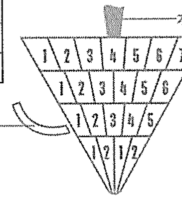
月　日（　）【今日の出来事：

食事	主食　つ(SV)	副菜　つ(SV)	主菜　つ(SV)	牛乳・乳製品つ(SV)	果物　つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動：	
体　重：	kg
薬・補助食品：	



水・お茶（　　　　）

菓　子（　　　　）

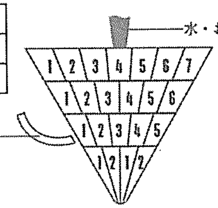
嗜好飲料（　　　　）

セルフチェック：

月　日（　）【今日の出来事：

食事	主食　つ(SV)	副菜　つ(SV)	主菜　つ(SV)	牛乳・乳製品つ(SV)	果物　つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動：	
体　重：	kg
薬・補助食品：	



水・お茶（　　　　）

菓　子（　　　　）

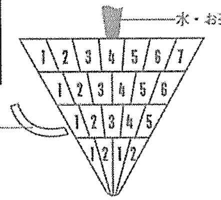
嗜好飲料（　　　　）

セルフチェック：

月　日（　）【今日の出来事：

食事	主食　つ(SV)	副菜　つ(SV)	主菜　つ(SV)	牛乳・乳製品つ(SV)	果物　つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動：	
体　重：	kg
薬・補助食品：	



水・お茶（　　　　）

菓　子（　　　　）

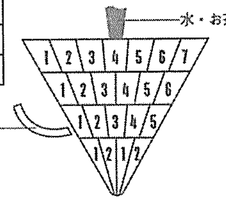
嗜好飲料（　　　　）

セルフチェック：

月　日（　）【今日の出来事：

食事	主食　つ(SV)	副菜　つ(SV)	主菜　つ(SV)	牛乳・乳製品つ(SV)	果物　つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動：	
体　重：	kg
薬・補助食品：	



水・お茶（　　　　）

菓　子（　　　　）

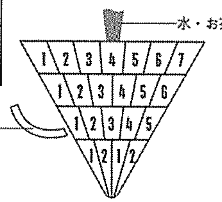
嗜好飲料（　　　　）

セルフチェック：

月　日(　)〖今日の出来事:

食事	主食 つ(SV)	副菜 つ(SV)	主菜 つ(SV)	牛乳・乳製品つ(SV)	果物 つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動:	
体　重:	kg
薬・補助食品:	



水・お茶（　　　）

菓　子（　　　）

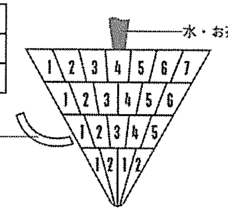
嗜好飲料（　　　）

セルフチェック：

月　日(　)〖今日の出来事:

食事	主食 つ(SV)	副菜 つ(SV)	主菜 つ(SV)	牛乳・乳製品つ(SV)	果物 つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動:	
体　重:	kg
薬・補助食品:	



水・お茶（　　　）

菓　子（　　　）

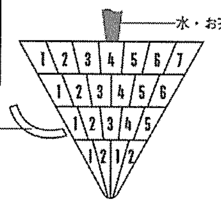
嗜好飲料（　　　）

セルフチェック：

月　日(　)〖今日の出来事:

食事	主食 つ(SV)	副菜 つ(SV)	主菜 つ(SV)	牛乳・乳製品つ(SV)	果物 つ(SV)
朝食					
昼食					
夕食					
間食					
合計					

運　動:	
体　重:	kg
薬・補助食品:	



水・お茶（　　　）

菓　子（　　　）

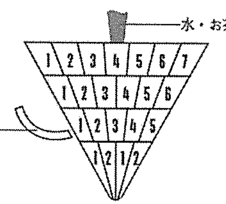
嗜好飲料（　　　）

セルフチェック：

◎今週のまとめ（妊娠＿＿＿週目）

曜日	主食 つ(SV)	副菜 つ(SV)	主菜 つ(SV)	牛乳・乳製品つ(SV)	果物 つ(SV)
日曜日					
月曜日					
火曜日					
水曜日					
木曜日					
金曜日					
土曜日					
平均					

体重変化量:＿＿＿＿＿kg



水・お茶（　　　）

菓　子（　　　）

嗜好飲料（　　　）

セルフチェック：

◎ 各週の平均摂取量（SV）をグラフに記入してみましょう。

	SV	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週	第 週
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果物	[ ]																																															
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[ ]内には普段の食事量を考慮した上での数値を記入してください。

British Journal of Nutrition (2006), **96**, 1154–1162 DOI: 10.1017/BJN20061921

Perceived body size and desire for thinness of young Japanese women: a population-based survey

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The present study describes findings in relation to perceived body size and 'desire for thinness' by age and residential areas ('metropolitan areas', 'large cities', 'small cities' and 'towns') among young Japanese women. Data on 1731 non-pregnant, non-lactating women aged 15–39 years from the 1998 National Nutrition Survey of Japan were used. Current body size was evaluated by BMI percentiles (lean, <5th; underweight, 5th ≤ BMI <25th; normal, 25th ≤ BMI < 75th; overweight, 75th ≤BMI <95th; obese, ≥95th), calculated for 5-year age groups. Perceived body size was obtained by self-report. We defined 'overestimation' as non-overweight, non-obese women who perceived themselves as being 'overweight' or 'obese'. Desired body size was evaluated by applying the desired BMI to these cut-off points. Of all the women, 48·4 % perceived themselves as being 'overweight' or 'obese', and 43·7 % desired a 'lean' or 'underweight' body size. Adjusted for the current BMI, the OR for 'overestimation' calculated by a logistic regression model was significantly elevated in the 15–19-year age group (OR 2·79; 95 % CI 1·76, 4·43), compared with the 25–29-year age group. The OR for 'desire for thinness' was significantly high in the 35–39-year age group (OR 2·74; 95 % CI 1·93, 3·89) and the 15–19-year age group (OR 2·26; 95 % CI 1·57, 3·24). Women living in metropolitan areas had higher OR for 'desire for thinness' (but not for 'overestimation') than did women in towns (OR 1·47; 95 % CI 1·05, 2·07). The findings suggest the nature of excessive weight concerns of young women in Japan; thus efforts to control such health-risk behaviours at a national level are urgent.

Underweight: Weight perception: Young women: Japan: Geographical differences

Almost all industrialised countries face epidemics of obesity, and Japan is no exception. A recent report from the WHO documented that the number of overweight adults worldwide has exceeded one billion, and that at least 300 million of these were clinically obese (World Health Organization, 2003). In Japan, the prevalence of overweight (BMI ≥25 kg/m^2) in adult men has risen approximately 10 % in the last two decades according to the National Nutrition Survey of Japan (NNS-J) (Yoshiike *et al.* 2002). One in every five men aged 20–29 years, and one in every three or four men aged over 30 years are now overweight (Ministry of Health, Labour and Welfare, 2004). However, the trend in Japanese women differs from men, because the prevalence of underweight is increasing, especially in young women (Ministry of Health, Labour and Welfare, 2004).

Overweight or obesity are known to be associated with an increased risk of chronic diseases, such as type 2 diabetes (Manson *et al.* 1990; Chan *et al.* 1994), CVD (Manson *et al.* 1990; Wilson *et al.* 2002), and certain forms of cancer (Calle & Thun, 2004), due to metabolic changes caused by excess fat. However, underweight is also associated with negative health consequences, such as nutritional deficiency (Russell *et al.* 1994), osteoporosis (Blum *et al.* 2001), and unfavourable pregnancy outcomes in women of childbearing age (Edwards *et al.* 1979). As in obesity, underweight is also an important risk factor to increased mortality risk in Japanese (Tsugane *et al.* 2002).

In Japan, we have a 10-year national plan to promote the health of the Japanese population named 'Health Japan 21', which was released in 2000. One of the plan's objective aims to decrease the prevalence of underweight (BMI <18·5 kg/m^2) in women aged 20–29 years to less than 15 %, and to increase the proportion of individuals who are aware of their own optimal weight to 90 % or more by 2010 (Ministry of Health, Labour and Welfare, 2000*a*). However, the recent data from the NNS-J showed little change in the prevalence of underweight from the baseline (Ministry of Health, Labour and Welfare, 2004).

Most previous studies regarding desire for thinness in young women are from Western societies, where most women are at risk of overweight or obesity rather than underweight. Another limitation is that previous studies on body dissatisfaction or other related issues in Japanese women were from small

Abbreviations: NNS-J, National Nutrition Survey of Japan.
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convenient samples or specific age groups such as adolescents or college students (Watanabe *et al.* 2003; Wardle *et al.* 2005). Even in the USA where many pioneering work in this area has been documented, a recent population-based study on the prevalence of overweight misperceptions and weight-control behaviours among normal-weight subjects included only adolescents, and used the self-reported height and weight measurements for the analyses (Talamayan *et al.* 2006). Other population-based studies were looking at misperceptions of body size as barriers to reducing overweight rather than underweight (Paeratakul *et al.* 2002; Kuchler & Variyam, 2003).

Takimoto *et al.* (2004) reported that the decrease in BMI from 1976 to 2000 was prominent among young Japanese women they studied (15–19, 20–24 and 25–29 years of age). However, BMI changes and the prevalence of underweight of women aged 15–19 years living in metropolitan areas predominated those living in smaller towns. That is, there was a difference in the prevalence of underweight by geographical region. McLaren & Gauvin (2003) reported that living among thinner women increases the likelihood of reporting dissatisfaction with body image. Therefore, we assumed that women living in metropolitan areas and large cities were more likely to misperceive their body size and report stronger desire for thinness compared with women living in smaller towns.

In accordance with the result of the previous studies and assumptions we made, the objective of the present study was to describe the situation of perceived body size and desire for thinness among young Japanese women, by using datasets from a population-based survey. Furthermore, we evaluated relationships of perceived body size and desire for thinness with age and residential areas.

Methods

Survey sample and methodology

Datasets of the NNS-J in 1998 were used in the present study (Ministry of Health, Labour and Welfare, 2000*b*). The NNS-J was initiated in 1945 to assess the nutritional status and socio-economic status of the Japanese population to obtain urgently needed food supplies from other countries, but it now monitors and assesses the dietary intakes and health outcomes of the population. Each November, approximately 15 000 members from nearly 5000 households in randomly sampled census units are surveyed by the local public health centres under the supervision of the Japanese Ministry of Health, Labour, and Welfare. There are three major components in the NNS-J. One is the physical examination survey, in which all participants aged 1 year and older are invited to have their height and weight measured at local public health centres in the selected survey area. Blood pressure measurements and a 1 d step tests using a pedometer are recorded for participants aged 15 years and older. Blood tests of haematological parameters, lipid profiles, and glucose levels are only conducted for adults aged 20 years and older, and blood is drawn 3 h or more after the last meal. All physical measurements are conducted by trained public health nurses, according to the measurement protocol in the NNS-J (Ministry of Health, Labour and Welfare, 2000*b*). The second component is the 1 d weighed dietary record of all members of the survey household. The third component is the dietary questionnaire, which all participants aged 15 years and older are asked to fill in. The contents of the dietary questionnaires differ each year. Before the analyses, we received permission of the use of NNS-J datasets from the Ministry of Health, Labour and Welfare.

We evaluated 1731 non-pregnant and non-lactating women aged 15–39 years for whom information on height and weight measurements and dietary data were available. Although the role of family members of patients with disordered eating behaviours has been discussed in clinical settings, there is no consistent evidence that women with eating disorders were more likely to have sisters than brothers, or to have more females than males in their family (Dolan *et al.* 1989; Britto *et al.* 1997). Therefore no adjustment was made in the present study for the number of women in a household. The 1731 women were classified into 5-year age groups (15–19, 20–24, 25–29, 30–34 and 35–39 years of age) and then categorised by their current body size as determined by BMI percentiles (5th, 25th, 75th, 95th percentile) calculated for each age group (Table 1). Body-size categories are as follows: lean (BMI $<$5th percentile); underweight (5th $\leq$BMI $<$25th percentile); normal (25th $\leq$BMI $<$75th percentile); overweight (75th $\leq$BMI $<$95th percentile); obese (BMI $\geq$95th percentile).

Outcome measures

Body-size perception was determined by the woman's response to the question: 'Which best describes your current body size: lean, underweight, normal, overweight, or obese?' We defined 'overestimation' of body size as being a woman's perception of being 'overweight' or 'obese' when her actual current body size was lean, underweight or normal. Therefore, the analyses were only focused on non-obese and non-overweight subjects. We then compared the 'overestimators' with the 'non-overestimators' for the measured and desired BMI, as well as the difference between measured and desired weight, by age and residential area.

Each woman also gave a response regarding her desired weight. To evaluate the desired body size of these women, we calculated the 'desired BMI' of each woman by applying her desired weight and her measured height. The desired BMI was categorised according to the BMI percentiles of her current age group. 'Desire for thinness' was defined as a woman having a desired BMI in the 'lean' or 'underweight' range.

Residential areas were defined by the population size of the woman's current residence. We considered a 'town' ($<$50 000 residents) as the base reference area, and compared it with 'metropolitan areas' ($\geq$ 1 000 000 residents), 'large cities' (150 000–1 000 000 residents) and 'small cities' (50 000–150 000 residents).

Statistical analysis

All numerical variables including age, height, weight and BMI values were expressed as mean values and SD. One-way ANOVA were used to compare numerical data across different age categories. To compare categorical data, χ^2 tests were applied. Logistic regression analyses with multivariate models were used to estimate the adjusted odds ratio OR of 'overestimation' of body size and 'desire for thinness'. $P<0{\cdot}05$ was considered to be statistically significant.

Table 1. Anthropometric characteristics of women by age groups and residential areas‡

(Mean values and standard deviations)

Variable	n	Age (years)		Measured values: Height (cm)		Measured values: Weight (kg)		Measured values: BMI (kg/m²)		Desired values: Weight (kg)		Desired values: BMI (kg/m²)		Difference between measured and desired weight (kg)		BMI cut-off points for current body size (percentiles): 5th (kg/m²)	25th (kg/m²)	75th (kg/m²)	95th (kg/m²)
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD				
Age group																			
15–19 years	327	–		157·6	5·0	51·2	8·0	20·6	2·9	46·6	4·4**	18·7**	1·4	4·6	6·2	17·0	18·7	21·5	25·6
20–24 years	277	–		157·9	5·6	51·2	7·2	20·6	2·7	47·3	4·8	19·0	1·5	3·9	5·3	16·9	18·8	21·9	25·5
25–29 years	330	–		158·2	5·7	51·6	8·4	20·6	3·0	48·2	5·1	19·2	1·5	3·4	5·8	17·1	18·7	21·9	26·5
30–34 years	372	–		157·7	5·2	52·8	8·4	21·2	3·3	48·7	4·6	19·6*	1·4	4·0	6·5	17·4	19·0	22·6	28·2
35–39 years	425	–		156·9*	5·2	53·9**	9·1	21·9**	3·5	49·2	4·9*	20·0**	1·5	4·7	6·9	17·9	19·5	23·3	29·1
Residential area																			
Metropolitan	277	27·5	7·1	157·8	5·3	51·7	7·6	20·7†	2·9	47·7	4·5	19·1†	1·4	4·0	5·3	–	–	–	–
Large cities	532	28·5	7·0	157·8	5·4	51·6	8·6	20·8†	3·2	48·1	4·9	19·3	1·6	3·6	6·4	–	–	–	–
Small cities	393	27·5	7·5	157·3	5·4	52·6	8·3	21·3	3·2	48·1	4·8	19·4	1·6	4·5	6·4	–	–	–	–
Towns	529	27·6	7·7	157·6	5·2	53·0	8·6	21·4	3·2	48·4	5·0	19·5	1·6	4·5	6·4	–	–	–	–

Mean value was significantly different from that of the 25–29-year age group: * $P<0·05$, ** $P<1155$.
† Mean value was significantly different from that of 'towns' ($P<0·05$).
‡ For details of definition of terms, see p. 1155.

All data were analysed with the SAS statistical package (version 8; SAS Institute Inc., Cary, NC, USA).

Results

The characteristics of the study participants by age group are presented in Table 1. When we compared the measured weight with the desired weight for each age group, the difference between these two variables was smallest in women aged 25–29 years. Therefore, we considered this group as a reference for the following analyses. In regard to height, women aged 35–39 years showed a significantly lower value ($P<0·05$) compared with the reference group. In regard to mean desired weight, it was significantly lower ($P<0·01$) in the youngest group (15–19 years), but was significantly higher ($P<0·05$) in women aged 35–39 years. Mean desired BMI was significantly lower ($P<0·01$) in women aged 15–19 years, but it was significantly higher in women aged 30–34 years ($P<0·05$), as well as in women aged 35–39 years ($P<0·01$). In regard to the difference between current and desired weight, there were no significant differences across age groups.

Table 1 also shows the characteristics of the study participants by residential areas. The mean age of the women was similar in the four residential areas. When compared with women residing in towns, BMI values were significantly lower in women from metropolitan areas and large cities ($P<0·05$). The mean desired BMI was significantly lower ($P<0·05$) in women from metropolitan areas than in women residing in towns. The mean difference between measured and desired weight was smallest in women from large cities, but this was not statistically significant.

Table 2 shows the distributions of perceived body size and desired body size according to actual body size by age groups: 48·4 % of all women perceived themselves as being 'overweight' or 'obese'. In women whose actual body sizes were neither overweight nor obese, the proportion of women who believed that they were 'overweight' or 'obese' (overestimation) was lowest (23·4 %) in the 25–29-year age group: 38·6 % of non-overweight, non-obese women in the 15–19-year age group overestimated their body sizes. The prevalence of overestimation was 32·7, 31·9 and 36·7 % in non-overweight, non-obese women in the 20–24-year, 30–34-year and 35–39-year age groups, respectively. In all age groups, underweight women were more likely to perceive themselves as being 'normal' than women in the normal category. The proportion of women who had the desire to be in the 'lean' or the 'underweight' category was 53·5, 46·9, 36·7, 36·8 and 43·1 % in the five age groups. Most women who were currently lean or underweight desired their body size to be 'lean' or 'underweight'.

Table 3 shows the distribution of perceived body size and desired body size according to current body-size categories grouped by the residence area. The proportion of obese women was 4·0 % in metropolitan areas, 3·4 % in large cities, 5·9 % in small cities and 5·9 % in towns. In women who were neither overweight nor obese, the proportion of overestimation was 33·6 % in metropolitan areas, 31·3 % in large cities, 33·9 % in small cities and 33·3 % in towns. The proportion of women whose desired body size was in the 'lean' or the 'underweight' category was 49·8 % in metropolitan areas, 47·4 % in large cities, 41·7 % in small cities and 36·5 % in towns.

Table 2. Distributions of perceived and desired body size according to actual body size by age groups*

		Perceived body size										Desired body size									
		Lean		Under-weight		Normal		Overweight		Obese		Lean		Underweight		Normal		Overweight		Obese	
Current body size	*n*	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
15–19 years																					
Lean	16	5	31·3	3	18·8	7	43·8	1	6·3	–	–	10	62·5	5	31·3	1	6·3	–	–	–	–
Underweight	66	5	7·6	15	22·7	34	51·5	10	15·2	2	3·0	9	13·6	49	74·2	5	7·6	3	4·5	–	–
Normal	164	1	0·6	7	4·3	74	45·1	61	37·2	21	12·8	9	5·5	75	45·7	80	48·8	–	–	–	–
Overweight	66	–	–	–	–	10	15·2	21	31·8	35	53·0	2	3·0	12	18·2	48	72·7	4	6·1	–	–
Obese	15	–	–	–	–	1	6·7	3	20·0	11	73·3	1	6·7	3	20·0	7	46·7	4	26·7	–	–
Total	327	11	3·4	25	7·6	126	38·5	96	29·4	69	21·1	31	9·5	144	44·0	141	43·1	11	3·4	–	–
20–24 years																					
Lean	13	9	69·2	3	23·1	1	7·7	–	–	–	–	3	23·1	7	53·8	3	23·1	–	–	–	–
Underweight	57	5	8·8	12	21·1	34	59·6	6	10·5	–	–	7	12·3	42	73·7	8	14·0	–	–	–	–
Normal	138	–	–	2	1·4	74	53·6	50	36·2	12	8·7	1	0·7	63	45·7	74	53·6	–	–	–	–
Overweight	56	–	–	–	–	3	5·4	23	41·1	30	53·6	–	–	6	10·7	45	80·4	5	8·9	–	–
Obese	13	–	–	–	–	1	7·7	1	7·7	11	84·6	–	–	1	7·7	9	69·2	2	15·4	1	7·7
Total	277	14	5·1	17	6·1	114	40·8	80	28·9	53	19·1	11	4·0	119	43·0	139	50·2	7	2·5	1	0·4
25–29 years																					
Lean	16	7	43·8	6	37·5	3	18·8	–	–	–	–	3	18·8	10	62·5	3	18·8	–	–	–	–
Underweight	66	4	6·1	18	27·3	42	63·6	2	3·0	–	–	4	6·1	44	66·7	18	27·3	–	–	–	–
Normal	166	3	1·8	7	4·2	100	60·2	44	26·5	12	7·2	2	1·2	53	31·9	111	66·9	–	–	–	–
Overweight	66	–	–	–	–	2	3·0	28	42·4	36	54·5	1	1·5	4	6·1	56	84·8	5	7·6	–	–
Obese	16	–	–	–	–	–	–	–	–	16	100·0	–	–	–	–	8	50·0	6	37·5	2	12·5
Total	330	14	4·2	31	9·4	147	44·5	74	22·4	64	19·4	10	3·0	111	33·6	196	59·4	11	3·3	2	0·6
30–34 years																					
Lean	18	10	55·6	7	38·9	1	5·6	–	–	–	–	4	22·2	10	55·6	4	22·2	–	–	–	–
Underweight	75	10	13·3	20	26·7	42	56·0	3	4·0	–	–	7	9·3	44	58·7	24	32·0	–	–	–	–
Normal	186	1	0·5	10	5·4	89	47·8	73	39·2	13	7·0	4	2·2	61	32·8	121	65·1	–	–	–	–
Overweight	75	–	–	–	–	3	4·0	20	26·7	52	69·3	1	1·3	5	6·7	65	86·7	4	5·3	–	–
Obese	18	–	–	–	–	–	–	1	5·6	17	94·4	–	–	1	5·6	15	83·3	2	11·1	–	–
Total	372	21	5·6	37	9·9	135	36·3	97	26·1	82	22·0	16	4·3	121	32·5	229	61·6	6	1·6	–	–
35–39 years																					
Lean	21	7	33·3	8	38·1	6	28·6	–	–	–	–	7	33·3	11	52·4	3	14·3	–	–	–	–
Underweight	85	6	7·1	28	32·9	47	55·3	4	4·7	–	–	7	8·2	62	72·9	16	18·8	–	–	–	–
Normal	213	1	0·5	4	1·9	95	44·6	91	42·7	22	10·3	6	2·8	82	38·5	123	57·7	2	0·9	–	–
Overweight	85	–	–	–	–	1	1·2	33	38·8	51	60·0	1	1·2	6	7·1	72	84·7	6	7·1	–	–
Obese	21	–	–	–	–	–	–	–	–	21	100·0	–	–	1	4·8	14	66·7	6	28·6	–	–
Total	425	14	3·3	40	9·4	149	35·1	128	30·1	94	22·1	21	4·9	162	38·1	228	53·6	14	3·3	–	–

* For details of definition of terms, see p. 1155.

Table 3. Distributions of perceived and desired body size according to actual body size by residential area*

			Perceived body size										Desired body size									
			Lean		Under-weight		Normal		Overweight		Obese		Lean		Under-weight		Normal		Over-weight		Obese	
Residential area	Current body size	*n*	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Metropolitan	Lean	13	4	30·8	5	38·5	4	30·8	–	–	–	–	7	53·8	5	38·5	1	7·7	–	–	–	–
	Underweight	58	3	5·2	12	20·7	37	63·8	4	6·9	2	3·4	7	12·1	43	74·1	8	13·8	–	–	–	–
	Normal	146	1	0·7	5	3·4	73	50·0	55	37·7	12	8·2	4	2·7	64	43·8	78	53·4	–	–	–	–
	Overweight	49	–	–	–	–	6	12·0	15	30·6	28	57·1	1	2·0	7	14·3	38	77·6	3	6·1	–	–
	Obese	11	–	–	–	–	–	–	1	9·1	10	90·9	–	–	–	–	7	63·6	4	36·4	–	–
	Total	277	8	2·9	22	7·9	120	43·3	75	27·1	52	18·8	19	6·9	119	43·0	132	47·7	7	2·5	–	–
Large cities	Lean	33	14	42·4	10	30·3	8	24·2	1	3·0	–	–	9	27·3	16	48·5	8	24·2	–	–	–	–
	Underweight	126	12	9·5	30	23·8	77	61·1	7	5·6	–	–	11	8·7	87	69·0	26	20·6	2	1·6	–	–
	Normal	260	1	0·4	12	4·6	124	47·7	98	37·7	25	9·6	6	2·3	109	41·9	145	55·8	–	–	–	–
	Overweight	95	–	–	–	–	2	2·1	34	35·8	59	62·1	3	3·2	9	9·5	71	74·7	12	12·6	–	–
	Obese	18	–	–	–	–	–	–	1	5·6	17	94·4	–	–	2	11·1	9	50·0	6	33·3	1	5·6
	Total	532	27	5·1	52	9·8	211	39·7	141	26·5	101	19·0	29	5·5	223	41·9	259	48·7	20	3·8	1	0·2
Small cities	Lean	16	7	43·8	6	37·5	3	18·8	–	–	–	–	3	18·8	9	56·3	4	25·0	–	–	–	–
	Underweight	74	7	9·5	26	35·1	34	45·9	7	9·5	–	–	5	6·8	53	71·6	16	21·6	–	–	–	–
	Normal	190	3	1·6	9	4·7	90	47·4	72	37·9	16	8·4	7	3·7	77	40·5	105	55·3	1	0·5	–	–
	Overweight	90	–	–	–	–	6	6·7	37	41·1	47	52·2	1	1·1	7	7·8	77	85·6	5	5·6	–	–
	Obese	23	–	–	–	–	–	–	3	13·0	20	87·0	1	4·3	1	4·3	19	82·6	1	4·3	1	4·3
	Total	393	17	4·3	41	10·4	133	33·8	119	30·3	83	21·1	17	4·3	147	37·4	221	56·2	7	1·8	1	0·3
Towns	Lean	22	13	59·1	6	27·3	3	13·6	–	–	–	–	5	27·7	15	68·2	2	9·1	–	–	–	–
	Underweight	91	8	8·8	25	27·5	51	56·0	7	7·7	–	–	11	12·1	54	59·3	26	28·6	–	–	–	–
	Normal	271	1	0·4	4	1·5	145	53·5	94	34·7	27	10·0	7	2·6	88	32·5	175	64·6	1	0·4	–	–
	Overweight	114	–	–	–	–	5	4·4	39	34·2	70	61·4	1	0·9	9	7·9	101	86·6	3	2·6	–	–
	Obese	31	–	–	–	–	2	6·5	–	–	29	93·5	–	–	3	9·7	19	61·3	7	22·6	2	6·5
	Total	529	22	4·2	35	6·6	206	38·9	140	26·5	126	23·8	24	4·5	169	31·9	323	61·1	11	2·1	2	0·4

For details of definition of terms, p. 1155.

Table 4 shows the measured and desired BMI, as well as the difference between measured and desired weight by the degree of 'overestimation'. In regard to age, the proportion of 'overestimators' in women aged 25–29 years was the smallest (23·4 %) among all age groups, compared with the 15–19-year group where 38·6 % were 'overestimators'. In regard to residential areas, there were fewer 'overestimators' in large cities (31·3 %) than in small cities (33·3 %). In total, 32·8 % of women were considered as 'overestimators'. In regard to the difference between the measured and desired BMI, the measured BMI of 'overestimators' was significantly higher than that of 'non-overestimators' ($P<0·01$) regardless of age or residential areas. The mean desired BMI was also higher in the 'overestimators', but the difference between the two groups was relatively small compared with the differences in the measured BMI between the two groups across all age groups and residential areas. The desired BMI was similar in 'overestimators' and 'non-overestimators' in women in the 15–19-year age group, and their desired BMI was below 18·5 kg/m^2 in both 'overestimators' and 'non-overestimators'. Differences between measured and desired weight in 'overestimators' were similar across all age groups, and were significantly ($P<0·01$) larger compared with 'non-overestimators'. Significant differences ($P<0·01$) in the gap between measured and desired weight between 'overestimators' and 'non-overestimators' were seen in all residential areas.

We calculated the OR for the related variables to 'overestimation' in non-obese, non-overweight women using a multivariate logistic regression model adjusted for the current BMI (Table 5). In this analysis, 427 women were defined as 'overestimators'. The OR for 'overestimation' were 2·79 (95 % CI 1·76, 4·43; $P<0·01$) in the 15–19-year age group and 0·75 (95 % CI 0·47, 1·18; $P=0·21$) in the 35–39-year age group, compared with the 25–29-year age group. The OR for 'overestimation' increased with the population size of the residence area, but was not significant.

We calculated the OR for the related variables for 'desire for thinness' with all subjects, using a multivariate logistic regression model adjusted for the current BMI (Table 6). In regard to age group, 756 were defined as having 'desire for thinness' in the analyses. The OR for 'desire for thinness'

Table 4. Comparisons of the measured and desired body mass index, and 'difference between measured and desired weight' between 'overestimators' and 'non-overestimators' by age group and residential area†

Variable	n	Measured BMI (kg/m^2) Mean	SD	Desired BMI (kg/m^2) Mean	SD	Difference between measured and desired weight (kg) Mean	SD
Age group							
15–19 years							
Overestimators	95	20·0**	0·9	18·4	1·1	4·0**	2·3
Non-overestimators	151	18·9	1·3	18·3	1·3	1·4	3·4
20–24 years							
Overestimators	68	20·3**	1·0	18·7*	1·1	4·2**	2·5
Non-overestimators	140	18·9	1·5	18·5	1·0	1·1	3·5
25–29 years							
Overestimators	58	20·6**	0·9	19·0*	1·0	4·0**	2·2
Non-overestimators	190	18·9	1·3	18·7	0·9	0·4	2·7
30–34 years							
Overestimators	89	20·1**	1·0	19·4**	1·0	4·2**	2·4
Non-overestimators	190	19·5	1·4	19·1	1·1	0·0	3·5
35–39 years							
Overestimators	117	20·6**	1·1	19·8**	1·0	4·3**	2·2
Non-overestimators	202	19·5	1·4	19·3	1·2	0·5	3·1
Residential area							
Metropolitan							
Overestimators	73	20·6**	1·1	19·1**	1·0	3·8**	2·0
Non-overestimators	144	19·1	1·4	18·6	1·0	1·3	2·9
Large cities							
Overestimators	131	20·9**	1·3	19·0*	1·1	4·5**	2·5
Non-overestimators	288	18·8	1·3	18·8	1·1	0·1	3·4
Small cities							
Overestimators	95	20·8**	1·2	19·0	1·3	4·4**	2·6
Non-overestimators	185	19·1	1·4	18·9	1·2	0·6	3·4
Towns							
Overestimators	128	20·9**	1·1	19·3*	1·2	3·9**	2·0
Non-overestimators	256	19·3	1·4	19·0	1·3	0·8	3·1
Total							
Overestimators	427	20·8**	1·2	19·1**	1·2	4·2**	2·3
Non-overestimators	873	19·1	1·4	18·8	1·2	0·6	3·3

Mean value was significantly different from that of 'non-overestimators' in the same category: * $P<0·05$, ** $P<0·01$.
† For details of definition of terms, see p. 1155.

Table 5. Multivariate logistic regression analyses for 'overestimation' by age group and residential area*
(OR and 95 % CI)

Variable	OR	95 % CI	*P*
Age group			
15–19 years	2·79	1·76, 4·43	<0·01
20–24 years	1·57	0·96, 2·56	0·07
25–29 years	1·00	Referent	
30–34 years	0·98	0·62, 1·57	0·94
25–39 years	0·75	0·47, 1·19	0·21
Residential area			
Metropolitan	1·41	0·91, 2·17	0·12
Large cities	1·42	0·98, 2·05	0·06
Small cities	1·25	0·84, 1·86	0·28
Towns	1·00	Referent	

* Analyses were adjusted for the current BMI; subjects were restricted to non-obese and non-overweight women in the analyses. For details of definition of terms, see p. 1155.

Table 6. Multivariate logistic regression analyses for 'desire for thinness' by age group, residential area and overestimation of body size*
(OR and 95 % CI)

Variable	OR	95 % CI	*P*
Age group			
15–19 years	2·26	1·57, 3·24	<0·01
20–24 years	2·05	1·41, 2·98	<0·01
25–29 years	1·00	Referent	
30–34 years	1·31	0·92, 1·86	0·13
25–39 years	2·74	1·93, 3·89	<0·01
Residential area			
Metropolitan	1·47	1·05, 2·07	0·03
Large cities	1·31	0·98, 1·74	0·07
Small cities	1·19	0·88, 1·63	0·26
Towns	1·00	Referent	
Overestimation of body size†			
Yes	1·33	1·03, 1·70	0·03
No	1·00	Referent	

* Analyses were adjusted for the current BMI. For details of definition of terms, see p. 1155.
† Subjects were restricted to non-obese and non-overweight women in the analyses.

were 2·26 (95 % CI 1·57, 3·24; $P<0·01$) in the 15–19-year age group and 2·74 (95 % CI 1·93, 3·89; $P<0·01$) in the 35–39-year age group, compared with the 25–29-year age group. In regard to residential area, 747 women were defined as having 'desire for thinness'. The OR for 'desire for thinness' increased as the population size increased. The OR was significantly higher in women who resided in metropolitan areas (OR 1·47 (95 % CI 1·05, 2·07); $P=0·03$). In addition, women who had overestimated their body size (*n* 427) were 1·33 times more likely to have 'desire for thinness' than those who did not (OR 1·33 (95 % CI 1·03, 1·70); $P=0·03$).

Discussion

The present results clearly demonstrated that (1) both measured and desired BMI of women living in metropolitan areas were significantly lower compared with towns, (2) body-size perception was the most accurate in women aged 25–29 years, (3) significant 'overestimation' of body size was observed in women aged 15–19 years, (4) both young and middle-aged women had significantly higher 'desire for thinness', (5) women living in metropolitan areas had significantly higher 'desire for thinness', and (6) women who overestimated their body sizes were more likely to desire thinner body sizes than those who did not. However, findings from our present study did not support one of our hypotheses that women living in larger cities were more likely to overestimate their body size than women living in smaller towns. Women living in larger cities tended to overestimate their body sizes, but no significant association was observed.

The present study demonstrated that 'desire for thinness' is not only observed in young Japanese women, but also in middle-aged women. Pubertal changes and weight gains in young women have a significant effect on the development of one's body image and body satisfaction (Cash & Pruzinsky, 2002; Suka *et al.* 2005). This is also observed in teenage girls and female college students in Japan, who have the strong 'desire for thinness', despite the fact that they are not overweight (Kaneda *et al.* 2004; Wardle *et al.* 2005). Our findings on increased 'desire for thinness' in young women are in accordance with these existing studies. However, research on middle-aged Japanese women in relation to weight perceptions and 'desire for thinness' has been limited. In the UK, for example, 'desire for thinness' of elderly women was reported to be equivalent to that of young women (Hetherington & Burnett, 1994). In addition, Allaz *et al.* (1998) found that many older women in Switzerland continued to engage in dieting, despite the fact that they were of normal weight, reflecting the continued pressure felt by women to lose weight. In the present study, the measured body weight in women aged 35–39 years was significantly higher compared with the reference group of 25–29 years. Therefore, we assume that weight gain due to ageing brings dissatisfaction in current body size, because thinness is a standard definition of attractiveness for women at all ages.

There are several points that should be considered when interpreting the present results. First, the present study is a cross-sectional observation which makes it difficult to determine the causal relationships even though the results were generated from nationally representative samples. Second, the BMI cut-off points we applied in the present study were neither the international standard nor the Japanese standard developed by the Japan Society for the Study of Obesity (Matsuzawa *et al.* 2000). These standards were both established based on risks of chronic diseases or mortality. In other words, these are more obesity-oriented. The present study, on the other hand, is aimed at identifying extravagant weight-control behaviours of young Japanese women, in which the increased prevalence of underweight (BMI $<18·5\,kg/m^2$) and extreme underweight (BMI $<17·0\,kg/m^2$) has been the major public health problem (Takimoto *et al.* 2004). The number of overweight women in the young generation are rather scarce, contrary to the worldwide obesity epidemic. These facts raised the assumption that the BMI distribution curve of this population group was likely to skew to the lower end than the upper. In addition, we had to consider significant change in the BMI distribution curve with advancing age. We assume that the application of neither the international nor the Japanese standard cut-off points disables quantitative comparisons with corresponding studies from other population groups. However, the increase in the prevalence of underweight is specific to this population group in the first place. Therefore, the use of relative BMI cut-off points to define body-size categories is an appropriate approach to learn specific characteristics of this particular population group. The findings suggest the nature of excessive weight concerns of young women in Japan. Underweight was also evident in this population group; thus efforts to control such health-risk behaviours of young women at a national level are urgent.

Women are more likely to experience less bodily satisfaction and are more likely to have lower self esteem and negative consequences (i.e. eating disorders) compared with men, regardless of age (Cash & Pruzinsky, 2002). In the present study, despite the fact that a large proportion of women were not overweight, they overestimated their body size and wanted to become even leaner. According to the 2002 NNS-J report, 12·9 % of underweight (BMI $<18{\cdot}5\,kg/m^2$) women aged 15 years and older were actually trying to lose weight. Dieting behaviours among underweight women were prominent in women aged 15–19 years (41·0 %), and the rate decreased with advanced age. Furthermore, 52·0 % of normal-weight (BMI $18{\cdot}5–24{\cdot}9\,kg/m^2$) women were trying to lose weight, and the prevalence rate of women aged 15–19 years, 20–29 years and 30–39 years were 68·6, 63·8 and 55·4 %, respectively. These results suggest that the increase in the prevalence of underweight among young Japanese women is partly due to unnecessary weight control of non-obese individuals. It has been reported that body image concerns during adolescence are related to lower self esteem and are related to increased risks for eating disorders (Cash & Pruzinsky, 2002). In addition, weight-concerned mothers have an impact on their child's behaviours, such as negative weight concerns and unhealthy dieting behaviours (Francis & Birch, 2005). Health professionals need to disseminate information on the risks of unhealthy weight-control behaviours and the benefits of a healthy diet, especially to women of reproductive age. Further studies are needed to identify how overestimation of body sizes and strong 'desire for thinness' observed in this very lean population group are related to poor health of young Japanese women.

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ORIGINAL ARTICLE

Folate intakes and folate biomarker profiles of pregnant Japanese women in the first trimester

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Objective: To assess the status of dietary folate intake, serum and red blood cell (RBC) folate, and related nutritional biomarkers in healthy Japanese women in early pregnancy.
Design: A cross-sectional, observational study.
Subjects: Pregnant women in the first trimester, at 7–15 weeks gestation ($n=70$), who were not consuming any folate supplements or folate fortified foods.
Methods: Three-day dietary records were obtained from each subject to assess dietary folate intake. Blood samples were collected for measurement of biomarkers. Biomarkers and nutrient intake were analyzed in two groups defined by their serum folate concentrations: the low folate group (serum folate <9 ng/ml) and the high folate group (serum folate $\geqslant 9$ ng/ml).
Result: Mean serum and RBC folate concentrations in all subjects were 10.3 and 519 ng/ml, respectively. These levels were remarkably higher than the reported values from many other countries despite our subjects receiving no folic acids supplements. However, mean folate intake by our subjects from natural foods was 289 μg/day, which is thought to be low according to the Japanese dietary recommendation specified for pregnant women. The intake of spinach and fruits was significantly greater in the high folate group than in the low folate group.
Conclusion: Folate intake was thought to be adequate to maintain a desirable level of serum folate concentration in Japanese pregnant women in the first trimester, although the intake of folate from natural food was not high enough to meet the recommended daily intake.
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Contributors: NM has contributed to data collection and analysis, the main investigation, and writing the paper. HT was involved in planning and coordinating the study, data collection and analysis, and produced the draft of the paper. KU was the supervisor and coordinator of the investigation. AI and KK were involved in data collection and analysis. SA, MY, HF and SO were responsible for selection of patients, and contributed to data collection. HI was involved in the study design. NY designed the study and was the overall supervisor of the project, and approved the manuscript.
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Introduction

It is well known that the periconceptional intake of folate is very important, as an adequate intake of folic acid will significantly reduce the risk of neural tube defects (NTDs). Many studies in Europe, China and the United States have shown that the periconceptional use of folic acid prevents NTDs (Berry *et al.*, 1999; Werler *et al.*, 1999; Ray *et al.*, 2002). In 2000, the Japanese government recommended that all women planning a pregnancy should consume an additional

400 μg/day of folate, referring to scientific evidence and recommendations in the other countries (Ministry of Health, Labour, and Welfare, Japan, 2005). Food fortification with folic acid is not popular in Japan, and the use of supplemental folic acid has not become widespread. Furthermore, there has been little awareness of this in Japan, and folate has not recently been added but was added 5 years ago to the 5th standard tables of food composition in Japan. Accordingly, there had not been fully investigated about folate intake and folate related biomarker in Japanese people. Recently, Kondo *et al.* (2005) reported folate intake and serum folate concentration in pregnant Japanese women including all trimesters. However, there are no studies on folate intake and folate-related biomarkers including RBC folate concentration in pregnant Japanese woman in the first trimester. For primary prevention of NTD, folate nutrient in early pregnancy is very important.

According to the National Nutrition Survey in Japan, dietary natural folate intake in young Japanese women is similar to the reported intake in the United States and in many other countries (Ministry of Health, Labour, and Welfare, Japan, 2001). As sources of folate in the Japanese diet may differ from those in other societies, it is necessary to assess folate levels in pregnant Japanese women, especially in early pregnancy, to evaluate the current Japanese diet in terms of adequacy of folate nutrition.

We conducted this study to investigate the association between folate intake and folate-related biomarkers (folate concentrations in serum and red blood cells (RBC)) in pregnant Japanese women who were not consuming any dietary folate supplements.

Methods

Study design and subjects

We selected two study sites in a public and a private hospital in the Tokyo Metropolitan Area, in cooperation with the Department of Gynecology. The public hospital is located in an uptown area and is a tertiary hospital with many patients referred from smaller clinics or hospitals in the local area. The private hospital is located in a downtown area and is a primary care hospital mainly specializing in gynecology. We have continued cross-sectional and longitudinal observational studies on pregnant women without major complications who visited the two hospitals in the period from February 2002 to March 2003, who agreed to participate in the surveys, and who gave written informed consent.

In this report we focused on subjects who were interviewed and examined in the first trimester. Of 106 subjects, 36 were excluded due to inadequate data for dietary intake, and five were excluded because they consumed folate supplements or folate fortified foods. A total of 70 subjects were included in this cross-sectional analysis, although only 50 of them had data for RBC folate concentration because RBC samples could not be collected from 20 subjects. The study protocol was approved by the Institutional Ethics Committee of the authors' affiliations.

Data collection of lifestyle and other background factors

A self-administered questionnaire was used to gather information on dietary habits, drinking, smoking and other background information, which was directly checked by interviewers in the survey suits. The height and prepregnancy body weight of the subjects were asked for in the questionnaire, while the current body weight was measured using a calibrated mechanical scale.

Dietary intake

Weighed dietary records were obtained from each subject for three nonconsecutive days within a week. Subjects were given detailed instructions by trained dietitians on how to weigh and record the consumed foods, using a colored instruction leaflet to illustrate the methods and examples. When the subjects visited the hospital for blood sampling, the dietitians checked all the recorded sheets and interviewed the subjects to clarify any ambiguous points.

The consumption of nutrients and foods was estimated from the records by a computerized dietary analysis program *Kokurakucho* (NTT Inc., Japan). A food composition database based on the Fifth Revision of the Standard Food Composition Table was incorporated in the dietary analysis program, which allowed for changes in nutrients during the cooking process (Watanabe *et al.*, 2003).

Blood sampling and analysis

Fasting blood samples were drawn for the measurement of hematological parameters (hemoglobin, hematocrit, and RBC count) and folate-related biomarkers. The measurements of biomarkers except for RBC folate were performed by SRL Inc. (Tokyo). Chemiluminescent immunoassay was used for the measurement of serum folate and vitamin B_{12}. High-performance liquid chromatography (HPLC) and enzyme immunoassay were used for the measurement of homocysteine and serum ferritin, respectively.

Whole blood was collected in a heparinized tube and preserved with 0.5% ascorbate solution for the measurement of RBC folate by microbiological assay using *Lactobacillus casei* ($n=50$) (Horne, 1997) based on previous reports. Samples were diluted with 0.05% ascorbic acid solution and preincubated for 30 min at 37°C for deconjugation of folate polyglutamates. Ninety six-well microplates were used for incubation of samples and medium containing *L. casei.* The plates were incubated for 48 h at 37°C. The optical density of each well was measured using a single wavelength of 570 nm. RBC folate level was then calculated from the mean whole-blood folate value by subtracting folate content of serum in the sample, and corrected by hematocrit value (Hoffbrand *et al.*, 1966).

Statistical analysis

Biomarkers and nutrient intake were analyzed in two groups according to the median of their serum folate concentrations because it is a short-term indicator of dietary folate intake: the 'low folate group' (serum folate <9 ng/ml) and the 'high folate group' (serum folate ⩾9 ng/ml). Comparison between the two groups was performed using an unpaired *t*-test for nutrient intakes and Mann–Whitney's *U* test for intakes of food groups because of their skewed distributions. Correlations across selected blood biomarkers were analyzed by Spearman's correlation coefficients. To diminish the influence of the absolute amount of food intake on the selected nutrients and also to obtain indicators of the nutritional quality of daily food patterns, nutrient densities expressed per 1000 kcal were used for further analyses.

Results

General characteristics

The general characteristics of the subjects are presented in Table 1. The age of the subjects ($n=70$) ranged from 17 to 41 years. The median point of the folate concentration

Table 1 Characteristics of study subjects

Variables	*n = 70*	
	Mean (s.d.)	*Range*
General characteristics		
Age	29.9 (5.0)	17–41
Weeks of gestation at survey	10.6 (1.8)	7–15
Primipara (%)	81.4	—
Height (cm)	158.5 (5.0)	147–168
Prepregnancy weight (kg)	52.2 (9.1)	38–80
Current weight (kg)	53 (8.8)	38–85
Prepregnancy BMI (kg/m^2)	20.8 (3.9)	16.1–34.7
Current BMI	21.1 (3.6)	16.3–34.9
Vitamin[a] or mineral supplement use (%)	11.4	—
Smoking (%)	18.6	—
Drinking (%)	2.9	—
Blood biomarkers		
Serum folate (ng/ml)	10.3 (5.0)	5.5–33.0
RBC folate (ng/ml)[b]	519 (231)	165–1104
Plasma homocysteine (nmol/ml)	5.2 (1.4)	2.7–10.7
Plasma vitamin B_{12} (pg/ml)	423 (134)	230–930
Hemoglobin (g/dl)	12.6 (0.9)	10.2–14.3
Hematocrit (%)	36.3 (2.6)	29.9–41.5
Serum ferritin (ng/Ml)	42.4 (37.2)	4.6–210

[a]Except folate.
[b]$n=50$.

Table 2 Demographic and anthropometric characteristics in groups defined by serum folate concentration

Variables	*Serum folate*				*P-values*
	<9 ng/ml (n = 34)		*⩾9 ng/ml (n = 36)*		
	Mean (s.d.)	*Range*	*Mean (s.d.)*	*Range*	
General characteristics					
Age[a]	30.2 (5.4)	17–41	29.4 (4.0)	17–37	0.506
Weeks of gestation at survey[a]	10.8 (2.1)	7–15	10.4 (1.3)	8–13	0.41
Primipara (%)[b]	71	—	92	—	<0.0001
Height (cm)[a]	158.6 (4.6)	148–168	158.5 (5.0)	147–167	0.812
Prepregnancy body weight (kg)[a]	52.2 (8.9)	40–80	52.1 (8.3)	38–76	0.949
Current body weight (kg)[a]	53.9 (9.2)	42.5–85	52.0 (6.5)	38–66	0.359
Prepregnancy BMI (kg/m^2)[a]	20.8 (3.6)	16.2–32.9	20.7	16.1–34.7	0.891
Current BMI[a]	21.4 (3.7)	17–34.9	16.1–34.7	16.3–30.1	0.435
Vitamin[c] or mineral supplement use (%)[b]	8.8	—	8.3	—	0.151
Smoking (%)[b]	20.6	—	16.7	—	0.327
Drinking (%)[b]	2.9	—	2.8	—	0.967
Blood biomarkers					
Serum folate (ng/ml)	7.5 (0.9)	5.5–8.9	13.1 (5.3)	9–33	0.0001
RBC folate[d] (ng/ml)	429 (154)	210–978	605 (263)	165–1104	0.01
Plasma homocysteine (nmol/ml)	5.6 (1.5)	3.7–10.7	4.9 (1.3)	2.7–7.8	0.052
Plasma vitamin B_{12} (pg/ml)	405 (116)	230–690	432 (152)	250–940	0.410
Hemoglobin (g/dl)	12.4 (1.0)	10.2–14.3	12.8 (0.7)	10.9–14.2	0.083
Hematocrit (%)	35.6 (2.7)	29.9–39.6	37.0 (2.3)	31.8–41.5	0.03
Serum ferrtin (ng/ml)	39.0 (28.2)	6.8–120	45.1 (37.8)	6.1–210	0.449

[a]Unpaired *t*-test.
[b]χ^2-test.
[c]Except folate.
[d]<9 ng/ml ($n=24$), ⩾9 ng/ml ($n=26$).

(9 ng/ml) subdivided the subjects into the 'low folate group' ($n = 34$) and the 'high folate group' ($n = 36$).

The demographic and anthropometric characteristics of the two groups are presented in Table 2. Age, week of gestation, height and body mass index (BMI) did not differ significantly between the two groups. The number of primipara was significantly higher in the higher group than that in the lower group. The number of users of other vitamin supplements was not different in the two groups, although the number of smokers was marginally higher in the lower group.

Biological markers

Blood biological markers of all study subjects are shown in Table 1.

Mean levels of serum and RBC folate concentration were 10.3ng/ml ($n = 70$) and 519ng/ml ($n = 50$), respectively. The distribution of serum folate concentration is shown in Figure 1. Serum folate was <6 ng/ml in 4.3% of subjects, and ⩾13 ng/ml in 14.3% of subjects. Although none of the subjects took any folate supplements, the mean serum and RBC folate levels were higher than in published reports in other countries (Cuskelly *et al.*, 1996; Brown *et al.*, 1997).

When the selected biological markers were compared between the two groups, the group with higher serum folate concentrations showed higher RBC folate concentrations ($P = 0.01$) and a higher hematocrit ($P = 0.03$) than the group with lower serum folate concentrations (Table 2). Homocysteine levels, the other marker affecting blood folate concentration, were marginally higher in the group with lower serum folate concentrations.

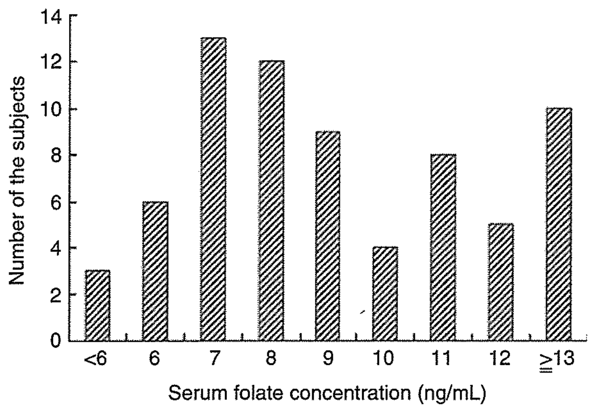

Figure 1 Distribution of serum folate concentration in all subjects ($n = 70$).

Correlation coefficients across blood biomarkers

Correlation coefficients across blood biomarkers are shown in Table 3. Serum folate was positively correlated with RBC folate, plasma B_{12}, hemoglobin, albumin and hematocrit, and inversely correlated with plasma homocysteine. Although RBC folate concentration was inversely correlated with plasma homocysteine, no significant correlation was observed between other biomarkers.

Dietary intake

Average nutrient intakes per day in all subjects from 3-day diet records are shown in Table 4. When comparing with the newly revised dietary recommendation for pregnant women in Japan, intakes of calcium, copper, vitamin A, B_2, B_{12} and vitamin C seem to be relatively adequate although a proportion of each distribution did not reach the level of estimated average requirements. Average intakes of folate, iron, zinc, vitamin D, B_1 and B_6 were lower than the recommended values. The distribution of folate intake in the two groups classified according to serum folate concentration is shown in Figure 2. More than 70% of subjects had a folate intake below 200 μg/day.

Energy-adjusted nutrient intakes (nutrient per 1000 kcal) in the two groups are shown in Table 5. Folate, calcium and fiber intakes per 1000 kcal were significantly greater in the high folate group than in the low folate group.

We also analyzed the mean daily consumption of foods groups (Table 6). In some food groups the intake levels differed significantly between the low folate group and the high folate group; the subjects in the high folate group consumed more spinach, fruit, and fruits juice, and fewer meats, oils and fats than the low folate group.

Discussion

Many recent studies have indicated that folate nutrient status is very important for women in early pregnancy because folic acid reduces the risk of NTD (Berry *et al.*, 1999; Werler *et al.*, 1999; Ray *et al.*, 2002). Many countries recommend a high-folate diet and folic acid supplements for pregnant women and women wishing to become pregnant (Green, 2002). However, the folate nutritional

Table 3 Correlation coefficients between blood biomarkers in all subjects

	Serum folate	*RBC folate*	*Plasma homocystein*	*Plasma vitamin B_{12}*	*Hemoglobin*	*Albumin*	*Hematocrit*	*Serum ferritin*
Serum folate	1.000	0.464**	−0.420****	0.300*	0.308*	0.452****	0.358***	−0.0006
RBC folate		1.000	−0.336*	0.128	0.105	0.076	0.067	−0.200

All data are log-transformed.
*$P<0.05$, **$P<0.01$, ***$P<0.005$; ****$P<0.001$.

Table 4 Nutrient intake/day from natural food sources in study subjects

Variables	*Japanese recommendation for pregnant women in first trimester*		*All subjects* (n = 70)	
	18–29 years old	*30–49 years old*	*Mean (s.d.)*	*Range*
Energy (kcal)	2100	2050	1782 (489)	1007–3690
Total protein (% of energy)	<20	<20	14.1 (9.5)	9.5–22.1
Total fat (% of energy)	20–30	20–30	28.7 (6.3)	12.6–42.8
Cholesterol (mg)	<600	<600	309 (157)	56–885
Calcium (mg)	700	600	601 (325)	93–2013
Iron (mg)	19.5	19.5	7.0 (4.1)	1.0–33.2
Copper (mg)	0.8	0.8	1.04 (0.36)	0.26–2.79
Zinc (mg)	10	10	7.4 (2.4)	1.9–18.4
Vitamin A (μg/RE)	670	670	982 (839)	110–4022
Vitamin D (μg)	7.5	7.5	5.7 (6.0)	0.5–40.8
Vtamin B_1 (mg)	1.1	1.1	1.06 (1.53)	0.21–13.37
Vtamin B_2 (mg)	1.2	1.2	1.94 (5.06)	0.30–44.18
Vitamin B_6 (mg)	2.0	2.0	1.6 (3.9)	0.3–34.2
Vtamin B_{12} (μg)	2.8	2.8	6.2 (5.5)	0.5–31.1
folate (μg)	440	440	289 (151)	68–1151
Vtamin C (mg)	110	110	143 (202)	11–1249
Fiber (g)	21	20	12.9 (5.9)	1.9–46.3
Sodium chloride equivalent (g)	<8	<8	10.5 (4.2)	1.6–27.7

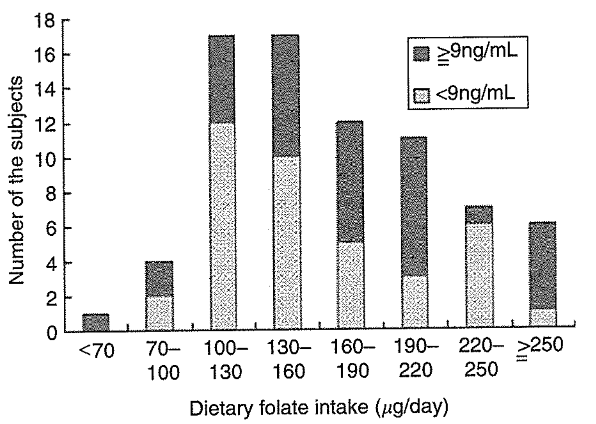

Figure 2 Distribution of RBC folate concentration in groups defined by serum folate concentration. Gray bar: low folate group (<9 ng/ml), black bar: high folate group (≥9 ng/ml).

profile of Japanese pregnant women has not been fully investigated because there has been little awareness of this in Japan, and folate has only recently been added to the Dietary Reference Intakes for Japanese and the Standard Food Composition Table. Specifically, there has been no study of folate intake and blood folate biomarkers in woman in early pregnancy in Japan. Folate is also important to achieve normal birth weight because it is reported that a low intake of folate in pregnant women is associated with low birth weight (Rao *et al.*, 2001). Therefore, it is important to study folate nutrition in pregnant women in Japan.

The recommended dietary allowance (RDA) of folate in early pregnancy for prevention of NTD is 440 μg/day in the Dietary Reference Intakes for Japanese, 2005 (Ministry of Health, Labour, and Welfare, Japan, 2005). Mean folate intake/day in all subjects was 289 μg/day in the present study. Only 8.6% of subjects had a folate intake above 250 μg/day, and folate intake was below the RDA in 94 % of subjects. The National Nutrition Survey in Japan showed that the mean folate intake of Japanese women aged 20–50 years was 200–300 μg/day (Ministry of Health, Labour, and Welfare, Japan, 2005). Folate intake was not sufficient in pregnant Japanese women in the first trimester. However, they showed a higher mean serum folate concentration (10.3 ng/ml) than reported in other countries. For example, The US data from NHANES III 1988–1994 showed mean serum and RBC folate levels, 4.8 and 159.9 ng/ml, respectively for reproductive age but nonpregnant women, which were observed before the mandated folate fortification in this country (CDC, 2002). Even in low intake groups in the present study, most subjects had serum folate concentrations above 7 ng/ml. Hirooka (2001) reported that the mean serum folate concentration in nonpregnant Japanese women aged 21–22 years was 17.9 nmol/l (7.4 ng/ml). The level is lower than in the present study. All our subjects were above the lower border of the normal serum folate range, 3.0 ng/ml (Jacques *et al* 1999). On the other hand, Kondo *et al* reported that Japanese pregnant women revealed serum folate of 11.9 ng/ml, which is the average of all trimester. As our present data is only a first trimester, it is need to investigate serum folate of pregnant women in the second and third trimester. Many trials have reported that folic acid supplements or a high folate diet increased serum folate levels compared with baseline (Cuskelly *et al.*, 1996; Brown *et al.*, 1997; Jacques *et al.*, 1999). However, serum folate concentrations of our subjects were same level with reported data of folic acid supplements user. It was very interesting because users of folic acid supplements were not

Table 5 Energy-adjusted nutrient intake/day from natural food sources in groups defined by serum folate concentration

Variables	*Serum folate*				P-*value*
	<9 ng/ml (n = *34)*		*≥9 ng/ml* (n = *36)*		
	Mean (s.d.)	*Range*	*Mean (s.d.)*	*Range*	
Energy (kcal)	1856 (424)	1042–2887	1734 (535)	1007–3690	0.300
Total protein (% of energy)	14.0 (1.9)	9.9–17.9	14.3 (2.6)	11.1–22.1	0.653
Total fat (% of energy)	29.9 (6.7)	12.6–42.8	27.7 (5.8)	17.9–41.1	0.151
Cholesterol (mg/1000 kcal)	180 (62)	44–345	167 (74)	49–726	0.433
Calcium (mg/1000 kcal)	293 (105)	158–540	374 (169)	92–953	0.018
Iron (mg/1000 kcal)	3.7 (0.8)	2.7–6.3	4.21(1.84)	2.1–11.4	0.115
Copper (mg/1000 kcal)	0.57 (0.11)	0.40–0.89	0.60 (0.12)	0.39–0.84	0.308
Zinc (mg/1000 kcal)	4.1 (0.7)	3.1–6.0	4.29 (0.79)	2.57–6.39	0.327
Vitamin A (μg/RE/1000 kcal)	533 (479)	123–2643	570 (354)	173–1805	0.717
Vitamin D (μg/1000 kcal)	3.1 (2.8)	0.6–9.7	3.5 (5.0)	0.34–29.2	0.676
Vitamin B_1 (mg/1000 kcal)	0.52 (0.31)	0.26–1.94	0.68 (1.12)	0.32–7.15	0.417
Vitamin B_2 (mg/1000 kcal)	0.71 (0.36)	0.39–2.24	1.50 (3.89)	0.4–23.6	0.235
Vitamin B_6 (mg/1000 kcal)	0.61 (0.36)	0.34–2.26	1.2 (2.98)	0.4–18.3	0.29
Vitamin B_{12} (μg/1000 kcal)	3.3 (2.25)	0.86–8.59	3.6 (3.2)	0.3–16.2	0.622
folate (μg/1000 kcal)	144 (49)	70–314	182 (76)	62–392	0.013
Vitamin C (mg/1000 kcal)	62 (108)	10–661	112 (142)	13–668	0.105
Fiber (g/1000 kcal)	6.7 (1.6)	3.0–9.7	7.8 (2.7)	3.9–15.8	0.036
Sodium chloride equivalent (g/1000 kcal)	4.3 (1.4)	1.8–8.1	4.2 (1.8)	1.8–11	0.727

Table 6 Mean intakes (g/day) of main food groups in groups defined by serum folate concentration

Variables	*Serum folate*		P-*value*
	<9 ng/ml (n = *34)*	*≥9 ng/ml* (n = *36)*	
	Mean (s.d.)	*Mean (s.d.)*	
Grain	534.5 (175.2)	501.5 (268.5)	0.259
Rice	229.8 (89.5)	206.0 (136.3)	0.155
Breads	53.1 (37.0)	49.8 (42.2)	0.819
Noodles, Pasta	88.8 (70.3)	84.9 (96.8)	0.437
Nuts, Seed	2.6 (6.0)	1.8 (3.1)	0.542
Potatoes	46.8 (44.5)	52.2 (78.0)	0.778
Sugar	4.0 (5.0)	4.9 (5.3)	0.513
Confectionaries	45.4 (41.9)	49.5 (59.6)	0.938
Oil, Fats	16.2 (8.5)	11.9 (6.0)	0.037
Meats	82.8 (41.6)	58.7 (42.6)	0.013
Fish/shell fish	44.0 (30.3)	43.8 (35.4)	0.710
Eggs	20.2 (25.9)	30.1(22.9)	0.635
Milk	78.0 (99.3)	165.4 (178.7)	0.090
Other milk products	96.9 (109.3)	72.1 (72.5)	0.250
Cheeses	4.8 (5.7)	4.8 (7.8)	0.744
Soybean, soybean products	37.5 (39.4)	36.7 (52.2)	0.543
Mushrooms	9.3 (12.0)	12.4 (18.2)	0.754
Colored vegetables	76.6 (55.2)	104.0 (81.7)	0.086
Carots	10.8 (14.4)	14.6 (18.7)	0.614
Tomatoes	24.6 (40.7)	33.7 (36.7)	0.108
Spinach	8.4 (11.3)	18.9 (31.0)	0.043
Pepper	5.9 (7.4)	2.4 (4.7)	0.058
Other vegetables	104.9 (50.3)	120.2 (113.8)	0.947
Fruits	136.7 (135.6)	239.7 (146.6)	0.001
Citrus fruits	23.4 (28.5)	43.8 (58.9)	0.110
Apples	29.8 (40.1)	26.7 (54.4)	0.621
Bananas	16.6 (21.4)	19.4 (39.5)	0.562
Fruits juice	56.8 (74.5)	94.2 (104.4)	0.040
Coffee, Cocoa	69.6 (91.0)	41.5 (76.8)	0.338
Tea	183.9 (254.6)	215.6 (187.1)	0.324
Alcohol beverages	13.3 (37.0)	4.9 (13.8)	0.174

included, and none of the participants ate foods fortified with folate.

We analyzed nutrient intake and consumption of food groups in the two groups defined by serum folate concentration: the high folate (serum folate ≥9 ng/ml) group and the low folate (serum folate <9 ng/ml) group. The high folate group showed higher energy-adjusted intakes of folate, calcium and fiber compared with the low folate group. Many studies have reported that folic acid is directly correlated with blood folate concentration, and is useful for the prevention of NTD (Cuskelly *et al.*, 1996; Brown *et al.*, 1997; Berry *et al.*, 1999; Jacques *et al.*, 1999; Werler *et al.*, 1999; Ray *et al.*, 2002). As dietary folate contains a polyglutamate chain, the bioavailability of folate varies widely with different foods and cooking styles. Utilization of polyglutamate is affected by many factors, such as intestinal matrix effects or pH. Therefore, the bioavailability of natural food folate is thought to be 20–75% that of folic acid (Gregory, 2001; van den Berg *et al.*, 2002; Melse-Boonstra *et al.*, 2002; Kim *et al.*, 2004). The only sources of folate in the subjects of the present study were natural foods. Therefore, it is very important to clarify the association between the intake of natural food folate in Japanese food and blood folate concentrations. Some researchers reported that high folate diets, fresh berries, citrus fruit, and vegetables significantly increased blood folate concentrations or significantly decreased plasma total homocysteine (Brouwer *et al.*, 1999; Koebnick *et al.*, 2001; Silaste *et al.*, 2003). We compared the mean consumption of food groups in two groups classified by serum folate concentration. The intakes of colored vegetables, spinach and fruits were significantly greater in the high folate group than in the low folate group, while the intake of meats, oils and fats was greater in the low folate group than in the high folate group. Although plasma homocysteine levels were inversely correlated with serum folate and RBC folate levels, it did not differ significantly between the two groups. Serum folate levels were positively correlated with RBC folate and plasma vitamin B_{12} levels. Serum folate also correlated significantly with other blood markers, hemoglobin, albumin, hematocrit and serum ferritin. These findings suggested that the eating pattern in pregnant Japanese women, which maintained a sufficient serum folate concentration, may also support a healthy pregnancy. The National Nutrition Survey, Japan (Takimoto *et al.*, 2003) found that pregnant Japanese women were aware of the importance of adopting healthy behaviors (smoking less, drinking less, etc.) and taking more milk, fruit or colored vegetables during pregnancy. In the present study, the typical dietary pattern of women in early pregnancy, especially in the high folate group, included a high intake of vegetable, fruits, milk, soy products and fish, and a low intake of oil and fat, and meat.

Levels of vitamin B_{12}, which supports folate metabolism, and calcium were adequate in our subjects. The main dietary source of calcium in Japan is milk. Milk contains folate-binding protein (FBP). As it has been reported that FBP may increase the bioavailability of dietary folate (Jones and Nixon, 2002; Jones *et al.*, 2003), adequate milk consumption may be partly responsible for higher serum folate concentrations in pregnant Japanese women. RBC folate concentrations varied widely between subjects, especially in the high folate group. This suggests that RBC folate may be preferable to serum or plasma folate for the prediction of NTD risk (Bunduki *et al.*, 1995; Daly *et al.*, 1995). Brown *et al* showed that a folate concentration of $\geqslant$400 ng/ml in early pregnancy decreased the risk of NTD (Brown *et al.*, 1997). In the present study, most of the subjects showed a RBC folate concentration $\geqslant$400 ng/ml, although a few of the subjects had a RBC folate concentration $<$200 ng/ml, even in the high serum folate group. It is therefore possible that preconception folate nutrition may be insufficient in some subjects, because RBC folate concentration is a longer-term index of folate nutrition than serum folate. However, RBC data in the present study were preliminary ($n=50$), and further studies are needed.

Our study is the first to describe folate nutrition in early pregnancy in Japan. Further study is needed using longitudinal studies from preconception to early pregnancy to determine the appropriate intake of folate in pregnant Japanese women in the first trimester.

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