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Association of Energy Intake and Macronutrient Composition with Overweight and Obesity in Malay Women from Klang Valley

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ABSTRACT

This cross-sectional study investigates the association between energy intake and macronutrient composition of the diet with overweight and obesity among Malaysian women. One hundred and fifteen adult Malay women aged 20 to 59 years (mean age 37.2±7.6 years) were interviewed. Dietary intake was assessed using the food history method. Body weight status was assessed using weight, height, waist circumference and fat percentage measurements. When energy intake was assessed for accuracy, only 41% of the subjects (n=47) were normal energy reporters. Among the normal energy reporters, 55% were of normal weight whereas 32% and 13% were overweight and obese. Mean energy intake for normal weight, overweight and obese subjects was 1685±199 kcal/day, 1810±166 kcal/day and 2119±222 kcal/day, respectively. Energy intake increased with body mass index (BMI) category. Among the overweight and obese, energy intake was respectively higher by 125 kcal/day and 434 kcal/day as compared to their normal weight counterparts ($p<0.001$). There was also a significant, moderate and positive correlation between energy intake and BMI ($r=0.635$), waist circumference ($r=0.545$), and body fat percentage ($r=0.534$). When macronutrient composition of diet was analysed (% energy and g/1000 kcal), there was no significant difference in carbohydrate, protein or fat intake between the obese, overweight and normal weight subjects. There was also no significant correlation between macronutrient composition of the diet and body weight status. Based on these findings, we conclude that the subjects' body weight status is likely to be influenced by energy intake rather than the macronutrient composition of the diet.

Keywords: Energy intake, Klang Valley, macronutrient composition, obese Malay women, overweight Malay women

INTRODUCTION

Aetiologically, overweight and obesity is classically represented as an imbalance between energy intake and energy expenditure. While an increase in energy intake has been shown to parallel an increase in body mass index (Trichopoulou *et al.*, 2000; Stubbs and Lee, 2004; Howarth *et al.*, 2007), there is conflicting evidence as to the

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role macronutrients play in the development of overweight and obesity. A review by Astrup (2008) of 13 papers showed that the optimal diet for prevention and treatment of weight gain and obesity is fat-reduced and high in low-energy density carbohydrates. Even so, a critical review of 50 articles looking at high-protein low-refined carbohydrate diets documented increases in thermogenesis and satiety levels which facilitate weight loss (Halton & Hu, 2004).

Globally, obesity has become a pandemic with prevalence statistics escalating rapidly among many levels of society in both developed and developing countries (Prentice, 2006). In Malaysia, data from National Health and Morbidity Surveys conducted in 1996 (Lim *et al.*, 2000) and 2006 (NHMS III, 2006) showed that the prevalence of overweight and obese adult Malaysians has increased respectively by 1.7 and 3.2 fold in just a span of a decade. These surveys also point to high obesity rates among Indian and Malay women. Corresponding to the increase in prevalence of overweight and obesity, Malaysian adults appear to have increased their fat intake while decreasing their carbohydrate intake over the years (Mirnalini *et al.*, 2008). To date, there has not been any local studies directly associating energy and macronutrient intake with overweight and obesity.

As such, this study aims to determine in a sample of Malay adult women working in the Klang Valley, if macronutrient composition of the diet is associated with overweight and obesity.

METHODOLOGY

Study design and sampling

This is a cross-sectional study conducted on a convenience sample over a period of six months. The subjects participated in this study on a voluntary basis from six offices of the Employees Provident Fund (EPF) situated in the Gombak, Setapak, Kuala Lumpur, Petaling Jaya, Shah Alam and Klang areas of the Klang Valley, Selangor. These offices were chosen as they represented a geographical cross-section of the Klang Valley. Subjects gave informed consent and were interviewed at their respective workplaces.

Malaysian female adults of the Malay ethnic group aged between 18 to 59 years were recruited to participate in the study. The ethnicity of the subjects was limited to only one ethnic group to reduce genetic influences on body weight regulation. Subjects excluded from participating in this study presented with either one of the following criteria: underweight (BMI <18.5 kg/m^2); morbid obesity (BMI ≥ 40.0 kg/m^2); pregnancy; at risk of anorexia nervosa and bulimia nervosa; presence of clinical problems such as endocrine diseases and metabolic diseases; and addiction to drug or alcohol.

Sample size was calculated at 113 subjects based on four parameters: the difference of energy intake between normal weight and overweight subjects set at 212 kcal/day $\pm$ 535 kcal/day (Davis *et al.*, 2006); a 33.5% prevalence of overweight and obesity among adult Malay females (Lim *et al.*, 2000); a 95% level of confidence; and an 80% study power.

The study obtained ethical approval from the Research and Ethics Committee of Hospital University Kebangsaan Malaysia.

Socio-demographic characteristics

A questionnaire was administered to obtain socio-demographic data such as age, marital status, education level and household income.

Anthropometric assessment

Body weight was measured to the nearest 0.1 kg using the Tanita Body Fat Analyzer (TBF-300, Tanita Corporation, Tokyo, Japan). Subjects removed their shoes and socks, and stood upright in the middle of the platform. Body weight was evenly distributed between both legs and their head placed in the Frankfurt plane before height was measured to the nearest 0.1 cm using the microtoise tape (SECA bodymeter 208, Germany).

Body Mass Index (BMI) was calculated as body weight in kilograms divided by height in metres squared. Subjects were identified as normal, overweight and obese based on WHO (1998) classifications.

Waist circumference was measured to the nearest 0.1 cm with a tape. Readings were taken at the end of a normal expiration, from the level mid-point between the lower costal border (10th rib) and the iliac crest. Subjects were identified as having excessive abdominal adiposity if their waist circumference exceeded 80 cm (WHO/IASO/IOTF, 2000).

Percentage body fat was determined to the nearest 0.1% using the bio-impedence technique with the aid of the two-point, step-on Tanita Body Fat Analyzer (TBF-300, Tanita Corporation, Tokyo, Japan). This measurement was recorded using the same technique applied for measuring body weight after the subjects emptied their urinary bladders.

Dietary intake assessment and analysis

The diet history method was employed to assess the subjects' habitual energy, carbohydrate, protein and fat intake. The subjects were interviewed and their average intake over a period of 7 days were analysed. Household measurements were used to facilitate quantification of portion sizes which were then converted to metric measurements (g) and analysed based on the Nutrient Composition of Malaysian Foods Table (Tee *et al.*, 1997) and the Singapore Food Composition Guide (Singapore Ministry of Health, 2001). Packaged foods were analysed based on the nutrient content of their labels.

Evaluation of energy under- and over-reporters

Energy over- and under-reporting was identified using cut-off points based on the ratio between reported energy intake (EI) and calculated basal metabolic rate (BMR) (Livingstone & Black, 2003). BMR was calculated using the predictive equation published by Ismail *et al*. (1998). An EI:BMR ratio of below 1.2 identified energy under-reporters while a ratio of >2.4 identified energy over-reporters (Black, 2000). Subjects with EI:BMR ratios of between 1.2 to 2.4 constituted energy intake (EI) normal-reporters.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS for Windows) version 10.0 was used for statistical analysis. Descriptive statistics were used to represent average age, anthropometric status and dietary intake. Pearson's Correlation was used to identify the correlation between dietary intake and anthropometric variables while one-way ANOVA was used to analyse the difference in dietary intakes between the normal, overweight and obese groups.

RESULTS

Socio-demographic characteristics

The subjects had a mean age of 37.2±7.6 years and 83.5% of the subjects were married. All subjects received secondary education with slightly more than half (52.2%) earning a household income of more than RM3,500 per month.

Based on BMI classifications, the normal, overweight and obese subjects did not differ greatly with regard to marital status, education level and household income (Table 1). There was also no significant difference between the mean age of normal (36.7±7.3 years), overweight (37.1±7.8 years) and obese (38.2±7.8 years) subjects.

Anthropometric status

Mean body weight, height, BMI, waist circumference and percentage body fat of the subjects are presented in Table 2. Based on

Table 1. Socio-demographic characteristics of subjects

	Total (n=115)	*Normal weight (n=51)*	*Overweight (n=38)*	*Obese (n=26)*
	n (%)	*n(%)*	*n(%)*	*n(%)*
Age group				
20 – 29 years	23 (20)	13 (25.5)	8 (21.1)	2 (7.7)
30 – 39 years	37 (32.2)	15 (29.4)	10 (26.3)	12 (46.2)
40 – 49 years	53 (46.1)	23 (45.1)	19 (50.0)	11 (42.3)
50 -59 years	2 (1.7)	0 (0)	1 (2.6)	1 (3.8)
Marital status				
Single	18 (15.7)	9 (17.6)	7 (18.4)	2 (7.7)
Married	96 (83.5)	41 (80.4)	31 (81.6)	24 (92.3)
Widowed	1 (0.9)	1 (2.0)	0 (0)	0 (0)
Education level				
Secondary	75 (65.2)	33 (64.7)	27 (71.1)	15 (57.7)
Tertiary	40 (34.8)	18 (35.3)	11 (28.9)	11 (42.3)
Monthly household income				
< RM1,500	4 (3.5)	1 (2.0)	3 (7.9)	0 (0)
RM1,500 – RM3, 500	49 (42.6)	23 (45.1)	16 (42.1)	10 (38.5)
> RM3,500	62 (53.9)	27 (53.0)	19 (50.0)	16 (61.5)

Table 2. Physical characteristics of subjects

	Total (n=115)	*Normal weight (n=51)*	*Overweight (n=38)*	*Obese (n=26)*
	Mean±SD	*Mean±SD*	*Mean±SD*	*Mean±SD*
Weight (kg)	63.5 ± 13.0	53.2 ± 5.7*	64.5 ± 6.9*	82.0 ± 7.6*
Height (m)	1.55 ± 0.05	1.55 ± 0.05	1.54 ± 0.05	1.55 ± 0.05
BMI (kg/m^2)	26.4 ± 5.2	22.0 ± 1.9*	27.1 ± 1.7*	34.1 ± 2.8*
Waist circumference (cm)	80.2 ± 10.0	72.3 ± 5.6*	81.8 ± 5.5*	93.1 ± 6.4*
Body fat (%)	37.7 ± 8.6	30.4 ± 4.9*	40.5 ± 4.9*	48.1 ± 4.8*

*Significant difference in body weight, BMI, waist circumference and percentage body fat between groups (ANOVA), p<0.001

their BMI, 44.3% of the subjects are of normal body weight while those who are overweight and obese make up 33.0% and 22.6% respectively of the total sample size. Body weight, BMI, waist circumference and percentage body fat were significantly different between the normal, overweight and obese groups (p<0.001). These readings were highest in the obese and lowest among the normal weight subjects.

Dietary intake

Evaluation of energy under- and over-reporters

When energy intake was assessed for accuracy, 59% (n=68) of the entire sample

Table 3. Proportion of normal weight, overweight and obese subjects in normal and under-reporters

	Total subjects(n=115)		
	Normal weight n(%)	*Overweight n(%)*	*Obese n(%)*
Normal reporters (n=47)	26 (55.3)	15 (31.9)	6 (12.8)
Under reporters (n=68)	25 (36.8)	23 (33.8)	20 (29.4)

under-reported their energy intakes. The prevalence of under-reporting appears to increase with obesity. The percentage of subjects who under-reported increased from 49.0% to 60.5% and 76.9% in the normal weight, overweight and obese categories. None of the subjects over-reported their energy intakes. Only 47 subjects reported their energy intakes within the normal range. Of these, the proportion of normal weight, overweight and obese subjects is 55.3%, 31.9% and 12.8% respectively (Table 3).

Differences in energy and macronutrient intake between normal and overweight/obese subjects

When the differences in energy and macronutrient intake between normal, overweight and obese subjects were investigated using data from the total sample (N=115), the one-way ANOVA test revealed no significant differences. This may be attributed to the systematic bias resulting from a high percentage of energy under-reporters amongst the overweight and obese subjects. Subsequently, further ANOVA tests were conducted only among the subjects who normally reported their energy intakes (n=47) to compare energy and macronutrient intakes between normal, overweight and obese groups. Results from normal energy reporters showed that average energy intake increased with BMI category. Among the overweight and obese subjects, energy intake is higher by 125 kcal/day and 434 kcal/day, respectively, compared to their normal weight counterparts ($p<0.001$). Interestingly, this significant difference in energy intake, however, is not reflected in their macro-nutrient intakes. Intake of carbohydrate, protein and fat was not significantly different between the normal, overweight and obese subjects. Table 4 highlights the differences in energy and macronutrient intakes between the different BMI categories.

Correlation between energy and macronutrient intake with anthropometric measurements

Within the total sample, a weak but significant correlation was seen between energy intake and BMI ($r=0.209$, $p=0.025$), waist circumference ($r=0.287$, $p=0.002$) and percentage body fat ($r=0.200$, $p=0.032$). Within the normal energy reporters, the correlation between energy intake and the above three anthropometric measurements increased to a moderately positive relationship ($p<0.001$) (Table 5). No significant correlation was seen between macro-nutrient intakes and anthropometric measurements among the total sample and the normal energy reporters' subset.

DISCUSSION

Energy under-reporting

The percentage of energy under-reporters within the overweight and obese group in this study is comparable to findings from other studies which indicated an energy under-reporting incidence of 46% - 66% in

Table 4. Energy and macronutrient intake of subjects

Nutrient	*Total subjects n=115*			*Normal energy reporters n=47*		
	Normal weight n=51	*Overweight n=38*	*Obese n=26*	*Normal weight n=26*	*Overweight n=15*	*Obese n=6*
	Mean±SD	*Mean±SD*	*Mean±SD*	*Mean±SD*	*Mean±SD*	*Mean±SD*
Energy (kcal/day)	1466 ± 283	1491 ± 308	1627 ± 377	1685 ± 199*	1810 ± 166*	2119 ± 222*
Protein (% energy)	13.5 ± 2.4	13.3 ± 2.5	14.1 ± 2.9	13.7 ± 2.0	12.3 ± 2.0	12.3 ± 2.1
Fat (% energy)	31.0 ± 6.4	32.4 ± 6.6	33.5 ± 5.8	31.2 ± 6.5	31.8 ± 7.2	33.3 ± 6.7
Carbohydrate (% energy)	55.5 ± 6.4	54.3 ± 7.9	52.4 ± 7.0	55.1 ± 6.6	55.9 ± 9.4	54.4 ± 8.4
Protein (g/1000kcal)	34.3 ± 6.1	34.1 ± 6.2	35.1 ± 7.4	34.5 ± 5.1	32.3 ± 5.0	30.8 ± 5.3
Fat (g/1000kcal)	34.4 ± 7.1	36.4 ± 7.3	37.3 ± 6.4	34.8 ± 7.3	36.0 ± 8.0	37.2 ± 7.4
Carbohydrate (g/1000kcal)	139.2 ± 16.0	136.7 ± 19.7	131.7 ± 17.4	138.1 ± 16.5	141.5 ± 23.5	136.0 ± 21.0

*Significant difference in energy intake between groups (ANOVA), $p<0.001$

Table 5. Correlation between dietary intake and anthropometric measurements of normal energy reporters (n=47)

Dietary intake	*BMI (kg/mP2P)*		*Waist circumference (cm)*		*Body fat (%)*	
	r	*p value*	*r*	*p value*	*r*	*p value*
Energy (kcal/day)	0.635*	<0.001	0.545*	<0.001	0.534*	<0.001
Protein (g/1000kcal)	-0.240	0.104	-0.178	0.232	-0.166	0.264
Fat (g/1000kcal)	0.093	0.532	-0.041	0.783	-0.038	0.801
Carbohydrate (g/1000kcal)	-0.004	0.976	0.002	0.987	0.063	0.675

* Significant correlation between energy intake and BMI, waist circumference and body fat (Pearson's Correlation), $p<0.001$

their overweight and obese subjects (Greet & Mieke, 2006; Abbott *et al*., 2008). Energy under-reporting appears to increase with BMI. A study by Gnardellis *et al.* (1998) indicated that obese individuals are twice as likely to under-report energy intake compared to normal weight individuals. In fact, the tendency to under-report among women increases with higher BMIs (Mendez *et al*., 2004). The tendency to under-report among overweight/obese subjects should be taken into account when interpreting data from studies comparing dietary intake with body weight status. In order to minimise systematic bias resulting from energy under-reporting, only data from normal energy reporters should be used to assess the association between energy and macro-nutrient intake with overweight and obesity.

Energy intake

This study found that the overweight and obese subjects consumed 125 kcal/day and 434 kcal/day more than their normal weight counterparts. Cross-sectional studies conducted in similar veins corroborate this finding. A study conducted in America reported that overweight and obese female subjects collectively ate 212 kcal/day more than their age- and height-matched normal weight counterparts (Davis *et al.*, 2006). Duvigneaud *et al.* (2007) also reported that Flemish overweight and obese female adults ate 25 kcal/day and 219 kcal/day more than normal weight females. This positive correlation between energy intake and body weight status is further supported by results of the WHO MONICA aggregate level analyses which found that increasing energy supply is closely associated with the increase in overweight and obesity in European countries (Silventoinen *et al.*, 2004). Data from Australia and the United States also show that increased self-reported energy intake is associated with obesity (Stubbs & Lee, 2004).

Macronutrient intake

Contrary to what is seen with energy intake, the relationship between different macro-nutrient composition of diets and body weight status is not as well defined. Until recently, dietary fat intake had been considered one of the primary determinants of excessive body weight (Hill *et al.*, 2000). All the same, data showed that the increase in the prevalence of obesity seen in America paradoxically coincided with a decrease in fat intake (Heini & Weiser, 1997). In the context of the EPIC study conducted in Europe, Trichopoulou *et al.* (2002) showed that protein intake is positively associated with BMI. In addition, their data suggested that neither saturated or monounsaturated lipids nor carbohydrates play a major role in increasing BMI over and beyond that indicated by their energy content. Weigle *et al.* (2005) showed that increasing dietary protein at a constant carbohydrate intake exerts an anorexic effect which leads to sustained decrease in *ad libitum* caloric intake.

Nonetheless, this study did not find an association between any of the macronutrients with body weight status. While this result is from normal energy reporters who form a relatively small sample, results from other studies support this finding. The previously quoted study by Duvigneaud *et al.* (2007) looked at normal energy-reporters and found that there was no difference in percentage of energy intake from fat, carbohydrate and protein in overweight and obese women compared to women with normal weight. In addition, a 5-year Danish cohort study did not find an association between energy intake from fat or carbohydrate with changes in waist circumference (Halkjaer *et al.*, 2006). McLaughlin *et al.* (2006) in their randomised trial showed that when a hypocaloric diet is administered, differing levels of macronutrient composition were equally effective for weight loss. In addition, two other trials looking at both short and long-term weight loss showed that while a low-carbohydrate diet induced better weight loss than a low-fat diet after 6 months, no difference in weight loss was seen between these two diets after 12 months (Astrup *et al.*, 2004).

The association between macronutrient intake and body weight status seen in this study may also be the result of other interplaying factors which have not been taken into account. McCrory *et al.* (2000) identified dietary variety and palatability as factors which can affect energy intake. In addition, larger portion size leads to greater energy intake and higher BMI in the long run. Well-controlled, laboratory-based studies have also shown that providing adults with larger food portions leads to significant increases in energy intake (Ello-Martin *et al*., 2005). As shown by Heitmann *et al.* (1995), genetic predisposition to obesity can also influence how macronutrient intake affects body weight status. The basic rule of energy balance applies and any hypocaloric diet will induce weight loss and promote effective weight management. While modifying the macro-nutrient content of a diet can be a useful strategy in reducing the energy content of a diet, it is by no means the only factor affecting energy intake.

CONCLUSION

This study found that the subjects' body weight status is influenced by energy intake but not by macronutrient composition of the diet. While energy intake is clearly associated with body weight status, health professionals should consider the weight of evidence before promoting one form of macro-nutrient distribution over another to prevent and treat overweight and obesity.

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