European Journal of Clinical Nutrition (2014) 68, 804–810

www.nature.com/ejcn

PUBLIC HEALTH NUTRITION HIGHLIGHTS ORIGINAL ARTICLE

Dietary supplement use and its effect on nutrient intake in Korean adult population in the Korea National Health and Nutrition Examination Survey IV (2007–2009) data

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BACKGROUND/OBJECTIVES: Although there is an increasing trend of dietary supplement (DS) use, few researches have evaluated nutrient intake from DS. This study aimed to establish a nutrient database (NDB) for DS and estimate the effect of DS on total nutrient intake by Korean adults.

SUBJECTS/METHODS: The NDB for DS was established using the label information of products reported in the Korea National Health and Nutrition Examination Survey (KNHANES) IV. Of the 16 031 participants who were ⩾20 years old, 2053 products were reported as being taken by 5606 subjects. But nutrient composition could be identified by searching product name only in 1158 products consumed by 3844 subjects (DS users). Total nutrient intake of DS users was obtained by combining intakes from diet and DS.

RESULTS: Dietary supplement use was higher in women, in middle-aged people and in those with higher education and low smoking and drinking preferences. Nutrients obtained from food were higher in DS users than in nonusers for most nutrients, particularly in women. When total nutrient intake was evaluated in DS users, the percentage of subjects whose intake was below the estimated average requirement for Koreans decreased for several vitamins and minerals, but the percentage of subjects whose intake was above the tolerable upper intake levels increased for vitamin A, vitamin C and iron.

CONCLUSIONS: The newly developed NDB for DS will be an important resource for more accurate assessment of nutrient intake as well as evaluation of the relationship between nutrition and health. Further research is needed to update a more comprehensive NDB applicable to diverse populations.

European Journal of Clinical Nutrition (2014) **68,** 804–810; doi:10.1038/ejcn.2014.77; published online 14 May 2014

INTRODUCTION

Several studies reported increasing trends in dietary supplement (DS) use in Korea and other industrialized countries. According to the Korea National Health and Nutrition Examination Survey (KNHANES), the proportion of adults aged 20 years or older reporting DS use was 21.8% in men and 32.0% in women in 2005,[1] but this increased to 27.4% in men and 40.5% in women aged 19 or older in 2009.[2] In the United States, the percentage of adults aged 20 years or older that consumed DS was 53.0% in 2003–2006, according to the results from the US National Health and Nutrition Examination Survey (NHANES).[3] This is a marked increase in DS use considering the fact that only 28.0% of men and 38.0% of women reported DS use in the NHANES 1971–1975.[3] DS intake data from the National Diet and Nutrition Survey in the United Kingdom showed that among adults aged 19 to 64 years, only 9.0% of men and 17.0% of women reported taking DS in 1986/1987, but the proportion was reported to be 33.0% in 2008/2009–2010/2011.[4,5]

Since the Health Functional Foods Act was enacted in 2002 in Korea (www.mfds.go.kr), DSs were classified as either pharmaceutical drugs (PDs) or health functional foods (HFFs). In a previous study in healthy Korean adults, 30–60% responded to taking vitamin-mineral supplements, and these supplement users tended to be of a higher socioeconomic status and more highly educated compared with nonusers, and had a tendency to prefer vitamin products more than minerals.[6–8] Other Korean studies showed that 30–60% of adults used HFF, and these users had a higher socioeconomic status, higher education level and generally more interest in health compared with nonusers, and women were more common HFF users compared with men.[9–11] As commonly consumed DSs are vitamin-mineral supplements, DS use can have a significant impact on nutrient intake.

From a study that used the 2007–2008 NHANES data, when nutrient intakes from food and DSs were combined in adults, the total nutrient intake of DS users was significantly higher than that of nonusers.[12] Results from the Hawaii-Los Angeles multiethnic cohort study showed that the nutrient adequacy of DS users improved, but the possibility of overconsumption of iron, zinc, vitamin A and niacin was observed.[13] A study using data from the multiethnic study of atherosclerosis also reported that, although calcium, magnesium and vitamin C intake from DSs contributed to meeting dietary requirements, they were also associated with the risk of overconsumption.[14] Therefore, failure to include nutrients originating from DSs can lead to erroneous conclusions about nutritional assessments of individuals and/or communities.[15]

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Received 11 September 2013; revised 6 March 2014; accepted 19 March 2014; published online 14 May 2014

Although it is known that DSs have an effect on nutrient intake, there has been no study that has quantitatively evaluated the impact of DS use on nutrient intake by Koreans, mainly due to the absence of a nutrient database (NDB) for DSs. This study aimed to evaluate the interest of developing an NDB for DSs used by adults from KNHANES IV (2007–2009) to calculate nutrient intake from food as well as from DSs among DS users and to evaluate nutrient inadequacies and risks of overconsumption after combined nutrient intake from DSs and food in the Korean adult population.

MATERIALS AND METHODS

Data source

Data from dietary surveys from the KNHANES IV (2007–2009) of 16 031 adults aged 20 years and older were used for this study. The KNHANES used strata and primary sampling units to pool samples of individuals and households from the Korean population. Detailed information of KNHANES is available.[16]

Data on socio-demographic and lifestyle factors were obtained from the health survey. The ages of the subjects were grouped into '20–39 years', '40–59 years' or '60 years and older', and education levels were divided into 'elementary school or less', 'junior-high school', 'high school' and 'college or more' categories. Data on alcohol consumption were based on average alcohol intake at one time and grouped into five categories, 'do not drink', '1–2 glasses', '3–6 glasses' and '7 glasses and more'. For smoking status, data were grouped into 'never smoked', 'quit smoking' and 'currently smoking' categories. Physical activity status was 'regular' if the subject answered that he/she did moderate physical activity for at least 30 min at a time for 5 or more days a week and 'none' if he/she failed to meet this level of activity.

Identification of DS users and products

Questions on DS use were part of the nutritional survey that was collected at household visitations.[16] The survey consisted of two questions: 'In the past year, have you consumed any vitamin or mineral supplements for at least 2 weeks on a continuous basis?' and 'In the past year, have you consumed any HFFs for at least 2 weeks on a continuous basis?'. Subjects who answered 'yes' on either one question were classified as DS users and were further questioned to specify a maximum of four different DSs by brand or product name, the type of dosage form (for example, tablet, capsule) and dosage per serving. A total of 5606 subjects (34.2%) among 16 031 adults aged 20 years and above were classified as DS users. Among DS users, 4507 specified the products that they consumed.

Classification of DS

Products specified by the 4507 subjects as consumed were compiled and classified into two categories: PD and HFF. In Korea, DSs are classified as PD or HFF and governed by the Korean Ministry of Food and Drug Safety (www.mfds.go.kr). Dietary supplements in PD are nonprescriptive medications and provide information on their ingredients as chemical forms with their weights. To obtain the nutritional values for effective nutrients present in PD, computation was applied using the chemical formulae and proportions of the ingredients. In contrast, HFF are regarded as food, and nutritional values were obtained directly from their nutrition fact labels. Owing to this difference, it was the first step to classify DSs as PDs or HFFs.

To classify DSs as PDs, each product was searched by product name and using keywords in the Korea Pharmaceutical Information Service (kpis.or.kr) and other drug websites, such as Korean Medical Library Engine (www.kmle.co.kr) and Druginfo (druginfo.co.kr). To classify DSs as HFFs, the search engine provided by the Korean Ministry of Food and Drug Safety website (www.foodnara.go.kr) was used. The remaining products, identifiable by manufacturer and sales company, were searched via the respective company websites for product information and were classified as PD or HFF accordingly. Finally, products that could not be identified using the above methods were classified as 'unidentified'.

Of the 2053 products reported to be consumed by 4507 users, a total of 1588 (77.4%) products, 381 PDs and 1207 HFFs, were used to establish the NDB, excluding the remaining 465 unidentified products (Figure 1).

Development of the NDB for DS

The NDB for DS provides the nutrient composition of one serving of each identified product. If there were multiple products manufactured by the same company with the same nutrient contents but with different names than those given by the survey subjects, both names were included in the NDB along with any information about the date of the name change to track changes in product names. If incomplete or insufficient product names were given, such as generalized names (for example, vitamin C, vitamin E), or products with similar names but different nutrient contents were listed (for example, vitamin C 500 mg, vitamin C 1000 mg), then the products were treated separately and assigned different codes.

Among the 1588 identified products, NDB consists of 380 PDs and 778 HFFs. It accounted for 56.4% of the 2053 total products reported by 4507 subjects, and they accounted for 79.7% of total DS consumption frequency (Figure 1).

Effect of DS use on nutrient intake

The effect of DS on nutrient intake in 3844 users of DS products that were included in the NDB was compared with the nutrient intake in 10 425 nonusers (Figure 1). Nutrient intake from DSs was calculated by multiplying three components: (1) the standard amount of DS consumption as specified in the NDB, (2) the actual amount of DSs consumed in one serving and (3) the frequency of DS consumption in 1 day. The KNHANES IV surveyed the amount and dosage form of DS consumed at one time. The frequency of DS use was grouped into one of five categories: three or more times per day, twice per day, once per day, two to five times per week and once or less per week. The daily consumption frequency of DSs was assigned as 3, 2, 1, 0.5 and 0.14, respectively, for each of the above five categories. Daily nutrient intake from the DS ('y') was calculated as following:

$$y = a \times \frac{b}{c} \times d$$

where a = nutrient per standard serving of DS, b = amount of DSs consumed per serving, c = standard dose for one serving and d = frequency of DS intake in 1 day.

The usual intake of nutrients from food by the study subjects was based on 24-h recall data and estimated as described by Kim *et al.*[17] using C-SIDE (Software for Intake Distribution Estimation, version 1.02, 1996; available from the Center for Survey Statistics and Methodology, Iowa State University, Ames, IA, USA). To calculate total nutrient intake, data on nutrients from food sources and DSs were combined.

Statistical analysis

Statistical analyses in this study were performed using the SAS program (version 9.3, Cary, NC, USA) and the level of significance was set at $P < 0.05$. To analyze the 2007–2009 KNHANES combined data, pooled weight was calculated considering the number of sample units.[16] The prevalence of DS use according to socio-demographic and lifestyle factors was analyzed by the PROC SURVEYFREQ procedure for a complex sampling design. The usual or total intake of nutrients was compared between DS users and nonusers using the PROC SURVEYREG procedure after adjusting for socio-demographic and lifestyle factors. The Dietary Reference Intakes for Koreans[18] was used as a reference to evaluate nutrient intake. Subjects whose usual nutrients were below the estimated average requirement (EAR) were evaluated as at risk of being inadequate, whereas those exceeding the tolerable upper intake levels were evaluated as being prone to overconsumption.

RESULTS

Prevalence of DS use

Among 16 031 adults aged 20 years and above in KNHANES IV (2007–2009), 34.2% responded as taking DSs (Table 1). The prevalence of DS use was highest among those who were middle-aged and received higher levels of education. The low alcohol consumption group and 'never smoked' group also showed a higher prevalence of taking DS. The motivation of most people who took DS was reported to be from 'recommendation of family or friends' (52.9%) or 'their own choice' (38.7%) (data not shown). Subjects who responded as taking DS but were excluded from the

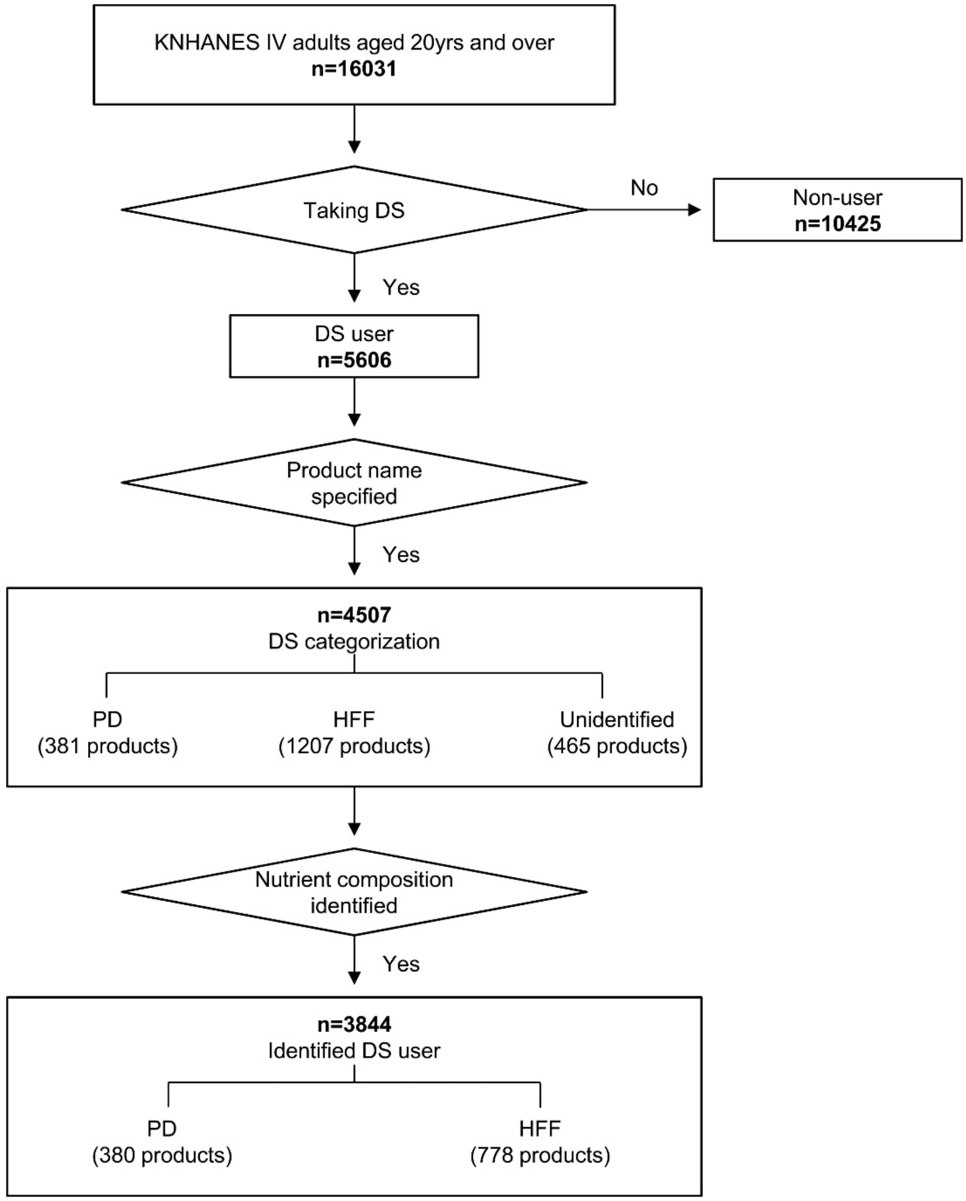

Figure 1. Development process of NDB for DS. KNHANES IV, Korea National Health and Nutrition Examination Survey IV (2007–2009).

nutrient intake calculation due to inaccurate product information tended to have lower education levels and were 'currently smoking' ($P < 0.01$) but other characteristics were similar compared with those whose reported products were included in the NDB (data not shown).

NDB of DS

Table 2 shows the number of products and nutrients included in the NDB for DSs. In the NDB, 1158 DS products were included and had an average number of nutrients 5.5 ± 6.0. The most frequently consumed type of DSs was 'vitamin-mineral' (39.0%). Among total frequency of taking DSs, 91.0% reported consuming products from the top 10 types.

Effect of DS use on nutrient intake

The nutrient intake among DS users who obtained each nutrient from DS is shown in Table 3. The nutrients obtained most frequently from DSs were vitamin C and calcium in both sexes. These two nutrients were also the most common among products listed in the NDB (458 DSs included vitamin C, 323 DSs included calcium; data not shown).

Table 4 shows the mean nutrient intakes of nonusers and users, respectively. When the usual nutrient intakes from food alone were compared, DS users had a significantly higher intake of energy and several nutrients compared with nonusers. When supplement intake was included, both male and female DS users had a significantly higher intake of all nutrients, except carbohydrate and sodium, compared with nonusers.

Nutrient intake was also evaluated according to age and gender-specific EAR, and the percentage of subjects whose intake was below the EAR among nonusers and users are presented in Figure 2. With respect to riboflavin, the percentage of male subjects whose intake was below the EAR was 77.8% among nonusers and 70.1% among users, decreasing to 39.1% among users when supplement intake was included. Similar trends were found for all nutrients in both men and women. An improvement

Table 1. Characteristics of adults and DS users from the KNHANES IV

	Total N	*Nonusers* (n = 10 425), *% (s.e.)*[a]	*DS users* (n = 5606), *% (s.e.)*[a]	P[b]	*Identified DS users* (n = 3844), *% (s.e.)*[a]	P[c]
Total	16 031	65.8 (0.6)	34.2 (0.6)		23.1 (0.5)	
Male	6527	72.6 (0.7)	27.4 (0.7)	< 0.001	18.1 (0.6)	< 0.001
Female	9504	59.2 (0.8)	40.8 (0.8)		28.0 (0.7)	
Age						
20–39 years	5140	69.2 (0.9)	30.8 (0.9)	< 0.001	20.7 (0.8)	< 0.001
40–59 years	5814	62.0 (0.9)	38.0 (0.9)		25.8 (0.8)	
60 years and older	5077	66.3 (1.0)	33.7 (1.0)		22.9 (0.8)	
Education						
Elementary school or less	4589	70.8 (0.9)	29.2 (0.9)	< 0.001	18.6 (0.7)	< 0.001
Junior-high school	1729	65.6 (1.5)	34.4 (1.5)		22.4 (1.2)	
High school	4958	66.2 (0.8)	33.8 (0.8)		22.6 (0.7)	
College or more	3666	59.8 (1.1)	40.2 (1.1)		28.5 (1.0)	
Alcohol intake at one time						
Do not drink any	4723	63.4 (1.0)	36.6 (1.0)	< 0.001	25.2 (0.9)	< 0.001
1–2 glasses	3882	58.0 (1.1)	42.0 (1.1)		29.0 (1.0)	
3–6 glasses	3818	66.3 (1.0)	33.7 (1.0)		22.6 (0.9)	
7 glasses or more	2551	72.2 (1.1)	27.8 (1.1)		17.5 (0.9)	
Smoking status						
Never	9054	59.8 (0.8)	40.2 (0.8)	< 0.001	27.5 (0.7)	< 0.001
Quit smoking	2900	66.0 (1.1)	34.0 (1.1)		23.3 (1.0)	
Currently smoking	3026	74.9 (0.9)	25.1 (0.9)		15.5 (0.8)	
Physical activity[d]						
None	12 750	65.2 (0.7)	34.8 (0.7)	0.51	23.4 (0.6)	0.65
Regular	2154	64.3 (1.4)	35.7 (1.4)		23.9 (1.2)	

Abbreviations: DS, dietary supplement; KNHANES IV, Korea National Health and Nutrition Examination Survey IV (2007–2009). [a]Percentage calculated from weighted frequency. All analyses accounted for the complex sampling design effect and appropriate weights of the national survey. [b]Analysis of the prevalence according to socio-demographic and lifestyle factors among DS users ($n = 5606$) and nonusers . [c]Analysis of the prevalence according to socio-demographic and lifestyle factors among identified DS users ($n = 3844$) and nonusers. [d]Moderate physical activity for at least 30 min, 5 days a week.

Table 2. The number and types of dietary ingredients contained in the products of the NDB for DS[a]

Type	*Frequency*			*No. of products*	*No. of nutrients*			
	Total	*Male*	*Female*		*Total*	*Macronutrients*	*Vitamins*	*Minerals*
Vitamin-mineral	2045 (39.0)	677 (43.1)	1368 (37.3)	330 (28.5)	12.5 ± 6.3	0.4 ± 0.9	7.7 ± 3.8	4.3 ± 3.2
Vitamin	994 (19.0)	309 (19.7)	685 (18.7)	187 (16.1)	3.6 ± 2.9	0.6 ± 0.9	2.7 ± 2.6	0.3 ± 0.6
Omega-3 fatty acid	598 (11.4)	188 (12.0)	410 (11.2)	125 (10.8)	1.9 ± 1.1	1.6 ± 1.0	0.2 ± 0.5	0.0 ± 0.1
Mineral	319 (6.1)	29 (1.9)	290 (7.9)	122 (10.5)	2.4 ± 1.7	0.3 ± 0.7	1.0 ± 1.4	1.1 ± 1.0
Glucosamin	420 (8.0)	92 (5.9)	328 (8.9)	90 (7.8)	1.6 ± 1.7	1.0 ± 1.2	0.1 ± 0.4	0.5 ± 0.9
Gamma-linolenic acid	154 (2.9)	22 (1.4)	132 (3.6)	47 (4.1)	1.8 ± 1.0	1.6 ± 0.9	0.2 ± 0.4	0.1 ± 0.4
Red ginseng	129 (2.5)	61 (3.9)	68 (1.9)	26 (2.2)	2.3 ± 1.0	2.1 ± 0.8	0.0 ± 0.0	0.2 ± 0.4
Health tonic and alternatives	51 (1.0)	23 (1.5)	28 (0.8)	21 (1.8)	10.5 ± 6.2	0.0 ± 0.0	7.7 ± 3.6	2.8 ± 3.5
Blood (circulation) tonic	29 (0.6)	11 (0.7)	18 (0.5)	20 (1.7)	1.1 ± 1.5	0.0 ± 0.0	1.1 ± 1.5	0.0 ± 0.0
Metabolic tonic	29 (0.6)	10 (0.6)	19 (0.5)	15 (1.3)	6.8 ± 0.8	0.0 ± 0.0	5.7 ± 1.9	1.1 ± 1.8
Others[b]	471 (9.0)	148 (9.4)	323 (8.8)	175 (15.1)	2.3 ± 2.3	1.3 ± 1.3	0.6 ± 1.5	0.4 ± 0.7
Total	5239 (100.0)	1570 (100.0)	3669 (100.0)	1158 (100.0)	5.5 ± 6.0	0.8 ± 1.1	3.1 ± 4.0	1.6 ± 2.6

Abbreviations: DS, dietary supplement; NDB, nutrient database. [a]Values are *n* (%) or mean ± s.d. [b]Included in dietary supplement products such as protein/amino acid products, chlorella, aloe, royal jelly, squalene products and so on.

in nutrient adequacy was observed in DS users when supplement intake was included in the analysis. However, an increased risk in overconsumption of specific nutrients in some subjects from supplementation was also noted. For example, 3.6, 3.8 and 2.9% of subjects' intake of vitamin A, vitamin C and iron from total nutrient intake was higher than the upper intake levels in men and 3.8, 3.2 and 4.3% for each of the above nutrients in women (data not shown).

DISCUSSION

In this study, we established an NDB for 1158 DS products out of 2053 products that were reported in the KNHANES IV (2007–2009). To estimate total nutrient intake, intakes from food and DS were combined. The prevalence of DS use was 34.2% and was associated with characteristics of demographic and lifestyle factors. Nutrient intake from food alone was higher in DS users than in nonusers for energy and several nutrients.

Table 3. Nutrient intakes among DS users who had obtained each nutrient from dietary supplements[a]

	Identified DS users			
	Male (n = *1209)*		*Female* (n = *2635)*	
	N	*Mean ± s.e.*	N	*Mean ± s.e.*
Vitamin A (μg RE)	286	1051.7 ± 90.5	573	1165.5 ± 139.8
Vitamin D (μg)	303	7.5 ± 0.7	712	8.2 ± 1.1
Vitamin E (mg)	508	37.4 ± 4.6	1019	42.7 ± 4.1
Vitamin K (μg)	89	33.4 ± 2.7	165	31.4 ± 1.6
Vitamin C (mg)	848	494.8 ± 32.2	1654	476.4 ± 21.9
Thiamin (mg)	531	14.9 ± 1.1	1008	12.1 ± 0.6
Riboflavin (mg)	546	6.4 ± 0.4	1087	7.1 ± 0.4
Niacin (mg)	440	48.3 ± 3.1	931	42.6 ± 2.1
Vitamin B_6 (mg)	522	5.5 ± 0.4	1044	7.6 ± 0.5
Folate (μg)	338	306.3 ± 11.0	794	340.8 ± 10.3
Vitamin B_{12} (μg)	470	17.2 ± 2.8	899	36.8 ± 6.4
Pantothenic acid (mg)	414	17.9 ± 0.9	860	17.6 ± 0.8
Calcium (mg)	527	129.4 ± 8.2	1140	174.6 ± 8.2
Phosphorus (mg)	279	85.3 ± 4.4	447	103.2 ± 6.0
Sodium (mg)	295	8.0 ± 1.8	581	9.6 ± 0.7
Potassium (mg)	235	33.0 ± 1.5	392	33.7 ± 1.7
Magnesium (mg)	361	92.7 ± 3.4	670	92.1 ± 3.2
Iron (mg)	402	9.3 ± 0.5	830	13.6 ± 0.7
Zinc (mg)	486	10.2 ± 0.5	899	9.4 ± 0.3
Copper (mg)	362	1.4 ± 0.1	617	1.4 ± 0.1
Manganese (mg)	417	1.8 ± 0.1	823	1.7 ± 0.1
Iodide (μg)	325	96.0 ± 3.5	576	99.8 ± 4.1
Selenium (μg)	266	31.4 ± 1.4	502	29.8 ± 1.2
Molybdenum (μg)	142	32.3 ± 1.4	228	34.6 ± 1.9

Abbreviations: DS, dietary supplement; RE, retinol equivalent. [a]Nutrients from DSs of DS users less than 10 persons not included in table.

We found that DS users were more likely to be female, to be more educated and to have healthier lifestyles compared with nonusers. This was in agreement with other studies conducted in Korea.[1,19,20] Our findings are also consistent with studies from other countries, including the United States, the United Kingdom, France, Germany and Italy, all of which found similar associations between DS use and demographic and lifestyle characteristics: higher usages in those who were women, more educated, nonsmokers, more physically active or had more knowledge about nutrition and organic products.[21–26]

In this study, the intake of all nutrients except for carbohydrate and sodium from foods was significantly higher in users than nonusers, and this trend was more evident among women. Another Korean population study showed no significant difference in nutrient intake, except for energy, between users and nonusers.[27] However, that study did not account for HFF in DS and the calculated nutrient intake from food was based on 24-h recall data rather than usual intake, which could have affected the results. Another study showed that DS users had higher intake of folate, vitamin A and vitamin E from food alone;[28] among men, magnesium, copper, potassium and selenium intakes were higher, whereas intakes of all minerals except selenium appeared to be higher in women.[29]

Our findings suggest that supplementation has an effect on the overall intake level of many nutrients. The percentage of subjects whose intake was below the EAR for calcium and riboflavin was very high, 41.7–80.4%, when nutrient intake from food alone was included. Inadequate intake of calcium and riboflavin is commonly reported in Korea, as the typical Korean diet is rice-based with many plant foods and the consumption of dairy products is typically very low. Thus, supplement intake posits a possibility of being an important contribution in supplying these nutrients

Table 4. Nutrient intakes of DS users and nonusers by nutrient sources[a]

	Male (n = *5945)*					*Female* (n = *8324)*				
	Nonusers (n = *4736)*	*Identified DS users* (n = *1209)*				*Nonusers* (n = *5689)*	*Identified DS users* (n = *2635)*			
	Food	*Food*	*Food+DS*	p[b]	p[c]	*Food*	*Food*	*Food+DS*	p[b]	p[c]
Energy (kcal)	1803.2 ± 10.8	1878.7 ± 19.3	1883.6 ± 19.4	0.0029	0.0015	1769.6 ± 8.9	1875.4 ± 13.5	1881.6 ± 13.5	< 0.0001	< 0.0001
Carbohydrate (g)	300.5 ± 1.7	310.7 ± 3.0	311.2 ± 3.0	0.8894	0.8622	296.9 ± 1.6	312.1 ± 2.4	312.8 ± 2.4	0.1592	0.0927
Fat (g)	31.9 ± 0.3	35.6 ± 0.6	35.9 ± 0.6	0.0002	< 0.0001	31.6 ± 0.3	35.5 ± 0.4	35.8 ± 0.4	0.0003	< 0.0001
Protein (g)	63.0 ± 0.4	67.8 ± 0.9	67.9 ± 0.9	0.0059	0.0069	61.8 ± 0.4	67.7 ± 0.6	67.9 ± 0.6	< 0.0001	< 0.0001
Vitamin A (μg RE)	780.6 ± 8.4	847.4 ± 16.1	1102.7 ± 32.2	0.6377	< 0.0001	773.3 ± 9.0	884.2 ± 14.3	1142.3 ± 35.7	0.0006	< 0.0001
Vitamin C (mg)	101.2 ± 0.9	108.8 ± 1.8	465.1 ± 24.7	0.1707	< 0.0001	101.4 ± 1.1	114.1 ± 1.5	418.2 ± 15.2	0.0002	< 0.0001
Thiamin (mg)	1.2 ± 0.0	1.2 ± 0.0	7.8 ± 0.5	0.9402	< 0.0001	1.2 ± 0.0	1.2 ± 0.0	5.9 ± 0.3	0.0041	< 0.0001
Riboflavin (mg)	1.0 ± 0.0	1.1 ± 0.0	4.1 ± 0.2	0.0002	< 0.0001	1.0 ± 0.0	1.2 ± 0.0	4.2 ± 0.2	< 0.0001	< 0.0001
Niacin (mg)	14.7 ± 0.1	15.6 ± 0.2	33.3 ± 1.4	0.7576	< 0.0001	14.3 ± 0.1	15.8 ± 0.1	31.2 ± 0.8	< 0.0001	< 0.0001
Calcium (mg)	462.3 ± 3.1	504.7 ± 7.3	561.9 ± 8.7	0.0006	< 0.0001	460.8 ± 3.4	515.5 ± 5.4	591.0 ± 7.3	< 0.0001	< 0.0001
Phosphorus (mg)	1079.9 ± 6.4	1141.5 ± 13.2	1160.9 ± 13.4	0.1395	0.0009	1060.7 ± 6.0	1157.4 ± 9.5	1174.7 ± 9.8	< 0.0001	< 0.0001
Sodium (mg)	4677.4 ± 32.9	4856.0 ± 69.9	4857.9 ± 69.9	0.9768	0.8745	4664.5 ± 35.2	4906.9 ± 51.0	4909.0 ± 51.0	0.7623	0.9210
Potassium (mg)	2851.4 ± 19.0	3057.1 ± 36.9	3063.4 ± 37.0	0.0287	0.0304	2800.0 ± 20.0	3141.4 ± 31.3	3146.4 ± 31.4	< 0.0001	< 0.0001
Iron (mg)	13.9 ± 0.1	15.0 ± 0.3	18.1 ± 0.4	0.1398	< 0.0001	13.6 ± 0.1	15.6 ± 0.2	20.0 ± 0.3	< 0.0001	< 0.0001

Abbreviations: DS, dietary supplement; RE, retinol equivalent. [a]Values are mean ± s.e. [b]Adjusted for age, education level, alcohol consumption, smoking status and energy intake adjusted for nutrients excluding energy when analyzing nutrient intakes from only food source among DS users and nonusers. [c]Adjusted for age, education level, alcohol consumption, smoking status and energy intake adjusted for nutrients excluding energy when analyzing total nutrient intakes from combination of food and DS sources in DS users and nonusers.

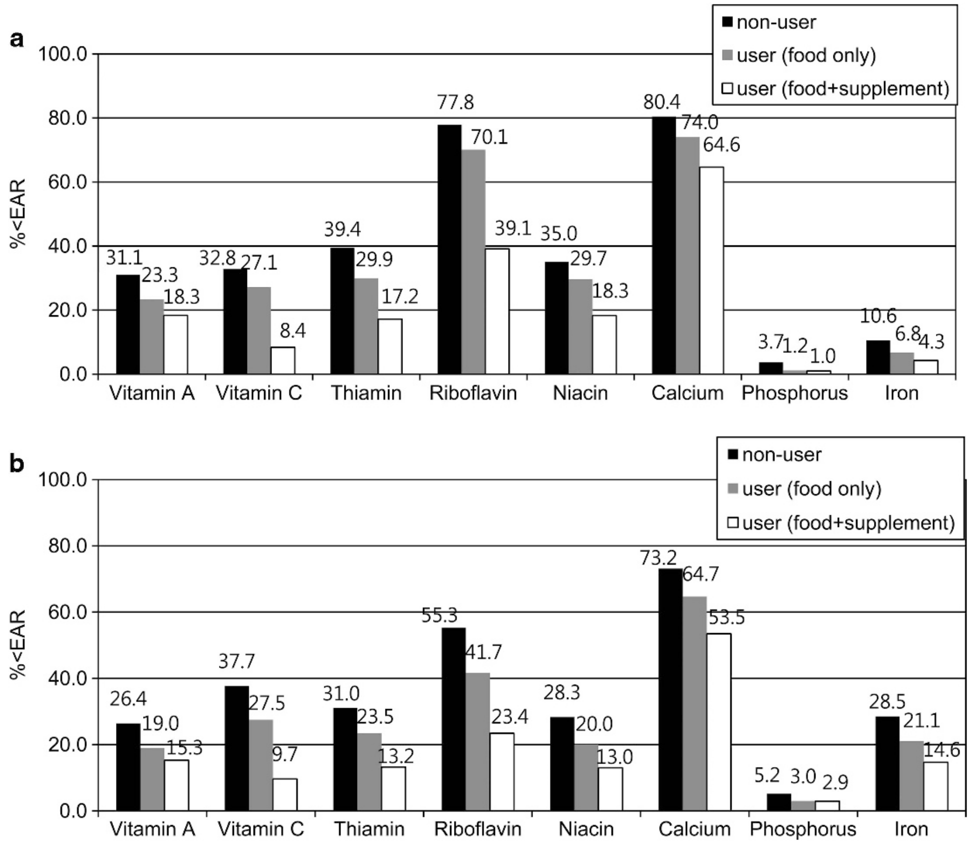

Figure 2. The percent of people whose intake was below EAR among nonusers and users; (**a**) males and (**b**) females.

and lowering the possibility of inadequate intake within the adult population.

Similarly, several studies conducted in diverse ethnic groups showed improvements in overall nutrient adequacy when nutrients from DS were taken into account.[13,14,28–30] In the multiethnic cohort study of a US adult population, multivitamin usage improved the prevalence of nutrient adequacy by an average of 8 percent points for both men and women.[13] In a Canadian community health study, supplement users were at a lower risk of inadequacy for most nutrients compared with nonusers.[30]

Although the purpose of supplementation is to complement nutrient inadequacies of the diet, the possibility of overconsumption of some nutrients, such as vitamin A, vitamin C and iron, should be seriously considered. The average amount of vitamin A consumed via supplements by DS users was above 1000 μg retinol equivalents, which is far above the recommended nutrient intake for vitamin A in Korea.[18] The same has been observed for vitamin C, whereas iron intake from supplement use is close to the recommended level. These results are consistent with studies conducted in other countries. An increased percentage of people whose intake exceeded the upper intake levels for vitamin A, vitamin C, niacin, iron and zinc, calcium or magnesium from a combination of food and supplements was reported in the US adult population[13,14,28,29] and 10% or more DS users reported intakes exceeding the upper intake levels for folic acid, niacin, zinc, calcium and iron among the Canadian adult population.[30]

There are several limitations of this study. First, we established an NDB for identifiable DSs only. Unidentified products had incomplete information. For example, DS information was collected between 2007 and 2009 but there was difficulty in finding product information that was dropped off the market due to the ever shifting DS market. Some DS labels did not contain detailed information on the amounts of each nutrient (HFF in particular). However, similar challenges to developing an NDB of DS have been described in previous studies.[31–33] Second, we obtained NDB of DS on the basis of label information. No verification of this information or of the ingredients in HFF was undertaken. Thus, the actual nutrient intake of subjects might be underestimated. It is suggested that future studies put greater effort into updating or including more products in the NDB that are applicable to a more diverse population as well as into searching for more valid methods for developing an NDB of DS. Finally, there was no information regarding the purpose of taking DS, so we could not consider such factors. Some people took DS because of medical or nutritional problems. However, according to our subanalysis, the most common motivation was recommendation from family or friends.

Nevertheless, our study is the first to estimate total nutrient intake including DS for the Korean population using national data. Our study provides a strong foundation for future studies on DS use and its impact on the nutritional status of the population. Because of the extensive international trade of DS products, our NDB may be applicable for use in other countries.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1 Lee JS, Kim JS. Factors affecting the use of dietary supplements by Korean adults: data from the Korean National Health and Nutrition Examination Survey III. *J Am Diet Assoc* 2009; **109**: 1599–1605.

2 Korea Centers for Disease Control and Prevention. *Korea Health Statistics 2009: Korea National Health and Nutrition Examination Survey (KNHANES IV-3)*. Korea Centers for Disease Control and Prevention, Ministry of Health and Welfare: Seoul, Korea, 2010.
3 Gahche J, Bailey R, Burt V, Hughes J, Yetley E, Dwyer J *et al.* Dietary supplement use among US adults has increased since NHANES III (1988-1994). *NCHS Data Brief* 2011; **61**: 1–8.
4 Henderson L, Irving K, Gregory J, Bates CJ, Prentice A, Perks J *et al. The National Diet & Nutrition Survey: Adults Aged 19 to 64 Years. Vol 3: Vitamin and Mineral Intake and Urinary Analytes*. TSO: London, UK, 2003.
5 Bates B, Lennox A, Prentice A, Bates C, Swan G. *National Diet and Nutrition Survey. Headline Results from Years 1 and 2 (Combined) of the Rolling Programme (2008-/2009–2009/2010)*. Department of Health and Food Standards Agency: London, UK, 2011.
6 Yoo YJ, Hong WS, Choi YS. The experience of nutrient supplement use among adults in the Seoul area. *J Korean Soc Food Sci Nutr* 2001; **30**: 357–363.
7 Kim YJ, Mun JA, Min HS. Supplement dose and health-related life style of vitamin-mineral supplement user among Korean middle-aged. *Korean J Community Nutrition* 2004; **9**: 303–314.
8 Song BC, Kim MK. Patterns of vitamin-mineral supplement usage by the elderly in Korea. *Korean J Nutr* 1997; **30**: 139–146.
9 Chung HK, Lee HY. Consumption of health functional foods according to age group in some regions of Korea. *J Korean Diet Assoc* 2011; **17**: 190–205.
10 Kim SH. A study on the use of health functional foods and its related influencing factors of university students in Korea. *Korean J Food Culture* 2010; **25**: 150–159.
11 Kim SH, Han JH, Kim WY. Health functional food use and related variables among the middle-aged in Korea. *Korean J Nutr* 2010; **43**: 294–303.
12 Kennedy ET, Luo H, Houser RF. Dietary supplement use pattern of U.S. adult population in the 2007-2008 National Health and Nutrition Examination Survey (NHANES). *Ecol Food Nutr* 2013; **52**: 76–84.
13 Murphy SP, White KK, Park S-Y, Sharma S. Multivitamin-multimineral supplements' effect on total nutrient intake. *Am J Clin Nutr* 2007; **85**: 280S–284S.
14 Burnett-Hartman AN, Fitzpatrick AL, Gao K, Jackson SA, Schreiner PJ. Supplement use contributes to meeting recommended dietary intakes for calcium, magnesium, and vitamin C in four ethnicities of middle-aged and older Americans: the Multi-Ethnic Study of Atherosclerosis. *J Am Diet Assoc* 2009; **109**: 422–429.
15 Block G, Sinha R, Gridley G. Collection of dietary-supplement data and implications for analysis. *Am J Clin Nutr* 1994; **59**: 232S–239S.
16 Korea Centers for Disease Control and Prevention. *The Fourth Korea National Health and Nutrition Examination Survey(KNHANES IV)*. Korea Centers for Disease Control and Prevention, Ministry of Health and Welfare: Seoul, Korea, 2010.
17 Kim DW, Shim JE, Paik HY, Song WO, Joung HJ. Nutritional intake of Korean population before and after adjusting for within-individual variations: 2001 Korean National Health and Nutrition Survey Data. *Nutr Res Pract* 2011; **5**, 266–274.
18 The Korean Nutrition Society. *Dietary reference intakes for Koreans, 1st revision*. The Korean Nutrition Society: Seoul, Korea, 2010.
19 Kim JS, Lee JS, Shin AS, Kang MH, Shin DS, Chung HR *et al.* Sociodemographic and lifestyle factors are associated with the use of dietary supplements in a Korean population. *J Epidemiol* 2010; **20**: 197–203.
20 Ock SM, Hwang SS, Lee JS, Song CH, Ock CM. Dietary supplement use by South Korean adults: Data from the national complementary and alternative medicine use survey (NCAMUS) in 2006. *Nutr Res Pract* 2010; **4**: 69–74.
21 Pouchieu C, Andreeva VA, Péneau S, Kesse-Guyot E, Lassale C, Hercberg S *et al.* Sociodemographic, lifestyle and dietary correlates of dietary supplement use in a large sample of French adults: results from the NutriNet-Sante cohort study. *Br J Nutr* 2013; **110**: 1480–1491.
22 Harrison R, Holt D, Pattison D, Elton P. Are those in need taking dietary supplements? A survey of 21 923 adults. *Br J Nutr* 2004; **91**: 617–624.
23 Radimer K, Bindewald B, Hughes J, Ervin B, Swanson C, Picciano MF. Dietary supplement use by US adults: data from the National Health and Nutrition Examination Survey, 1999–2000. *Am J Epidemiol* 2004; **160**: 339–349.
24 Foote JA, Murphy SP, Wilkens LR, Hankin JH, Henderson BE, Kolonel LN. Factors associated with dietary supplement use among healthy adults of five ethnicities: the Multiethnic Cohort Study. *Am J Epidemiol* 2003; **157**: 888–897.
25 Giammarioli S, Boniglia C, Carratu B, Ciarrocchi M, Chiarotti F, Mosca M *et al.* Use of food supplements and determinants of usage in a sample Italian adult population. *Pub Health Nutr* 2012; **16**: 1768–1781.
26 Reinert A, Rohrmann S, Becker N, Linseisen P. Lifestyle and diet in people using dietary supplements. *Eur J Nutr* 2007; **46**: 165–173.
27 Lee YO, Song YJ. Sociodemographic characteristics, lifestyle factors, and nutrient intake by taking vitamin/mineral supplements. *Korean J Food Culture* 2010; **25**: 480–486.
28 Bailey RL, Fulgoni VL, Keast DR, Dwyer JT. Examination of vitamin intakes among US adults by dietary supplement use. *J Acad Nutr Diet* 2012; **112**: 657–663.
29 Bailey RL, Fulgoni VL, Keast DR, Dwyer JT. Dietary supplement use is associated with higher intakes of minerals from food sources. *Am J Clin Nutr* 2011; **94**: 1376–1381.
30 Shakur YA, Tarasuk V, Corey P, O'Connor DL. A comparison of micronutrient inadequacy and risk of high micronutrient intakes among vitamin and mineral supplement users and nonusers in Canada. *J Nutr* 2012; **142**: 534–540.
31 Yonemori KM, Morimoto Y, Wilkens LR, Murphy SP. Development of a supplement composition database for the SURE study. *J Food Compos Anal* 2009; **22**: S83–S87.
32 Reinivuo H, Marjamäki L, Heikkilä M, Virtanen SM, Valsta L. Revised Finnish dietary supplement database. *J Food Compos Anal* 2008; **21**: 464–468.
33 Dwyer J, Picciano MF, Raiten DJ. Food and dietary supplement databases for what we eat in America–NHANES. *J Nutr* 2003; **133**: 624S–634S.