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Level of Non-high-density-lipoprotein Cholesterol and Its Related Factors in Chinese Han Students

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Abstract ***Objective:*** The aim of this study was to investigate the concentration of non-high-density lipoprotein cholesterol in Chinese Han students of varying ages and genders, and to find out its related factors. ***Methods:*** We examined 20208 Han students (10573 boys and 9635 girls) aged between 6-17 years old who came from 6 districts throughout China. The examination, performed during 2009-2010, involved a clinical examination and self-administered questionnaire. Based on the criteria defined by the American Academy of Pediatrics for children and adolescents in 2011, we defined high non-high-density lipoprotein cholesterol (total cholesterol minus high-density lipoprotein cholesterol) at a level ≥3.75 mmol/l. We set gender, age, obesity, physical activities, sleep duration, eating patterns and sedentary activities as related factors and performed logistic regression analysis. ***Result:*** The percentage of high non-high-density lipoprotein cholesterol was 4.1% in 6-17 years old children and adolescents in China. Non-high-density lipoprotein cholesterol concentration was significantly higher in girls than boys. Biological maturity was positively associated with non-high-density lipoprotein cholesterol concentration. Gender, weekly sport frequency, eating patterns, biological maturity and obesity were the related factors of high non-high-density lipoprotein cholesterol concentrations. ***Conclusion:*** The concentrations of non-high-density lipoprotein cholesterol in children and adolescents are strongly determined by gender. Obesity, gender and biological maturity contributed to the variance in non-high-density lipoprotein cholesterol and should be considered in future evaluation of non-high-density lipoprotein cholesterol status. Children and adolescents who did more sports and ate more vegetables were less likely to have a higher non-high-density lipoprotein cholesterol level.

Key words Children; Lifestyle; Non-high-density-lipoprotein cholesterol; Obesity

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Introduction

Cardiovascular disease is one of the most prominent causes of mortality world widely. A key related factor of atherosclerotic cardiovascular disease is the presence of dyslipidemia. Together with elevated blood pressure, obesity, and diabetes mellitus, dyslipidemia is a component of metabolic syndrome and associated with an increasing incidence of coronary heart disease.[1,2] It has been suggested that less than optimal lipid and lipoprotein levels in children and adolescents may lead to an increased risk of cardiovascular disease in adulthood.[3] Non-high-density lipoprotein cholesterol (non-HDL-C), calculated as total cholesterol (TC) minus high-density lipoprotein cholesterol (HDL-C),[4] is a clinical value which reflects the concentration of many atherogenic lipoproteins, including low-density lipoprotein cholesterol (LDL-C), very-low-density lipoprotein cholesterol (VLDL-C), intermediate-density lipoprotein cholesterol (IDL-C), and lipoprotein(a), and is easy to use in clinical practice. Non-HDL-C concentration is an important predictor of premature atherosclerosis[5] and a reduction in non-HDL-C concentrations in adults has been associated with reduced risk for cardiovascular disease outcomes.[6] In 2011, the American Academy of Pediatrics (AAP) redefined dyslipidemia, by adopting the non-HDL-C level (instead of the LDL cholesterol level), triglyceride level (TG), and HDL-C level as three major criterions. Additionally, the cutoffs of TG and HDL-C level were adjusted.[7] There are so many surveys about the status of TG and HDL-C levels in Chinese children and adolescents, but surveys about non-HDL-C are absent in China. Also, it has been previously established that serum lipid levels are affected by various factors, including life styles, physical exercises and drugs.[8] The aims of this study are to investigate the levels of non-HDL-C in Chinese Han students with different age and gender, and to find out its related factor through logistic regression. This would help us guide the preventive and/or therapeutic interventions of high non-HDL-C levels in children and adolescents in China.

Participants and Methods

Study Sample

The participants of this study were 20208 full-time Han students (10573 boys and 9635 girls) from six major regions throughout China, each of which consisted of 2500-3500 participants aged 6-17 years old and with different characteristics. The present cross-sectional study was conducted in Northern area (Peking, Tianjin) which consisted of 6177 samples (3176 boys and 3001girls), Eastern area (Shanghai, Hangzhou) which consisted of 6937 (3860 boys and 3077 girls) and Middle Western area (Nanning, Chongqing) which consisted of 7094 (3537 boys and 3557 girls). Individuals mentally or physically unfit to undergo the study were excluded before informed consent was signed. Ethical approval for the study was obtained from the Children's Hospital of Zhejiang University, School of Medicine.

Data Collection

Informed consents were sent to the subjects' parents before the study to explain the objectives of the study and provide information about location, time and procedures. Date collection was performed by a team of trained teachers, nurses, pediatricians and laboratory personnel. The participants were asked to stay at school after night fasting for 8-12 hours. Data collection included a structured questionnaire detailing their ages, genders, biological maturity and lifestyle characteristics including eating patterns, sleep duration, physical activities and sedentary activities. Besides, a clinical examination, including weight, height and stage of Tanner was performed. And if the results of the biological maturity in questionnaire and stage of Tanner by clinical examination were different, we chose the latter. Moreover, venous blood was drawn for the measurement of blood TC and HDL-C. Research technicians measured body weights to an accuracy of 100 grams using a standard beam balance scale with subjects barefoot and wearing light indoor clothing. Body height was recorded to the nearest 0.5 centimeter using a ruler attached to the scale. The body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. A 2 mL venous blood extraction was conducted with sterilised syringes and slowly transferred into glass tubes without anticoagulants. Blood samples were clotted at room temperature. They were sent to a clinical laboratory and centrifuged at 2000 rpm for 15 minutes within 2 hours in the same morning. The serum thus obtained was analysed on the same day for TC and HDL-C using an automatic biochemistry analyser. The level of non-HDL-C was calculated as TC level minus HDL-C level. Subjects with chronic diseases which may influence the lipid profiles such as diabetes mellitus, hypertension and familial dyslipidemia were excluded.

Variables

In 2011, the American Academy of Pediatric (AAP) redefined dyslipidemia for children and adolescents as follows: TG level ≥1.47 mmol/l, or HDL cholesterol level <1.03 mmol/l, or non-HDL cholesterol level ≥3.75 mmol/l. According to this new definition, we defined high non-HDL-C as non-HDL-C ≥3.75 mmol/l. Sleep duration was investigated by the question "How long did you sleep everyday in the previous week?" in the lifestyle survey. Sleep duration of participants ranged from 6 to 12 hours. Participants were asked about the types and times spent on daily physical activities in their spare time for recreation, exercise, or sport in the previous week. Questions about subjects sedentary activities were asked as "How many time did you spend on watching television, surfing the Web, playing video games and engaging in other computer-based pursuits everyday in last week?". Eating patterns were measured by the question "What is your regularly eating style? A meat based diet, mainly vegetarian diet, or meat in half and half". Obesity was defined as a body mass index (BMI) value higher than the 85th percentile for the child's age and sex, recommended by the International Obesity Task Force (IOTF).[9] Biological maturities were evaluated by Tanner stage.

Statistical Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS, Version 18.0. SPSS Inc., Chicago, IL, United States). Means and standard deviations of each serum lipid were computed and displayed with Mean±SD. Student t test and Chi-square test analysis of variance was used to test the initial differences between the boys and girls. Then, the binary logistic regression was used to analyse the related factors of high non-HDL-C level. The estimates and 95% confidence interval (CI) of the coefficients were displayed. Percentiles of non-HDL-C level by age- and gender- specific were calculated. Percentiles graphic were made by lmsChartMaker.

Results

52.3% of the subjects were boys. The mean age was 12.8±2.78 years. The mean non-HDL-C concentration was 2.42 mmol/l. 4.1% of subjects had non-HDL-C concentrations greater than 3.75 mmol/l. Concentration of non-HDL-C, age and sleeping duration (Mean±SD) of boys and girls are shown in Table 1. Non-HDL-C concentration was significantly higher in girls than in boys, the means were 2.47 mmol/l and 2.38 mmol/l, respectively. The average age and sleeping duration of girls and boys were 12.45, 11.51 years and 8.48, 8.73 hours per day, respectively. Tables 2 and 3 display respectively the percentiles of non-HDL-C concentration of boys and girls in China among 6-17 years. The percentiles graphs of non-HDL-C level by age and gender are shown in Figures 1 and 2. With age, obesity, sleeping duration, eating patterns, sports frequency, sedentary activities (watch TV, play digital game) and biological maturity of the participants as determinant factors, with/without high non-HDL-C level as the dependent variables, using binary logistic regression models, results in Table 4. It displays that obesity was a significantly harmful factor of high non-HDL-C level both in boys and girls, the OR was 2.306 (*P*=0.000). Subjects who participated in sport frequently and had the "mainly-vegetable" eating pattern were less likely to have high non-HDL-C level. Biological maturity was positively correlated with non-HDL-C level. Neither sleeping duration nor hours of sedentary activities were related factors of serum non-HDL cholesterol level both in girls and boys. Non-HDL-C levels were significantly different between genders. Odds ratio of being high non-HDL-C was 1.360 for girls. Through the percentile graphs (Figures 1 and 2), we can detect that non-HDL-C

Table 1 Non-high-density lipoprotein cholesterol (non-HDL-C) levels, age and sleeping duration (Mean±SD) of boys and girls

	Age (year)		non-HDL-C (mmol/l)		Sleep duration (hours)	
Gender	N	Mean±SD	N	Mean±SD	N	Mean±SD
Mmale	10573	12.09±2.80	9562	2.38±0.73	10167	8.79±1.03
Female	9635	12.07±2.78	8584	2.47±0.72*	9276	8.71±1.05
Total	20285	12.08±2.79	18258	2.42±0.73	19527	8.75±1.04

*p<0.05

concentration among Chinese students aged 6-17 years was stable. Logistic regression also displayed that age (among 6-17) was not a related factor.

Discussion

Screening of appropriate children and adolescents for high non-HDL-C level and treating those at high related are important for the long-term prevention of cardiovascular disease. Our study found that girls had significantly higher serum non-HDL-C levels than boys. Biological maturity was positively correlated with non-HDL-C. These results were identical to Spinneker et al's report conducted in Europe.[10] We also found that obesity was a factor of high non-HDL-C levels in children and adolescents in China. Participating in sports frequently and having eating patterns with more vegetables and fruits were the protective factors

Table 2 Percentiles of non-high-density lipoprotein cholesterol (non-HDL-C) among 6-17 years Chinese male students

		Non-HDL-C level (mmol/l)						
Age (years)	**N**	**P5**	**P10**	**P25**	**P50**	**P75**	**P90**	**P95**
6	145	1.54	1.64	1.95	2.30	2.70	3.03	3.20
7	426	1.40	1.55	1.90	2.28	2.65	3.20	3.44
8	581	1.27	1.45	1.74	2.20	2.65	3.10	3.53
9	739	1.38	1.56	1.90	2.28	2.75	3.17	3.46
10	802	1.41	1.61	2.00	2.37	2.77	3.21	3.50
11	988	1.51	1.67	2.04	2.40	2.83	3.29	3.70
12	1008	1.44	1.61	1.95	2.36	2.93	3.50	3.84
13	1157	1.30	1.47	1.78	2.20	2.67	3.18	3.52
14	1149	1.36	1.51	1.83	2.24	2.73	3.24	3.74
15	1077	1.33	1.54	1.83	2.25	2.72	3.17	3.56
16	674	1.41	1.60	1.91	2.35	2.88	3.46	3.90
17	335	1.69	1.81	2.09	2.43	2.97	3.47	3.72

Table 3 Percentiles of non-high-density lipoprotein cholesterol (non-HDL-C) among 6-17 years Chinese female students

		Non-HDL-C level (mmol/l)						
Age (years)	**N**	**P5**	**P10**	**P25**	**P50**	**P75**	**P90**	**P95**
6	141	1.70	1.81	2.09	2.37	2.77	3.07	3.27
7	389	1.37	1.65	1.95	2.33	2.73	3.20	3.39
8	519	1.30	1.46	1.77	2.25	2.72	3.34	3.62
9	683	1.37	1.65	1.97	2.42	2.88	3.43	3.68
10	708	1.55	1.67	2.03	2.38	2.87	3.28	3.54
11	886	1.51	1.67	2.03	2.45	2.90	3.39	3.80
12	872	1.50	1.71	1.98	2.41	2.84	3.34	3.64
13	1067	1.31	1.57	1.90	2.29	2.73	3.13	3.45
14	1156	1.44	1.58	1.92	2.32	2.79	3.29	3.67
15	967	1.46	1.63	1.99	2.44	2.92	3.47	3.80
16	560	1.56	1.74	2.13	2.55	3.03	3.57	3.96
17	298	1.71	1.95	2.31	2.67	3.09	3.54	3.89

of high non-HDL-C level. It is consistent with Bradlee et al, who detected that girls consuming more fruits and non-starchy vegetables as well as more whole grains, were much less likely to have high-risk lipid levels.[11] Among 6-17 years, age change was not a related factor to non-HDL-C concentration. Formerly, in 2009 Alberty et al reported there has no age-related differences in non-HDL-C levels between Slovak Roma and Caucasian children.[12] In 2011, the AAP issued the new definition, in which, the maximal serum level of TG was significantly different between above and below 10 years of age.[7] However, it was the same cutoff of non-HDL-C in children and adolescents with different ages and gender. In our study, we adopt the same newly defined criteria issued by the AAP for high non-HDL-C level in children and adolescents, we consider is reasonable, because in this survey, we found

Table 4 Binary logistic regression of non-high-density lipoprotein cholesterol

						Exp (B)	95% CI of Exp (B)	
	B	S.E.	Wald	df	Sig.		Lower	Upper
Gender	0.307	0.100	9.486	1	0.002	1.360	1.118	1.654
Age	0.045	0.026	2.925	1	0.087	1.046	0.994	1.100
Sleep duration	-0.023	0.035	0.418	1	0.518	0.978	0.912	1.047
Sedentary activities	-0.001	0.023	0.003	1	0.957	0.999	0.954	1.045
Sport frequency	-0.085	0.023	13.552	1	0.000	0.918	0.878	0.961
Eating patterns	-0.441	0.105	17.739	1	0.000	0.643	0.524	0.790
Obesity	0.836	0.067	155.507	1	0.000	2.306	2.023	2.630
Biological maturity	0.104	0.052	4.016	1	0.045	1.110	1.002	1.228
Constant	-3.310	0.511	41.904	1	0.000	0.037		

B=coefficient; S.E.=standard error; df=degree of freedom; Sig.=significance; Exp (B)=estimated odds ratio; CI=confidence interval

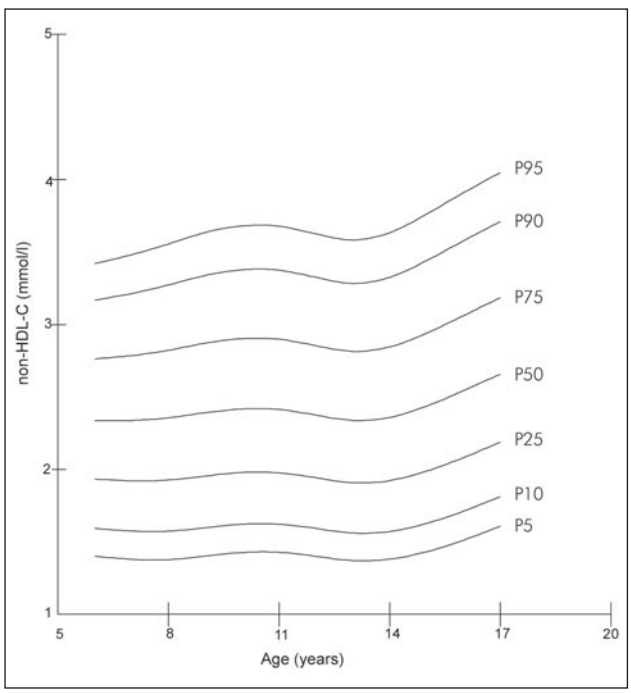

Figure 1 Percentiles of non-high-density lipoprotein cholesterol (non-HDL-C) among Chinese female students.

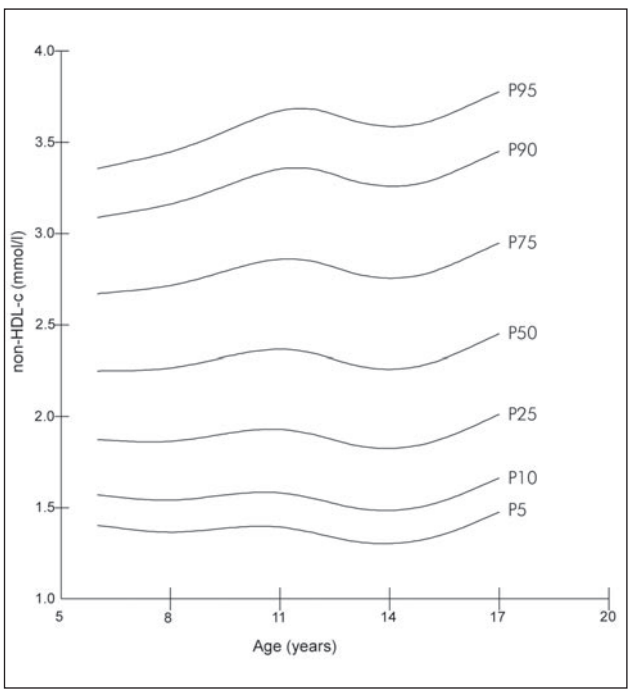

Figure 2 Percentiles of non-high-density lipoprotein cholesterol (non-HDL-C) among Chinese male students.

that there was no relationship between non-HDL-C level and age. With regard to sleep duration, the mean of sleep duration was 8.79 hours in boys and 8.71 hours in girls in our study, while sleep duration was not a related factor of high non-HDL-C concentration. This was not consistent with previous reports. As far as we know, studies about the relationship between sleep duration and serum lipid/lipoprotein had different results. Study by Katano et al also found an association between dyslipidemia and shorter sleep duration.[13] In another study by Kaneita et al, both short and long sleep duration were associated with a high serum TG level or a low HDL cholesterol level, whereas compared with men sleeping 6-7 hours, the risk of a high LDL cholesterol level was lower among men with sleeping duration ≥8 hours.[14] Gangwisch et al found among females, each additional hour of sleep was associated with a 17% decreased odds of being diagnosed with high cholesterol in young adulthood in 2010.[15]

In 2008, the U.S. Department of Health and Human Services (HHS) issued the Physical Activity Guidelines for Americans.[16] It recommended that children and adolescents do 1 hour or more of physical activity a day that should include vigorous-intensity physical activity at least 3 days a week. We found that in our survey subjects who do physical activity frequently had a lower risk of high non-HDL-C level. This is consistent with previous Meta analytic work in which Kelley et al found a statistically significant decrease of approximately 4% as a result of walking in adults.[17] The viewpoint that obesity is a risk factor of dyslipidemia was validated one more time in our study. Previously, Lamb et al found adverse lipid concentrations and high adiposity were significantly associated in youths.[18] Spinneker et al also found that fat mass and body fat were significantly correlated with HDL-C, LDL-C, non-HDL-C both in boys and girls.[10] Aggoun et al and Beauloye et al found that obese, sedentary children and adolescents exhibit hypertension, dyslipidemia, and markers of atherosclerosis more frequently than others.[19, 20] However, Pate et al concluded that more time that children spend in sedentary activities, the less fit they are.[21] We did not observe the association between sedentary activities and high non-HDL-C concentration in this study. By analysing our data, we found that children and adolescents in our cross-section study mostly spent less than 2 hours on sedentary activities. We speculated possibly the time was too short to have an effect, and also sedentary activity may influence other lipid profiles such as TG, but not non-DHL-C.

Conclusion

The percentage of high non-HDL-C level in Chinese Han children and adolescents was 4.1%. Non-HDL-C level in children and adolescents was mainly determined by gender. Obesity also produced an effect on the variance in non-HDL-C and should be considered in future evaluation of non-HDL-C status. Children and adolescents who participated in more sports and ate less meat had a lower risk of high non-HDL-C level.

In short, obesity girls who had developed biological maturity, did not do physical activity frequently and did not like eating vegetables and fruits were most likely to be a high non-HDL-C.

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Declaration of Conflicts of Interest

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