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age-race distribution
cholesterol
sex-specific distribution
triglyceride

Plasma Cholesterol and Triglyceride Distributions in 13,665 Children and Adolescents: the Prevalence Study of the Lipid Research Clinics Program

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Summary

The age-, race-, and sex-specific distributions for plasma cholesterol (CH) and triglyceride (TG) are described for the 13,655 individuals under 20 years of age who were examined at the first visit (visit I) of the Prevalence Study of the Lipid Research Clinics (LRC) Program. Composite findings are presented from the seven North American LRC's where children were included in the target population. Cholesterol values are higher for blacks than for whites, but triglyceride values are higher for whites than for blacks. In both the CH and TG distributions for the combined races, the mean values for females are generally higher than for males. For cholesterol, consistent age-associated differences occur. On average, the CH values peak in late childhood and decline during adolescence. The decrease in mean values for CH is most marked for white males. The values for TG tend to increase in early adolescence. This report expands the available information about lipid distributions in young populations and describes the extent of the variation in plasma lipids associated with race and sex for each year of age, 0 to 19 years.

Speculation

The pattern of age-associated differences found in these population-based, cross-sectional surveys points to the need for prospective studies of lipid levels in cohorts examined before puberty and followed throughout adolescence and into early childhood. Such longitudinal studies may reveal the biological explanation for the age-curve of the mean values for lipids.

INTRODUCTION

Atherosclerotic cardiovascular disease is the leading cause of morbidity and mortality in the United States and other industrialized countries (19–21, 39, 40). Atherosclerosis is a chronic disease process which often precedes the clinical manifestations of myocardial infarction, angina pectoris, and stroke. An increasing amount of evidence suggests that the genesis of atherosclerosis is in childhood or adolescence (2, 10, 22). Primary prevention of atherosclerosis might therefore reasonably begin in the pediatric age group if the etiological factors can be identified and modified in the young. Epidemiological studies in adults have shown that elevated plasma cholesterol, hypertension, and cigarette smoking are especially associated with increased risk for the development of atherosclerotic cardiovascular disease (5, 17). The epidemiological evidence that hypertriglyceridemia is a separate risk factor for ischemic heart disease is contradictory (4, 33). In some families with inherited hyperlipidemias, however, hypertriglyceridemia without hypercholesterolemia appears to be associated with premature cardiovascular disease (15). Children of persons who have myocardial infarction also tend to have elevated lipids (11, 18, 41). Plasma lipids are transported by lipoproteins, two classes of which, beta or low-density lipoproteins (LDL) and prebeta or very-low-density lipoproteins (VLDL), appear atherogenic (14, 45). Recent evidence suggests that the level of alpha or high-density lipoproteins (HDL) is inversely related to risk for cardiovascular disease (5, 17, 29).

Recently several epidemiological studies have been undertaken to delineate similar "descriptors of risk" in children. As a first step, these surveys provide descriptive information for age-, race-, and sex-specific distributions of these risk factors in the young. From this information base, hypotheses may then be tested during longitudinal follow-up and evaluation.

The Prevalence Study of the LRC Program was designed to provide a significant pediatric component which would encompass population groups of diverse socioeconomic and ethnic composition (26). One-fourth of the persons sampled in the North American component of the LRC study persons were under twenty years of age. The purpose of this report is to describe the distribution of plasma levels of cholesterol and triglycerides in these children and adolescents and to determine age-, race-, and sex-associated differences in the plasma lipid levels as measured during the first examination (Visit I) of the LRC Prevalence Study.

MATERIALS AND METHODS

STUDY POPULATION

This report presents the composite findings for subjects 0 to 19 years of age from the seven North American LRC's where studies of children were included in the target populations. Children enrolled in schools were sampled in Houston and Cincinnati. In five other sites (Oklahoma, LaJolla, Minnesota, Toronto, and Baltimore), studies based on industrial populations and their families or samples of households contributed data on children.

Of the 19,479 person <20 years of age who were eligible for the visit I component of the LRC Prevalence Study, 15,622 (80.2%)

were examined. The analysis for this report includes only the data for examined persons who met the following six criteria: (1) age, in completed years, of <20 years; (2) race, classified either as white or black; (3) lipid values based on unfrozen blood samples; (4) not currently taking medication prescribed to reduce blood pressure, blood lipids, blood glucose or uric acid and not taking hormone preparations; (5) not pregnant; and (6) fasting ≥12 hours before examination. Based on these criteria, 1 person was excluded due to an invalid recording of age, 136 persons could not be classified either as white or as black, and 505 exclusions were due to frozen blood samples. From the 14,980 remaining records which met the first three criteria, an additional 1,315 were excluded due to criteria 4, 5, and/or 6. Although some (≤50) individuals were excluded for more than one reason, the number of exclusions for each of the three remaining criteria were as follows: medication use, 306 (to reduce blood pressure, 6; lipids, 2; blood sugar, 23; uric acid, 2; and oral contraceptive use, 280); pregnant or uncertain, 37; and nonfasting, 1,022. Thus, this report is based on the 13,665 persons who met all of the six criteria for inclusion in the analysis.

STUDY DESIGN AND LABORATORY METHODS

Details of the overall study design of the LRC prevalence studies, including the definitions of the target populations, methods of sampling, and standardization of measurements and procedures are described in reference protocols, laboratory manuals, and other publications of the LRC program (25–27).

During visit 1, identification and sociodemographic information was obtained, and a blood sample was drawn from persons who had fasted at least 12 hr. More detailed examination was performed at a second visit (visit 2) in a 15% randomly selected group from visit 1 and in children who had hyperlipidemia at visit 1. The results of this second examination, which included measurements of height, weight, blood pressure, lipids and lipoproteins, secondary clinical chemistries, and a family and medical history, will be reported subsequently.

At visit 1, 15 ml of blood were drawn into an evacuated tube containing 16 mg of disodium ethylenediaminetetracetic acid. Plasma was prepared within 4 hr by centrifugation at 4°C for 45,000 g-min. An isopropanol extract of plasma was prepared and treated with zeolite to remove interfering substances. Total plasma cholesterol and triglyceride concentrations were determined from this extract on either the Autoanalyzer I (Baylor, Johns Hopkins, and LaJolla LRC's) or on the Autoanalyzer II (Cincinnati, Oklahoma, Minnesota, and Toronto) after each of the laboratories had completed the LRC lipid standardization program (3, 29). The performance of each laboratory was monitored internally by means of serum pools of known cholesterol and triglyceride values established by reference methods. The precision achieved during analysis of these internal control pools have been published elsewhere (1, 3, 28). In addition, the performance of the laboratories was monitored by external quality control during the course of the study. A total of 864 samples from 18 serum pools with concentrations ranging from 59 to 349 mg/dl for cholesterol and 36 to 274 mg/dl for triglycerides were analyzed. Criteria for acceptable performance during external surveillance have been published previously (1, 28).

METHODS OF ANALYSIS

The age-specific distributions for cholesterol and triglycerides are examined separately for males and females and for both blacks and whites. Large sample sizes for ages six or greater allowed analysis for the four race-sex groups by single year of age, which revealed patterns that would have been obscured by the use of wider age intervals. When the number in an age, race, and sex group was less than 50 persons, the number is enclosed with brackets in the tables, and selected statistics are presented for completeness of information only. For sample size ≥50, 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles were calculated in addition to the mean and standard deviation. Differences in cholesterol and triglyceride distributions by sex and race were tested by a two-sample Kolmogorov-Smirnov statistic (36).

RESULTS

OVERALL DISTRIBUTIONS

The relative frequency distributions for plasma cholesterol are presented for white males and black males (Fig. 1) and for white females and black females (Fig. 2). Comparable frequency distri-

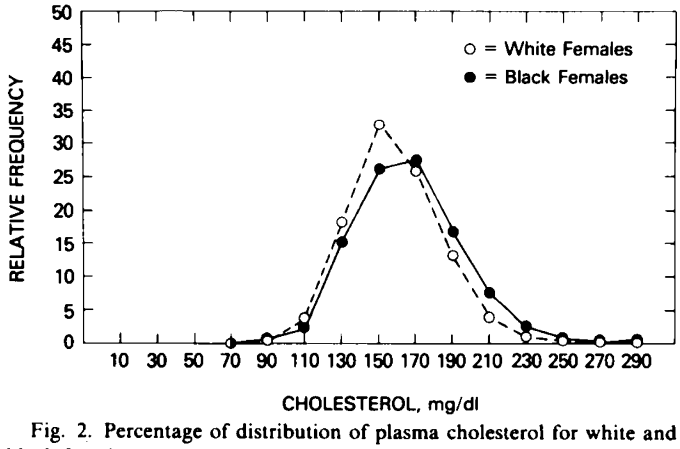

Fig. 2. Percentage of distribution of plasma cholesterol for white and black females.

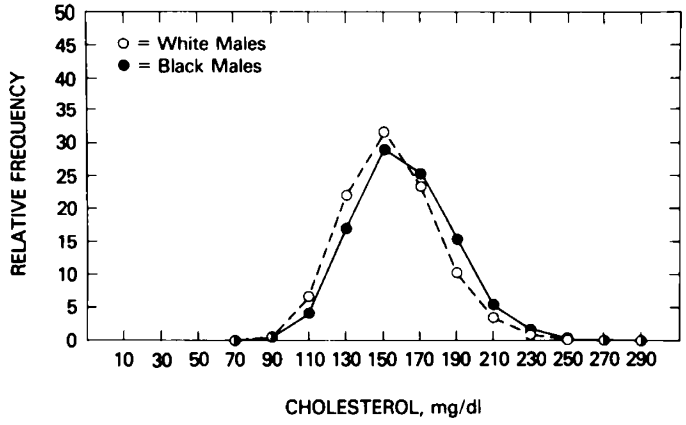

Fig. 1. Percentage of distribution of plasma cholesterol for white and black males.

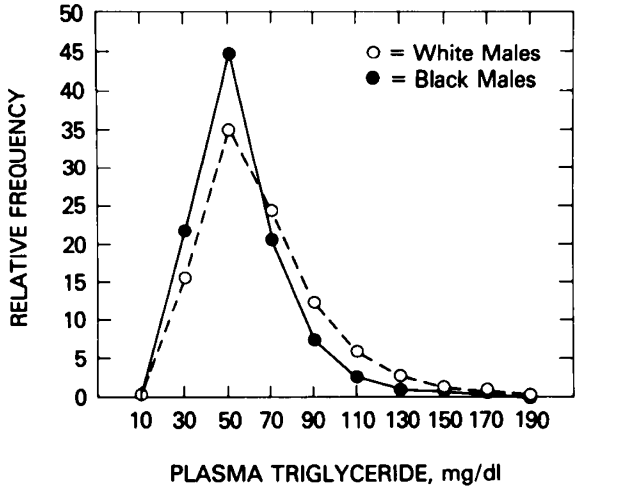

Fig. 3. Percentage of distribution of fasting triglyceride for white and black males.

butions are presented for plasma triglycerides in Figures 3 and 4. The points plotted in these figures represent the relative frequency of a 20-unit interval centered at the midpoint (*i.e.*, points plotted at 130 represent the relative frequency of the interval 120 to 140 mg/dl). Frequencies for each ethnic group sum to 100%.

The relative frequency distribution of plasma cholesterol for black males is shifted slightly to the right of that for white males ($P < 0.0001$) (Fig. 1). For the 5737 white males and for the 1350 black males, mean values for plasma cholesterol were 155 and 162 mg/dl, respectively. The distribution of plasma cholesterol for black females is similarly shifted to the right when compared to white females ($P < 0.0001$) (Fig. 2). Mean values for the 5288 white females and 1290 black females were 159 and 167 mg/dl, respectively.

Conversely, the relative frequency distribution of plasma triglyceride for white males is shifted somewhat to the right of that for black males ($P < 0.0001$) (Fig. 3) with means for black and white males of 57 and 67 mg/dl, respectively. Similarly, the triglyceride distribution for white females is shifted towards higher values than for black females. Mean values for black and white females were 61 and 70 mg/dl, respectively, $P < 0.0001$ (Fig. 4).

For the combined races (not shown), the distribution for females was generally higher for both triglyceride and cholesterol than for males ($P < 0.0001$).

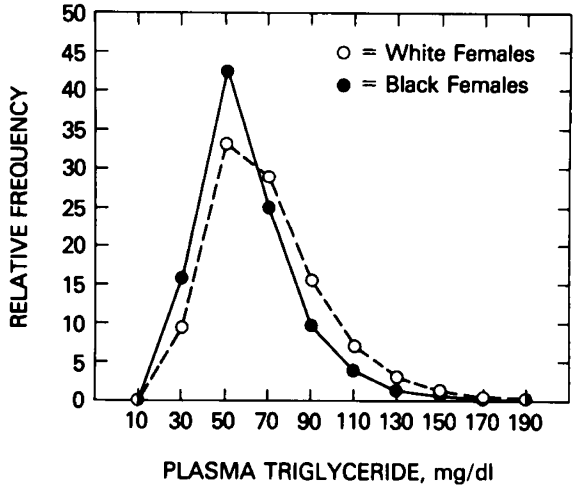

Fig. 4. Percentage of distribution of fasting triglyceride for white and black females.

LIPID DISTRIBUTIONS BY AGE, RACE AND SEX

Figures 5 to 6 and Tables 1 to 4 show the measures of central tendency (mean ± S.D.) and selected positional values (percentiles) for cholesterol and triglyceride for white and black males and females by single year of age. The mean values tend to be slightly higher than the 50th percentile values, indicating a positive skewness of the distributions. This skewness is more apparent for the distribution of triglyceride than for cholesterol in all four of the race- and sex-specific subgroups.

AGE-ASSOCIATED DIFFERENCES

Cholesterol. Within the aggregated data, certain consistent age-associated differences in plasma cholesterol occur. When the race-

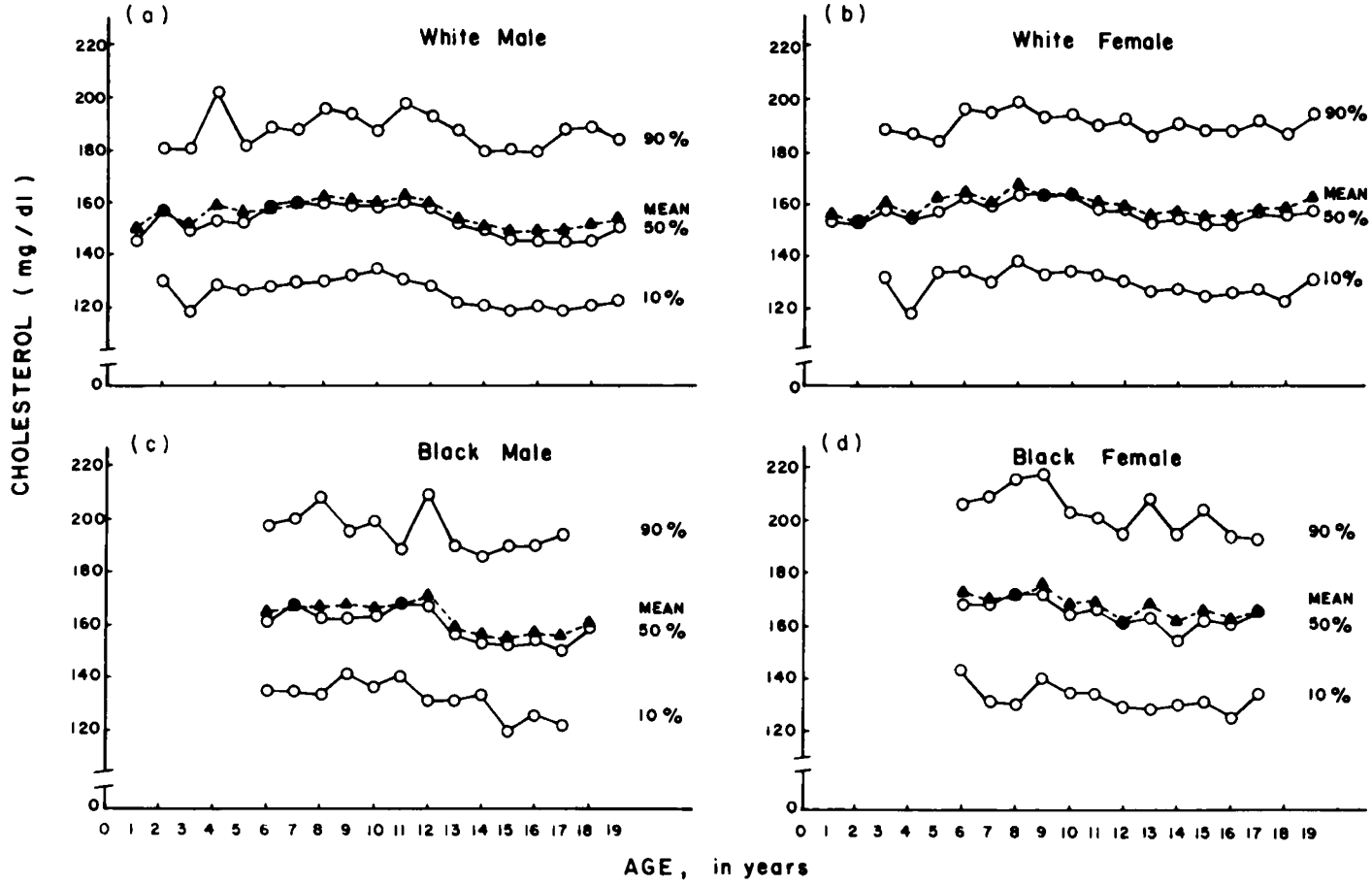

Fig. 5. Race- and sex-specific distributions of mean and percentile values of plasma cholesterol by age.

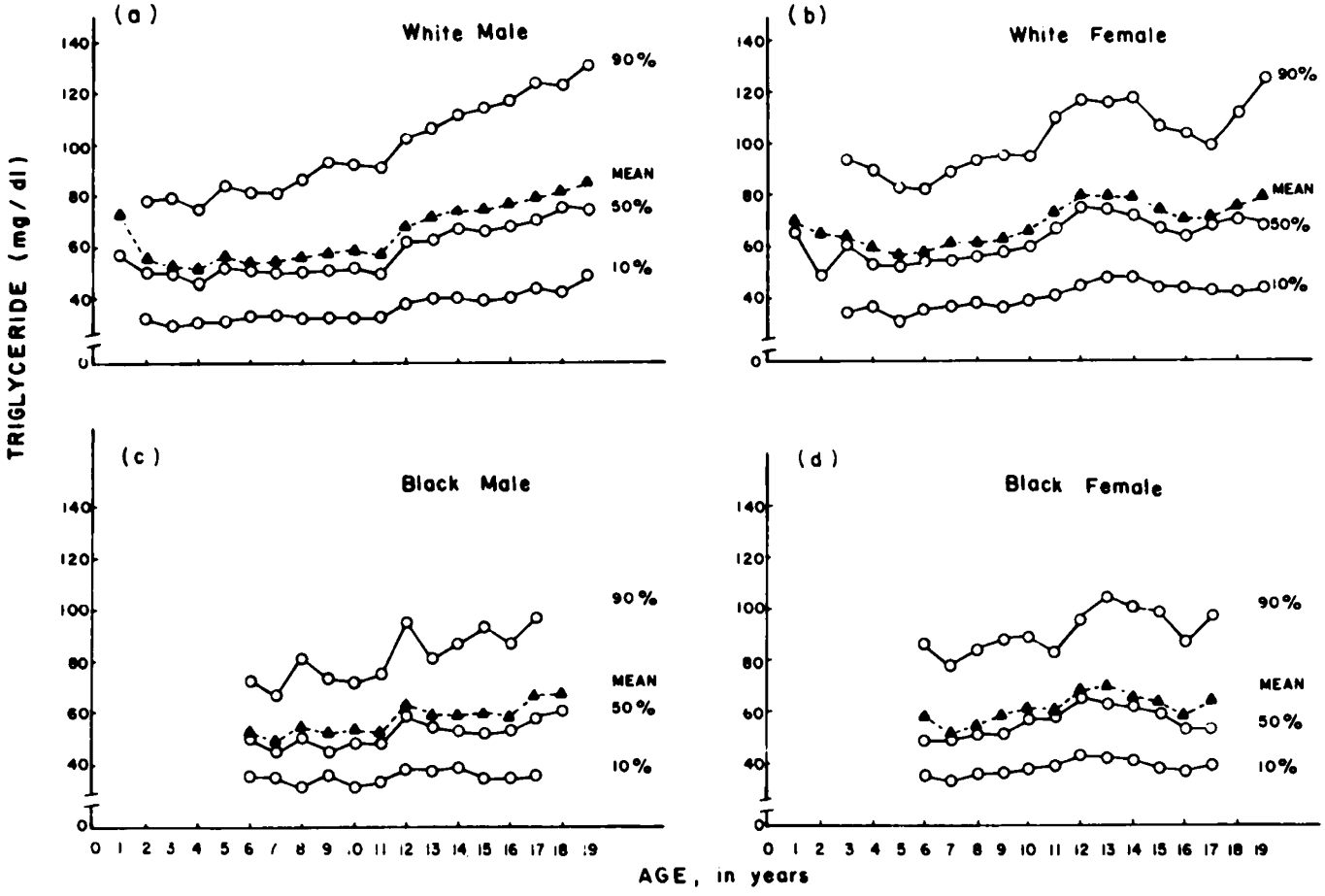

Fig. 6. Race- and sex-specific distributions of mean and percentile values of fasting triglyceride by age.

Table 1. *Plasma cholesterol and plasma triglycerides: mean and percentile distribution for white males*

	Cholesterol (mg/dl)										Triglycerides, (mg/dl)									
Age[1]	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th
0	[10]	143	29								[10]	63	21							
1	[36]	150	25			136	146	156			[36]	73	37			42	57	95		
2	[49]	158	22			140	158	173			[49]	55	22			40	51	67		
3	66	151	26	110	118	131	149	170	181	193	66	53	18	28	30	38	50	66	79	84
4	77	159	31	115	128	139	154	175	203	221	77	52	20	29	31	38	47	57	75	89
5	72	156	27	113	126	139	152	173	182	203	72	56	21	26	31	42	52	67	84	88
6	278	158	24	120	128	141	158	174	189	201	278	54	19	31	33	40	51	64	81	96
7	275	159	23	122	130	144	160	175	188	195	275	55	23	29	34	40	50	64	81	107
8	332	162	29	121	130	144	160	177	196	206	332	56	23	29	33	40	50	65	86	101
9	294	161	24	123	132	144	159	173	194	203	294	58	25	30	33	41	51	67	93	111
10	455	159	21	127	135	145	158	173	188	196	455	58	25	29	33	41	52	68	92	105
11	409	162	27	124	131	144	160	177	198	211	409	57	25	29	33	40	50	68	91	106
12	572	160	26	121	128	142	158	175	193	203	572	68	30	34	38	48	62	81	103	125
13	411	153	26	115	122	135	152	170	188	195	411	71	36	35	40	48	63	83	107	143
14	426	152	26	114	121	134	150	166	180	195	426	73	33	35	41	51	67	87	112	134
15	508	149	26	111	119	130	146	165	181	194	508	74	35	34	40	52	66	87	115	134
16	639	149	25	113	120	132	146	163	180	192	639	77	41	35	41	52	68	90	117	146
17	417	150	27	110	119	131	146	165	188	204	417	79	38	39	44	55	70	89	124	160
18	238	152	30	113	121	133	146	168	189	199	238	81	35	39	43	57	75	97	123	155
19	173	154	26	114	123	137	151	168	185	196	173	85	38	44	49	58	74	101	131	172

[1] All ages, n = 5,737.

[2] Where $n < 50$ persons, n is enclosed in brackets to denote that caution should be used in interpretation of the values presented.

Table 2. *Plasma cholesterol and plasma triglycerides: mean and percentile distribution for white females*

	Cholesterol (mg/dl)										Triglycerides, (mg/dl)									
Age[1]	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th
0	[6]	148	36								[6]	82	20							
1	[31]	156	27			136	153	174			[31]	70	21			57	66	83		
2	[33]	152	25			137	153	166			[33]	65	31			42	49	71		
3	57	160	26	118	132	143	157	173	189	201	57	63	23	32	34	45	61	78	94	110
4	59	155	28	108	118	136	155	176	187	196	59	59	22	34	37	45	53	68	90	94
5	86	162	28	126	134	147	157	175	184	195	86	56	24	28	31	41	52	66	83	93
6	253	165	24	129	134	145	163	183	196	205	253	57	21	32	36	43	54	65	82	95
7	220	160	25	124	130	142	159	176	195	202	220	61	31	32	37	43	54	73	89	112
8	297	166	24	129	139	147	164	182	199	209	297	61	24	34	38	44	56	71	93	104
9	261	163	24	120	133	146	164	179	193	205	261	63	26	32	36	44	58	74	95	110
10	417	163	25	127	134	146	163	177	194	205	417	66	28	35	39	48	60	76	95	116
11	338	161	22	126	133	144	158	175	190	200	338	73	31	36	41	51	67	86	110	126
12	536	161	24	124	131	144	158	175	192	203	536	79	30	38	45	58	75	96	117	132
13	344	155	23	122	127	138	153	169	186	192	344	79	31	43	48	56	74	93	116	136
14	441	157	25	120	128	142	155	171	191	198	441	79	32	38	48	58	72	92	117	138
15	553	155	25	119	125	138	152	170	188	199	553	74	35	39	44	52	67	84	107	127
16	675	155	27	121	126	139	152	168	188	197	675	71	31	37	44	52	64	82	104	120
17	351	158	26	119	128	140	157	172	192	202	351	70	25	40	43	51	68	83	99	113
18	193	157	25	116	123	140	156	172	187	199	193	75	29	39	42	56	70	87	112	126
19	137	162	29	123	131	146	158	174	194	212	137	79	46	40	44	54	69	87	126	135

[1] All ages, n = 5,288.

[2] Where n < 50 persons, n is enclosed in brackets to denote that caution should be used in interpretation of the values presented.

Table 3. *Plasma cholesterol and plasma triglycerides: mean and percentile distribution for black males*

	Cholesterol (mg/dl)										Triglycerides, (mg/dl)									
Age[1]	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th
0	[0]										[0]									
1	[2]	139	38								[2]	49	6							
2	[4]	154	15								[4]	52	24							
3	[8]	149	34								[8]	46	15							
4	[3]	164	31								[3]	64	39							
5	[8]	166	33								[8]	45	14							
6	97	164	29	128	134	144	161	179	198	213	97	53	20	33	35	40	50	60	72	94
7	52	167	26	116	134	149	167	181	200	208	52	49	13	33	34	38	45	56	67	75
8	103	167	29	129	133	147	162	185	208	218	103	54	23	28	31	40	50	61	81	96
9	74	168	23	135	141	150	162	185	195	200	74	53	18	33	36	41	45	62	73	81
10	118	167	24	126	136	151	164	186	199	206	118	53	24	29	31	40	48	61	72	95
11	68	167	22	133	140	153	168	178	189	191	68	52	18	30	33	37	47	65	75	81
12	120	171	31	127	131	149	169	195	209	216	120	63	24	32	38	45	59	73	95	100
13	88	159	23	124	131	144	156	174	190	195	88	58	25	33	37	43	54	66	81	90
14	91	157	23	115	133	143	153	169	186	195	91	58	21	32	38	44	53	66	86	98
15	138	154	28	110	120	135	152	172	190	200	138	59	26	28	35	41	52	68	94	97
16	200	157	26	120	125	138	154	176	190	199	200	57	23	31	35	41	52	64	86	102
17	126	156	28	118	122	137	150	173	194	208	126	65	36	32	35	45	57	73	97	122
18	[38]	163	25			145	159	172			[38]	65	27			48	61	73		
19	[12]	160	22								[12]	60	19							

[1] All ages, n = 1,350.

[2] Where n < 50 persons, n is enclosed in brackets to denote that caution should be used in interpretation of the values presented.

and sex-specific mean values for cholesterol are plotted for each year of age, the mean values for white males less than 11 years of age show no consistent pattern of differences by age (Table 1; Fig. 5). However, from 162 mg/dl at age 11, mean values for cholesterol are successively lower in each group, reaching 149 mg/dl at age 15. The curve rises from age 16, reaching 154 mg/dl at age 19.

For black males, a similar pattern is observed (Table 3; Fig. 5). The cholesterol means are generally stable below age 11. From 171 mg/dl at age 12, however, values decline 15 mg/dl to 156 mg/dl at age 17.

For white females, the means for plasma cholesterol vary below age 7. A peak mean value of 166 mg/dl occurs at age 8 (Table 2; Fig. 5). Mean values for cholesterol vary betwen 155 and 158 for age 13 to 18 years and then rise to 162 mg/dl for age 19.

Small sample sizes may account for the erratic variation in cholesterol means in black females during childhood (Table 4). However, from a mean of 176 mg/dl at age 9, the means decrease irregularly to 161 mg/dl at age 12. For the 13 to 19 year olds, the weighted average of the means is somewhat higher, 164 mg/dl (Table 4; Fig. 5), and the range is from 161 to 167 mg/dl.

Triglyceride. The graph of the age distribution of mean values for plasma triglyceride (Fig. 6) is also curved for each race-sex group. For white males (Table 1), no consistent pattern of age-associated differences for ages 3 to 11 is observed in the aggregated data for mean plasma triglyceride values. However, by age 12, the mean triglyceride value reaches 68 mg/dl, an increase of 11 from 57 mg/dl at age 11. Then the mean is higher in each successive age group. For age 19, the mean value for triglyceride is 85 mg/

dl. Thus, during the age period 12 to 19 years, the age curve for plasma triglyceride rises in white males in contrast to the age curve for cholesterol.

For black males (Table 3; Fig. 6), the means for plasma triglyceride vary from 45 to 64 mg/dl for ages below 11. As for white males, the mean values for plasma triglyceride then tend to increase. However, for black males, the increase in mean values for plasma triglycerides is not consistent throughout adolescence.

For white females (Table 2; Fig. 6), the mean value for plasma triglycerides is essentially stable (56 to 66 mg/dl) from age 3 to 10. For ages 12 to 14, however, the mean value is 79 mg/dl. Unlike that for white males, the age curve for mean values for plasma triglyceride in the white females does not continue to increase throughout adolescence, but falls to 70 mg/dl at age 17 and then increases again to the 12 to 14 year level (79 mg/dl) for age 19 years.

For black females (Table 4; Fig. 6), the mean values for plasma triglyceride are erratic for ages less than 6 years, probably reflecting the small number of observations. From ages 9 to 17, however, the mean values for plasma triglyceride range from 59 to 70 mg/dl. In a pattern similar to that for white females, mean values for triglyceride for black females decline to 59 mg/dl by age 16 and then increase slightly for the 17 year olds. The numbers were not sufficient for stable estimates for the 18 and 19 year olds.

DISCUSSION

The large sample size, the biracial nature of the study populations, and the diversity of their geographical environments provide an extensive, well-defined, and consistently analyzed data base for study of lipids in children. The summary data on the distributions for cholesterol and triglyceride for the aggregate population (Tables 1 to 4) should provide valuable information for the researcher, as well as the practitioner, for assessment of individual children relative to this population distribution. Conventionally, the 90th or 95th percentile has been used for identification of children with "elevated" cholesterol and triglyceride. These arbitrary cutpoints do not necessarily represent a threshold value for "disease" and are not necessarily an indication of need for further diagnostic maneuvers and therapy. By virtue of the phenomenon of regression towards the mean, some children initially identified at the 90th or 95th percentile for cholesterol and triglyceride will have on repetitive sampling levels below the upper cutpoints (6, 7).

Other problems inherent in the indiscriminant use of upper cutpoints and other statistics as threshold values for disease should also be considered. For example, the age-adjusted, race- and sex-specific mean values for CH and TG varies considerably among the LRC (Table 5). In clinical judgment, the magnitude of the clinic differences may not be of much practical importance; however, some of the differences among clinics are statistically significant (and will be the subject of later reports).

Although this analysis includes a very large number of children and adolescents (13,665), the number of persons in certain age, race, and sex groups was not large enough for calculation of reliable estimates. Where the value is based on less than 50 persons (denoted by brackets in the tables), the mean and selected percentiles are presented for completeness of information only; they are not offered as a clinical resource because they may be unstable estimates.

Generally, females had somewhat higher plasma cholesterol and triglyceride levels than males. These differences were small and may reflect the higher levels of LDL and VLDL lipoproteins in girls, as reported for the Bogalusa Study (38) and preliminary analysis of data for visit 2 of the LRC Prevalence Study (34, 42). If so, the direction of these childhood male-female differences in lipoproteins does not persist past early adulthood because adult males have been reported as having higher levels of LDL and

Table 5. *Age-adjusted[1] clinic means for whites*

	Males		Females	
	Cholesterol	Triglyceride	Cholesterol	Triglyceride
Baylor	147	71	156	70
Cincinnati	152	83	156	78
Johns Hopkins	146	73	153	71
La Jolla	154	66	161	68
Minnesota	149	76	157	77
Toronto	149	82	157	82

[1] Adjusted to age 15 by covariance analysis (37).

Table 4. *Plasma cholesterol and plasma triglycerides: mean and percentile distribution for black females*

	Cholesterol (mg/dl)										(Triglycerides, mg/dl)									
Age[1]	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th	n[2]	$\bar{X}$	S.D.	5th	10th	25th	50th	75th	90th	95th
0	[2]	124	33								[2]	86	45							
1	[6]	154	29								[6]	52	18							
2	[5]	160	19								[5]	43	5							
3	[7]	167	24								[7]	51	10							
4	[4]	147	17								[4]	68	13							
5	[8]	183	48								[8]	51	10							
6	102	172	24	138	143	152	169	185	206	216	102	57	29	29	35	41	49	64	86	108
7	60	170	29	126	131	150	170	187	209	216	60	52	17	27	33	40	49	62	78	82
8	100	172	31	124	130	145	172	194	215	226	100	54	19	31	35	40	51	63	84	90
9	68	176	33	133	140	154	171	184	217	235	68	60	30	33	36	45	51	66	88	100
10	131	169	30	128	134	148	164	187	203	211	131	60	20	36	38	45	57	70	89	97
11	65	168	26	131	134	150	167	183	201	213	65	61	18	33	39	47	58	72	83	92
12	128	161	26	121	129	142	161	177	195	203	128	68	22	37	43	51	65	79	96	109
13	70	167	31	120	128	145	163	188	208	219	70	70	25	37	42	49	63	88	105	112
14	80	161	29	120	130	139	154	180	195	205	80	66	24	38	41	49	62	74	101	110
15	150	166	27	129	131	147	163	185	204	211	150	64	28	34	38	46	58	74	99	121
16	192	162	27	120	125	142	161	179	194	206	192	59	24	32	36	43	54	68	87	95
17	83	166	25	124	134	150	165	179	193	208	83	62	25	36	39	44	53	71	97	107
18	[23]	167	28			144	165	86			[23]	66	35			42	54	70		
19	[6]	166	27								[6]	55	18							

[1] All ages, n = 1,290.

[2] Where $n < 50$ persons, n is enclosed in brackets to denote that caution should be used in interpretation of the values presented.

VLDL lipoproteins and lower levels of HDL lipoproteins than females (5, 17, 34).

The sex-specific mean values for plasma cholesterol for blacks were higher than for whites at ages 6 to 19. Such differences are of considerable interest, and the magnitude of some differences is potentially of physiologic significance. These black-white differences are similar to those reported for 5 to 14-year-old school children in Bogalusa, LA where black children had higher HDL cholesterol levels, which accounted for their higher total cholesterol levels (38). However, in samples of umbilical cord blood, no significant black-white differences in HDL levels or in other lipid and lipoprotein constituents were reported (12). The relative contributions of heredity and environment to black-white HDL differences remain to be further elucidated (43). A detailed analysis of pediatric black-white differences in regard to lipoproteins will be available in the near future from the LRC (visit 2) studies.

Conversely, the sex-specific mean values for fasting plasma triglyceride concentrations for whites were higher than for blacks at all age points. These ethnic differences are also of interest and similar to the Bogalusa reports (9). These findings are not unexpected because in population groups, triglyceride and VLDL cholesterol levels are inversely related to HDL (5, 17). Thus, the finding that blacks have higher HDL cholesterol (38) and lower triglyceride levels than whites is consistent. Further assessment of these differences in triglyceride and HDL levels may be facilitated by forthcoming data on black-white differences in body size, obesity, and nutritional intake. Whether the modest black-white differences in cholesterol, triglyceride, and HDL levels have clinical significance (2) remains to be evaluated.

The third aspect of the aggregate data, the age-associated differences in mean values for cholesterol and triglyceride, was investigated. A general pattern of fairly stable mean values for plasma cholesterol for all age, sex, race groups is noted for ages under 11 years for males and for ages under 8 to 9 for females. Subsequently, for all groups, there is a gradual average decline of approximately 13 mg/dl in mean plasma cholesterol which continues through ages 15 to 16 for females and 16 to 17 for males and then is followed by a gradual increase by ages 18 and 19. For plasma triglycerides, from ages 3 to 11 for males and 3 to 9 for females, the mean values vary within a narrow range for all age, sex, and race groups, but at ages 11 to 12, a gradual increase in plasma triglycerides is observed. For white males, this increase continues generally unabated throughout the teenage years. For females, the mean values for triglyceride increase to about age 13, fall through ages 15 to 17, and then increase. The interpretation of these data is clearly limited by the fact that this is a cross-sectional, not a longitudinal, study. Cross-sectional data from several recent studies (8, 9, 13, 16, 31, 35) have shown similar age-associated differences in cholesterol and triglyceride levels. Longitudinal studies (23, 24, 30) have also shown similar cholesterol and triglyceride changes in small cohorts.

Although the children studied in the LRC Prevalence Study are not a representative sample of a more general population, the information gathered should be useful and generalizable under reasonable constraints.

The age-associated differences in the magnitude and direction of triglyceride and cholesterol suggest a complex relationship between the variables age, sex, and race. Some of the largest age differences in lipid values occur around the time of pubescence and the adolescent spurts in height and weight, raising the possibility that the phenomena may be related. Concomitant hormonal changes may be more directly related.

The 95th percentile values for triglycerides and for cholesterol are considerably lower than previous National Heart, Lung, and Blood Institute standard cutpoints for 0 to 19 years: 230 mg/dl for total plasma cholesterol and 140 mg/dl for triglyceride (25). These lower cholesterol values may reflect differing laboratory methods or the downward trend in plasma cholesterol values observed in a sample of the United States population (32). The overall effect of new standards based on these LRC findings will be to increase estimates of the prevalence of "hyper" and lipidemia in children. Only for black females of age 9 do these values exceed the previous NHLBI standard of 230 mg/dl for cholesterol. Only for white males aged 13, 16, 17, 18 and 19 do these 95th percentiles exceed the previous National Heart, Lung, and Blood Institute standard of 140 mg/dl for triglyceride.

No large-scale longitudinal study has followed changes in lipids and lipoproteins in population cohorts throughout adolescence and into young adulthood. Longitudinal studies are, however, underway at the Bogalusa and Muscatine Specialized Centers of Research and at the Cincinnati LRC. These prospective data may clarify the relation between levels of sex hormones and plasma lipids and lipoproteins.

Longitudinal assessment of children at all deciles of the distribution for cholesterol and triglyceride may provide important information on "tracking." Ability to predict that a child will remain in an elevated decile for cholesterol and/or triglyceride may be relevant for prediction of risk for coronary heart disease. If, in fact, children with elevated values for coronary heart disease risk factors tend to retain these increased values over time, as has been suggested by preliminary data (6, 44), then identification of pediatric hyperlipidemia may be an important first step in the prevention of the atherosclerotic process (10, 22). The possible long-term significance of elevated levels of cardiovascular "risk factors" detected in children cannot be evaluated until results from longitudinal studies of childhood cohorts are available.

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