20-Year Trends in Lipid Intake From Korean Adults: Using Korea National Dietary Survey Data

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Research

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Abstract

Background: This study was undertaken to analyze 20-year trend regarding the lipid intake of Korean adults according to general characteristics, dietary behavior, food groups, and the Dietary Reference Intakes for Koreans (KDRIs), using KNHANES (Korea National Health and Nutrition Examination Survey) data.

Methods: This study selected adults who participated in the 24-hour recall method to investigate the trend of lipid intake for the 20-year period from 1998 to 2018 of the KNHANES. A total of 86,222 individuals with adults aged 19 and over were included in the study.

Results: The lipid intake increased significantly in all individuals (+7.34g), men (+9.71g), and women (+4.93g) (p for trend<0.001) from the first to the seventh term. The lipid ratio contributed to energy increased significantly in all individuals (+3.52% percentage points), men (+3.12% percentage points), and women (+3.90% percentage points) over the 20-year period (p for trend<0.001). Lipid intake increased significantly overall as well as by sex, age, residential area, education level (except below 12 years of education), and presence of obesity and abdominal obesity increased over the 20-year period. Total plant and animal lipid intake has increased over the 20-year period from 1998 to 2018. Specifically, the ratio of lipid intake from potatoes, sugars, seeds and nuts, seaweed, beverages, meats, eggs, dairy products, and other animal foods has increased, while that from grains, beans, vegetables, mushrooms, fruits, vegetable oils, fish and shellfish, and animal fats has decreased.

Conclusions: The results of this study will aid in the preparation of basic data for nutrition policy and proper nutrition and dietary education with the aim of improving the diets of Koreans nationwide.

Background

Recently, nutritional imbalance caused by the development of the food industry and various dietary changes has emerged as an important problem. While the proportion of the population consuming excessive amounts of calories and fat has increased, the proportion with insufficient intake of vitamins and minerals, including calcium, iron, and riboflavin, remains high [1]. In addition, the prevalence of chronic diseases such as obesity, diabetes, and hypercholesterolemia, which are known to be closely related to diet, has been increasing steadily [2–4].

Lipids, which are composed of triglycerides, sterols, and fatty acids, play important roles as a component of cell membranes and an important source of energy and promote the absorption of fat-soluble vitamins [5]. Essential fatty acids (n-6 and n-3 fatty acids), which are important mediators of immune functions in the body, are taken in through foods [6]. Deficiency of essential fatty acids due to reduced lipid intake or malabsorption can cause dermatitis, weakened immune function, and delayed wound healing. Inhibited lipoprotein lipase activity, suppressed bile production and gallbladder obstruction, intestinal mucosal injury and short GI tract, gastrectomy and gastric hyperacidity, and cystic fibrosis can also lead to the development of lipid malabsorption [7]. In addition, fats play an important role in the taste of and preference for foods by affecting the texture and flavor of foods in cooking [8]. However, excessive intake of lipids can increase the risk of cerebrovascular and cardiovascular disorders, dyslipidemia, diabetes, hypertension, and obesity, because lipids provide more than twice the energy of carbohydrates and proteins [9].

Korean studies on fat intake include an evaluation of total fat and fatty acid intakes [10,11] and trends of total fat and fatty acid intakes and chronic health conditions [12], while non-Korean studies include mainly fat intake, foods contributing to fat intake [13], intakes by fat type [14], and relationships between fat intake and chronic diseases [15,16]. Recently, specific diets have emerged as an important factor, with studies reporting that fat types and fat source foods, rather than total fat intake, are correlated with dyslipidemia and cardiovascular and cerebrovascular diseases. These diets include the Mediterranean diet, which includes vegetables, fruits, whole grains, low-fat dairy products, fish, and fowl [17–19].

Previous studies done on fat intake in Korea mainly focused on data analysis of the most recent 10 years and national data for short periods. Thus, this study was undertaken to analyze the fat intake of Korean adults according to general characteristics, dietary behavior, food groups, and the Dietary Reference Intakes for Koreans (KDRIs), using KNHANES (Korea National Health and Nutrition Examination Survey) data spanning the 20 years from 1998 to 2018. The results of this study will aid in the preparation of basic data for nutrition policy and proper nutrition and dietary education with the aim of improving the diets of Koreans nationwide.

Methods

Study design and survey data

The KNHANES is a large-scale statistical survey conducted by extracting representative samples from the population of a whole nation to gain a comprehensive understanding of national health and nutrition and has been used as basic data for public health policies, such as policies on national nutrition improvement, disease prevention, and development of health promotion programs [20]. The sample survey plots were extracted every year: for November to December in 1998 (first term) and 2001 (second term), April to June in 2005 (third term), July to December in 2007 (fourth term, first half-year), and year-round since 2008 (fourth term, second half-year) [21]. Also, the KNHANES is composed of a health survey questionnaire, physical examination, and nutrition survey, among which the nutrition survey is composed of a diet survey, food frequency questionnaire, food intake survey using the 24-hour recall method, and food security survey, for the purpose of understanding the levels of food and nutrient intake and dietary habits of the Korean population [20].

Study participants

The study selected adults aged 19 and over who participated in the 24-hour recall method to investigate the trend of fat intake for the 20-year period from 1998 to 2018 of the KNHANES. Among them, individuals with abnormal data, such as less than 500 kcal or over 5,000 kcal total daily energy intake, and individuals taking health supplements were excluded (Fig. 1). And also, individuals who did not participate a nutrition survey including a food frequency questionnaire and a 24-hour dietary recall were excluded(missing data). A total of 86,222 individuals were included in the study: 7,404 in the first term (1998), 6,987 in the second term (2001), 6,433 in the third term (2005), 15,939 in the fourth term (2007–2009), 17,130 in the fifth term (2010–2012), 15,772 in the sixth term (2013–2015), and 16,557 in the seventh term (2016–2018). The KNHANES data used in this study were approved by the KCDC (Korea Centers for Disease Control and Prevention) Institutional Review Board (IRB) (approval numbers: 2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C, 2013-07CON-03-4C, 2013-12EXP-03-5C, and 2018-01-03-P-A). Among these, the 2015–2017 KNHANES survey was conducted without the deliberation of the IRB, because studies were to be conducted directly by the government for public welfare, according to Article 2, Subparagraph 1, of the Bioethics and Safety Act and Article 2, Paragraph 2, Subparagraph 1, of the Enforcement Regulations of the same Act. However, the IRB deliberation has been reopened for the collection of human materials and provision of raw data to third parties since 2018 [1].

Lipid intake

The lipid intake data used in the study were the lidid intake (variable name: Nf_fat) data listed in the 24-hour recall survey. Various fatty acid data used in previous studies to analyze lipid intake trends of adults and adolescents [10, 12, 22] were not included for the first term (1998) to fifth term (2010–2012). As in the study by Song & Shim [10], the same codes have been used for the same foods since the fatty acid data of the fourth term (2007–2009) and sixth term (2013 ~ 2015) can be merged through food code matching. However, the trends for the 20-year period cannot be analyzed because the food codes were different from the first term (1998) to the third term (2005), and for substitutional foods, in particular, it is almost impossible to combine the fatty acid data. Therefore, in this study, the analysis was performed using lipid intake data from diets.

General characteristics

General characteristics of the individuals were analyzed using sex, age, education level, residential area, and household income. For sex, residential area, and household income, the basic variables included in the KNHANES raw data were used as is, while for education level, job status (occupation), marital status, and age, properly modified data were used for the study on the basis of the health survey questionnaire. First, for education level, “elementary school graduate” and “middle school graduate” were combined into “below high school graduate,” which was used along with “high school graduate” and “college and higher.” Marital status was divided into unmarried and married; residential area, into urban area and rural (*eup/myeon*) area; and job status, into worker (employed) and non-worker (unemployed). The prevalence of obesity was determined using BMI variables, with a value of less than 18.5 kg/m2 being designated as underweight; between 18.5 kg/m2 and 23.0 kg/m2, as normal weight; between 23.0 kg/m2 and 25.0 kg/m2, as overweight; and over 25.0 kg/m2, as obese, on the basis of the WHO Asia-Pacific guidelines. Abdominal obesity was defined as a waist circumference of over 90 cm in men and over 85 cm in women, and all others were defined as the normal group, according to the criteria of the Korean Society for the Study of Obesity [23]. The individuals were divided into age groups of 19–29, 30–49, 50–64, 65–74, and over 75 years old.

Dietary behavior

Dietary behavior was analyzed in terms of meals, meals by cooking location, number of times eating out, and level of food security. Meals (variable name: n_meal) were divided into breakfast, lunch, and dinner, and the eating of each meal was analyzed. For snacks, individuals who selected snacks (variable value: 4) from the variables for meals were classified as taking snacks, and all other individuals were classified as taking no snacks. Cooking location, similar to the classification used in the study of Chung et al. [24], was classified using the eating-out variables (variable name: n_mtype) of: homemade meals (prepared at home, packed lunch prepared at home, prepared at neighbor’s or relative’s home), commercial food services (Korean foods, western foods, Chinese foods, Japanese foods, snack foods, bakery, street stand/store, box lunch, instant foods such as ramen, fast foods, convenience store foods, and other types of eating out), and institutional food services (school meal service, workplace meal service, preschool/kindergarten meal service, senior-center meal service, free meal service, temple/religion-related meal service, and other meal service). The number of times eating out (variable name: L_OUT_FQ) used questionnaire items of the dietary survey after modification. “Once a day” and “more than twice a day” were combined into “more than once a day,” while “1–2 times a week,” “3–4 times a week,” and “5–6 times a week” were combined into “1–6 times a week,” and “1–3 times a month” and “less than once a month” were used without modification. The level of food security was classified on the basis of previous studies using the question “Which best describes the diet of your household for the past year?”, which has been used as a question on the dietary survey since the third term (2005) of the KNHANES [25, 26]. The level of food security was classified and used for analysis as follows. Those who answered “Everyone in our family has enough food and a sufficient variety of food and can eat as much as we want” as “sufficiently food secure”; “Everyone in our family has enough food, but we can’t eat a wide variety of food,” as “mildly food insecure”; “We have sometimes had insufficient amounts of food to eat due to economic difficulties,” as moderately food insecure”; and “We have often had insufficient amounts of food to eat due to economic difficulties,” as “severely food insecure.”

Food group classification

Individual 24-hour recall food intake survey data was used to analyze lipid intake by food group, and the food group classification used the animal/plant foods presented in the KNHANES and Reprocessed Food Group Classification 2 (variable name: N_Kindg in 1998 and 2001 and N_Kindg2 after 2001) variables. The final classifications were: 1) grains and their products, 2) potatoes and starches, 3) sugars and their products, 4) beans and their products, 5) seeds and nuts and their products, 6) vegetables, 7) mushrooms, 8) fruits, 9) vegetable oils, 10) seaweed, 11) beverages and liquors, 12) seasonings, 13) other plant foods, 14) meats and their products, 15) eggs, 16) fish and shellfish, 17) milk and dairy products, 18) animal fats, and 19) other animal foods.

Statistical analysis

All analyses were performed using SAS (Statistical Analysis System, SAS Institute, Cary, NC, USA) Version 9.4, and statistical significance was tested at α = 0.05. Because the KNHANES data were collected using multistage stratified cluster sampling, the analysis was performed in consideration of the stratification variable (Strata: Kstrata), clustering variable (Cluster: PSU (primary sampling unit)), and weight (Wt_ntr_t (time series weight) was used for the 1998, 2001, and 2005 data, and Wt_ntr was used for other years). Categorical variables such as the general characteristics and dietary behavior of the individuals in each year were expressed as frequency (n) and weighted percentages using frequency analysis, and the significance was tested using the chi-squared test. Continuous variables such as lipid intake and food intake were expressed as mean and standard error using descriptive analysis. For the significance of lipid intake and food intake by year, the p for trend values was obtained using PROC SURVEYREG. At this time, prior to the analysis, the lipid intake by sex was adjusted using age and energy intake, and the lipid intake by age was adjusted using sex and energy intake. The lipid intake and food intake were adjusted using sex, age, and energy intake.

Results

Trends of energy and lipid intake by year and lipid ratio contributed to energy

The results of the trends of each year's energy intake, lipid intake, and lipid ratio contributed to energy for all individuals and sex are presented in Fig. 2. The energy intake did not vary significantly among all individuals from the first term (1998) to the seventh term (2016–2018). It increased significantly (p for trend < 0.001) in men, while decreasing significantly (p for trend < 0.001) in women. The lipid intake increased significantly in all individuals (+ 7.34 g), men (+ 9.71 g), and women (+ 4.93 g) (p for trend < 0.001) from the first to the seventh term. The lipid ratio contributed to energy increased significantly in all individuals (+ 3.52% percentage points), men (+ 3.12% percentage points), and women (+ 3.90% percentage points) over the 20-year period (p for trend < 0.001).

General characteristics of individuals

The general characteristics of the individuals are shown in Table 1. There was no significant difference in sex, with the proportion of men ranging from 49.2–49.6% and that of women from 50.4–51.0% over the 20-year period. By age, the proportion of individuals under 49 years old decreased, and that over 50 years old increased (50 to 64 years old: 9.5 percentage points increase, 65 to 74 years old: 3.2 percentage points increase, over 75 years old: 3.9 percentage points increase) ($p < 0.001$). The average age also increased ($p < 0.001$). By residential area, the proportion of urban residents increased in all years by about 7.3%p (percentage points), rising from 77.5% in the first term to 84.8% in the seventh, while the proportion of rural residents decreased by about 7.3%p (percentage points), falling from 22.5% in the first term to 15.2% in the seventh term ($p < 0.034$). Marital status showed that the proportion of married individuals was significantly higher than unmarried individuals in all years ($p < 0.001$). The household income level of the "low" group decreased by 2.9%p(percentage points) from the first to seventh term. On the other hand, the household income level of the "high" group increased by about 3%p (percentage points), rising from 28.5% in the first term to 31.5% in the seventh term ($p < 0.001$). For work status, there was a significantly higher proportion of workers compared to non-workers in all years ($p < 0.001$). In terms of education level, the group with less than 12 years of education (below middle school graduate) decreased by 12.8%p(percentage points) from the first to seventh term, while the group with more than 12 years of education (above college graduate) increased by about 25.3%p (percentage points) over the same period ($p < 0.001$). In terms of the presence of obesity, the normal group decreased by about 8.0%p, while the obese group increased by about 9.3%p (percentage points) over the 20-year period ($p < 0.001$). Average BMI rose significantly by about 0.86 kg/m2, from 23.09 kg/m2 in the first term to 23.95 kg/m2 in the seventh term ($p < 0.001$). Regarding the presence of abdominal obesity, the obese group increased significantly by about 8%p (percentage points), from 20.58% in the first term to 28.56% in the seventh ($p < 0.001$). Waist circumference increased significantly by about 2.42 cm, from 79.84 cm in the first term to 82.26 cm in the seventh ($p < 0.001$).

Table 1
General characteristics of subject samples (1998 ~ 2018)

	□(1998)		□(2001)		□(2005)		□(2007 ~ 2009)		□(2010 ~ 2012)		□(2013 ~ 2015)	
	n	%[a]	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Gender												
Male	3434	49.2	3204	49.3	2867	49.3	6488	49.3	6987	49.0	6554	49.2
Female	3970	50.8	3783	50.7	3566	50.7	9451	50.7	10143	51.0	9218	50.8
Age												
19 ~ 29	1527	26.6	1352	25.6	1030	22.2	1995	20.1	1871	18.9	1832	18.0
30 ~ 49	3294	45.8	3356	45.9	2973	46.0	6303	44.6	6060	42.5	5354	40.1
50 ~ 64	1631	18.1	1383	18.2	1439	19.7	3933	21.9	4797	24.1	4392	26.1
65 ~ 74	668	6.4	619	7.1	711	8.1	2509	8.7	2853	8.9	2580	9.3
75+	284	3.2	277	3.2	280	4.0	1199	4.7	1549	5.6	1614	6.5
Average (Mean, SE)	41.3	0.3	41.8	0.3	43.3	0.3	44.6	0.2	45.6	0.2	46.5	0.2
Residential area												
Urban	4572	77.5	5415	80.3	5077	81.6	11586	80.8	13439	79.8	12586	82.0
Rural area	2832	22.5	1572	19.7	1356	18.4	4353	19.2	3691	20.2	3186	18.0
Marital status												
Unmarried	1186	20.8	1172	22.2	1049	22.4	1923	19.4	2194	21.7	2300	21.6
Married	6218	79.2	5814	77.8	5377	77.6	13635	80.6	14893	78.3	13459	78.4
Household income												
Low	1661	18.7	1414	21.5	1391	19.3	3363	16.2	3472	16.3	3206	15.8
Middle-low	1728	21.9	1626	25.3	1620	26.0	3879	25.2	4380	27.2	3982	24.9
Middle-high	2128	30.8	1633	25.8	1713	28.2	4094	28.7	4543	29.3	4174	29.0
High	1887	28.5	1909	27.5	1647	26.5	4167	29.9	4501	27.2	4319	30.4
Occupation												
Unemployed	4556	59.8	4078	59.3	3878	61.0	8379	60.0	8924	63.6	7753	62.2
Employed	2848	40.2	2907	40.7	2550	39.0	6429	40.0	6667	36.4	5807	37.8
Educational Level												
< 12 years	3184	34.4	2356	31.3	2194	28.9	6026	29.6	5703	27.5	4541	24.4
12 year	2581	39.2	2489	37.6	2207	35.4	4296	31.6	4328	29.9	3758	28.9
≧ 12 years	1639	26.4	2134	31.2	2029	35.7	4550	38.8	5559	42.5	5250	46.8
Obesity status [d]												
Underweight	360	5.5	286	5.3	207	4.6	704	4.8	754	4.9	619	4.4
Normal	3021	46.9	2356	42.1	1856	39.3	5946	39.9	6538	40.5	5853	39.9
Overweight	1465	22.0	1356	23.2	1202	24.7	3579	23.9	3738	22.6	3476	22.9
Obesity	1754	25.6	1716	29.4	1518	31.5	4678	31.4	5040	32.0	4882	32.8

[a] Weighted %, [b] p-value by chi-square, [c] All p for trend were calculated by surveyreg procedure of SAS. [d] Underweight : BMI < 18.5 kg/m^2, Normal : 18.5 kg/m^2
23.0 kg/m^2 ≦ BMI < 25.0 kg/m^2, Obesity: 25.0 kg/m^2 ≦ BMI, [e] Abdominal obesity: Meal (Waist circumference ≥ 90 cm), Female(Waist circumference ≥ 85 cm

	�(1998)		�(2001)		�(2005)		�(2007 ~ 2009)		�(2010 ~ 2012)		�(2013 ~ 2015)	
	n	%[a]	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
BMI (kg/m^2)	23.09	0.05	23.40	0.05	23.62	0.06	23.61	0.04	23.65	0.04	23.77	0.04
Abdominal obesity status [e]												
Normal	5119	79.42	4312	76.49	3589	75.99	10739	74.93	11828	75.54	10864	75.13
Abdominal obesity	1481	20.58	1398	23.51	1196	24.01	4157	25.07	4219	24.46	3965	24.87
Waist circumference (cm)	79.84	0.16	80.72	0.17	80.64	0.17	81.19	0.14	80.92	0.14	81.34	0.13

[a] Weighted %, [b] p-value by chi-square, [c] All p for trend were calculated by surveyreg procedure of SAS. [d] Underweight : BMI < 18.5 kg/m^2, Normal : 18.5 kg/m^2
23.0 kg/m^2 ≦ BMI < 25.0 kg/m^2, Obesity: 25.0 kg/m^2 ≦ BMI, [e] Abdominal obesity: Meal (Waist circumference ≥ 90 cm), Female(Waist circumference ≥ 85 cm

Lipid intake in each year by general characteristics

The results of lipid intake in each year by general characteristics are shown in Table 2. Lipid intake increased significantly overall as well as by sex, age, residential area, education level (except below 12 years of education), and presence of obesity and abdominal obesity over the 20-year period, regardless of adjustment (sex, age, and energy intake) (Unadjusted p for trend < 0.05, Adjusted for trend < 0.001). However, in the case of education level, the group with less than 12 years of education (below middle school graduate) showed changes in lipid intake (24.04–30.15 g/day) from the first to seventh terms, but the difference was not significant when not adjusted. When it was adjusted using sex, age, and energy intake, the lipid intake increased (p for trend < 0.001).

Table 2
Trends of Lipid intake by General characteristics

Intake, g/day	(1998)		(2001)		(2005)		(2007 ~ 2009)		(2010 ~ 2012)		(2013 ~ 2015)		(2016 ~ 2018)		Un
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	p-t
Total	38.80	0.63	39.87	0.62	43.16	0.58	37.91	0.37	42.92	0.41	45.28	0.39	46.14	0.40	< 0
Sex															
Male	44.06	0.83	45.38	0.86	49.54	0.78	45.31	0.57	51.06	0.59	52.29	0.56	53.77	0.56	< 0
Female	33.70	0.59	34.51	0.61	36.96	0.59	30.71	0.34	35.10	0.41	38.49	0.39	38.63	0.38	< 0
Age															
19 ~ 29	47.26	1.18	46.71	1.12	53.12	1.18	48.93	0.91	57.30	1.08	59.78	0.91	59.84	1.10	< 0
30 ~ 49	41.37	0.76	43.79	0.82	46.95	0.80	41.86	0.49	47.99	0.56	51.18	0.54	52.87	0.60	< 0
50 ~ 64	29.42	0.79	30.70	0.82	34.78	0.80	30.70	0.48	35.20	0.48	38.89	0.56	39.91	0.51	< 0
65 ~ 74	21.13	0.83	23.57	1.27	25.31	0.89	21.55	0.49	24.71	0.47	27.47	0.56	30.22	0.55	< 0
75+	19.39	1.27	17.39	1.04	21.53	1.41	17.05	0.59	18.26	0.49	19.62	0.49	22.28	0.53	< 0
Residential area															
Urban	40.96	0.72	41.83	0.71	44.82	0.67	39.24	0.42	44.36	0.45	46.22	0.44	47.21	0.43	< 0
Rural area	31.35	1.28	31.87	1.34	35.83	1.24	32.33	0.85	37.23	1.10	40.99	1.03	40.15	1.14	< 0
Marital status															
Unmarried	36.98	0.62	38.43	0.67	40.50	0.61	35.07	0.37	39.23	0.40	41.87	0.41	42.54	0.41	< 0
Married	45.72	1.31	44.92	1.23	52.39	1.12	48.90	0.97	56.24	1.00	57.62	0.85	58.26	0.95	< 0
Household Income															
Low	29.29	1.00	31.55	1.16	32.44	1.08	27.87	0.81	30.10	0.79	29.44	0.72	32.70	0.89	0.0
Middle-low	35.27	0.96	38.70	1.04	43.78	1.04	36.89	0.69	42.39	0.74	43.58	0.64	44.45	0.74	< 0
Middle-high	41.12	1.01	42.57	1.05	45.96	0.94	40.39	0.61	46.93	0.72	48.77	0.66	49.33	0.65	< 0
High	45.24	0.93	45.52	1.05	47.57	0.95	42.21	0.60	46.79	0.66	51.75	0.68	51.42	0.68	< 0
Occupation															
Employed	40.50	0.72	43.08	0.79	46.18	0.69	40.86	0.45	45.89	0.53	48.74	0.49	49.52	0.51	< 0
Unemployed	36.26	0.79	35.20	0.83	38.46	0.78	32.34	0.52	37.32	0.59	39.12	0.58	40.12	0.59	< 0
Educational Level															
< 12 years	27.47	0.56	27.91	0.70	30.15	0.68	24.04	0.40	26.39	0.45	27.48	0.46	27.32	0.45	0.5

[a] All p for trend were calculated by surveyreg procedure of SAS. [b] Total and all variables (excluding sex and age) were adjusted for sex, age and energy intake for age and energy intake. [d] Categorical age was adjusted for sex and energy intake.

Intake, g/day	(1998)		(2001)		(2005)		(2007 ~ 2009)		(2010 ~ 2012)		(2013 ~ 2015)		(2016 ~ 2018)		Un
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	p-t
12 year	42.16	0.86	42.16	0.80	45.21	0.81	38.51	0.55	43.08	0.64	44.29	0.59	43.82	0.58	0.0
≧ 12 years	48.59	1.00	49.03	0.93	51.67	0.98	46.78	0.59	53.16	0.62	54.82	0.60	55.11	0.57	< 0
Obesity status															
Underweight	35.78	1.98	39.48	2.02	42.09	2.74	37.53	1.36	43.70	1.40	44.76	1.50	46.07	1.57	< 0
Normal	39.36	0.79	39.20	0.73	42.81	0.93	37.27	0.53	41.87	0.55	45.25	0.55	45.18	0.54	< 0
Overweight	38.88	0.94	39.00	1.00	41.70	1.04	37.95	0.66	42.03	0.77	44.37	0.67	45.33	0.69	< 0
Obesity	36.69	0.91	38.83	1.09	42.83	0.98	37.16	0.56	43.82	0.69	45.07	0.67	47.25	0.65	< 0
Abdominal obesity status															
Normal	39.38	0.69	39.98	0.65	43.48	0.70	38.31	0.42	43.41	0.45	45.91	0.43	46.14	0.43	< 0
Abdominal obesity	34.50	0.95	36.08	1.09	39.41	1.09	34.72	0.59	40.31	0.77	42.08	0.75	45.33	0.70	< 0

[a] All p for trend were calculated by surveyreg procedure of SAS. [b] Total and all variables (excluding sex and age) were adjusted for sex, age and energy intake for age and energy intake. [d] Categorical age was adjusted for sex and energy intake.

Dietary behavior by survey year and lipid intake by dietary behavior

The results of dietary behavior by survey year are shown in Supplementary Table 1. For breakfast, the proportion of those who skipped the meal increased significantly by 14.2%p (percentage points), nearly doubling the ratio, from 11.8% in the first term to 26.0% in the seventh term ($p < 0.001$). For lunch and dinner, the proportion of those who ate both meals was over 90% in all years. The proportion of those who ate snacks increased by about 21.0%p (percentage points), rising from 72.3% in the first term to 93.3% in the seventh term ($p < 0.001$). In terms of cooking location, homemade meals declined by about 16%p (percentage points) over the 20-year period, falling from 95.9% in the first term to 79.5% in the seventh term ($p < 0.001$). On the other hand, eating out rose by about 33.9%p (percentage points), from 64.0% in the first term to 97.9% in the seventh ($p < 0.001$). And the proportion of people using food service facilities ranged from 82.6–87.3%. In terms of the number of times subjects ate out, the proportion of those who ate out more than once a week rose by about 21.1%p (percentage points), from 22.6% in the first term to 43.7% in the third term, and then decreased to around 25.5–28.6% from the fourth term onward, which is slightly higher than in the first term but much lower than in the third term ($p < 0.001$). By level of food security, the proportion of the “sufficiently food secure” group increased by 22.4%p (percentage points), from 33.8% in the third term, when the survey was conducted for the first time, to 56.2% in the seventh term ($p < 0.001$).

The lipid intakes by dietary behavior are shown in Table 3. For daily meals, breakfast decreased significantly by about 1.13 g, from 7.61 g in the first term to 6.49 g in the seventh term (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001). On the other hand, lunch, dinner, and snacks all increased from the first to seventh term (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001). Regarding cooking location, lipid intake from meals prepared at home fell significantly over the 20-year period (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001), while lipid intake from meals provided by commercial food services rose significantly (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001). The number of times eating out per week showed that lipid intake for the group that ate out more than once a day and one to six times a week increased over the 20-year period (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001), while lipid intake for the group that ate out one to three times a month showed no significant change when not adjusted, and that for the group that almost never ate out decreased significantly when not adjusted (Unadjusted p for trend < 0.001). When adjusted by sex, age, and energy intake, however, lipid intake increased significantly (Adjusted p for trend < 0.001). Finally, lipid intake by level of food security showed that the “enough food secure,” “mildly food insecure,” and “moderately food insecure” groups all increased significantly even when not adjusted (Unadjusted p for trend < 0.05) and also when adjusted by sex, age, and energy intake (Adjusted p for trend < 0.001).

Table 3
Trends of Lipid intake by Dietary behavior.

Intake, g/day	□(1998)		□(2001)		□(2005)		□(2007 ~ 2009)		□(2010 ~ 2012)		□(2013 ~ 2015)		□(20
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mea
Daily meal													
Breakfast	7.61	0.20	6.89	0.19	7.28	0.16	5.76	0.08	6.05	0.09	6.39	0.10	6.4
Lunch	11.08	0.23	11.82	0.23	13.51	0.28	11.55	0.16	12.46	0.18	13.30	0.17	13.3
Dinner	13.43	0.36	14.61	0.36	15.29	0.36	12.89	0.21	14.57	0.25	15.32	0.23	16.9
Snack	6.67	0.28	6.56	0.24	7.08	0.21	7.71	0.15	9.84	0.18	10.26	0.17	9.2
Ratio (%)[c]													
Breakfast	22.90	0.34	19.77	0.30	19.50	0.32	18.34	0.19	16.97	0.20	16.54	0.18	16.4
Lunch	30.32	0.40	31.08	0.39	31.68	0.35	30.94	0.24	29.35	0.23	29.67	0.22	29.5
Dinner	32.18	0.41	32.96	0.37	33.07	0.40	31.66	0.25	31.19	0.25	31.65	0.24	33.5
Snack	14.60	0.50	16.19	0.45	15.73	0.36	19.06	0.26	22.48	0.25	22.13	0.24	20.4
Cooking location													
Home	23.34	0.48	18.68	0.50	20.94	0.44	16.22	0.22	16.59	0.24	15.23	0.21	15.
Commercial place	13.52	0.45	18.62	0.52	18.74	0.52	19.09	0.31	23.92	0.38	27.65	0.36	28.
Institution	1.93	0.13	2.56	0.18	3.47	0.22	2.59	0.12	2.40	0.11	2.40	0.10	2.3
Ratio (%)[c]													
Home	66.34	0.75	53.85	0.82	56.07	0.72	51.76	0.45	45.96	0.44	40.91	0.42	39.
Commercial place	28.51	0.73	39.80	0.78	36.64	0.77	42.37	0.45	48.82	0.42	53.98	0.40	55.
Institution	5.16	0.31	6.34	0.39	7.28	0.39	5.83	0.22	5.20	0.20	5.11	0.18	5.0
Eating-out Frequency													
≧ 1/day	43.99	1.11	46.94	0.90	49.99	0.85	49.17	0.71	55.09	0.80	57.05	0.73	58.
1 ~ 6/week	43.81	1.07	43.83	1.03	46.31	1.20	40.88	0.53	45.19	0.54	45.79	0.47	45.
1 ~ 3/month	40.50	1.07	39.30	1.19	39.04	1.04	29.82	0.50	32.19	0.56	33.37	0.62	33.
Seldom	30.31	0.78	27.39	0.88	28.10	0.78	21.72	0.49	23.30	0.92	22.14	0.64	22.
Food insecurity													
Enough food secure	-[d]	-	-	-	41.40	1.10	40.02	0.48	45.39	0.58	46.71	0.51	48.
Mildly food insecure	-	-	-	-	38.27	0.90	37.58	0.51	41.83	0.56	45.16	0.55	43.
Moderately food insecure	-	-	-	-	30.53	1.78	29.48	1.48	31.99	1.70	35.77	1.47	33.
Severely food insecure	-	-	-	-	34.65	4.57	25.94	2.40	19.66	2.67	24.22	2.72	25.

[a] All p for trend were calculated by surveyreg procedure of SAS. [b] Adjusted for sex, age and energy intake. [c] Ratio (%)=(Lipid intake from each meal/Total lipic investigate questions related to this variable.

Lipid intake and ratio by food group classification

The results of lipid intake and ratio by food groups are shown in Table 4. Overall, all plant and animal lipid intakes increased over the 20-year period (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001). In detail, lipid intake from grains, potatoes, sugars, nuts, seaweed, beverages, other plant foods and meats, eggs, dairy products, and other animal foods increased regardless of adjustment (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001). On the other hand, lipid intake from beans, vegetables, mushrooms, vegetable oils, fish and shellfish, and animal fats all decreased regardless of adjustment (Unadjusted p for trend < 0.01, Adjusted p for trend < 0.001). In the case of fruits, the intake declined significantly when adjusted by sex, age, and energy intake (Adjusted p for trend = 0.0122). The ratio of lipid intake from each food group contributed to the total lipid intake showed that the proportion of lipid intake from all plant foods decreased (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001), while that from animal fat foods increased significantly (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001). Specifically, the proportion of lipid intake from potatoes, sugars, seeds and nuts, seaweed, beverages, meats, eggs, dairy products, and other animal foods increased (Unadjusted p for trend < 0.01, Adjusted p for trend < 0.001). Meanwhile, the proportion of lipid intake from grains, beans, vegetables, mushrooms, fruits, vegetable oils, fish and shellfish, and animal fats decreased (Unadjusted p for trend < 0.001, Adjusted p for trend < 0.001).

Table 4
Trends regarding Intake and ratio of Lipid from Food groups consumed per day.

Intake, g/day	(1998)		(2001)		(2005)		(2007 ~ 2009)		(2010 ~ 2012)		(2013 ~ 2015)		(2016 ~ 2018)		Unadjus
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	p-trend[a]
Total plant food	19.68	0.32	20.90	0.35	23.58	0.34	21.78	0.21	24.29	0.24	25.27	0.24	24.02	0.23	< 0.001(-
Cereals and grain products	8.30	0.20	6.31	0.20	7.34	0.21	6.14	0.10	7.68	0.13	8.26	0.15	7.90	0.13	< 0.001(-
Potatoes and starches	0.28	0.07	0.10	0.02	0.10	0.02	0.12	0.01	0.18	0.02	0.33	0.03	0.29	0.02	< 0.001(-
Sugars and sweets	0.05	0.02	0.05	0.01	0.08	0.02	0.10	0.01	0.20	0.02	0.36	0.03	0.32	0.02	< 0.001(-
Legumes and their products	1.60	0.05	2.13	0.06	2.63	0.07	2.56	0.05	2.36	0.05	2.29	0.04	1.89	0.04	0.0214(-
Seeds and nuts	0.62	0.05	0.63	0.05	1.46	0.07	0.96	0.04	1.31	0.05	1.76	0.06	1.70	0.05	< 0.001(-
Vegetables	1.20	0.02	1.29	0.02	1.36	0.02	1.16	0.01	1.11	0.01	0.82	0.01	0.65	0.01	< 0.001(-
Mushrooms	0.01	0.001	0.02	0.002	0.01	0.001	0.01	0.0004	0.01	0.0004	0.01	0.0003	0.01	0.0004	< 0.001(-
Fruits	0.35	0.01	0.24	0.01	0.14	0.01	0.34	0.01	0.36	0.01	0.27	0.01	0.24	0.01	0.0647(-
Seaweeds	0.10	0.01	0.09	0.01	0.12	0.01	0.34	0.01	0.25	0.01	0.24	0.01	0.31	0.01	< 0.001(-
Plant oils and fats	5.40	0.14	7.80	0.20	7.43	0.16	6.46	0.10	7.01	0.11	6.56	0.10	6.38	0.09	0.0097(-
Beverages	0.14	0.02	0.07	0.01	0.65	0.03	1.04	0.03	1.22	0.02	1.28	0.02	0.94	0.02	< 0.001(-
Other plant food	1.62	0.06	2.17	0.08	2.26	0.07	2.56	0.07	2.61	0.07	3.10	0.09	3.37	0.09	< 0.001(-
Total animal food	19.12	0.44	18.97	0.44	19.58	0.39	16.13	0.26	18.63	0.28	20.01	0.25	22.12	0.26	< 0.001(-
Meat, poultry & products	11.40	0.39	12.17	0.41	11.20	0.34	9.89	0.22	11.96	0.25	12.71	0.22	14.19	0.23	< 0.001(-
Eggs	2.22	0.07	2.32	0.08	2.68	0.08	1.64	0.03	1.76	0.04	2.56	0.05	2.65	0.05	< 0.001(-
Fish and shellfish	2.75	0.11	2.99	0.11	2.92	0.09	2.15	0.05	2.20	0.05	1.89	0.05	1.85	0.05	< 0.001(-
Milks and dairy products	1.75	0.09	1.41	0.06	2.03	0.08	2.28	0.06	2.57	0.07	2.64	0.06	3.12	0.08	< 0.001(-
Animal oils and fats	0.99	0.05	0.06	0.01	0.73	0.03	0.13	0.01	0.13	0.01	0.20	0.01	0.23	0.01	< 0.001(-
Other animal food	0.01	0.004	0.02	0.02	0.01	0.005	0.03	0.01	0.01	0.002	0.01	0.002	0.08	0.01	< 0.001(-
Ratio (%)[3)]															
Total plant food	57.79	0.46	59.30	0.45	59.84	0.42	63.22	0.27	62.38	0.26	59.91	0.24	56.77	0.25	< 0.001(-
Cereals and grain products	24.51	0.37	16.95	0.34	16.88	0.32	17.14	0.19	19.17	0.21	18.84	0.21	18.01	0.20	< 0.001(-
Potatoes and starches	0.53	0.06	0.22	0.04	0.16	0.03	0.29	0.02	0.37	0.03	0.55	0.04	0.51	0.03	< 0.001(-

[a] All p for trend were calculated by surveyreg procedure of SAS. [b] Adjusted for sex, age and energy intake. [c] Ratio (%)=(Lipid intake from each food/Total lipic

Intake, g/day	(1998)		(2001)		(2005)		(2007 ~ 2009)		(2010 ~ 2012)		(2013 ~ 2015)		(2016 ~ 2018)		Unadjus
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	p-trend[a]
Sugars and sweets	0.07	0.02	0.11	0.03	0.16	0.03	0.21	0.03	0.36	0.03	0.69	0.05	0.66	0.04	< 0.001(
Legumes and their products	5.66	0.17	6.84	0.19	7.85	0.21	8.64	0.14	7.10	0.14	6.82	0.12	5.59	0.11	< 0.001(
Seeds and nuts	1.56	0.10	1.58	0.10	3.39	0.12	2.47	0.07	2.99	0.08	3.96	0.10	4.05	0.10	< 0.001(
Vegetables	4.84	0.10	5.43	0.14	4.83	0.10	4.71	0.06	4.04	0.06	2.86	0.04	2.19	0.03	< 0.001(
Mushrooms	0.04	0.003	0.08	0.01	0.04	0.004	0.03	0.001	0.03	0.001	0.02	0.001	0.03	0.001	< 0.001(
Fruits	1.28	0.05	1.02	0.04	0.44	0.02	1.29	0.04	1.21	0.04	0.91	0.02	0.76	0.03	< 0.001(
Seaweeds	0.39	0.03	0.31	0.02	0.44	0.02	1.32	0.05	0.88	0.03	0.83	0.03	1.05	0.04	< 0.001(
Plant oils and fats	13.67	0.23	20.11	0.32	17.42	0.27	16.85	0.17	16.35	0.17	14.53	0.17	14.35	0.15	< 0.001(
Beverages	0.44	0.05	0.17	0.03	2.05	0.08	3.71	0.09	4.14	0.09	4.13	0.09	3.15	0.08	< 0.001(
Other plant food	4.80	0.13	6.48	0.19	6.19	0.14	6.56	0.11	5.74	0.10	5.77	0.11	6.42	0.12	0.0012(
Total animal food	42.21	0.46	40.70	0.45	40.16	0.42	36.78	0.27	37.62	0.26	40.09	0.24	43.23	0.25	< 0.001(
Meat, poultry & products	21.39	0.49	22.08	0.45	19.36	0.40	19.61	0.26	20.89	0.27	22.64	0.25	24.52	0.27	< 0.001(
Eggs	5.49	0.17	5.91	0.19	5.91	0.15	4.43	0.08	4.37	0.08	6.09	0.11	6.41	0.11	< 0.001(
Fish and shellfish	7.97	0.26	8.85	0.28	7.89	0.20	6.67	0.12	5.92	0.11	4.95	0.10	4.93	0.10	< 0.001(
Milks and dairy products	4.45	0.20	3.71	0.16	4.86	0.17	5.73	0.14	6.17	0.14	6.06	0.13	6.83	0.13	< 0.001(
Animal oils and fats	2.90	0.11	0.12	0.02	2.12	0.09	0.25	0.02	0.24	0.02	0.33	0.02	0.37	0.02	< 0.001(
Other animal food	0.01	0.01	0.03	0.01	0.03	0.01	0.08	0.02	0.03	0.01	0.02	0.00	0.17	0.02	< 0.001(

[a] All p for trend were calculated by surveyreg procedure of SAS. [b] Adjusted for sex, age and energy intake. [c] Ratio (%)=(Lipid intake from each food/Total lipic

Trends of proper lipid ratio contributed to energy according to the Dietary Reference Intakes for Koreans (KDRIs).

The results for the trends of lipid intake ratio contributed to energy, according to the 2015 KDRIs, are shown in Table 5. In the group with less than proper lipid ratio contributed to energy by KDRI (< 15%), the ratio decreased by about 16.5%p (percentage points) for all individuals over the 20-year period, falling from 48.5% in the first term to 32.0% in the seventh. The ratio fell by about 14.7%p (percentage points) in men and about 18.2%p (percentage points) in women. In terms of the prevalence of obesity in the group with less than proper lipid ratio contributed to energy, the prevalence rose by about 8.4%p (percentage points) in all individuals, from 28.3% in the first term to 36.7% in the seventh. In men, it increased by about 13.1%p (percentage points), rising from 25.2% in the first term to 38.3% in the seventh term. In women, it rose by about 4.5%p (percentage points) over the 20-year period, from 30.8% at the first term to 35.3% in the seventh. The prevalence of abdominal obesity increased by about 8.2%p (percentage points) in all individuals, from 24.2% in the first term to 32.4% in the seventh term. In men, the prevalence rose by 11.2%p (percentage points), increasing from 20.2% in the first term to 31.4% in the seventh. In women, meanwhile, it increased by 3.9%p (percentage points), rising from 27.4% in the first term to 33.3% in the seventh term.

Table 5
Trends regarding Proper lipid ratio contributed to energy according to Korean Dietary Reference Intakes (KDRIs).

	(1998)		(2001)		(2005)		(2007 ~ 2009)		(2010 ~ 2012)		(2013 ~ 2015)		(2016 ~ 2018)		p-value
	n or mean	%[a] or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	
Less than proper lipid ratio contributed to energy (< 15%)															
Total (n, %)	3926	48.5	3251	44.5	2659	38.3	8353	44.9	7953	40.2	6678	36.8	6068	32.0	< 0.001[b]
Carbohydrate (%, SE)	75.53	0.32	76.48	0.17	75.57	0.16	77.02	0.10	77.29	0.10	77.68	0.10	76.57	0.12	< 0.001(+)[c]
Protein (%, SE)	14.62	0.31	13.84	0.13	14.17	0.10	13.10	0.06	12.87	0.06	12.40	0.07	13.10	0.09	< 0.001(-)[c]
Lipid (%, SE)	9.84	0.09	9.68	0.09	10.26	0.09	9.88	0.05	9.84	0.06	9.92	0.05	10.33	0.06	< 0.001(+)[c]
Obesity ratio[d] (n, %)	1016	28.3	884	31.3	684	32.4	2601	33.2	2422	32.5	2208	34.8	2124	36.7	< 0.001[b]
Abdominal obesity ratio[e] (n, %)	903	24.2	772	27.4	600	27.7	2478	29.0	2267	28.5	1978	29.3	1975	32.4	< 0.001[b]
Male (n, %)	1716	45.5	1365	41.2	1109	35.1	3228	41.5	3106	37.0	2750	35.5	2574	30.8	< 0.001[b]
Carbohydrate (%, SE)	75.19	0.31	75.63	0.24	75.26	0.20	76.45	0.13	76.75	0.15	77.17	0.14	76.11	0.17	< 0.001(+)[c]
Protein (%, SE)	14.68	0.28	14.38	0.18	14.35	0.14	13.35	0.09	13.11	0.10	12.65	0.10	13.38	0.13	< 0.001(+)[c]
Lipid (%, SE)	10.13	0.11	9.99	0.13	10.39	0.12	10.20	0.07	10.14	0.08	10.18	0.07	10.51	0.08	< 0.001(+)[c]
Obesity ratio[d] (n, %)	348	25.2	341	30.3	284	34.9	945	34.6	868	32.1	895	36.7	908	38.3	< 0.001[b]
Abdominal obesity ratio[e] (n, %)	298	20.2	271	23.2	222	26.6	855	27.7	762	26.2	751	28.8	797	31.4	< 0.001[b]
Female (n, %)	2210	51.4	1886	47.7	1550	41.5	5125	48.3	4847	43.3	3928	37.9	3494	33.2	< 0.001[b]
Carbohydrate (%, SE)	75.82	0.44	77.20	0.17	75.82	0.19	77.50	0.11	77.74	0.11	78.13	0.12	76.99	0.13	< 0.001(+)[c]
Protein (%, SE)	14.58	0.42	13.38	0.11	14.03	0.13	12.88	0.07	12.67	0.07	12.17	0.08	12.85	0.09	< 0.001(-)[c]
Lipid (%, SE)	9.60	0.10	9.42	0.10	10.15	0.11	9.62	0.06	9.59	0.07	9.69	0.07	10.16	0.07	< 0.001(+)[c]
Obesity ratio[d] (n, %)	668	30.8	543	32.0	400	30.6	1656	32.1	1554	32.8	1313	33.2	1216	35.3	0.036[b]
Abdominal obesity ratio[e] (n, %)	605	27.4	501	30.6	378	28.5	1623	30.1	1505	30.3	1227	29.8	1178	33.3	0.006[b]
Proper lipid ratio contributed to energy (15 ~ 30%)															
Total (n, %)	2980	43.9	3156	46.6	3227	52.1	6642	47.6	7780	49.8	7567	51.7	8315	53.0	< 0.001[b]
Carbohydrate (%, SE)	63.33	0.17	63.63	0.14	63.00	0.15	63.89	0.09	63.70	0.09	64.07	0.09	63.28	0.08	0.3497(-)[c]
Protein (%, SE)	15.94	0.15	15.42	0.10	15.84	0.11	15.18	0.07	15.11	0.07	14.37	0.06	15.07	0.06	< 0.001(+)[c]
Lipid (%, SE)	20.73	0.09	20.96	0.09	21.16	0.09	20.93	0.06	21.19	0.06	21.55	0.06	21.65	0.05	< 0.001(+)[c]

[a] Weighted %, [b] p-value by chi-square, [c] p for trend was calculated by surveyreg procedure of SAS. [d] Obesity: BMI ≧ 25 kg/m^2, [e] Abdominal obesity: Meal (Waist circumference ≥ 90 cm), Female (Waist circumference ≥ 85 cm).

	□(1998)		□(2001)		□(2005)		□(2007 ~ 2009)		□(2010 ~ 2012)		□(2013 ~ 2015)		□(2016 ~ 2018)		p-value
	n or mean	%[a] or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	
Obesity ratio[d] (n, %)	647	23.5	704	27.8	707	30.4	1851	30.3	2244	31.8	2266	32.1	2610	33.9	< 0.001[b]
Abdominal obesity ratio[e] (n, %)	509	17.3	530	20.4	506	21.4	1509	22.2	1695	21.9	1696	22.7	2177	26.9	< 0.001[b]
Male (n, %)	1481	46.4	1564	49.6	1510	54.7	2884	50.8	3337	52.8	3232	53.5	3624	54.9	< 0.001[b]
Carbohydrate (%, SE)	63.20	0.23	63.51	0.15	63.10	0.18	63.80	0.14	63.81	0.13	64.07	0.12	63.29	0.12	0.2490(+)[c]
Protein (%, SE)	16.20	0.19	15.61	0.11	15.71	0.13	15.22	0.10	15.05	0.09	14.38	0.08	15.15	0.09	< 0.001(-)[c]
Lipid (%, SE)	20.61	0.11	20.88	0.11	21.19	0.11	20.98	0.08	21.15	0.09	21.55	0.08	21.57	0.07	0.0049(+)[c]
Obesity ratio[d] (n, %)	329	24.8	370	29.9	342	33.6	976	37.4	1133	38.2	1160	39.4	1401	42.4	< 0.001[b]
Abdominal obesity ratio[e] (n, %)	249	17.9	263	20.2	249	23.7	684	23.9	797	23.9	832	26.6	1130	32.8	< 0.001[b]
Female (n, %)	1499	41.4	1592	43.7	1717	49.5	3758	44.5	4443	46.9	4335	49.9	4691	51.1	< 0.001[b]
Carbohydrate (%, SE)	63.47	0.21	63.75	0.20	62.89	0.21	63.98	0.11	63.58	0.12	64.08	0.11	63.27	0.11	0.8057(+)[c]
Protein (%, SE)	15.66	0.17	15.21	0.13	15.98	0.17	15.13	0.08	15.18	0.08	14.37	0.07	14.99	0.07	< 0.001(-)[c]
Lipid (%, SE)	20.87	0.12	21.04	0.13	21.13	0.11	20.88	0.08	21.25	0.07	21.56	0.07	21.73	0.07	< 0.001(+)[c]
Obesity ratio[d] (n, %)	318	22.1	334	25.6	365	27.4	875	22.7	1111	25.2	1106	24.8	1209	25.3	< 0.001[b]
Abdominal obesity ratio[e] (n, %)	260	16.8	267	20.6	257	19.4	825	20.4	898	19.8	864	18.7	1047	20.9	0.094[b]
More than Proper lipid ratio contributed to energy (> 30%)															
Total (n, %)	498	7.6	580	8.9	547	9.6	944	7.5	1397	10.0	1527	11.6	2174	15.0	< 0.001[b]
Carbohydrate (%, SE)	45.72	0.55	46.64	0.43	47.33	0.41	48.11	0.29	47.92	0.25	49.37	0.18	47.86	0.19	< 0.001(+)[c]
Protein (%, SE)	17.01	0.29	16.55	0.22	16.31	0.22	16.17	0.16	16.45	0.14	15.13	0.11	15.80	0.11	< 0.001(-)[c]
Lipid (%, SE)	37.27	0.43	36.81	0.35	36.36	0.30	35.72	0.23	35.64	0.19	35.50	0.14	36.34	0.14	0.0545(-)[c]
Obesity ratio[d] (n, %)	91	20.4	128	28.5	127	32.9	226	27.7	374	30.7	408	29.5	683	34.5	0.002[b]
Abdominal obesity ratio[e] (n, %)	69	15.5	96	19.0	90	22.2	170	19.0	257	20.7	291	20.3	544	26.1	< 0.001[b]
Male (n, %)	237	8.1	275	9.2	248	10.1	376	7.7	544	10.2	572	11.0	832	14.3	< 0.001[b]
Carbohydrate (%, SE)	45.49	0.78	46.06	0.63	47.94	0.51	48.44	0.40	48.16	0.37	49.72	0.28	47.64	0.30	0.0014(+)[c]
Protein (%, SE)	17.30	0.33	16.77	0.28	16.22	0.30	16.32	0.23	16.59	0.23	15.08	0.18	15.89	0.17	< 0.001(-)[c]
Lipid (%, SE)	37.21	0.65	37.17	0.50	35.83	0.40	35.24	0.32	35.24	0.26	35.21	0.24	36.47	0.23	0.4108(-)[c]
Obesity ratio[d] (n, %)	50	25.7	78	39.4	73	43.5	115	36.6	192	39.1	209	40.4	359	46.8	0.007[b]

[a] Weighted %, [b] p-value by chi-square, [c] p for trend was calculated by surveyreg procedure of SAS. [d] Obesity: BMI ≧ 25 kg/m^2, [e] Abdominal obesity: Meal (Waist circumference ≥ 90 cm), Female (Waist circumference ≥ 85 cm).

	□(1998)		□(2001)		□(2005)		□(2007 ~ 2009)		□(2010 ~ 2012)		□(2013 ~ 2015)		□(2016 ~ 2018)		p-value
	n or mean	%[a] or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	*n* or mean	% or SE	
Abdominal obesity ratio[e] (n, %)	36	18.5	59	26.6	49	27.6	78	24.1	129	26.3	140	26.2	283	35.0	0.001[b]
Female (n, %)	261	7.2	305	8.6	299	9.1	568	7.3	853	9.8	955	12.1	1342	15.7	< 0.001[b]
Carbohydrate (%, SE)	45.98	0.70	47.24	0.52	46.67	0.51	47.76	0.42	47.67	0.32	49.07	0.24	48.07	0.23	< 0.001(+)[c]
Protein (%, SE)	16.69	0.39	16.32	0.34	16.41	0.28	16.02	0.22	16.30	0.18	15.17	0.15	15.72	0.15	< 0.001(-)[c]
Lipid (%, SE)	37.33	0.52	36.44	0.40	36.92	0.35	36.22	0.32	36.03	0.26	35.76	0.17	36.22	0.17	0.0210(-)[c]
Obesity ratio[d] (n, %)	41	15.4	50	18.6	54	23.3	111	19.3	182	22.5	199	20.4	324	23.9	0.124[b]
Abdominal obesity ratio[e] (n, %)	33	12.8	37	12.1	41	17.3	92	14.3	128	15.3	151	15.4	261	18.6	0.106[b]

[a] Weighted %, [b] p-value by chi-square, [c] p for trend was calculated by surveyreg procedure of SAS. [d] Obesity: BMI ≧ 25 kg/m^2, [e] Abdominal obesity: Meal (Waist circumference ≥ 90 cm), Female (Waist circumference ≥ 85 cm).

The proper lipid ratio contributed to energy by KDRIs ranges from 15–30%. In all individuals, the ratio increased by 10.0%p (percentage points) over the 20-year period, rising from 43.9% in the first term to 53.0% in the seventh. The ratio increased by about 8.5%p (percentage points) in men and 10%p (percentage points) in women over the 20-year period. In terms of the prevalence of obesity in the group with proper lipid ratio contributed to energy, it increased by 10.4%p (percentage points) in all individuals, from 23.5% in the first term to 33.9% in the seventh. In men, it increased by 17.6%p (percentage points), from 24.8% in the first term to 42.4% in the seventh. In women, the prevalence rose by 3.2%p (percentage points), from 22.1% in the first term to 25.3% in the seventh. For the prevalence of abdominal obesity, the prevalence rose by 9.6%p (percentage points) in all individuals, from 17.3% in the first term to 26.9% in the seventh. In men, it rose by 14.9%p (percentage points), from 17.9% in the first term to 32.8% in the seventh. In women, it increased by about 4.1%p (percentage points), rising from 16.8% in the first term to 20.9% in the seventh. In the group with more than 30.0% of proper lipid ratio contributed to energy, the prevalence doubled from 7.6% in the first term to 15.0% in the seventh, with a 6.2%p (percentage points) increase in men and slightly more than doubling in women (from 7.2% in the first term to 15.7% in the seventh). The prevalence of obesity in this group increased by 14.1%p (percentage points) in all individuals over the 20-year period, with a 21.1%p (percentage points) increase in men and 8.5%p (percentage points) increase in women. The prevalence of abdominal obesity in all individuals increased by about 10.6%p (percentage points), rising from 15.5% in the first term to 26.1% in the seventh. In men, it increased by 17.5%p (percentage points), from 18.5% in the first term to 35.0% in the seventh. In women, meanwhile, it increased by 5.8%p (percentage points), from 12.8%p (percentage points) in the first term to 18.6% in the seventh term.

Discussion

This study analyzed the lipid intake trends of Korean adults using the lipid intake data included in the KNHANES data spanning the 20-year period from 1998 to 2018. With this, factors related to the lipid intake of Korean adults over the 20-year period were investigated.

The study results showed that the lipid intake ratio contributed to energy ranged from 16–21% on average for all individuals, men, and women. This level was included in the proper range of the lipid ratio contributed to energy of 15–30% recommended by the 2015 KDRIs [27]. Lipid intake increased significantly from the first to the seventh term for all individuals (+ 7.34 g), men (+ 9.71 g), and women (+ 4.93 g). The lipid intake ratio contributed to energy also rose significantly over the same period for all individuals (+ 3.52%p), men (+ 3.12%p), and women (+ 3.90%p). Song et al. [12] analyzed the lipid intake trends of Korean adults over an eight-year period (2007–2015) and reported that energy, total lipid, saturated fatty acids, unsaturated fatty acids, n-3 fatty acids, and n-6 fatty acids all increased steadily over the period. However, in a recent study that used the 2016–2017 KNHANES data [22], the intake ratio of polyunsaturated fatty acids remained unchanged, but that of saturated fatty acids increased. Overall, the lipid intake of Korean adults seems to be increasing. It is known that fats not only supply energy to the human body but are also used as a component of cell membranes and aid the absorption of fat-soluble vitamins [5]. These fats can also be transformed into other fatty acids according to the body’s needs and serve a function in immune responses and as various chemical messengers [6]. On the other hand, lipids can provide more than twice the energy of carbohydrates or proteins, and thus excessive lipid intake can increase the risk of obesity. Particularly, excessive intake of saturated fatty acids or trans fatty acids can increase the risk of cerebrovascular and cardiovascular disorders, dyslipidemia, diabetes, and hypertension [9]. Therefore, it is considered that data are needed for dietary guidelines and nutrition education in the future to prevent increases in lipid intake.

Lipid intake by type of meal showed that intake via breakfast decreased continuously but increased through lunch, dinner, and snacks over the 20-year period. This is thought to be related to the significant increase in the proportion of people skipping breakfast, which increased from 11.8% in 1998 to 26.0% in 2016–2018, more than doubling over the 20-year study period. People who skip breakfast tend to eat more food at lunch or dinner, particularly high-fat meats.

Studies have shown that skipping breakfast is highly correlated to obesity prevalence, high serum cholesterol, and high blood pressure. In this study, the group that consumed less energy at breakfast showed a higher fat-to-energy ratio and protein-to-energy ratio and lower carbohydrate-to-energy ratio [28–31].

The lipid intake by cooking location showed that intake increased significantly through meals prepared by commercial food services. Previous studies [32–34] also reported similar results of increased lipid intake from the meals provided by commercial food services. In a study conducted on the eating-out trends of Korean adults for the 14 years from 1998 to 2012, the lipid intake ratio of eating out increased from 19.2% in 1998 to 21.7% in 2012 [32]. Also, a study on nutrient intake changes caused by eating out from 2010 to 2015 showed that carbohydrate and protein intakes decreased, while lipid intake increased continuously. The intake of refined processed foods and high-fat foods increases the more one eats out and consumes convenience foods. Moreover, food delivery has expanded due to the increased number of women in the workplace, reduced family size, and increased number of one-person households, in line with the social and economic changes in Korea [35].

Lipid intake by level of food security showed that the “enough food secure,” “mildly food insecure,” and “moderately food insecure” groups all increased significantly except “severely food insecure”. This trend may be related that most of meals and processed foods contain lipid.

According to the results of this study, total plant and animal lipid intake has increased over the 20-year period from 1998 to 2018. Specifically, the ratio of lipid intake from potatoes, sugars, seeds and nuts, seaweed, beverages, meats, eggs, dairy products, and other animal foods has increased, while that from grains, beans, vegetables, mushrooms, fruits, vegetable oils, fish and shellfish, and animal fats has decreased. Supporting this result, the survey of lipid intake from major foods conducted using the 2013 KNHANES data showed that total fats and fatty acids from pork were the major food source for lipid intake [11]. Also, according to result of previous study [36], the foods that contributed most to the lipid intake of Koreans were pork, soybean oil, beef, eggs, and ramen, showing a high representation of animal foods. Because fats are present in various types and forms in foods, it is believed that the type of fatty acid, rather than the total lipid intake, has a greater effect on the blood lipid profile. In particular, monounsaturated fatty acids and n-3 fatty acids are largely contained in plant foods such as beans, seeds, and nuts, while polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are present in high concentration in fish. Thus, proper education on and intake of various types of fatty acids is recommended [11, 19].

Although it was not investigated in this study, the lipid intake might be different not only by type of meal but also diet. Recently, diets have emerged as an important factor, as diets such as the Mediterranean diet and USDA diet, which emphasize vegetables, fruits, whole grains, low-fat dairy products, fish, and fowl, are reported to reduce the risk of dyslipidemia and cardiovascular/cerebrovascular diseases [27, 37]. Also, it has been reported that diets affect obesity and thus are considered to be significantly related to genes associated with chronic disorders [27, 38, 39]. In the future, epidemiology and clinical intervention research should be performed on the basis of the results of this study on Koreans.

The proportion of individuals who had a proper fat ratio contributed to energy by the KDRIs (fat ratio range: 15–30%) increased by about 10.0%p (percentage points) over the 20-year period, rising from 43.9% in the first term (1998) to 53.0% in the seventh (2016 ~ 2018). This suggests that lipid intake has increased in the diets of Koreans compared to protein and carbohydrate intakes. However, several studies recently reported that groups with high carbohydrate intake, rather than lipid intake, were at higher risk of chronic diseases, including obesity [40, 41]. In this study, the group with high carbohydrate intake ratio contributed to energy was the group with less than proper fat ratio contributed to energy (< 15%), and the carbohydrate intake ratio was 75–78%. This exceeds the carbohydrate intake ratio by about 10–13% according to the 2015 KDRI (55–65%). The prevalence of obesity and abdominal obesity in this group, such as the obesity prevalence (38.3%) in men in the seventh term (2016 ~ 2018), was about 4.1–8.5% lower than that of the groups with proper (lipid intake ratio: 15–30%, obesity prevalence: 42.4%) or more than proper fat ratio contributed to energy (lipid intake ratio: over 30%, obesity prevalence: 46.8%) according to the 2015 KDRIs. This is slightly different from the results of previous studies on high carbohydrate intake. However, in the case of carbohydrates, a high-carbohydrate diet featuring foods with high dietary fiber content reportedly reduces blood lipid levels, including triglycerides, more than a carbohydrate diet with foods with low fiber content [42]. Although the details should be checked further, it is believed that the obesity prevalence in men in this study might be explained by the results reported by such previous studies. Therefore, the type of carbohydrates ingested and their effects should be considered in future studies. Also, the difference in the obesity prevalence between this study and other previous studies should be confirmed in detail in the future, although there might be a difference due to the types of fatty acids. To support this, in-depth studies on the relationship between the intake of fats and fatty acids and chronic diseases, including obesity, will be needed, along with meta-analyses and systemic reviews that investigate disease prevalence more systematically and scientifically using long-term follow-up cohort study data such as the Korean Genome and Epidemiology Study (KoGES), which has been conducted since 2001 and recently completed its seventh follow-up study, and accumulated data.

As the association between the KNHANES data of the Ministry of Health and Welfare and the cause of death statistics of Statistics Korea [43] becomes possible in Korea, studies similar to the previous study on Americans, in which the mortality rates of high-fat diet groups and high-carbohydrate diet groups were compared [44], will be able to be conducted on Koreans.

This study has some limitations. First, we could not assess the actual intake of total lipid from the participants' diet because of collecting the one-day 24-h recall data. However, the results of this study may be generalized to Korean adults due to KNHANES data is based on a large nationally representative sample.

Second, analysis of trends using data on various fatty acids data was not performed, as reported in the previous study by Song & Shim [10], and total lipid intake was analyzed according to general characteristics, dietary behavior, food groups, and KDRIs criteria. This is because fatty acid data have been collected since the 2016 KNHANES and the food code was the same as in the 2007–2015 KNHANES data, and fatty acid data seemed to be applied to the relevant years' KNHANES data and used in the study. To enable detailed studies on various lipid intake trends to be conducted in Korea in the future, the food and meal codes should be standardized for the KNHANES data prior to 2007, and fatty acid data should be listed for all terms of the KNHANES data. In the future, lipid intake analysis should be performed for foods listed in the food frequency questionnaire conducted from 2012 to 2016, and thus studies on the annual lipid intake of Koreans, which cannot be deduced by the 24-hour recall survey, and comparative studies should be performed.

Conclusions

This study was undertaken to analyze 20-year trend regarding the lipid intake of Korean adults according to general characteristics, dietary behavior, food groups, and the KDRIs, using KNHANES data. The lipid intake increased significantly in all individuals (+ 7.34 g), men (+ 9.71 g), and women (+ 4.93 g) (p for trend < 0.001) from the first to the seventh term. The lipid ratio contributed to energy increased significantly in all individuals (+ 3.52% percentage points), men (+ 3.12% percentage points), and women (+ 3.90% percentage points) over the 20-year period (p for trend < 0.001). Lipid intake increased significantly overall as well as by sex, age, residential area, education level (except below 12 years of education), and presence of obesity and abdominal obesity increased over the 20-year period. Total plant and animal lipid intake has increased over the 20-year period from 1998 to 2018. Specifically, the ratio of lipid intake from potatoes, sugars, seeds and nuts, seaweed, beverages, meats, eggs, dairy products, and other animal foods has increased, while that from grains, beans, vegetables, mushrooms, fruits, vegetable oils, fish and shellfish, and animal fats has decreased. The results of this study will aid in the preparation of basic data for nutrition policy and proper nutrition and dietary education with the aim of improving the diets of Koreans nationwide.

Abbreviations

BMI: Body mass index; CI: Confidence interval; KDRIs: Dietary Reference Intakes for Koreans; KNHANES: Korea National Health and Nutrition Examination Survey; OR: Odds ratio; SE: Standard error; KoGES: Korean Genome and Epidemiology Study; USDA: United States Department of Agriculture; EPA: Eicosapentaenoic acid; DHA: Docosahexaenoic acid; KCDC: Korea Centers for Disease Control and Prevention; IRB: Institutional Review Board

Declarations

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Not applicable.

Author Contributions

All authors had a significant role in this study. YS Kwon contributed to the writing and the data analysis of the manuscript. S Ju and Y Hwang contributed to study design of this study; S Ju and H Chu has primary responsibility for the final content. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analyzed during this present study are available in https://knhanes.cdc.go.kr/knhanes/eng/index.do.

Ethics approval and consent to participate

The KNHANES data used in this study were approved by the KCDC IRB (approval numbers: 2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C, 2013-07CON-03-4C, 2013-12EXP-03-5C, and 2018-01-03-P-A). Among these, the 2015-2017 KNHANES survey was conducted without the deliberation of the IRB, because studies were to be conducted directly by the government for public welfare, according to Article 2, Subparagraph 1, of the Bioethics and Safety Act and Article 2, Paragraph 2, Subparagraph 1, of the Enforcement Regulations of the same Act. However, the IRB deliberation has been reopened for the collection of human materials and provision of raw data to third parties since 2018. Informed consent was obtained from all subjects.

Consent for publication

Not applicable.

Competing of Interests

All authors declare no potential conflict of interest.

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Figures

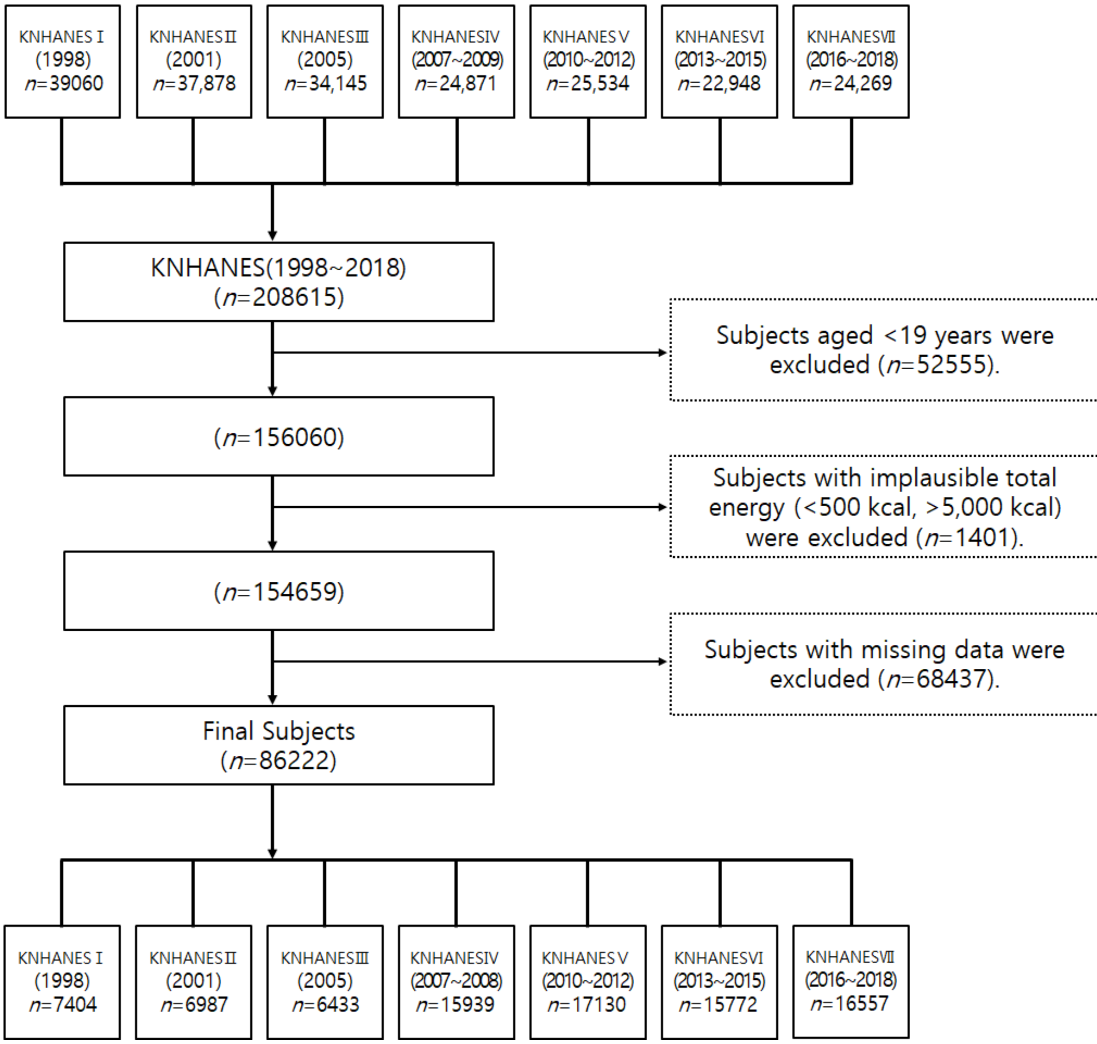
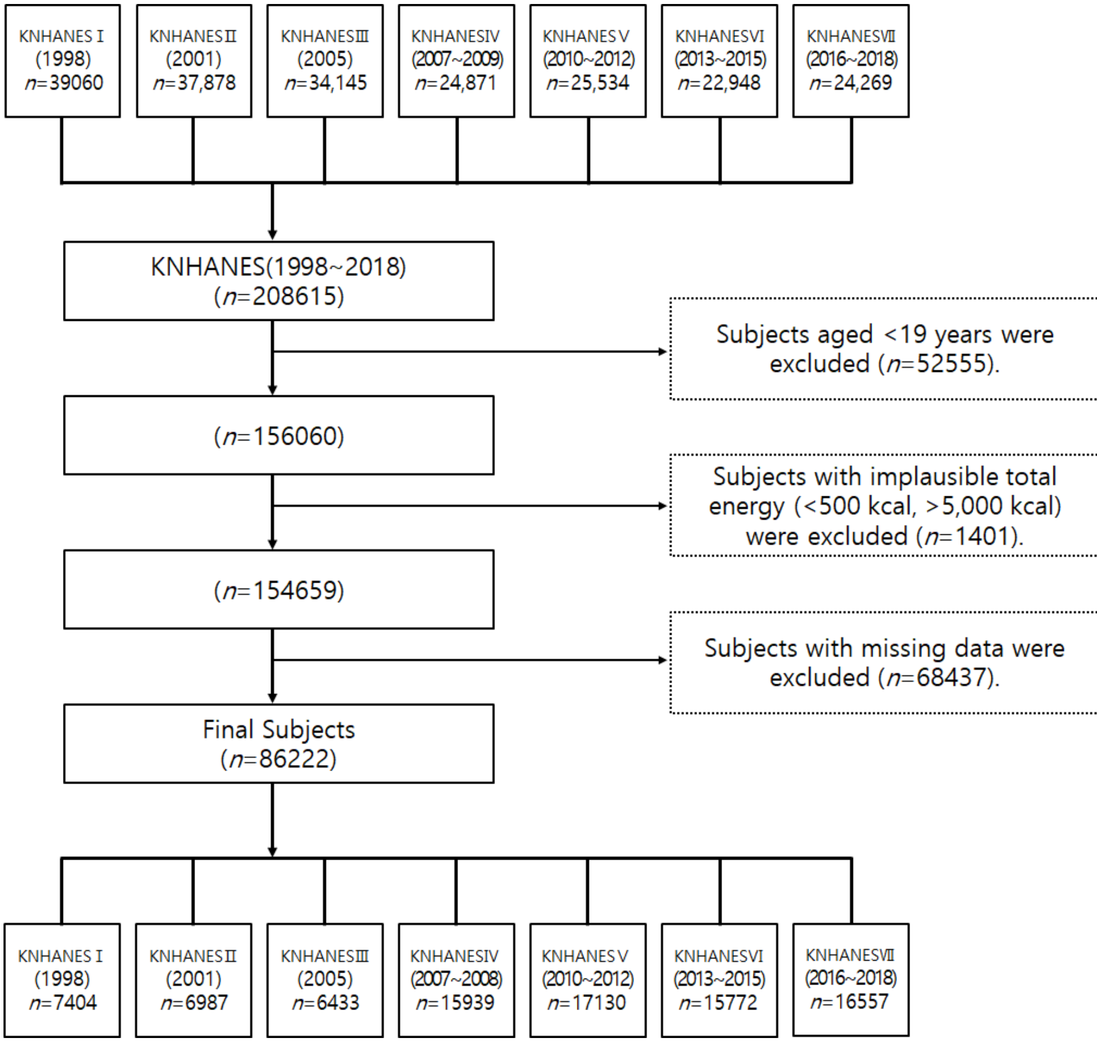


Figure 1

Flow chart for subject sample of this study



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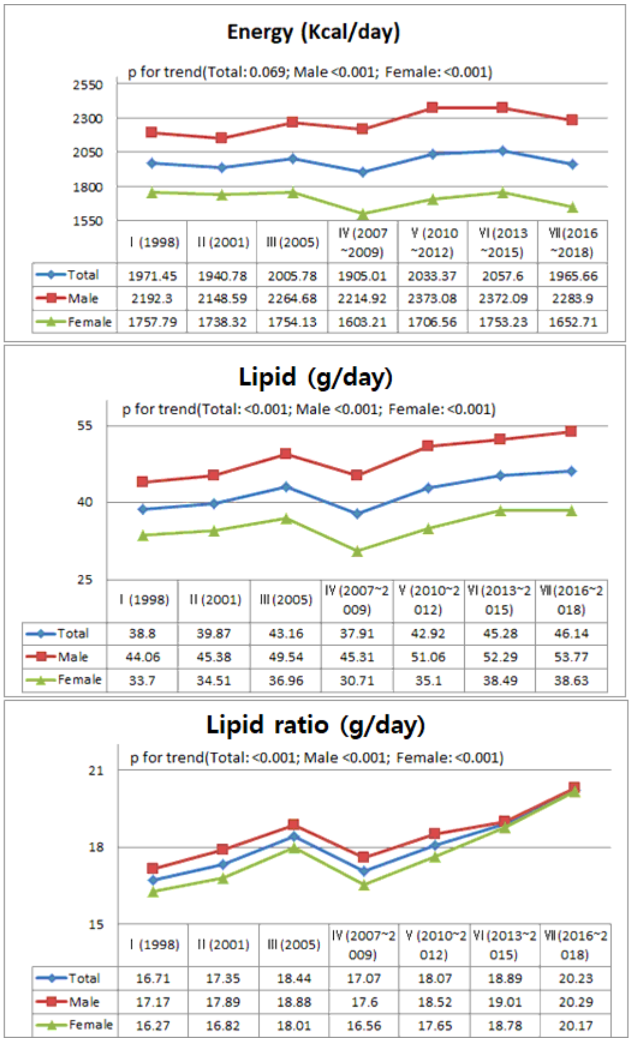
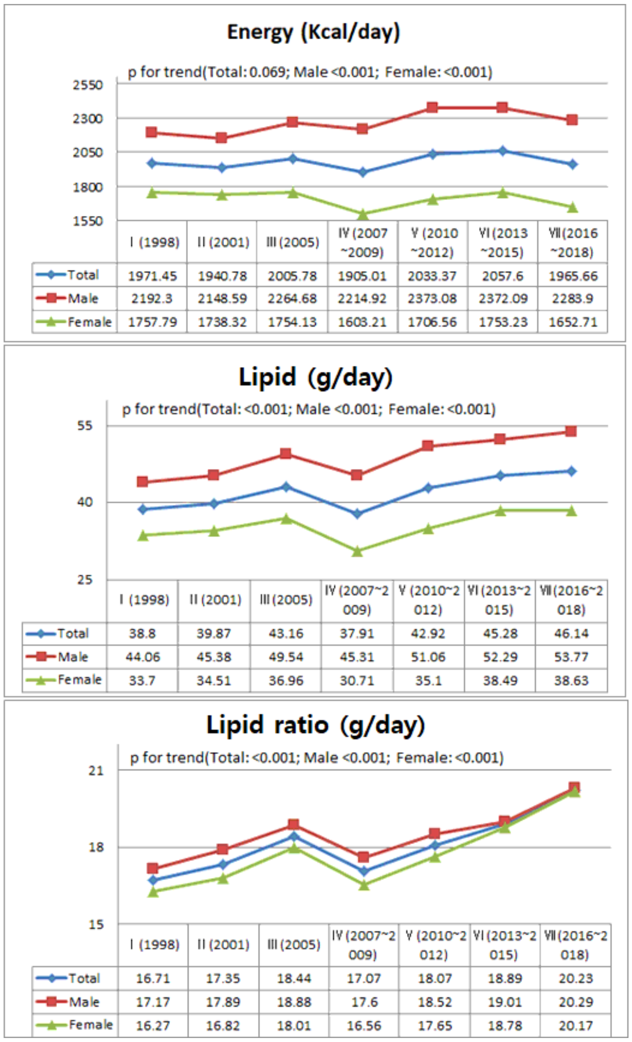


Figure 2

Trend of Lipid intake according to year of Korean adultsa a All p for trend were calculated by surveyreg procedure of SAS.



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