CHANGES OF SERUM TOTAL CHOLESTEROL AND TRIGLYCERIDE LEVELS IN NORMAL SUBJECTS IN JAPAN IN THE PAST TWENTY YEARS

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Serum lipid levels of 10,977 normal Japanese subjects in 1980 were determined by a joint study of 14 institutions, specializing in lipid research, located in 9 districts of Japan. The data obtained were compared with those in 1960 and 1970. Total cholesterol (TC) levels in 1980 increased with age except for the 1st decade and reached maximum (205 mg/dl) at the 7th decade. The mean value in any age was higher than that of 20 years ago by 10–15 mg/dl. Triglyceride (TG) levels also increased with age and reached maximum (130 mg/dl) at the 7th decade. The mean values of subjects over the 5th decade were higher than those of 10 years ago by 10–20 mg/dl. In contrast with TC and TG, HDL-cholesterol levels were highest at the 1st decade and declined gradually with age. TC and TG levels of younger age (1st to 3rd decade) were equal to or even higher than those of Americans in 1972–76. It was concluded that serum lipid levels of Japanese have increased in the past 20 years and approached to the levels of Europeans and Americans.

Key Words:

Epidemiology
Serum cholesterol
Serum triglyceride
HDL-cholesterol
Atherosclerotic disease

THE survey of serum lipid levels in normal subjects in Japan was first conducted in 1960 (Chairman: Shigeo Okinaka)¹. Only serum total cholesterol (TC) levels were determined in 6,977 subjects (4,855 males, 2,122 females) in 7 large cities of the Kanto, Hokuriku, Kinki and Kyushu areas. The TC levels were much lower

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Fig. 1. Location of the cities in the present study.

than in subjects of American and European countries²⁻⁴. Nevertheless, there was a positive relationship between the TC level and the incidence of ischemic heart disease. The second survey was carried out in 1970 (Chairman: Kenzo Oshima) with 3,555 subjects (2,441 males, 1,114 females) for TC and triglyceride (TG) levels.⁵ An increase of TC levels during the 10 years was pointed out. There was a regional difference in TC and TG levels between urban areas and fishing villages, which was considered to be caused by the difference in their dietary habits.

The present study was undertaken in order to assess the current status of serum lipid levels in Japan, from Tohoku to South West Islands area, and to clarify the changes in the past 20 years. The regional differences of serum lipid levels were also examined.

TABLE I NUMBER OF SUBJECTS

Area	Age									Total
	— 9	10—19	20—29	30—39	40—49	50—59	60—69	70—79	80—	
Male										
Tohoku	0	2	31	50	50	51	43	5	1	233
Kanto	0	36	73	191	317	195	94	59	26	991
Chubu	0	0	4	216	547	278	1	0	0	1046
Hokuriku	0	339	50	50	82	89	108	103	51	872
Kinki	167	179	45	124	190	117	62	36	7	927
Chugoku	0	42	210	100	95	118	126	1	0	692
Shikoku	0	0	0	6	40	42	43	19	0	150
Kyushu	0	0	17	59	87	82	38	0	0	283
South West Islands	188	167	83	101	125	109	79	63	29	944
Total	355	765	513	897	1533	1081	594	286	114	6138
Female										
Tohoku	0	1	20	51	64	53	45	4	0	238
Kanto	0	108	290	105	133	136	90	46	24	932
Chubu	0	0	0	0	0	0	0	0	0	0
Hokuriku	0	308	28	78	65	84	124	178	132	997
Kinki	165	171	36	110	113	96	78	38	9	816
Chugoku	0	29	51	31	41	28	16	0	0	196
Shikoku	0	0	0	26	49	52	46	26	4	203
Kyushu	0	0	22	90	138	130	49	0	0	429
South West Islands	151	146	70	100	102	156	149	106	48	1028
Total	316	763	517	591	705	735	597	398	217	4839
Grand total	671	1528	1030	1488	2238	1816	1191	684	331	10977

TABLE II SERUM LEVELS OF TC, TG AND HDL-C OF JAPANESE IN 1980

Lipid	Sex	Age								
		— 9	10—19	20—29	30—39	40—49	50—59	60—69	70—79	80—
TC	Male	174.5	159.4	176.5	191.9	196.8	199.2	193.3	192.1	183.9
		± 30.6	± 35.2	± 39.3	± 37.7	± 37.7	± 38.5	± 40.0	± 41.2	± 40.2
	Female	179.2	170.8	172.9	177.8	191.2	211.3	213.6	210.6	195.1
		± 31.3	± 32.3	± 37.3	± 34.3	± 38.8	± 40.7	± 39.4	± 43.5	± 41.3
	Total	176.7	165.1	174.3	186.1	195.0	204.3	204.5	202.9	191.2
		± 31.0	± 34.3	± 38.1	± 37.0	± 38.1	± 39.9	± 40.9	± 43.5	± 41.2
TG	Male	67.5	80.8	106.1	124.6	127.5	125.8	128.2	119.7	109.0
		± 33.1	± 46.0	± 78.0	± 93.1	± 98.3	± 83.8	± 216.8	± 58.7	± 43.9
	Female	70.7	89.0	83.4	83.0	95.5	111.8	132.4	125.3	113.4
		± 33.2	± 45.4	± 39.6	± 42.8	± 64.4	± 63.4	± 83.6	± 76.8	± 61.2
	Total	69.0	84.8	94.7	108.1	117.4	120.1	130.3	123.0	111.9
		± 33.2	± 45.9	± 62.8	± 79.8	± 90.2	± 76.5	± 164.4	± 69.9	± 55.8
HDL-C	Male	61.3	58.9	54.7	52.6	52.4	53.2	52.3	47.7	42.9
		± 14.0	± 11.9	± 14.4	± 14.6	± 15.3	± 16.0	± 16.2	± 12.6	± 8.8
	Female	58.8	59.5	58.0	59.4	59.0	59.1	51.8	47.6	44.4
		± 11.3	± 11.7	± 13.0	± 15.6	± 15.6	± 16.5	± 14.0	± 10.5	± 10.4
	Total	60.1	59.2	56.7	56.1	55.4	56.3	52.0	47.6	43.9
		± 12.8	± 11.8	± 13.7	± 15.5	± 15.8	± 16.5	± 15.0	± 11.4	± 9.9

Values are expressed as mean ± SD (mg/dl).

TC = total cholesterol, TG = triglyceride, HDL-C = HDL-cholesterol

MATERIALS AND METHODS

The Members of the Committee

The committee was organized mainly by the members from same area as the 2 previous surveys^{1, 5}, being specialists in lipid research. In addition, the members from Chugoku, Shikoku and South West Islands areas were also included. The institutions, cities (Fig. 1) and representatives were as follows:

Tohoku area

Third Department of Internal Medicine, Tohoku University (Sendai), Prof. Yoshio Goto, M.D.

Kanto area

First Department of Internal Medicine, Tokai University (Isehara), Prof. Yuichiro Goto, M.D.

First Department of Internal Medicine, University of Tokyo (Tokyo), Lecturer Chikayuki Naito, M.D.

Second Department of Internal Medicine,

Nihon University (Tokyo), Prof. Tadao Yasugi, M.D.

Department of Dermatology, Tokai University (Isehara), Prof. Muneo Okido, M.D.

Chubu area

Department of Geriatrics, University of Nagoya (Nagoya), Prof. Fumio Kuzuya, M.D.

Hokuriku area

Department of Gerontology, Kanazawa Medical University (Kanazawa), Prof. Hiroshi Sekimoto, M.D. (Chairman)

Second Department of Internal Medicine, Kanazawa University (Kanazawa), Prof. Ryoyu Takeda, M.D.

Kinki area

Department of Pathological Science, Research Institute, National Cardiovascular Center (Suita), Director Akira Yamamoto, M.D.

First Department of Internal Medicine, Kobe University (Kobe), Prof. Hisashi Fukuzaki, M.D.

Chugoku area

First Department of Internal Medicine,

Fig. 2. Serum total cholesterol levels of Japanese in 1980.

Fig. 3. Changes in serum total cholesterol levels of Japanese in the past 20 years.

Fig. 4. Regional difference in serum total cholesterol levels.

Hiroshima University (Hiroshima), Lecturer
Goro Kajiyama, M.D.

Shikoku area

Second Department of Internal Medicine,
Ehime University (Matsuyama), Prof. Tatsuo
Kokubu, M.D.

Kyushu area

Department of Internal Medicine, Institute of
Constitutional Medicine, Kumamoto University
(Kumamoto), Prof. Haruo Uzawa, M.D.

South West Islands area

Second Department of Internal Medicine,
Ryukyu University (Naha), Prof. Goro Mimura,
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Subjects

The present study was conducted on 10,977 subjects, 6,138 males and 4,839 females. The age and sex distributions of these subjects are shown in Table I.

Determination of Serum Lipids

TC and TG levels were determined by the enzymatic methods. In the 2 previous surveys,^{1, 5} the Zak-Henly method^{6, 7} was employed for TC⁸ and in the survey of 1970⁵ the acetylacetone method^{9, 10} was employed for TG. We compared the enzymatic methods with non-enzymatic methods. The TC values obtained by Zak-Henly

Fig. 5. Serum triglyceride levels of Japanese in 1980.

Fig. 6. Changes in serum triglyceride levels of Japanese in the past 10 years.

Fig. 7. Regional difference in serum triglyceride levels.

method and enzymatic method agreed well, the difference being less than 1 mg/dl in the range of 50–500 mg/dl. Therefore, the present data of TC were compared with those of the past studies without any correction. As for TG, the enzymatic method produced 4–10 mg/dl higher values than the acetylacetone method in the range of 50–300 mg/dl. However, since the difference was negligible as compared with the difference in TG levels between 1970 and 1980, the present data of TG were not corrected. The HDL fraction was separated by the precipitation method. Each institution used either heparin- Ca^{2+} (or Mn^{2+}) or dextran sulfate- Mg^{2+} as the precipitating agent depending on its familiar method. HDL-cholesterol (HDL-C) was determined by the enzymatic method.

In order to evaluate the inter-institutional variation of measurements, standard serum sam-

ples were delivered to all institutions 3 times during the period of investigation, and TC, TG and HDL-C levels were measured. The values varied 3–7% for TC, 7–9% for TG and 5–7% for HDL-C. According to the deviation from the standard sera, all data from each institution were corrected.

All data were collected and calculated by the staffs of Department of Pathological Science, Research Institute, National Cardiovascular Center, and Department of Gerontology, Kanazawa Medical University.

RESULTS

Table II shows the levels of TC, TG and HDL-C of normal Japanese subjects in 1980.

TC Levels

TC levels of subjects in their 1st decade were

Fig.8. HDL-cholesterol levels of Japanese in 1980.

Fig.9. Changes in the intake of total energy (upper), total fat and animal fat (lower) of Japanese in the past 30 years.

higher than those of subjects in their 2nd decade in both sexes (Fig. 2). After that, the levels increased with age, reaching a maximum at the 6th (male, 199 mg/dl) or the 7th decade (female, 214 mg/dl). In the older age group over the 7th decade, they declined slightly. TC levels of females under the 2nd decade and over the 6th decade were higher than those of males by 5–20 mg/dl. TC levels of total subjects reached maximum, 205 mg/dl, at the 7th decade. Figure 3 demonstrates the changes in TC levels during the past 20 years. At any age, the levels in 1980 were higher than those in 1960 by 10–15 mg/dl. The levels in 1980 were also higher than those in 1970 except for subjects in their 3rd decade. The

higher levels of the 3rd decade subjects in 1970 may be ascribed to the fact that the subjects were confined to those of urban areas only. The reason of lower levels over the 6th decade in 1970 than in 1960 is not clear. Figure 4 shows the regional difference in the TC levels. The levels were higher in Kanto, Chubu, Kinki and South West Islands areas, and lower in Tohoku, Hokuriku, Shikoku and Kyushu areas. In males, the regional difference was more evident over the 5th decade.

TG Levels

TG levels also increased with age, reaching maximum at the 7th decade (male, 128 mg/dl, female, 132 mg/dl, total, 130 mg/dl) (Table II and Fig. 5). Male TG levels of the 3rd to 6th decade were higher than females by 15–40 mg/dl. Mean TG levels over the 5th decade increased by more than 10 mg/dl in the past 10 years (Fig. 6). Figure 7 shows the regional difference of TG levels in 1980. The variation between age was large and definite trends, such as in the TC levels, were not observed. Nevertheless, the TG levels of Kanto and South West Islands were higher and those of Tohoku area were lower.

HDL-cholesterol Levels

The Japanese HDL-C levels in the whole country were first determined in the present study (Table II and Fig. 8). In contrast with TC and TG, HDL-C levels were highest at the 1st decade and decreased in general with age in both sexes. The levels of females of the 3rd to 6th decade were higher than those of males by 3–7 mg/dl.

Changes of the Nutritional Situation in the Past 30 Years

Figure 9 shows the changes of the intake of total energy, total fat and animal fat of Japanese in the past 30 years.¹¹ Total energy intake in 1960, when the first survey of serum lipid levels was carried out, was about 2,100 Cal per day. In 1970, at the second survey, the amount increased to over 2,200 Cal. However, the energy intake decreased thereafter except for 1971, and the value in 1980 was equal to those in 1960s. In contrast, the intake of total fat and animal fat have increased continuously. The animal fat intake in 1980 (27 g/day) was about 3 times larger than that in 1960.

DISCUSSION

The first survey of serum lipid levels of

Fig. 10. Comparison of serum total cholesterol levels between Japan and U.S.A. The data of the U.S.A. were cited from References 12 and 13.

Fig. 11. Comparison of serum total cholesterol levels between Japan and U.S.A. The data of the U.S.A. were cited from Reference 13.

Fig. 12. Comparison of serum triglyceride levels between Japan and U.S.A. The data of the U.S.A. were cited from Reference 13.

Japanese in the whole country was conducted in 1960¹, when malnutrition after the World War II had been almost eliminated. The TC levels of

normal Japanese in 1960 were much lower than those of Western people²⁻⁴. The total energy intake was about 2,100 Cal per day. In 1970, the energy intake increased to about 2,200 Cal and the intake of animal fat was doubled. The TC levels below the 5th decade in 1970⁵ were higher than those in 1960. In 1980 the energy intake declined to the levels of 1960s, but the intakes of total fat and animal fat were about 2 and 3 times larger than those in 1960, respectively. It was demonstrated that TC levels at any age have increased by 10–15 mg/dl in the past 20 years and also TG levels by more than 10 mg/dl over the 5th decade. On the other hand, the TC levels in Americans have declined gradually in the past 20 years¹²⁻¹⁴ (Figs. 10 and 11), so that the levels of Japanese approached to those of Americans. Especially, TC levels of Japanese youth (1st to 3rd decade) in 1980 were equal to or even higher than those of Americans in 1972–76¹³. The TG levels of males of the 1st and 2nd decade and those of females of the 1st to 3rd decade in Japanese also exceeded those of Americans in 1972–76¹³ (Fig. 12). Recent studies^{15, 16} have revealed that the TC levels in umbilical cord blood also increased as compared with the values of 20 years ago¹⁷ by about 15 mg/dl.

The increase of serum lipid levels may be due to the changes in the quality rather than the quantity of diet. Higher levels of serum lipids in urban area (Kanto, Chubu and Kinki) and in South West Islands, where the intake of animal fat is very high, also suggest that the increase of serum lipid levels may be caused by the westernization of dietary life. Therefore, it is essential that the dietary life, especially that of youth, must be improved in order to prevent the possible increase of the incidence of atherosclerotic disease due to hyperlipidemia in the near future.

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Appendix

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