

Dietary supplement consumption among urban adults influenced by psychosocial stress: its pronounced influence upon persons with a less healthy lifestyle

Hui-Jing Shi, Keiko Nakamura, Mari Shimbo and Takehito Takano*

Department of Health Promotion/International Health, Division of Public Health, Graduate School of Tokyo Medical and Dental University, Tokyo, Japan

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In order to examine the consumption of dietary supplements among urban adults and the impact of psychological stress on supplement use in relation to lifestyle, 375 interviews of a population-based sample of urban Japanese in 2002 were analysed. The usage of various supplements, stress process (daily stressors, psychological moderators, stress outcomes), personal health practices (smoking, alcohol drinking, physical exercise, fruit and vegetable juice consumption, health-conscious eating habits) and other background factors were measured. We examined the impacts of stress on the use of vitamin tablets and capsules, vitamin-enriched health drinks and health drinks for intestinal adjustment. The percentages of these three categories of supplement user were 26.9, 18.7 and 35.7%, respectively. After adjusting for potential confounders, subjects with 'two or more' daily stressors out of the eight stressors investigated consistently showed 2-fold higher levels of consumption of either vitamin tablets and capsules or vitamin-enriched drinks compared with their counterparts with 'one or less' daily stressors. Stress-outcome indicators also related, to a greater or less extent, to the elevated consumption of various supplements. Further lifestyle-stratified analyses revealed that the stress-supplementation relationships were weaker in subjects fulfilling more than three of the five investigated health practices (i.e. the healthy lifestyle group), but stronger in subjects with fewer than two healthy practices (i.e. the less healthy lifestyle group). In conclusion, dietary supplement consumption is independently associated with stress in urban adults. The uncontrolled use of supplements for the self-medication of stress or to compensate for unhealthy behaviour represents a health concern for the general population.

Dietary supplement: Psychosocial stress: Lifestyle

There has always been a great deal of interest in the discovery of new substances capable of improving biological functions and optimising health. Research findings published over the past two decades have established that some supplements are effective for preventing specific disorders (e.g. folic acid during the peri-conceptual period to reduce the risk of neural tube defects; Centers for Disease Control and Prevention, 1992), and some have the potential to prevent certain diseases or conditions, such as antioxidant vitamins for heart disease and stroke (Rimm *et al.* 1993; Stampfer *et al.* 1993), calcium-vitamin D for osteoporosis (Heany, 2000) and dietary polyphenolic compounds for cancer (Yang *et al.* 2001; Arts *et al.* 2002). Thus, an increasing number of people are experimenting with the use of various supplements to maintain their health and enhance their fitness (Slesinski *et al.* 1995; Greger, 2001; Shikany *et al.* 2003). As, however, not all supplements have beneficial health effects (Alpha-tocopherol, Beta-carotene Cancer Prevention Study Group, 1994), and the adverse long-term and/or cumulative effects of supplements intake are of public concern, it is important to examine the patterns of their consumption among the general population.

Supplement ingestion usually occurs in the context of achieving or maintaining a healthy lifestyle. A number of surveys

have profiled the general characteristics of dietary supplement-users as female, better educated, affluent, residents of urban areas and already possessing an adequate nutritional intake and a healthy lifestyle (Kirk *et al.* 1999; Greger, 2001; de Jong *et al.* 2003; Foote *et al.* 2003; Ishihara *et al.* 2003). Investigations performed among geriatricians and female physicians have shown, however, that the use of vitamins and supplements was not universal among people in these well-informed high socio-economic status groups, and that their usage rates did not significantly exceed those of the general public (Frank *et al.* 2000; Watts *et al.* 2001). Several studies have even suggested that individuals might actually use dietary supplements or functional foods as a means of compensating for unhealthy behaviours (Hilliam, 1996; Kirk *et al.* 1999; Radimer *et al.* 2000).

Such contradictions stimulated us to explore factors other than demographic and lifestyle variables that underlie people's decision to take dietary supplements. Recent consumer surveys among adults in the Tokyo Metropolitan Area indicated that the most common purpose of supplement ingestion was 'relief of stress or to recover from fatigue', followed by 'maintenance of physical health' and 'to compensate for insufficient nutrient ingestion' (Japan Management Association Research Institute,

Abbreviation: OR, odds ratio.

* Corresponding author: Professor Takehito Takano, fax +81 3 3818 7176, email takano.hlth@tmd.ac.jp

2002) because sufficient nutrient intake, either through dietary balancing or through supplementation, was believed to reduce the physiological decline caused mainly by fatigue and stress (Meiji Health-Bio Research Institute, 2003). Therefore, in the present study, it was hypothesised that psychosocial stress might link to supplement ingestion among urban citizens.

There has been a considerable increase in research into stress over the past 50 years. Stress is now seen as a dynamic and evolving process, and this has resulted in the distinction between stressors (problems, hardships or threats that challenge people's adaptive capacities), psychological moderators (social and personal resources that can be mobilised to contain, regulate or otherwise ameliorate the effects of the stressors) and stress outcomes (the effects of the stressors that are observed after the moderating resources have been taken into account) (Pearlin *et al.* 1981; Pearlin, 1995). In many studies, the stress process framework has been presented as a possible alternative to improve our understanding of the impacts of stress on health (Elliott, 2000; Vedhara *et al.* 2000; Katerndahl & Parchman, 2002).

We performed the present survey in urban areas of Japan to investigate the consumption of dietary supplements among adults and to examine the influence of psychological stress. The stress-supplementation relationship was tested by constructing stress as a process, treating lifestyle as a confounder and an effect modifier, and including a variety of supplement products that were commonly available in Japan at the time of the study.

Methods

Study setting and participants

In 2002, a cross-sectional survey designed to investigate dietary supplement use, lifestyle and psychosocial stress among Japanese adults was conducted in Edogawa City of Metropolitan Tokyo and Fukuroi City of Shizuoka Prefecture, which were selected as the study sites to cover areas of varying degrees of urbanisation. According to the national census for the year 2000, the population density of these two areas was 12 459 and 747 per km², respectively; the proportion of the population employed in agriculture and fishery was 0.29% and 7.38%, respectively, and the population growth rate from 1990 to 2000 was 9.5 and 12.5%, respectively.

Using a multistage random strategy, 600 subjects aged 20–69 years (300 in Edogawa City and another 300 in Fukuroi City) were selected from the residency registers with the approval of the relevant local government offices. After obtaining informed consent from the subjects by following the protocol for population-based interviews, household survey specialists visited each participant for face-to-face interviews administered as a structured questionnaire. In total, thirty-six interviewers worked for this study after a 3 d training course, and it took 30–45 min to conduct each interview. In total, 387 subjects completed the interview with valid data. The response rates were 49.2 and 58.2% for males and females, respectively, in Edogawa City and 61.8 and 67.6% in Fukuroi City. As the age, education and occupation distributions of respondents generally corresponded to those reported in the population census for the year 2000, our sample reasonably represented the population in the study areas.

The present analysis focused on 375 subjects (177 men, 198 women), excluding those with histories of heart attack, stroke or malignant tumours (twelve subjects).

Measures

Background characteristics. Background factors that could potentially affect supplement consumption included sex, age, education, city of residence, disease history and treatment. Final educational levels were grouped into 'high school or below' and 'college or above'. Subjects were grouped into 'user' and 'non-user' groups according to their current use of prescribed pharmaceuticals.

Use of dietary supplements. In Japanese, the term 'dietary supplement' refers not only to pure nutrients, such as vitamins and minerals, but also to '*eiyo hojo shokuhin*' (nutraceutical foods) and '*kenko shokuhin*' (health foods) fortified with specific nutrients, phytochemicals or active micro-organisms. Supplements can exist in various solid or liquid forms, and health drinks constitute a considerable part of Japan's supplement market.

A variety of products, grouped according to their ingredients and forms, were included in the questionnaire:

1. *Solid form*, including vitamins (multiple or individual vitamins, such as A, B complex, C, D, E and others), minerals (multiple or individual minerals, such as Fe, Ca, Zn, Mg, Se, etc.), proteins, amino acids, dietary fibre and herb or botanical extracts.
2. *Liquid form*, including: health drinks for intestinal adjustment that contained specific lactic acid-producing bacteria, oligo-sugars or soluble fibre; health drinks to combat hypertension, hypercholesterolaemia, hyperglycaemia and strain; health drinks to supply minerals, such as Fe or Ca; vitamin-enriched drinks for nourishing and energising that contained mainly vitamins and amino acids such as taurine; and other bottled beverages fortified with various dietary elements, such as Ca, Mg, soluble fibre and/or catechin.

For each type of supplement, participants were asked to respond 'yes' or 'no' to the question: 'Have you used this type of supplement during the past 12 months?' If the answer was in the affirmative, the specified ingestion frequency was recorded as 'almost daily', 'sometimes weekly', 'sometimes monthly' or 'several times during past year'. More than two pages of the questionnaire were devoted to dietary supplements. During the interview, photos of most supplement products with the ingredients marked were shown, and a chart of supplement products was used to help subjects to categorise products.

On the basis of subjects' responses on each supplement item, three generally reported categories of dietary supplements were used for the following association analyses. These were 'vitamin tablets and capsules', 'vitamin-enriched drinks' and 'drinks for intestinal adjustment'.

Psychosocial stress. Stress was constructed as a process to include three core components as follows.

First, *stressors* were considered. Rather than life events, everyday stressors, especially daily hassles, were identified as we assumed that irritations surrounding daily living might be the main motivator for supplement intake. Based on the thirty-item Daily Hassles Scale (Lazarus & Folkman, 1984) and considering activities in Japan, eight types of stressful condition were summarised for the sake of questionnaire length:

1. high workload caused by studying or domestic duties coupled with the commuting time;
2. life burdens regarding family members' health status or health care;

3. human relationships with colleagues, neighbours, relatives and friends;
4. feelings of an insecure future because of one's own potential unemployment or ill-health;
5. economic events, such as problems related to income, investments or debt;
6. being surrounded by air, water or noise pollution;
7. problems of self-visualisation, such as facial appearance or body shape;
8. others.

For each type, participants were asked to reply 'yes' or 'no' to the question: 'Did you feel irritated or troubled by such daily life situations in the last year?' A summary chronic daily stressor scale was produced with a range of 0 to 8, and Chronbach's alpha for these eight items was 0.60. Subjects were coded as 'more daily stressors' if they reported 'yes' to at least two conditions.

Second, *psychological moderators* were considered. These have a protective effect against the threats and demands of stressors. Social support and coping strategies were assessed. The question 'Are there any people you can turn to in times of stress?' was used to indicate perceived social support as 'present' or 'absent'. Subjects were asked about their primary strategies to cope with stressful situations, and each subject was finally classified into one of the following four types, as referred to in a previous study (Shima, 1994):

1. 'acts to solve problems', such as confrontation, reappraisal and planning to change their own behaviour and attitude;
2. 'focuses on positive emotions', such as chatting with friends, enjoying hobbies, drinking tea or playing sports;
3. 'focuses on negative emotions', such as ill-treating others, complaining about unfairness, overeating or avoiding work and study;
4. 'does nothing at all'.

Finally, *stress outcomes* were considered. The perceived level of fatigue, both physical and mental, was first identified as a simple indicator of response to the stressor, because this has been found to relate closely with somatic complaints of stress among Japanese (Iijima & Morimoto, 1988) and has been confirmed as a reliable indicator of self-perceived well-being (Goldberg *et al.* 2001). Participants were asked to describe their levels of each type of fatigue over the previous 4 weeks as either 'have a great deal', 'have', 'only a little' or 'not at all'. Minor psychiatric morbidity, assessed by the twelve-item Japanese version of the General Health Questionnaire, was used to determine the mental health outcome of stress. Each item was scored by the Likert method (0–1–2–3), and the upper tertile of total scores was used to define '> 12' as 'poorer mental health' and '≤ 12' as 'better mental health'.

Health lifestyle factors. Health lifestyle pattern was determined on the basis of the following five practices that show confirmed health benefits among Japanese:

1. *Not smoking regularly*, which included 'never smoked, ex-smoker or occasional smoker' in contrast to 'current regular smoker'.
2. *No or moderate alcohol consumption.* Based on the self-reported frequency and quantity of alcohol consumption, subjects were grouped according to the average number of cups of Japanese sake (22 g ethanol/cup) consumed per week as follows: '0–6 cups' indicated 'no or moderate alcohol

consumption', and '7 or more cups' indicated 'heavy alcohol consumption' using the upper quartile.

3. *Regular exercise* was based on the dichotomous responses to the question 'Do you currently perform moderate physical exercise?'
4. *Health-conscious eating habit.* Four relevant items were used: 'eating three meals regularly', 'having a balanced diet', 'avoiding excessive amounts of salty food' and 'avoiding overeating'. Subjects who responded 'yes' to at least two items were classified as 'having the habit of health-conscious eating'.
5. *Fruit and vegetable juice consumption.* Subjects were classified according to self-reported fruit and vegetable juice intake frequency over the past year as follows: 'at least weekly' or 'not'.

All questions regarding health practices were taken from the health sheet of the Japanese Ministry of Health, Labour and Welfare (2002).

A summated index was obtained by giving the same weight to each of the five practices and used as an indicator of health lifestyle, providing a whole picture of health-related behaviour. The distribution of this health lifestyle index was close to normal (subject proportions for index = 0, 1, 2, 3, 4 and 5 were 4.0, 14.9, 22.9, 30.7, 21.6 and 5.9%, respectively). The population was also split into two by defining those who fulfilled at least three practices as 'healthy lifestyle', while the others were classified as 'less healthy lifestyle'.

Statistical analysis

Statistical analyses were performed using SPSS for Windows (version 110.1; SPSS Inc., Chicago, IL, USA). For descriptive purposes, absolute numbers and percentages of subjects were calculated for each kind of supplement. Adjusted odds ratios were calculated using multivariate logistic regression to examine the effects of explanatory variables on 'use' (= 1) or 'non-use' (= 0) of each of the three targeted categories of dietary supplements. A three-step process was used to determine the models of supplementation. Initially, the participant's background variables, including sex, age, education, city of residence and use of pharmaceutical medication, were tested for independent associations with supplement intake (model I). In the second step, lifestyle factors were included to assess their impact on supplementation after controlling for background variables (model II). Finally, use of supplements was regressed on each stress process indicator, adjusting for lifestyle and other background factors (model III). To examine the effect modification of lifestyle on the stress-supplementation relationship, model III was fitted separately for the two stratified samples, i.e. 'healthy lifestyle group' and 'less healthy lifestyle group'.

Results

General profile of dietary supplementation

Of the 375 respondents included in the present study, a considerable number (134, 35.7%) reported having taken drinks for intestinal adjustment (mainly lactic acid drinks) during the past year, and 101 subjects (26.9%) had taken vitamin tablets or capsules in the past year, thirty-eight reporting their use on a daily basis. Multivitamins were used by 49.5% of all vitamin users, followed by individual vitamins, such as B complex (27.7%), C (26.7%) or

E and A and D (10.0%). A total of seventy subjects (18.7%) reported having used vitamin-enriched drinks.

Other supplements were reported less often but evenly. There were forty users of botanicals (twenty-six daily and fourteen non-daily), and thirty-seven users of bottled beverages fortified with multiple dietary elements. Twenty-nine subjects reported having used minerals, with more than half taking Ca and Fe, only a small proportion taking Zn/Mg/Se/others. Fewer than ten respondents reported the use of protein, amino acids, dietary fibre, or health drinks for hyperglycaemia, hypertension, hypercholesterolaemia, specific mineral absorption and relaxation.

Uses of supplements by background factors, health lifestyle and psychosocial stress

The top part of Table 1 shows the percentages of the three grouped supplement users divided according to background variables. Adjusted odds ratios (OR) calculated by model I indicated that the intake of vitamin tablets and capsules was significantly common among women and better-educated subjects, whereas such user characteristics became insignificant for vitamin-enriched health drinks. On the other hand, consumers of vitamin-enriched drinks were more likely to be younger, live in the Metropolitan Tokyo area and be non-users of prescribed pharmaceuticals. Regarding drinks for intestinal adjustment, only 'being female' significantly related to increased consumption.

The percentages of the three groups of dietary supplement users divided according to health lifestyle, the comprehensive indicator comprising five health practices, are shown in the lower part of Table 1. The significant OR calculated by model II indicated that healthy lifestyle independently increased the consumption of vitamin tablets and capsules,

vitamin-enriched drinks and drinks for intestinal adjustment. Analysis of each practice on an individual basis instead of by the comprehensive lifestyle indicator indicated that all practices except 'health-conscious eating habit' were consistently related to an elevated use of all supplements to a greater or lesser extent; for example, those smoking regularly were less likely to use vitamin tablets and capsules (OR = 0.52, 95% CI 0.27, 0.99), and those drinking alcohol moderately and taking fruit and vegetable juice at least weekly were more likely to use vitamin-enriched drinks (OR = 2.27, 95% CI 1.13, 4.57 and OR = 3.74, 95% CI 2.11, 6.63, respectively).

After additional adjusting the stress process indicators in model III (Table 2), the OR for health lifestyle was not reduced but remained significant for each targetted supplement indicator in each logistic regression (ranging from 1.9 to 2.1; all $P < 0.01$). However, subjects experiencing more daily stressors had a 2.0 (95% CI 1.2, 3.3) and 2.0 (95% CI 1.2, 3.6)-fold higher level of the consumption of vitamin tablets and capsules and vitamin-enriched drinks compared with their counterparts with fewer daily stressors. Stress outcome indicators also related to an elevated consumption of vitamin tablets and capsules (OR ranging from 1.3 to 1.7), vitamin-enriched drinks (OR ranging from 1.3 to 2.0) and drinks for intestinal adjustment (OR ranging from 0.9 to 1.5). With regard to psychological moderators, no statistically significant association could be found.

Differences in the stress-supplementation relationship according to lifestyle

Lifestyle-stratified analysis showed the different stress-supplementation relationship between strata (Table 3). In comparison

Table 1. Use of dietary supplements in relation to background factors (from model I*) and lifestyle factors (from model II†) among urban adults in Japan, 2002

	n	Vitamin tablets and capsules		Vitamin-enriched drinks		Drinks for intestinal adjustment	
		% of users	OR (95% CI)	% of users	OR (95%CI)	% of users	OR (95%CI)
Background factors							
Sex							
Male	177	19.8	1	15.8	1	28.8	1
Female	198	33.3	2.3 (1.4, 3.9)	21.2	1.4 (0.8, 2.5)	41.9	1.8 (1.2, 2.9)
Age (years)							
20–34	86	29.1	1	31.4	1	32.6	1
35–54	182	30.2	1.2 (0.7, 2.2)	20.3	0.6 (0.4, 1.2)	39.6	1.4 (0.8, 2.5)
55–69	107	19.6	0.9 (0.4, 1.8)	5.6	0.2 (0.1, 0.5)	31.8	1.1 (0.6, 2.2)
Education							
High school or below	265	20.4	1	15.1	1	35.1	1
College or above	109	42.2	3.1 (1.8, 5.2)	27.5	1.5 (0.9, 2.7)	36.7	1.1 (0.7, 1.8)
City of residence							
(Urbanised) Metropolitan Tokyo	188	29.8	1	23.4	1	37.8	1
(Urbanising) Fukuroi City	187	24.1	0.8 (0.5, 1.3)	13.9	0.6 (0.3, 1.0)	33.7	0.9 (0.6, 1.3)
Pharmaceuticals							
User	103	30.1	1	10.7	1	33.0	1
Non-user	272	25.7	0.7 (0.4, 1.2)	21.7	1.6 (0.8, 3.4)	36.8	1.2 (0.7, 2.0)
Health lifestyle							
Less healthy	157	18.5	1	15.3	1	26.1	1
Healthy	218	33.0	2.0 (1.1, 3.4)	21.1	1.9 (1.1, 3.5)	42.7	2.0 (1.2, 3.3)

OR, odds ratio.

*Model I refers to the logistic regression on use (= 1) or non-use (= 0) of supplement categories with all five background variables entered simultaneously.

†Model II refers to the logistic regression on use (= 1) or non-use (= 0) of supplement categories when the lifestyle factor was added into the equation containing all five background variables.

Table 2. Use of dietary supplements in relation to stress process indicators (from model III*) among urban adults in Japan, 2002

Stress process indicators	n	Vitamin tablets and capsules		Vitamin-enriched drinks		Drinks for intestinal adjustment	
		% of users	OR (95 % CI)	% of users	OR (95 % CI)	% of users	OR (95 % CI)
Chronic daily stressors							
Less (≤ 1)	243	21.8	1	14.0	1	33.3	1
More (≥ 2)	132	36.4	2.0 (1.2, 3.3)	27.3	2.0 (1.2, 3.6)	40.2	1.2 (0.8, 2.0)
Social support							
Present	308	26.9	1	19.2	1	36.4	1
Absent	66	27.3	1.2 (0.6, 2.3)	16.7	1.1 (0.5, 2.3)	33.2	1.0 (0.6, 1.9)
Coping strategy							
Acts to solve problems	64	39.1	1.4 (0.6, 3.3)	28.1	1.1 (0.5, 2.9)	48.4	1.8 (0.8, 3.8)
Focuses on positive emotions	190	26.3	1.1 (0.5, 2.2)	16.8	0.8 (0.4, 1.8)	34.7	1.1 (0.6, 2.0)
Focuses on negative emotions	34	23.5	0.9 (0.3, 2.6)	14.7	0.6 (0.2, 2.0)	29.4	0.8 (0.3, 2.2)
Does nothing at all	73	19.2	1	16.4	1	28.8	1
Physical fatigue							
Absent or only a little	163	20.9	1	12.3	1	36.2	1
Present or a great deal	212	31.6	1.7 (1.0, 2.7)	23.6	2.0 (1.1, 3.6)	35.4	0.9 (0.6, 1.5)
Mental fatigue							
Absent or only a little	137	19.0	1	13.1	1	29.9	1
Present or a great deal	237	31.6	1.7 (0.9, 2.9)	21.9	1.3 (0.7, 2.4)	39.2	1.5 (0.9, 2.4)
Mental health							
Better (GHQ ≤ 12)	234	24.8	1	15.4	1	34.6	1
Poorer (GHQ > 12)	141	30.5	1.3 (0.8, 2.2)	24.1	1.8 (1.0, 3.3)	37.6	1.2 (0.7, 1.8)

OR, odds ratio; GHQ, General Health Questionnaire.

*Model III refers to the logistic regression on use (= 1) or non-use (= 0) of supplement categories when each stress process indicator was added into an equation containing the lifestyle factor and all five background variables (sex, age, education, city of residence, use of prescribed pharmaceuticals).

with the 'healthy lifestyle' group, the impact of daily stressors on use of various supplements nearly doubled and that of stress outcomes on the consumption of health drink (drinks for intestinal adjustment and vitamin-enriched drinks) was increased by between 2- and 4-fold in the 'less healthy lifestyle' group.

Subjects in both the healthy and the less healthy lifestyle group experienced the same level of daily stressors (mean 1.45 (SD 1.60)

v. 1.38 (SD 1.37); P for t test=0.641), but the latter showed a little more severe mental fatigue (1.53 (SD 0.91) v. 1.79 (SD 0.89); $P=0.006$) and poorer mental health (10.75 (SD 4.16) v. 12.10 (SD 3.97); $P=0.002$). It is worth looking at the stress-coping strategies in the different lifestyle groups. OR in Table 3 indicated that intake of vitamin tablets and capsules was more associated with 'acts to solve problems' than with stress outcomes in persons

Table 3. Odds ratios (95 % CI) of stress process indicators on dietary supplement use, analysed by logistic regression with lifestyle stratified as 'healthy' and 'less healthy', and background factors* being controlled, among urban adults in Japan, 2002

Stress process indicators	Vitamin tablets and capsules	Vitamin-enriched drinks	Drinks for intestinal adjustment
Subjects with healthier lifestyle (n 218)†			
Two or more chronic daily stressors	1.8 (0.9, 3.5)	1.4 (0.7, 2.9)	1.0 (0.5, 1.8)
Lack of social support	1.1 (0.5, 2.6)	0.9 (0.3, 2.6)	0.8 (0.3, 1.7)
Coping type ('does nothing at all' as reference)	1	1	1
Acts to solve problems	2.5 (0.8, 8.1)	0.8 (0.2, 2.8)	1.0 (0.4, 2.8)
Focuses on positive emotions	2.0 (0.7, 5.9)	0.8 (0.3, 2.6)	0.8 (0.3, 1.9)
Focuses on negative emotions	0.9 (0.2, 4.2)	1.1 (0.3, 5.2)	1.1 (0.3, 3.6)
Presence or a great deal of physical fatigue	1.6 (0.9, 3.0)	1.6 (0.8, 3.3)	0.7 (0.4, 1.3)
Presence or a great deal of mental fatigue	1.7 (0.8, 3.3)	0.8 (0.4, 1.8)	1.0 (0.5, 1.8)
Poorer mental health (GHQ > 12)	1.6 (0.8, 3.0)	1.1 (0.5, 2.3)	0.8 (0.4, 1.4)
Subjects with unhealthier lifestyle (n 57)†			
Two or more chronic daily stressors	3.3 (1.3, 8.1)	3.7 (1.4, 9.58)	2.0 (0.9, 4.3)
Lack of social support	1.6 (0.5, 5.0)	1.3 (0.4, 4.0)	1.5 (0.6, 3.7)
Coping type ('does nothing at all' as reference)	1	1	1
Acts to solve problems	0.8 (0.2, 3.3)	3.3 (0.7, 15.4)	6.2 (1.6, 24.5)
Focuses on positive emotions	0.4 (0.1, 1.2)	0.7 (0.2, 2.2)	1.4 (0.5, 3.5)
Focuses on negative emotions	0.9 (0.2, 4.1)	–	0.2 (0.0, 2.2)
Presence or a great deal of physical fatigue	1.6 (0.6, 4.2)	3.6 (1.2, 10.5)	1.4 (0.7, 3.0)
Presence or a great deal of mental fatigue	2.1 (0.7, 6.3)	4.3 (1.2, 16.1)	3.5 (1.4, 8.9)
Poorer mental health (GHQ > 12)	0.9 (0.4, 2.2)	5.1 (1.8, 14.3)	2.2 (1.1, 4.7)

GHQ, General Health Questionnaire.

*Background factors included sex, age, education, city of residence and use of prescribed pharmaceuticals.

†Out of 218 subjects with a healthy lifestyle, the user numbers of vitamin tablets/capsules, vitamin-enriched drinks and drinks for intestinal adjustment were 72, 46 and 91, respectively; out of 157 subjects with a less healthy lifestyle, the user numbers of those three supplement categories were 29, 24 and 41, respectively.

practising a healthy lifestyle, whereas the reverse was true in persons practising a less healthy lifestyle. However, such a relationship pattern could not be observed for vitamin-enriched drinks and drinks for intestinal adjustment. Prominent associations between 'acts to solve problems' and the intake of either drink could be found in those with a less healthy lifestyle.

Discussion

The present study found that vitamin tablets and capsules, vitamin-enriched drinks and drinks for intestinal adjustment account for the largest proportion of reported supplements. Combined with lifestyle and other socio-demographic variables, increased daily stressors showed a close relationship with an increased consumption of vitamin supplements; stress outcome indicators also related to a greater or less extent to elevated consumption of various supplements. Further stratified analyses confirmed that the magnitude of the influences of stress on supplement use could be modified by lifestyle; i.e. the impacts of daily stressors on various supplements and the impacts of stress outcome on the health drinks were much more marked among people with a less healthy lifestyle.

The stress process framework allows a comprehensive inspection from stressors to stress outcomes as well as psychological resources, although the interrelationships between these three components are dynamic and interchangeable, and the actual process is undoubtedly less linear and involves more reciprocal and feedback relationships (Pearlin, 1995). The broad associations of daily stressors and stress outcomes with various supplement indicators suggest that the impacts of stress on supplement ingestion are extensively embedded in the urban population. Three points should be taken into account to explain such a relationship.

First, people in contemporary society suffer from a large amount of stress. In contrast to eventful stressors, chronic stressors are rooted in the multiple social domains of modern daily life and may maintain a presence over considerable periods of time (Pearlin, 1989). The problematic features of modern life include strain arising in family and occupational roles, demands that exceed physical capacity, contextual strain caused by interactions with the community and/or neighbourhood (Pearlin, 1995) and even daily irritations such as commuting through heavy traffic and being surrounded by polluted air (Kanner *et al.* 1981; Cockerham 1995; Takano, 2003). As reported by Cockerham (1995): 'Situations themselves cannot always be assumed beforehand to produce physiological changes. Whether the stressful situation actually induces physiological change depends upon an individual's perception of the stress stimulus and personal meaning that the stimulus holds.' According to the number of 'yes' answers to the eight types of daily stressors sought in this study, some people did feel irritated or troubled by these daily life situations.

Second, many scientific studies have indicated the usefulness of some nutritional supplements in alleviating fatigue and enhancing functional performance. However, not all such trials have indicated efficacy of supplement use. For example, women with unexplained fatigue were shown to benefit from Fe supplements, but the effect was restricted to those with a low or borderline serum ferritin concentration (Verdon *et al.* 2003). *In vitro* experiments indicated that increased antioxidant levels retard or reverse the damaging effects of free radicals on neurons. However, vitamin E did not significantly slow down memory decline in

individuals with Alzheimer's disease, and a combination of vitamins E and C did not significantly improve college students' performance on several cognitive tasks (McDaniel *et al.* 2003). A study in mice showed that nutritive and tonic crude drugs had anti-fatigue effects after forced walking, but these substances were not effective in improving immobility after sleep deprivation or immobilisation stress (Tadano *et al.* 2003). Siberian ginseng supplementation has been reported to increase stamina and endurance, but a randomised clinical trial failed to support the claim that it enhanced affect or mood in healthy young adults (Cardinal & Engels, 2001). Scientifically sound information has been misdelivered as part of the marketing of supplements, and the general population has been encouraged to try various nutritional supplements for self-treatment to deal with stress rather than to make appropriate cognitive-behavioural adjustments.

Third, the wide availability of dietary supplements and the health claims conveyed by both the product labels and the media enable people to make decisions regarding taking supplements. Regulation regarding the health claims of supplement products is quite different from that regarding drugs, in which efficacy is as important as safety and claims must be substantiated by solid research before the drug is allowed on to the market (Kata & de Roos, 2003). In Japan, although it is prohibited to make medical claims regarding dietary supplement and functional foods, some claims for 'foods for specified health use' can be approved by the Ministry of Health. However, as the system regulating health-care claims for such products is voluntary and weak, there are many foods with unapproved claims on the market.

The associations between stress and supplement use were much more obvious among subjects in the 'less healthy lifestyle' group compared with the 'healthy lifestyle' group. This observation suggested that daily stressors and some stress outcomes might be the main motivator for the use of various supplements and functional foods to compensate for unhealthier behaviours. In the present study, subjects in the 'less healthy lifestyle' group experienced the same levels of chronic daily stressors but more severe mental fatigue and poorer mental health compared with those in the 'healthy lifestyle' group. The intake of vitamin tablets and capsules was more associated with 'acts to solve problems' than with stress outcomes in persons with a healthy lifestyle, whereas the reverse was true in those with a less healthy lifestyle. It seems that persons with a healthy lifestyle coped with stress more efficiently, partly by using vitamin tablets and capsules. However, the close association between the coping strategy of 'acts to solve problems' and the intake of health drinks in persons with a less healthy lifestyle also suggested that those people might try to relieve stress by consuming health drinks, but this consumption was proved to be not as efficient. As it has been well established that regular exercise and sufficient sleep facilitate more effective coping with stress (Lehmer & Bentley, 1997; Stepanski & Wyatt, 2003), continued self-medication to cope with stress or to compensate for unhealthy behaviours by simply ingesting a range of supplements without any control mechanism will become a serious concern.

The main advantage of the present study was the wide coverage of supplement products, especially health drinks, which are popular in Japan but have not previously been reported. This allowed us to do several things. First, we were able to profile the supplements consumed by the target population. This survey disclosed that the main supplements were health drinks related to

intestinal adjustment and various forms of vitamins, followed by minerals and herb derivatives or botanicals. Although only a small number of participants reported the use of supplements such as protein, amino acids, dietary fibre, and health drinks combatting lifestyle-related diseases, our results indicated that people do take various supplements other than conventional foods. Such a wide variety of reported supplements suggests the need to incorporate an assessment of dietary supplement use into research protocols when the intake of nutrients must be precisely quantified.

Second, we could verify the effects of lifestyle indicator and demographic characteristics. Our results showed that those who were practising a healthy lifestyle were consistently more likely to use various dietary supplements. There were, however, supplement-specific demographic characteristics. For example, users of vitamin tablets and capsules significantly tended to be female and highly educated and users of vitamin-enriched health drinks tended to be younger, live in urbanised areas and not use prescribed pharmaceuticals.

Finally, we were able to examine the consistency and/or variation in associations between stress and supplement use. The results of the present study indicated that daily stressors were related more closely with either vitamin supplement indicators, whereas stress outcomes were related more closely to the consumption of vitamin-enriched health drinks, which are common among younger subjects living in urbanised areas.

Several limitations of this study should also be addressed. The cross-sectional design did not allow us to explore the attractive time-dependent dynamics between the three components of the stress process and supplement consumption. Because of the small sample size, multiple users were not analysed any further in the present study. There is a concern that healthy lifestyle was determined by self-reports on a range of health practices based on subjects' understanding of their daily habits. However, all health practice items were taken from a national health survey, and items related to health-conscious eating habit were constructed from Japanese dietary guidelines (Tanaka & Sakamoto, 2002). In addition, we claim that the results showing an association between consumption of dietary supplements and people's own evaluation of their health practices indicate a practical message: people might have taken action to consume dietary supplements on the basis of their own perception of health-related behaviour. Another limitation is that we did not examine subjects' attitudes or beliefs about supplement products, which have been previously mentioned as predictors of the decision to use dietary supplements (Conner *et al.* 2001). In the present study, the independent impact of daily stressor and stress outcomes on the consumption of drinks for intestinal adjustment was not as significant as that on vitamin-enriched drinks. Future studies are needed to clarify the role of the perceived usefulness of specific products in the stress-supplementation relationship.

In conclusion, our study revealed the following:

1. There is a consistent positive relationship between healthy lifestyle and dietary supplementation, and supplement-specific demographic characteristics also exist.
2. Stress appear to be an independent factor underlying supplement consumption by urban adults.
3. Independent stress-supplementation associations are weaker among subjects with a healthy lifestyle but stronger among subjects with a less healthy lifestyle.

The results highlight the usefulness of considering psychological stress when exploring the practice of supplement use in urban environments. Evidence of an association between stress and supplement use will not only facilitate our understanding of the controversial features of dietary supplement consumption, but will also help in the design of programmes to provide support services for the promotion of a healthy lifestyle in urban areas where a wide range of supplements are available.

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