原　著

Lifestyle characteristics of dietary supplement users from a Japanese civil servant population

公務員集団における健康補助食品使用者の生活習慣特性

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Abstract

Objectives: While a number of studies from other countries indicate that dietary supplement users tend to have favorable physical characteristics or lifestyle behaviors, consistent results have not been confirmed by the limited number of investigations that have been conducted in Japan. The purpose of this study is to conduct a workplace-based survey to characterize supplement users in terms of dietary behavior and physical activity among a Japanese population of middle-aged civil servants.

Methods: Self-administered questionnaire data were collected from a cohort of 6,221 civil servants aged 35-59 in the year 2002. A total of 951 men and 370 women who had taken any dietary supplement during the previous month prior to the survey were regarded as "supplement users." Age- and sex-matched sampling of control subjects was then performed to compare lifestyle characteristics including eating behavior and physical activity between the two groups.

Results and Conclusion: Male supplement users were more likely than nonusers to smoke or drink less, be more concerned about daily dietary behaviors, exercise for 60 minutes or more per month, deliberately engage in physical activity, or engage in exercise. In summary, supplement use might serve as a marker of health-oriented lifestyle in general populations of middle-aged working men.

抄　録

海外での調査研究によれば、健康補助食品使用者は好ましい身体特性や生活習慣を有していると指摘されている。わが国でも同様の調査がいくつか行われてきたが、一致した結果は確認されていない。そこで我々は、中年の公務員集団における健康補助食品使用者の食生活と身体活動に関する特性を明らかにするための職域調査を実施した。

2002年に35～59歳の人からなる自治体職員コホート集団を対象とした健康調査で、自記式問診票への記入を依頼した。調査前1か月に何らかの健康補助食品を利用したことがある者を「補助食品利用者」とみなしたところ、男性951人と女性370人が該当した。この集団に対し性と年齢でマッチングされた対照群を設定し、食生活や身体活動を含む生活習慣特性に関する群間比較を行った。

男性補助食品利用者は対照に比較して、喫煙者が少なく飲酒量も少なかった。また日頃の食生活に気をつけている、月合計で60分以上の運動を行う、意識的に身体活動を行う、現在運動習慣があるという者の割合が高かった。結論として一般職域集団の中年男性では、補助食品利用が健康志向の生活習慣の指標となりうることが明らかにされた。

Key words: Lifestyle behavior; health foods; dietary behavior; physical activity; civil servant

Introduction

A rapid expansion in the sales of dietary supplements has been observed in Japan. A recent estimate indicated that the retail-based market scale of health foods approached 1.9 trillion Japanese yen (2.1 billion US dollars) for the year 2008. Factors accounting for this large consumption of dietary supplements includes the increasing research findings that demonstrate the potential effectiveness of dietary supplements for disease prevention and other health benefits.

According to the new conceptual framework developed by the Ministry of Education of Japan in1984, the functionalities of food are recognized at three levels[1] i.e., the primary, secondary, and tertiary function identified as nutritional, sensory, and physiological, respectively. Dietary supplements have focused particularly on the tertiary function, which is involved in the modulation of human physiology in such aspects as biorhythm regulation, nervous system, immune system, or body defense[2]. Supplement products are widely consumed in anticipation of health maintenance and promotion, weight control, cosmetic effects, or nutritional benefits. Regrettably, health issues resulting from inappropriate application such as overdosing or fraudulent mixture of ingredients in some dietary supplement products have been occasionally disclosed, stressing the importance of communication of sound information to consumers amid the growing interest in the use of dietary supplements. In response to the call for the establishment of a regulatory system, the Ministry of Health, Labor and Welfare has established and revised the scientifically-based labeling system in Japan for correct communication of health claims of dietary supplements1). The current regulatory standards categorize dietary supplements with health claims into either *Food with Nutritional Function Claims* or *Food for Specified Health Uses;* the rest are collectively classified as *Miscellaneous Health Food.*

A number of previous reports from abroad have suggested that supplement use may be a marker for a range of health-related consciousness and behavior, with supplement users being more health-conscious than nonusers and thus less likely to smoke, drink heavily, or be obese, and more likely to eat regularly and engage in physical activity[3-6]. However, the results of studies conducted in Japan investigating the association of dietary supplement use with health-related characteristics have varied. A large-scale population-based cohort study of over 78,000 participants revealed a significant linear relationship of supplement use with never-smoking history in men, lower body mass index (BMI), or higher frequency of exercise.[7] Another cohort study, on the other hand, indicated no significant association of dietary supplement use with such characteristics as smoking, drinking, or BMI[8]. These inconsistencies may be attributable to differences in the definition of dietary supplement use between studies. The data collection process, age distribution, unmeasured demographic attributes or lifestyle-relevant characteristics, or sample size of the studies may also have contributed to the variability in the relationship between dietary supplement use and health-related characteristics of the users.

In this study, we collected and analyzed data regarding various aspects of lifestyle and use of dietary supplements from middle-aged men and women, who have worked for Aichi Prefecture as civil servant. The particular focus was placed on lifestyle factors such as eating behavior and physical activity for the association with dietary supplement use among participants.

Methods

Study population and sampling method

This study adopted a case-control design to match age and gender among civil servants working for Aichi Prefecture in central Japan. The current study was conducted during the period of the annual health checkup program conducted in 2002, when 4,554 men and 1,667 women aged 35-59 participated in the survey, which included a self-administered questionnaire to elicit responses regarding the use of dietary supplements. The frequency of dietary supplement use was categorized as twice or more/day, once/day, 4-6/week, 2-3/week, once/week, less than once/week, or no use. We regarded subjects who had taken any dietary supplement during the past month prior to the survey as "dietary supplement users." A total of 1,171 men and 495

women were identified as supplement users; among them, 461 men and 240 women had taken a dietary supplement once a day or more, and were regarded as "high-frequency dietary supplement users." Since some of the variables used in the following analysis were missing, the eventual number of supplement users who comprised the group of cases was 1,321 (951 men and 370 women), among whom 560 (379 men and 181 women) were high-frequency users.

For comparison, a group of controls was assembled; first, subjects were all subgrouped on the basis of their gender and age-range spanning 5 years. The controls were then randomly selected from supplement nonusers with due consideration that, for every gender- and age-specific subpopulation, the frequency of cases and controls balance in the ratio of 1:1. A matching procedure for high-frequency supplement users vs. nonusers was similarly conducted to perform subgroup analysis. Variables of particular interest for the association with the use of dietary supplement in the current study included BMI, systolic and diastolic blood pressure, smoking history, alcohol drinking habits, medication for lifestyle-related diseases (any of hypertension, diabetes mellitus, dyslipidemia, or hyperuricemia), menopausal status in women, dietary behaviors (intake of breakfast, preference for salty taste, habit of eating to satiety, concern about dietary behavior), and physical activity (whether the subjects had performed exercise for a total of 60 minutes or more per month, perceived sufficiency of physical activity, deliberate engagement in physical activity, and engagement in exercise). Distribution and collection of the questionnaire sheets were conducted by means of surface mail. Weight and height for calculation of BMI (kg/m^2) and blood pressure at rest were measured as part of the annual health check-up program. The Ethics Committee of Nagoya University School of Medicine, Nagoya, Japan, approved the study protocol.

Statistical Analysis

Statistical analyses were performed separately for each gender. Unpaired t-test was used for the difference in age, BMI and blood pressure (systolic and diastolic) between the dietary supplement users and nonusers. Associations of dietary supplement use with lifestyle factors, which were treated as categorical variables in the statistical models, were evaluated using the Chi-square test. All statistical analyses were performed using the SPSS^R for Windows version 11.0. Results were considered statistically significant at $P < 0.05$.

Results

Table 1 gives the distribution in the frequency of dietary supplement use in the last month among the supplement users according to the gender and 5-year age intervals. Among these supplement users, high-frequency users (once or more daily) accounted for 39.9% in men and 48.6% in women. As shown in Table 2, some characteristics showed statistically significant differences between the supplement users and control subjects in men. Male supplement users tended to have lower diastolic blood pressure

Table 1. Frequency of dietary supplement use among 1,321 dietary supplement users

	users (N = 1,321)							nonusers
	≥ 2/day	1/day	4-6/week	2-3/week	1/week	< 1/week	sum	(N = 4,900)
	Men							
35-39	15	42	17	35	23	30	162	526
40-44	18	55	18	35	27	40	193	546
45-49	24	59	17	27	29	36	192	746
50-54	23	87	24	43	30	41	248	1,185
55-59	18	38	17	32	27	24	156	600
Total	98	281	93	172	136	171	951	3,603
	Women							
35-39	12	31	14	17	10	16	100	208
40-44	12	21	14	12	12	7	78	254
45-49	6	28	9	9	4	13	69	255
50-54	14	33	5	5	9	14	80	367
55-59	7	17	4	6	3	6	43	213
Total	51	130	46	49	38	56	370	1,297

than nonusers while systolic blood pressure showed no such difference, and they were less likely to be either a smoker or frequent drinker (> 6 days/week). Although the difference was not statistically significant, fewer male supplement users were given medicine for lifestyle-related disease treatment than nonusers (P = 0.051). Women showed no apparent differences in basic characteristics or menopausal status between supplement users and controls.

With respect to dietary behaviors, about 11% of supplement users reportedly skipped breakfast every day in both men and women (Table 3); this prevalence was not significantly different from that in the control group, however. Preference for salty foods and habit of eating to satiety were not associated with the use of dietary supplements, either. On the other hand, supplement users tended to be very or relatively concerned about their daily dietary behaviors in comparison to nonusers (Table 3). This association was significant in men but not in women (P = 0.10).

Those who exercise for a total of 60 minutes or more a month were more prevalent among supplement users than nonusers in men but not in women (Table 4). Those who perceived that their exercise had been sufficient or relatively sufficient

Table 2. Basic characteristics of 1,321 supplement users and 1,321 controls

Variable	Men					Women				
	Supplement user (N = 951)		Control (N = 951)		P for difference[a]	Supplement user (N = 370)		Control (N = 370)		P for difference[a]
	Mean	(min, max)	Mean	(min, max)		Mean	(min, max)	Mean	(min, max)	
Age (year)	47.3	(35, 59)	47.3	(35, 59)	0.91	45.5	(35, 59)	45.4	(35, 59)	0.94
Body mass index (kg/m^2)	23.2	(15.9, 34.9)	23.3	(15.4, 35.9)	0.45	21.6	(15.6, 31.6)	21.9	(16.6, 33.2)	0.11
Blood pressure (mmHg)										
Systolic	126.8	(85, 180)	127.0	(88, 191)	0.12	118.3	(84, 214)	119.7	(85, 178)	0.21
Diastolic	78.3	(50, 120)	79.8	(38, 120)	< 0.01	70.9	(49, 114)	71.2	(48, 120)	0.68
	Frequency	(%)	Frequency	(%)		Frequency	(%)	Frequency	(%)	
Smoking history										
Never	391	(41.1)	322	(33.9)		316	(85.4)	327	(88.4)	
Ever	278	(29.2)	280	(29.4)	< 0.01	27	(7.3)	16	(4.3)	0.22
Current	282	(29.7)	349	(36.7)		27	(7.3)	27	(7.3)	
Current drinking habit										
No	117	(12.3)	118	(12.4)		128	(34.6)	131	(35.4)	
< 5/week	479	(50.4)	417	(43.8)	0.010	185	(50.0)	180	(48.6)	0.93
≥ 6/week	355	(37.3)	416	(43.7)		57	(15.4)	59	(15.9)	
Medication for any lifestyle-related diseases[b]										
Yes	112	(11.8)	137	(14.4)	0.051	19	(5.1)	19	(5.1)	0.43
Menopausal status										
Postmenopausal	–		–			102	(27.6)	102	(27.6)	1.00

[a] P value calculated by unpaired t-test for age, BMI, and blood pressure, and by χ^2 test for other categorical variables.
[b] e.g., hypertension, diabetes mellitus, dyslipidemia, or hyperuricemia.

Table 3. Characteristics regarding dietary behaviors among supplement users and controls

Variable	Men					Women				
	Supplement user		Control		P value[a]	Supplement user		Control		P value[a]
	Frequency	(%)	Frequency	(%)		Frequency	(%)	Frequency	(%)	
Skip breakfast										
No	744	(78.3)	761	(80.1)		262	(70.8)	279	(75.4)	
Once in a while	105	(11.1)	103	(10.8)	0.49	67	(18.1)	47	(12.7)	0.13
Always	101	(10.6)	86	(9.1)		41	(11.1)	44	(11.9)	
Salty taste preference										
Prefer salty foods	60	(6.3)	67	(7.1)		7	(1.9)	5	(1.4)	
Usually prefer salty foods	533	(56.2)	557	(58.6)	0.54	129	(34.9)	143	(38.6)	0.58
Usually prefer bland foods	323	(34.1)	296	(31.2)		201	(54.3)	185	(50.0)	
Prefer bland foods	32	(3.4)	30	(3.2)		33	(8.9)	37	(10.0)	
Habit of eating to satiety										
Always eat to satiety	52	(5.5)	64	(6.7)		32	(8.7)	20	(5.4)	
Usually eat to satiety	538	(56.7)	504	(53.1)	0.21	194	(52.6)	215	(58.1)	0.11
Usually eat moderately	311	(32.8)	342	(36.0)		124	(33.6)	124	(33.5)	
Always eat moderately	48	(5.1)	40	(4.2)		19	(5.1)	11	(3.0)	
Concerned about daily dietary behaviors										
Very much	53	(5.6)	27	(2.8)		25	(6.8)	12	(3.2)	
Relatively	554	(58.3)	409	(43.1)	< 0.01	216	(58.4)	221	(59.7)	0.10
Not much	313	(32.9)	454	(47.8)		112	(30.3)	125	(33.8)	
Little	30	(3.2)	60	(6.3)		17	(4.6)	12	(3.2)	

Individuals with missing data were not included in the calculation.
[a] P value calculated by χ^2 test.

accounted for less than 20% among supplement users and nonusers; no significant difference in the distribution of perceived sufficiency of exercise was observed in either men or women. Dietary supplement users tended to engage more deliberately in physical activity than nonusers; this association was statistically significant only in men, however. Moreover, male dietary supplement users were also likely to engage in exercise, whether on a regular or irregular basis, but female users were not. Even among those without habitual exercise, supplement users were more highly motivated to begin exercise in the near future (data not shown).

Results of the comparison between high-frequency dietary supplement users and nonusers indicated no significant differences in age, BMI, or systolic and diastolic blood pressure (Table 5). There was a significant association between the smoking history and high-frequency supplement use in either gender, but the gender-specific tendency of this association was in the opposite direction; e.g., high-frequency supplement users were more likely to be a smoker in men but less likely in women than the control subjects. It is noteworthy that the majority of women were never smokers (91.7% in supplement users and 85.1% in nonusers). Neither alcohol drinking habit nor

Table 4. Characteristics regarding physical activity among supplement users and controls

Variable	Men					Women				
	Supplement user		Control		P value[a]	Supplement user		Control		P value[a]
	Frequency	(%)	Frequency	(%)		Frequency	(%)	Frequency	(%)	
Exercise of ≥ 60 minutes in monthly total										
Yes	591	(62.8)	515	(55.1)	< 0.01	161	(44.5)	165	(45.0)	0.48
No	350	(37.2)	419	(44.9)		201	(55.5)	202	(55.0)	
Perceived sufficiency of physical activity										
Sufficient	30	(3.2)	28	(3.0)		14	(3.9)	11	(3.0)	
Relatively sufficient	141	(14.9)	128	(13.5)	0.55	38	(10.5)	34	(9.2)	0.82
Relatively insufficient	340	(36.0)	325	(34.4)		102	(28.1)	101	(27.4)	
Insufficient	434	(45.9)	465	(49.2)		209	(57.6)	222	(60.3)	
Deliberate engagement in physical activity										
Always	146	(15.5)	105	(11.1)		34	(9.4)	27	(7.4)	
Sometimes	489	(51.8)	444	(46.9)	< 0.01	163	(44.9)	162	(44.3)	0.51
Once in a while	234	(24.8)	296	(31.3)		114	(31.4)	131	(35.8)	
Seldom	75	(7.9)	101	(10.7)		52	(14.3)	46	(12.6)	
Engagement in exercise										
No exercise	336	(35.7)	396	(42.0)		194	(53.9)	202	(55.2)	
Irregular exercise	340	(36.1)	312	(33.1)	0.018	105	(29.2)	102	(27.9)	0.92
Regular exercise	265	(28.2)	234	(24.8)		61	(16.9)	62	(16.9)	

Individuals with missing data were not included in the calculation.

[a] P value calculated by χ^2 test.

Table 5. Basic characteristics of 560 high-frequency supplement users and 560 controls

Variable	Men					Women				
	Supplement user (N = 379)		Control (N = 379)		P for difference[a]	Supplement user (N = 181)		Control (N = 181)		P for difference[a]
	Mean	(min, max)	Mean	(min, max)		Mean	(min, max)	Mean	(min, max)	
Age (year)	47.5	(35, 59)	47.4	(35, 59)	0.86	46.4	(35, 59)	46.3	(35, 59)	0.99
Body mass index (kg/m^2)	23.1	(15.9, 33.2)	23.2	(15.4, 35.9)	0.80	21.4	(15.6, 30.2)	22.1	(16.0, 33.1)	0.013
Blood pressure (mmHg)										
Systolic	126.7	(85, 180)	126.7	(86, 178)	1.00	120.6	(84, 214)	120.9	(87, 168)	0.86
Diastolic	78.6	(50, 120)	78.6	(38, 122)	0.96	71.5	(50, 114)	73.4	(49, 102)	0.11
	Frequency	(%)	Frequency	(%)		Frequency	(%)	Frequency	(%)	
Smoking history										
Never	141	(37.2)	150	(39.6)		166	(91.7)	154	(85.1)	
Ever	93	(24.5)	119	(31.4)	0.016	2	(1.1)	12	(6.6)	0.021
Current	145	(38.3)	110	(29.0)		13	(7.2)	15	(8.3)	
Current drinking habit										
No	56	(14.8)	57	(15.0)		65	(35.9)	67	(37.0)	
< 5/week	166	(43.8)	189	(49.9)	0.18	97	(53.6)	85	(47.0)	0.23
≥ 6/week	157	(41.4)	133	(35.1)		19	(10.5)	29	(16.0)	
Medication for any lifestyle-related diseases[b]										
Yes	58	(15.3)	59	(15.6)	0.92	11	(6.1)	10	(5.5)	0.82
Menopausal status										
Postmenopausal	–		–			62	(34.3)	60	(33.1)	0.80

[a] P value calculated by unpaired t-test for age, BMI, and blood pressure, and by χ^2 test for other categorical variables.

[b] e.g., hypertension, diabetes mellitus, dyslipidemia, or hyperuricemia.

medication for lifestyle-related diseases significantly differed between the high-frequency users and nonusers for both men and women.

Table 6 indicates that male high-frequency supplement users were less moderate in eating to satiety than nonusers. As shown in the table, both male and female high-frequency supplement users seemed more concerned about daily dietary behaviors than nonusers. The likelihood of exercising for more than 60 minutes per month, deliberately engaging in physical activity, and engaging in regular exercise was significantly higher in male users than in control subjects, while such associations were not observed in women (Table 7).

In additional analyses, subjects were classified into three subgroups according to the concentrations of fasting serum glucose for the association with dietary supplement use; however, no significant association was found (data not shown). Similar models were specified using fasting serum concentrations of triglyceride and uric acid as a categorized predictor, neither of which demonstrated significant associations

Table 6. Characteristics regarding dietary behaviors among high-frequency supplement users and controls

Variable	Men				Women			
	Supplement user		Control		P value[a]	Supplement user	Control	P value[a]
	Frequency	(%)	Frequency	(%)		Frequency (%)	Frequency (%)	
Skip breakfast								
No	300	(79.2)	322	(85.0)		130 (71.8)	132 (72.9)	
Once in a while	43	(11.3)	29	(7.7)	0.11	26 (14.4)	30 (16.6)	0.57
Always	36	(9.5)	28	(7.4)		25 (13.8)	19 (10.5)	
Salty taste preference								
Prefer salty foods	19	(5.0)	28	(7.4)		4 (2.2)	2 (1.1)	
Usually prefer salty foods	221	(58.3)	212	(55.9)	0.58	64 (35.4)	65 (35.9)	0.62
Usually prefer bland foods	126	(33.2)	125	(33.0)		97 (53.6)	103 (56.9)	
Prefer bland foods	13	(3.4)	14	(3.7)		16 (8.8)	11 (6.1)	
Habit of eating to satiety								
Always eat to satiety	20	(5.3)	36	(9.5)		14 (7.7)	11 (6.1)	
Usually eat to satiety	214	(56.6)	175	(46.2)	0.013	89 (49.2)	107 (59.1)	0.29
Usually eat moderately	124	(32.8)	149	(39.3)		68 (37.6)	56 (30.9)	
Always eat moderately	20	(5.3)	19	(5.0)		9 (5.0)	6 (3.3)	
Concerned about daily dietary behaviors								
Very much	31	(8.2)	15	(4.0)		18 (9.9)	2 (1.1)	
Relatively	231	(60.9)	155	(40.9)	< 0.01	105 (58.0)	110 (60.8)	< 0.01
Not much	107	(28.2)	184	(48.5)		48 (26.5)	61 (33.7)	
Little	10	(2.6)	25	(6.6)		10 (5.5)	7 (3.9)	

Individuals with missing data were not included in the calculation.
[a] P value calculated by χ^2 test.

Table 7. Characteristics regarding physical activity among high-frequency supplement users and controls

Variable	Men				Women			
	Supplement user		Control		P value[a]	Supplement user	Control	P value[a]
	Frequency	(%)	Frequency	(%)		Frequency (%)	Frequency (%)	
Exercise of ≥ 60 minutes in monthly total								
Yes	237	(63.0)	204	(54.8)	0.026	77 (43.3)	82 (45.3)	0.75
No	139	(37.0)	168	(45.2)		101 (56.7)	99 (54.7)	
Perceived sufficiency of physical activity								
Sufficient	15	(4.0)	9	(2.4)		9 (5.1)	1 (0.6)	
Relatively sufficient	67	(17.8)	54	(14.3)	0.20	22 (12.5)	18 (9.9)	0.053
Relatively insufficient	125	(33.2)	121	(32.0)		51 (29.0)	57 (31.5)	
Insufficient	169	(44.9)	194	(51.3)		94 (53.4)	105 (58.0)	
Deliberate engagement in physical activity								
Always	74	(19.7)	41	(10.8)		23 (13.1)	12 (6.7)	
Sometimes	190	(50.5)	159	(42.0)	< 0.01	79 (44.9)	83 (46.1)	0.12
Once in a while	80	(21.3)	131	(34.6)		52 (29.5)	67 (37.2)	
Seldom	32	(8.5)	48	(12.7)		22 (12.5)	18 (10.0)	
Engagement in exercise								
No exercise	140	(37.5)	173	(45.9)		96 (55.8)	98 (55.7)	
Irregular exercise	106	(28.4)	105	(27.9)	0.031	45 (26.2)	54 (30.7)	0.43
Regular exercise	127	(34.0)	99	(26.3)		31 (18.0)	24 (13.6)	

Individuals with missing data were not included in the calculation.
[a] P value calculated by χ^2 test.

with supplement use.

Discussion

The result of the present study that was conducted to examine lifestyle characteristics of dietary supplement users among middle-aged civil servants revealed some supplement-use related lifestyle factors. The results can be summed up as follows: both male and female supplement users do not differ in their anthropometrical parameters in comparison to nonusers; male supplement users smoke or drink less and are more mindful of their eating behavior; and male supplement users are more likely to engage in physical activity or exercise than nonusers.

Some previous reports have indicated that supplement users tend to be low in BMI[6,9,10], while others have exhibited otherwise[8,11]. Our results also indicated lack of significant association between dietary supplement use and BMI, although female high-frequency users tended to be leaner. In this regard, we included a food-frequency questionnaire (FFQ) as part of the survey, and estimated FFQ-based total energy intake that potentially influenced BMI; no significant difference in total energy intake between the supplement users and nonusers was observed (data not shown), suggesting that the supplement users among our subjects do not necessarily eat moderately.

The significantly lower smoking rate among male supplement users was in accord with the previous report[7], but the significantly higher smoking rate among male high-frequency supplement users has not been previously confirmed to the best of our knowledge. One possibility is that men who had tried but failed to quit smoking were inclined to high dependency on dietary supplement use; the low ever-smoking rate among the male high-frequency supplement users (24.5%) vs. nonusers (31.4%) might have reflected such an inclination. In addition, the observation that male supplement users drink more moderately than nonusers also agreed with one earlier study[3] but differed from another one[7]. Unlike men, women showed no associations of either smoking history or current drinking habit with their supplement use; this result should be interpreted cautiously because the proportion of female smokers or frequent drinkers was disproportionately low compared to that in men, which might have minimized the statistical effect size between the supplement users and nonusers.

Some evidence indicating that supplement users, particularly men, are more health-conscious than nonusers in terms of dietary behaviors or physical activity was obtained from the present study. For example, male supplement users seem to be more concerned about daily dietary behaviors; though not statistically significant, a similar tendency was confirmed in women (P = 0.10). The subgroup analysis, which resulted in a significant association between high-frequency supplement use and concern for dietary behaviors in both genders, corroborates this evidence.

Moreover, there were significant associations of supplement use with exercise of > 60 minutes per month, deliberate engagement in physical activity, and engagement in regular exercise among men; these results confirmed the assumption that supplement users tend to be more aware of health benefits gained from physical activity than nonusers, and is consistent with those of previous investigations indicating that supplement users exercise more often[9-12]. Reasons for the failure of women to demonstrate similar associations are yet to be explored; the small proportion of women who exercise or engage in physical activity in comparison to men may explain such a discrepancy. Interestingly, though male supplement users seem to be physically active compared to nonusers, sufficient or relatively sufficient exercise was perceived only by about 18% of them. Supposedly, the levels of their physical activity (occupational, commuting, household, or leisure-time) may not be felt to be satisfactory even by individuals who performed habitual exercise.

Taken together, it was found that dietary supplement users among middle-aged civil servants are characterized by their high health-consciousness and maintenance of healthier lifestyle in terms of eating habit and physical activity than are nonusers, providing evidence in support of the 'inverse supplement hypothesis[9]. Supplement use therefore might serve as a behavioral marker of healthy lifestyle in the general healthy population[4]. On the other hand, no significant associations were identified

between supplement use and some biochemical data (glucose, triglyceride, and uric acid). Thus, we could not conclude that the claimed beneficial effects of dietary supplement products on health maintenance and disease prevention were medically ascertainable. However, cautious interpretation of the absence of such associations should be considered since some unmeasured factors obscuring the health effects of supplement products may have been involved. For one thing, our questionnaire did not include questions to elicit reasons to begin dietary supplement intake; it was previously reported that people start to take supplements when they start to feel that their health and vigor are declining during the earliest stages of definable symptoms[4].

A limitation of this study is that the questionnaire was not designed to distinguish the consumed dietary supplements according to their ingredients or health claims[1]. Therefore, judgment of which products to be included in the category of dietary supplements was inevitably left to the respondents. An earlier study conducted by Imai et al. in Japan revealed that their supplement users were likely to feel less healthy than nonusers[8], a finding not in agreement with what has been reported in other studies. It should be noted that Imai et al. categorized dietary supplements according to type or ingredients, which enabled calculation of energy and nutrient intake for each category of supplements. However, they did not define functional foods and modified foods as the dietary supplement; we thus speculate that this may partly explain the between-study inconsistency in results. Another limitation is that, because our study design was cross-sectional, persistence in each subject's supplement use was unclear. Continuation or discontinuation of supplement use is regarded as important information in evaluating longitudinal cause/effect relationships of supplement use with lifestyle attributes or biological variables.

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