseline who developed overweight or obesity, by the total number of subjects with normal BMI at baseline. Information on demographic, socioeconomic and physical activity levels was obtained as potential confounding factors in examining the role of dietary intake (macronutrient quantity, Mediterranean diet score (Woo J et al., 2001) and food variety ratio (Sea MMM et al., 2004) in the development of overweight and obesity.

Adherence to the Mediterranean diet was calculated using the revised method described by (Trichopoulou A et al., 2003). Essentially adherence is represented by a scale where a value of 1 was assigned to consumption of food groups considered beneficial to health at or above the sex-specific median (vegetables, legumes, fruits and nuts, cereal, fish and monosaturated to saturated lipids ratio) and below the median for food groups (meat, poultry, dairy products). In addition, a value of 1 was also assigned to men and women with alcohol intake between 10–50g and 5–25g per day respectively. The range of the score is 0–9.

The food variety of each food group listed in the description of the dietary assessment was calculated on the percentage of different food items consumed within the corresponding

food group, regardless of the frequency and portion with which they were consumed (McCrory MA et al., 1999). Food variety ratio was calculated as the ratio of the variety of combined food groups which were inversely correlated to body fatness to the variety of combined food groups with positive relationships to body fatness. For the Hong Kong population, it was defined as the ratio of variety of snacks to the variety of grains and meat (Sea MMM et al., 2004). In addition, the quality of the diet was also examined by applying the Dietary Quality Index-International (DQI-I) (Kim S et al., 2003), which has been used to evaluate the quality of the Mediterranean diet (Tur JA et al., 2005). Essentially, four major aspects of the diet are assessed: variety, adequacy, moderation, and overall balance, each with subcomponents. The range is 0–100, with high score representing high quality. In this study, we did not have sufficient information to calculate the category of empty calorie foods under the aspect "moderation". Therefore the range of score for moderation was 0–24 instead of 0–30, and the DQI-I total score was 0–94 instead of 0–100. The odds ratio for per standard deviation increase of each of the dietary factors for the development of overweight was calculated, and adjusted for age and sex, as well as additional adjustments, education and physical activity. Owing to the few subjects that developed obesity, a similar analysis was not carried out.

Statistical Analysis

All analyses were performed with SPSS version 13.0 (SPSS Inc, Chicago, IL, USA). Chi-square test was used to compare the number of subjects with overweight or obese between different age and sex groups. Logistic regression adjusting for sex, age, education and physical activity were performed to assess the association between the normal and the overweight group. A p-value less than 0.05 was used to denote significant differences.

Results

While more women and older subjects returned for the follow up study, there were no differences in educational, and physical activity levels, macronutrients intake and dietary patterns between those who were lost to follow-up and those who returned (data not shown). Table 1 shows the number of subjects with normal BMI developing overweight (Table 1a, b) or obesity (Table 1c) during the 5–9 year follow-up period, by age and sex. Other categories of BMI changes are also shown: normal to normal, overweight/obese remaining overweight/obese, overweight/obese becoming normal. For men, the 5–9 year incidence of overweight is 22.6% (95% CI=15.0%–30.1%) ($\geq$ 23kg/m^2) or 11.5% (95% CI=7.3%–15.7%) ($\geq$ 25 kg/m^2), and for obesity 0.6% (95% CI=-0.2%–1.4%). The corresponding figures for women were 14.1% (95% CI=8.8%–19.5%); 9.7% (95% CI=6.6%–13.4%) and 3.0% (95% CI=1.3%–4.8%) respectively. Using the overweight criteria of $\geq$ 23 kg/m^2, significantly more

men became overweight compared with women. However, the incidence of obesity is about 5 times higher in women compared with men.

In multivariate analysis, after adjusting for confounding factors (age, sex, education and physical activity), increased variety of snacks and food variety ratio were associated with increased risk for developing overweight defined as BMI ≥ 23 kg/m^2 (Table 2). No associations with any of these variables were observed for the BMI ≥ 25 kg/m^2 group (Data not shown). The components of the DQI-I are shown in Table 3.

Discussion

This study showed that dietary pattern was a significant factor predisposing to the development of overweight and obesity in the Hong Kong Chinese population, after adjusting for confounding factors. The incidence of overweight and obesity was lower than that reported in 2 488 Chinese adults age 20–45 in seven provinces in China over an eight year period from 1989–1997, where the number of overweight subjects (BMI ≥ 25 kg/m^2) almost tripled in men and doubled in women (Bell AC et al., 2001). Men in the Hong Kong study also had a higher incidence compared with women. Contrary to the finding in Hong Kong, low physical activity was the strongest predictor, while dietary pattern was not examined. Although difference in assessment of physical activity and age structure of the cohorts exist, the different findings between these two Chinese population may also be explained by the rapid socioeconomic transition as a result of the rapid development of a market economy in

Mainland China during this period (compared with a stable situation in Hong Kong), as well as the wide variation in physical activity levels among the seven provinces compared with the fairly uniformly low level of physical activity in the Hong Kong Chinese population. The incidence of overweight and obesity is also lower compared with that reported for the Framingham cohort in 1995 (Vasan RS et al., 2005), where the 4 year risk for developing overweight and obesity in men ranged from 26–30% and 7–9% respectively, with corresponding figures for women being 14–19% and 5–7%. However, the figures for overweight are similar in the two populations if the criteria of BMI $\geq$ 23 kg/m^2 is used. Similar to the US population, the incidence is higher in men compared with women. It is uncertain whether this consistent gender difference is related to differences in dietary intake or physical activity levels.

Differences in dietary habits are likely to contribute in part to inter population differences in incidence of overweight/obesity, as well as differences in prevalence of diseases such as cardiovascular disease and cancer. The Mediterranean diet pattern is associated with lower risk of these diseases (Karger et al., 2000). The traditional Chinese diet has many similarities with the Mediterranean diet, with the exception of low dairy products and wine consumption, such that a Mediterranean diet score may be applied (Woo J, et al., 2001), and potential health benefits have been discussed (Woo J, et al.,1999). Recent studies have addressed the impact of non adherence to the Mediterranean dietary pattern on the

development of overweight and obesity, such that the rising prevalence of obesity in Mediterranean regions has been attributed to a nutrition transition away from traditional diets (Moreno LA et al., 2002). Adherence to the traditional Mediterranean diet pattern was found to reduce the risk of obesity after controlling for confounding factors such as socioeconomic status and physical activity in a Spanish study (Schroder H et al., 2004), and similar observations had been made for the Greek population (Wahlqvist ML et al., 1999). A recent study showed no association between Mediterranean diet score and BMI (Trichopoulou A et al., 2005), concluding that the current problem of overweight in Greece is likely to be related to reducing physical activity levels. The finding of this study showing a lack of association between adherence to the Mediterranean diet and the development of overweight lend further support to this observation.

Various studies in different populations have noted a relationship between food groups and weight gain or high body mass index. In the Women's Health Initiative observing 48 835 women over a seven year period, low fat diet with increased fruits, vegetable and grain consumption was associated with weight loss or prevention of weight gain (Howard BV et al., 2006), while a traditional diet in Brazil consisting predominantly of rice and beans compared with a more Westernized one with fat, added sugars, snacks etc was least associated with obesity adjusting for physical activity and other confounding factors (Sichieri R, 2002). Similarly, consumption of whole or refined grain breakfast cereal was inversely related to

weight gain adjusting for multiple confounding factors, in 17 881 US male physicians followed up for 4–13 years (Bazzano LA et al., 2005). Snacks and fast foods consumption appear to be associated with overweight/obesity in studies in Iran (Kelishadi R et al., 2003), India (Ghosh A et al., 2003), USA (Nicklas TA et al., 2003), US Latino population (Hubert HB et al., 2005), Chinese (Waller CE et al., 2003; Fu FH & Hao X, 2002) and US children (Francis LA et al., 2003; Sothern MS, 2004). It has been pointed out that the snacking habit per se is not related to weight gain, but rather the nature of snacks consumed, the majority of snacks consumed being fast foods that are energy dense with high fat content (Drummond S et al., 1996). Previously we have shown a positive correlation between body fat and snack variety, and an inverse relationship between body fat and variety of grains and meats (Sea MMM et al., 2004). The findings from the present longitudinal study give further support to the relationship between snack consumption and weight gain.

There are limitations to this study. Nutrient quantitation is not exact. The use of food frequency questionnaire rather than 24 hours recall may have overestimated the intake. We did not exclude subjects who may be underreporters. However, an estimate of possible underreporters using the ratio of energy intake: basal metabolic rate (BMR) <1.1 to <1.27 (Warwick P, 2006), and the calculated BMR equation for Chinese (Leung R et al., 2000), the prevalence ranges from 12.2 – 26.4%. In this study, we examined the value of BMI ≥ 23 kg/m^2 as a criterion for overweight, this being the value found in some Chinese populations to

be associated with increased cardiovascular risk factor levels (Ko GTC et al., 1999; Deurenberg-Yap M et al.,1999). However, although this criteria has been discussed by the World Health Organization, there have been few studies relating health outcomes to values for obesity compared with overweight, hence the value of $\geq$ 30 kg/m^2 is still used as representing obesity in this study. Only about 70% of the original cohort was available for follow up, and although there were no differences between subjects re-attending and those lost to follow-up other than greater attrition among men and extremes of age group, the numbers developing overweight/obesity were not high, so that some predisposing factors may not have achieved statistical significance. In this study, the use of food variety ratio, Mediterranean diet score and DQI-I was an attempt to quantitate particular dietary patterns, so that associations with health outcomes could be explored. However, it would be premature to discuss the clinical significance of an increase or decrease or the magnitude of change for these ratios. Rather, we take this opportunity, to examine prospective data to test previous observations regarding food variety ratios and Mediterranean dietary patterns. Randomized controlled trials would be needed to test these associations in a definitive way. In spite of this limitation, the study highlights the importance of dietary pattern in the development of overweight in this population, and provides information to guide public health efforts in the prevention of obesity and its concomitant morbidity, in particular diabetes.

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Table 1 5–9 years changes in BMI categories

(a) (overweight: BMI ≥23 kg/m²)

	<35						35–44						45–54						55+						Total					
	Men (n=72)		Women‡ (n=88)		Total‡ (n=160)		Men (n=94)		Women (n=102)		Total (n=196)		Men (n=96)		Women (n=102)		Total (n=198)		Men (n=85)		Women (n=93)		Total (n=178)		Men (n=347)		Women (n=385)		Total (n=732)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	N	%	n	%	n	%	n	%	n	%	n	%	n	%
N→N	21	29.2***	52	59.1	73	45.6	22	23.4*	46	45.1	68	34.7	28	29.2	28	27.5	56	28.3	18	21.2	14	15.1	32	18.0	89	25.6	140	36.4	229	31.3
O→O	38	52.8	28	31.8	66	41.3	54	57.4	44	43.1	98	50.0	56	58.3	55	53.9	111	56.1	51	60.0	63	67.7	114	64.0	199	57.3	190	49.4	389	53.1
O→N	5	6.9	6	6.8	11	6.9	10	10.6	5	4.9	15	7.7	7	7.3	10	9.8	17	8.6	11	12.9	11	11.8	22	12.4	33	9.5	32	8.3	65	8.9
N→O	8	11.1	2	2.3	10	6.3	8	8.5	7	6.9	15	7.7	5	5.2	9	8.8	14	7.1	5	5.9	5	5.4	10	5.6	26	7.5	23	6.0	49	6.7
Incidence of overweight %																									22.6		14.1			
(95%CI)																									(15.0 – 30.1)		(8.8 – 19.5)			

* p<0.05, *** p<0.001 by χ^2 Test comparing between sex, same age group

‡ p<0.001 by χ^2 Test comparing between age group, same gender
N = Normal BMI
O = Overweight
Incidence = N→O divided by the total number of subjects with normal weight at baseline

Table 1 5-9 year changes in BMI categories

b) Overweight: BMI ≥ 25 kg/m^2 – 29.9 kg/m^2

	< 35			35-44			45-54			55+			Total		
	Men (n=70)	Women‡ (n=83)	Total‡ (n=153)	Men (n=87)	Women (n=96)	Total (n=183)	Men (n=93)	Women (n=91)	Total (n=184)	Men (n=78)	Women (n=82)	Total (n=160)	Men (n=328)	Women (n=352)	Total (n=680)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
N→N	48 (68.6)	61 (73.5)	109 (71.2)	51 (58.6)	72 (75.0)	123 (67.2)	54 (58.1)	51 (56.0)	105 (57.1)	40 (48.8)	40 (48.8)	80 (50.0)	193 (58.8)	224 (63.6)	417 (61.3)
O→O	11 (15.7)	12 (14.5)	23 (15.0)	23 (26.4)	13 (13.5)	36 (19.7)	27 (29.0)	27 (29.7)	54 (29.3)	29 (35.4)	29 (35.4)	52 (32.5)	84 (25.6)	81 (23.0)	165 (24.3)
O→N	4 (5.7)	2 (2.4)	6 (3.9)	4 (4.6)	4 (4.2)	8 (4.4)	8 (8.6)	8 (8.8)	16 (8.7)	9 (11.0)	9 (11.0)	19 (11.9)	26 (7.9)	23 (6.5)	49 (7.2)
N→O	7 (10.0)	8 (9.6)	15 (9.8)	9 (10.3)	7 (7.3)	16 (8.7)	4 (4.3)	5 (5.5)	9 (4.9)	4 (4.9)	4 (4.9)	9 (5.6)	25 (7.6)	24 (6.8)	49 (7.2)
Incidence of overweight %													11.5	9.7	
(95%CI)													(7.3 – 15.7)	(6.6 – 13.4)	

O= overweight

N= normal BMI

‡ P<0.001 by χ^2 test between age groups, same gender

Incidence = N→O divided by the total number of subjects with normal weight at baseline

Table 1 5–9 year changes in BMI categories

c) Obesity: BMI ≥ 30 kg/m^2

	< 35			35–44			45–54			55+			Total		
	Men (n=72)	Women (n=88)	Total (n=160)	Men (n=94)	Women (n=102)	Total (n=196)	Men (n=96)	Women (n=102)	Total (n=198)	Men (n=85)	Women (n=93)	Total (n=178)	Men (n=347)	Women (n=385)	Total (n=732)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
N→N	70 (97.2)	82 (94.3)	152 (95.6)	87 (92.6)	95 (94.1)	182 (93.3)	93 (96.9)	91 (89.2)	184 (92.9)	78 (91.8)	82 (88.2)	160 (89.9)	328 (94.5)	350 (91.4)	678 (92.9)
O→O	2 (2.8)	4 (4.6)	6 (3.8)	4 (4.3)	5 (5.0)	9 (4.6)	1 (1.0)	4 (3.9)	5 (2.5)	3 (3.5)	4 (4.3)	7 (3.9)	10 (2.9)	17 (4.4)	27 (3.7)
O→N	0	0	0	2 (2.1)	0	2 (1.0)	1 (1.0)	3 (3.9)	5 (2.5)	4 (4.7)	1 (1.1)	5 (2.8)	7 (2.0)	5 (1.3)	12 (1.6)
N→O	0	1 (1.1)	1 (0.6)	1 (1.1)	1 (1.0)	2 (1.0)	1 (1.0)	4 (2.9)	4 (2.0)	0	6 (6.5)	6 (3.4)	2 (0.6)	11 (2.9)	13 (1.8)
Incidence of obesity %													0.6	3.0	
(95%CI)													(-0.2 – 1.4)	(1.3 – 4.8)	

O= obese
N= normal BMI
Incidence = N→O divided by the total number of subjects with normal weight at baseline

Table 2 Factors associated with the development of overweight

	N-N / O-N (N=294)	N-O (N=49)	O.R.† (95% C.I.)	
			Model 1	Model 2
	Mean ± SD	Mean ± SD	Adjust for sex and age	Adjust for sex, age, education and physical activity
Age	43.6 ± 11.1	44.7 ± 11.4		
Nutrient intake				
Energy (kJ)	10087.4 ± 2916.4	9144.3 ± 3029.0	1.15 (0.82 – 1.60)	1.22 (0.84 – 1.78)
Energy/body weight (kJ/kg)	160.3 ± 52.3	160.7 ± 48.1	0.97 (0.69 – 1.35)	1.00 (0.68 – 1.47)
Carbohydrate/4 186kJ	133.3 ± 18.5	135.4 ± 19.3	1.10 (0.80 – 1.50)	1.00 (0.70 – 1.44)
Protein/4 186kJ	46.4 ± 7.5	45.3 ± 6.9	0.89 (0.64 – 1.22)	1.00 (0.70 – 1.44)
Fat/4 186kJ	32.5 ± 6.0	31.8 ± 6.5	0.93 (0.68 – 1.27)	1.01 (0.71 – 1.45)
% fat intake	29.2 ± 5.4	28.7 ± 5.8	0.93 (0.68 – 1.27)	1.01 (0.71 – 1.45)
Cholesterol (mg)	332.7 ± 183.9	354.5 ± 174.6	1.09 (0.79 – 1.51)	1.14 (0.80 – 1.62)
Mediterranean diet score	3.8 ± 1.6	4.1 ± 1.4	1.15 (0.84 – 1.57)	1.35 (0.94 – 1.93)
Food variety (%) of each food group				
Grains	32.9 ± 11.7	32.7 ± 10.4	1.04 (0.76 – 1.44)	1.16 (0.82 – 1.66)
Vegetables	24.2 ± 10.1	23.2 ± 9.4	0.91 (0.66 – 1.25)	0.92 (0.65 – 1.31)
Fruits	15.4 ± 8.2	14.4 ± 7.7	0.91 (0.66 – 1.26)	0.97 (0.68 – 1.39)
Meats	19.9 ± 7.5	18.7 ± 5.9	0.84 (0.60 – 1.18)	0.89 (0.61 – 1.30)
Beverages	12.9 ± 8.3	11.6 ± 7.2	0.84 (0.58 – 1.21)	0.96 (0.63 – 1.45)
Snacks	6.9 ± 7.2	9.0 ± 8.3	1.33 (1.02 – 1.74)*	1.45 (1.06 – 1.98)*
Food variety ratio	0.1 ± 0.1	0.2 ± 0.1	1.32 (1.02 – 1.72)*	1.36 (1.01 – 1.82)*
DQI-I, total	56.9 ± 9.1	58.9 ± 7.6	1.25 (0.90 – 1.72)	1.32 (0.92 – 1.89)

N–N = Normal at baseline and followup
O–N = overweight at baseline and normal at followup
N–O = normal at baseline and overweight at followup

Food variety ratio = snack / (grain + meat)
DQI-I = Dietary Quality Index-International

* $p \leq 0.05$
† O.R. are per SD increase (using SD of the normal group as reference)
1 Kcal = 4.186 KJ

Table 3 Components of Diet Quality Index-International (DQI-I) and the percentage of the sample in component subcategories in normal and overweight subjects

Component	Score ranges	Points & Scoring criteria		Normal (n=294)	Overweight (n=49)
Variety	**0–20**			%	%
Overall food group variety (meat/poultry/fish/eggs; dairy/beans; Grain; fruit; vegetable)	0–15	15	≥1 serving from each food group/d	39.8	40.8
		12	Any one food group missing/d	38.4	46.9
		9	Any two food group missing/d	16.7	12.2
		6	Any three food group missing/d	3.4	0
		3	≥4 food group missing/d	1.0	0
		0	None from any food group	0.7	0
Within-group variety for protein source (meat, poultry, fish, dairy, beans, eggs)	0–5	5	≥3 different sources/d	53.7	61.2
		3	2 different sources/d	25.9	24.5
		1	From 1 source/d	13.6	10.2
		0	None	6.8	4.1
Adequacy	**0–40**				
Vegetable group [a]	0–5	5	≥100% recommendations	25.9	30.6
		3	50–100% recommendations	47.3	53.1
		1	<50% recommendations	20.7	8.2
		0	0% recommendations	6.1	8.2
Fruit group [a]	0–5	5	≥100% recommendations	25.5	30.6
		3	50–100% recommendations	39.5	42.9
		1	<50% recommendations	15.6	12.2
		0	0% recommendations	19.4	14.3
Grain group [a]	0–5	5	≥100% recommendations	0.3	0
		3	50–100% recommendations	23.5	26.5
		1	<50% recommendations	68.0	71.4
		0	0% recommendations	8.2	2.0
Fiber [a]	0–5	5	≥100% recommendations	0	0
		3	50–100% recommendations	12.9	12.2
		1	<50% recommendations	87.1	87.8
		0	0% recommendations	0	0
Protein	0–5	5	≥100% recommendations	100.0	100.0
		3	50–100% recommendations	0	0
		1	<50% recommendations	0	0
		0	0% recommendations	0	0
Iron [b]	0–5	5	≥100% recommendations	37.8	44.9
		3	50–100% recommendations	53.7	46.9
		1	<50% recommendations	8.5	8.2
		0	0% recommendations	0	0
Calcium [b]	0–5	5	≥100% recommendations	14.6	18.4
		3	50–100% recommendations	59.2	49.0
		1	<50% recommendations	26.2	32.7
		0	0% recommendations	0	0
Vitamin C [b]	0–5	5	≥100% recommendations	73.5	79.6
		3	50–100% recommendations	20.7	20.4
		1	<50% recommendations	5.8	0
		0	0% recommendations	0	0
Moderation	**0–24**				
Total fat	0–6	6	≤20% of total energy/d	3.7	6.1
		3	>20–30% of total energy/d	55.8	51.0
		0	>30% of total energy/d	40.5	42.9
Saturated fat	0–6	6	≤7% of total energy/d	33.7	34.7
		3	>7–10% of total energy/d	51.7	49.0
		0	>10% of total energy/d	14.6	16.3
Cholesterol	0–6	6	≤300 mg/d	50.3	44.9
		3	>300–400 mg/d	22.1	20.4
		0	>400 mg/d	27.6	34.7
Sodium	0–6	6	≤2400 mg/d	93.5	93.9
		3	>2400–3400 mg/d	5.1	6.1
		0	>3400 mg/d	1.4	0
Overall balance	**0–10**				
Macronutrient ratio (carbohydrate–protein–fat)	0–6	6	55–65; 10–15; 15–25	1.7	2.0
		4	52–68; 9–16; 13–27	10.5	18.4
		2	50–70; 8–17; 12–30	11.2	8.2
		0	Otherwise	76.5	71.4
Fatty acid ratio	0–4	4	P/S=1–1.5; M/S=1–1.5	19.0	22.4
		2	P/S=0.8–1.7; M/S=0.8–1.7	31.6	34.7
		0	Otherwise	49.3	42.9

M/S, ratio of MUFA to SFA intakes; P/S, ratio of PUFA to SFA intakes; SFA, saturated fatty acids.

[a] Based on 7118 kJ (1700 kcal) / 9211 kJ (2200 kcal) / 11304 kJ (2400 kcal)

[b] Based on the recommended daily intakes for Chinese people (Chinese Nutrition Society)