

Dyslipidemia in northeastern China

Research Article

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Abstract: Dyslipidemia, is a major risk factor for premature coronary artery disease. Our aim was to estimate the prevalence of dyslipidemia (blood lipid abnormalities) and other risk factors associated with coronary artery diseases among an adult population in northeastern China. Throughout the months of September and October of 2007, a population-based cross-sectional study was conducted and a total of 3,815 individuals were included. Total cholesterol (TC), high-density cholesterol (HDL-C), low-density cholesterol (LDL-C), and triglycerides (TG) were measured. A binary logistic regression analysis was conducted to determine risk factors associated with dyslipidemia. The prevalence of hypercholesterolemia, high LDL-C, low HDL-C, and hypertriglyceridemia were 17.3%, 27.8%, 11.66% and 29.85%, respectively. The prevalence of hypertension, central obesity, alcoholic liver disease (ALD), non-ALD, diabetes and metabolic syndrome was higher in serum lipid abnormality groups than in the non-dyslipidemia group ($p < 0.001$). In a binary logistic regression, hyperlipidemia was positively correlated with age, male, hypertension, high body mass index, etc. There were negative correlations with being female and the level of education a subject had attained. Dyslipidemia is a major risk factor for premature coronary artery diseases and an important public health issue in the northeastern part of China. Dyslipidemia is more frequent than expected based on previous studies. To control dyslipidemia, routine evaluations in clinics and community centers are needed, as well as effective public health education.

Keywords: Licorice • Hypokalemic myopathy • Renal damage • Hyperaldosteronism

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1. Introduction

Cardiovascular disease (CVD) is the leading cause of death in both developed and developing countries [1-3]. hypertension (HTN), dyslipidemia (DLP) and diabetes mellitus (DM) are considered as major risk factors contributing to this disease, [4,5] but dyslipidemia is a major risk factor of premature coronary artery disease. Over the past 20 years, China has experienced remarkable socioeconomic development, and the lifestyles, including the dietary habits of the people have changed dramatically [6,7]. Although an increasing number of Chinese individuals suffer from dyslipidemia, few of the studies have explored these factors leading to the condition. These factors that contribute to the increase remain unclear [8]. The current study explores risk factors associated with dyslipidemia based on a population in a northeastern region of China.

2. Material and Methods

2.1. Study design

This was a cross-sectional survey of households systematically selected from Dehui City, a county-level division of the province of Jilin in northeast China. Dehui has a population of 807,000, in 14 towns (urban) and 308 villages (rural). The economic status of the county is above mid-level compared to others in Jilin. Selection of towns and villages was based on geographic distribution and logistic considerations.

The sampling was random and multistaged. Each stage was divided into two tiers or phases. Phases 1 and 2 covered rural (9 villages) and urban (11 towns) areas, respectively. The sample size (N) was calculated based on a 10.0% prevalence (p) of dyslipidemia with a 1% uncertainty level (d), using the formula $N = t^2pq/d^2$

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(where $t \sim 2$ with 95% confidence; $q = 1 - p$). We therefore estimated that this would necessitate studying 3,600 subjects. A total of 6,043 eligible subjects were selected from the district. Eventually, a total of 3,850 subjects accepted questionnaires and physical check-ups, and 3,815 were included in this study. Participation in the study was voluntary.

The survey consisted of an interview (in the home) using a detailed questionnaire. The investigators stayed in each village for 1-2 months to conduct door-to-door interviews. Medical workers joined the team during the last month to conduct physical examinations which included blood pressure and anthropometric measurements, abdominal ultrasound and the collection of venous blood samples. Data confidentiality was guaranteed by the research team. All individuals who refused to undergo blood collection or who were not found during a second visit were excluded from the study. Physical exercise was defined as exercising strenuously for at least 20 min and outside professional activity. Physical activity levels were defined as low if the subject exercised less than once a week, moderate if the subject exercised at least once a week but less than every day, and high if the subject exercised one or more times per day. Waist circumference (WC) was measured in duplicate with subjects standing in a relaxed position. Body mass index (BMI) was calculated as weight (kilograms) divided by the height squared (meters²).

2.2. Definitions and preferred cutoff values

In accordance with the World Health Organization's Asian criteria.[9] Overweight was defined as a BMI $\geq 23 \text{ kg/m}^2$, and obesity as BMI $\geq 25 \text{ kg/m}^2$. Central obesity was defined as WC $\geq 90 \text{ cm}$ in men and WC $\geq 80 \text{ cm}$ in women. Persons whose mean blood pressure was $\geq 140/90 \text{ mmHg}$ or who were taking antihypertensive medications were classified as hypertensive. Persons with a fasting blood glucose $>7.0 \text{ mmol/L}$ or who were taking antidiabetic medication were considered to have diabetes mellitus. Metabolic syndrome (MS) was diagnosed according to the International Diabetes Federation consensus world wide definition for MS [10]. Nonalcoholic fatty liver disease (NAFLD) and alcoholic liver disease (ALD) were defined according to Chinese standard guidelines [11-12]. Blood samples were drawn in the morning after a fast longer than 12 hours (h) and were centrifuged at local medical locations. Serum samples were stored at 4°C and sent to the Department of Clinical Laboratory of the First Hospital of Jilin University; determinations were carried out within 24 h. The levels of fasting blood glucose (FBG), total cholesterol (TC), high-density cholesterol (HDL-C), low-density cholesterol (LDL-C), and triglycerides (TG)

were measured with a Synchron LX[®]20 autoanalyzer (Beckman Coulter, Brea, CA, USA). According to the Chinese guidelines on prevention and treatment of dyslipidemia in adults [13] hypercholesterolemia was defined as TC $\geq 5.18 \text{ mmol/L}$, high LDL-C as LDL-C $\geq 3.37 \text{ mmol/L}$, hypertriglyceridemia as TG $\geq 1.7 \text{ mmol/L}$, and low HDL-C as HDL-C $< 1.04 \text{ mmol/L}$. Dyslipidemia was defined as the presence of one or more abnormal serum lipid concentrations. The ratio of TC to HDL-C (TC/HDL-C) was considered abnormal if ≥ 4.5 .

2.3. Statistical methods

Comparisons between groups for quantitative data and prevalence of dyslipidemia were performed using the chi-square (χ^2) test. For associated risk factors of dyslipidemia, analysis was performed using binary logistic regression analysis. Results were shown as arithmetic mean and standard error of the mean (SEM) for quantitative data, and as percentages for qualitative data. An odds ratio (OR) at 95% confidence interval (CI) was used. All reported p -values are based on two-sided tests; $p < 0.05$ was considered statistically significant. The statistical calculations were performed with SPSS Statistics Software, 13.0.

In order to determine whether some risk factors were valid for our population, we recorded 15 variables in four major areas: cardiovascular risk factors (hypertension, NAFLD, BMI, WC, and FBG), demographic factors (age, sex, central obesity, and level of education), socioeconomic factors (household income and occupation), and lifestyle factors (diet habits, smoking habits, physical activity, and alcohol consumption). Separate univariate analyses were used to identify those variables associated with dyslipidemia. Because these variables are interrelated, we performed a binary logistic regression analysis through the Enter method to identify the effect of each variable while controlling for the effects of the other variables.

3. Results

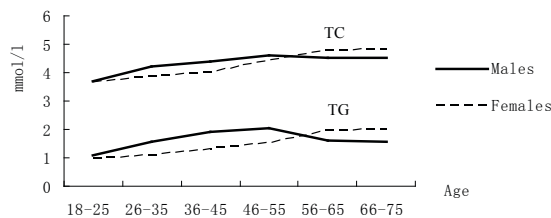
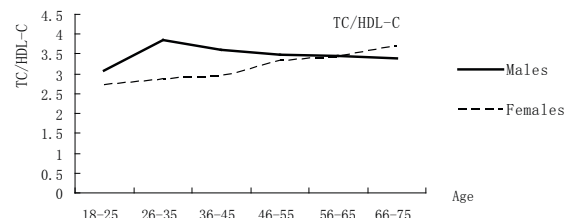
3.1. The prevalence of metabolic diseases in different groups of serum lipid abnormality

As shown in Table 1, the prevalence of hypertension, central obesity, ALD, NALD, DM and MS were higher in the serum lipid abnormality groups than in the non-dyslipidemia group ($p < 0.001$ in all cases). As the number of abnormalities in lipid parameters increased, a significantly higher proportion of metabolic diseases occurred.

Table 1. The prevalence of diseases in different groups of serum lipid abnormality.

Diseases	Non-dyslipidemia (%)	Serum lipid abnormality (%)			Total (N)
		1 ^a	2 ^b	3 ^c	
Hypertension	29.06	43.98*	50.86*	65.53*	1518
Central obesity	22.81	42.09*	53.22*	65.81*	1399
ALD	1.17	4.29*	6.12*	11.68*	143
NAFLD	6.99	17.59*	23.39*	40.74*	591
DM	1.49	5.23*	8.16*	15.38*	184
MS	5.5	28.79*	37.52*	58.4*	822

p < 0.001 compared with non-dyslipidemia. DM: diabetes; MS: metabolic syndrome; ALD: alcoholic liver diseases; NAFLD: non-ALD. ^aAbnormality in only one lipid parameter; ^bAbnormality in two lipid parameters; ^cAbnormality in three or four lipid parameters (TC, TG, LDL-C, and HDL-C).

Figure 1. Age trends for mean TC and TG in females (dashed lines) and males (solid lines).**Figure 2.** Age trends for mean TC/HDL-C in females (dashed lines) and males (solid lines).**Table 2.** Prevalence of dyslipidemia (%).

	criteria (mmol/L)	males (age, years)						total
		18-39	40-59	≥60	18-39	40-59	≥60	
Hypercholesterolemia	≥5.18	13.56**	20.05	17.3**	5.73	19.18	32.62	17.3
	≥6.2	2.45*	4.57	3.8	0.98	3.55	7.44	
Abnormally high LDL-C	≥3.37	17.65*	33.93	31.8**	11.14	31.61	46.8	27.8
	≥4.14	4.24	7.14	6.57*	2.78	5.95	12.76	
Hypertriglyceridemia	1.7	28.92**	36.27**	32.18*	15.4	29.13	43.26	29.85
	≥2.26	16.99**	24.41**	17.3	5.9	16.51	22.69	
Abnormally low HDL-C	1.04	21.1**	13.6**	37*	7.5	8.3	6.4	11.66
Combined hyperlipidemia	TC≥5.18 and TG≥1.7	7.51**	11	11.07*	2.78	9.15	18.79	9.17

***p* < 0.001; **p* < 0.05, between males and females in the same age group by χ^2 tests.

3.2. The prevalence of dyslipidemia

Serum TC and TG tended to increase with age up to 50 years, after which it decreased gradually in males (Figure 1) but increased rapidly in females (Figure 2). TC and TG were higher in females than in males in the age groups >55 years. TC/HDL-C increased significantly with age, but began to decrease gradually after 30 years of age in males (Figure 2).

The prevalence of dyslipidemia in the study population is summarized in Table 2. The desired TC concentration is ≤5.18 mmol/L. In the 18–39 year age group, 13.56% males and 5.73% females had a higher serum TC value. In the 40–59 year age group, the prevalence was approximately 20% for both genders. In the ≥60 year age group, 17.3% of males and 32.62% of females had a TC value above the desired concentration threshold. On the basis of the diagnostic criteria for dyslipidemia

in China, high TC (TC ≥ 6.2 mmol/L) occurred in 2.45% of males and 0.98% of females in the 18–39 year age group, in 4.57% of males and 3.55% of females in the 40–59 year age group, and in 3.8% of males and 7.44% of females in the ≥60 year age group. The prevalence of high LDL-C followed the same trend as that for high TC. HDL-C was abnormally low more often in males than in females. As shown in Table 3, 28.9% of males and 15.4% of females 18–39 years old had hypertriglyceridemia, as did 36.27% of males and 29% of females in the 40–59 year age group. In the ≥60 year age group, the prevalence of hypertriglyceridemia was higher in females (43.26%). Across the age groups, the prevalence of combined hyperlipidemia was significantly lower than that of isolated high TG or isolated high TC.

Table 3. OR for dyslipidemia for various risk factors.

	Hyperlipidemia ^a			TC/HDL-C (>4.5)		
	OR	95% CI	p-value	OR	95% CI	p-value
Age (years)						
40-60 vs. ≤39	1.43	1.23-1.67	<0.001	1.74	1.38-2.1	<0.001
≥60 vs. ≤39	1.58	1.27-1.97	<0.001	1.94	1.45-2.6	<0.001
Gender						
female vs. male	0.59	0.54-0.65	<0.001	0.24	0.18-0.32	<0.001
Hypertension						
yes vs. no	1.45	1.24-1.68	<0.001	1.41	1.16-1.7	<0.001
BMI (kg/m ²)						
23-25 vs. <23	1.25	1.04-1.52	0.019	NS	NS	NS
≥25 vs. <23	1.51	1.21-1.87	<0.001	NS	NS	NS
Fatty liver						
yes vs. no	2.5	2.1-3.1	<0.001	1.97	1.48-2.6	<0.001
Physical exercise						
moderate vs. low	NS	NS	NS	0.66	0.41-1.05	0.08
high vs. low	NS	NS	NS	0.52	0.35-0.79	0.002
Education level						
High school vs. primary school	0.76	0.66-0.87	<0.001	0.6	0.44-0.84	0.003
University vs. primary school	0.86	0.67-1.1	0.02	0.5	0.29-0.87	0.01
Daily alcohol consumption	NS	NS	NS	0.65	0.47-0.89	0.009
Level 1 vs. level 0						
Level 2 vs. level 0	NS	NS	NS	0.45	0.25-0.81	0.007
Level 3 vs. level 0	NS	NS	NS	0.45	0.21-0.95	0.03

NS: No statistical significance $p > 0.05$ ^aAbnormality in at least one lipid parameter.^bAlcohol consumption: ⁰never; ¹<40g/day; ²40-80g/day; ³>80g/day.

3.3. The prevalence of dyslipidemia and associated risk factors

Table 3 shows the relationships between dyslipidemia and various risk factors, determined by binary logistic regression. In general, hyperlipidemia to a significant degree was positively correlated with age ($p < 0.001$), being male ($p < 0.001$), hypertension ($p < 0.001$), high BMI ($p < 0.001$), and fatty liver disease ($p < 0.001$). There were negative correlations with being female and education level. Abnormally high TC/HDL-C was more prevalent among those of higher age, fatty liver and males. It was less prevalent among females, those with greater physical activity, high school or university graduates and those who consumed alcohol.

4. Discussion

Dyslipidemia is a common health problem in developing countries, and its prevalence is rising steadily [14]. This fact is alarming in the face of the relationship between dyslipidemia and atherosclerotic disease [15]. Here

we report results of a large population-based study conducted in northeastern China. Levels of dyslipidemia were determined in adults and risk factors associated with dyslipidemia (gender, physical exercise level, education level, and so forth) was investigated.

We compare our results with those of two prior studies. In a 1983–1984 study in Beijing and Guangzhou, Shou evaluated mean levels of TC, LDL-C, HDL-C and TG. [16] In a 2005 study conducted in Beijing, Zhi reported that in the 50–55 year age range, the mean TC and TG levels were, respectively, 5.01 mmol/L and 2.12 mmol/L for men, and 5.25 mmol/L, 1.66 mmol/L for women. The mean HDL-C and LDL-C levels were, respectively, 1.23 mmol/L and 2.91 mmol/L for men, and 1.50 mmol/L and 3.08 mmol/L for women [17]. Our results (Figure 1) for lipid levels were higher than those of Shou, [16] but lower than those of Zhi [17]. We speculate that this is due to a higher standard of living in Beijing than in the Jilin province. Additionally, compared with surveys in other countries the plasma lipid levels of adults from northeastern China are lower than those in Germany, England, and the United States [18,20]. The

levels of HDL-C and TG are higher in our study than in these three countries, but are similar to levels measured in India [17].

The prevalence of high TC (≥ 5.18 mmol/L), high LDL-C (≥ 3.37 mmol/L), low HDL-C (≤ 1.04 mmol/L) and hypertriglyceridemia (defined in [13]) were 17.3%, 27.8%, 29.85%, and 11.66% respectively in the present study. Compared with other surveys in China, prevalence of dyslipidemia is higher than in Taiwan [22], but lower than in Beijing [17]. The prevalence of dyslipidemia also tends to be higher in Western than in Asian countries [14]. Over the past two decades, the prevalence of dyslipidemia has increased in economically developing countries for both men and women [23].

In our study, females had blood lipid parameters in the normal range more often than did males for ages between 18 and 55, but females older than 55 had less favorable blood lipid parameters than males. For ages 18-60 years, females had a more favorable distribution of cholesterol sub-fractions, as indicated by lower TC/HDL-C, than males. However, these results were reversed for ages >60 years. The exact mechanisms by which age impacts lipid levels are unknown. It may be that changes in hormone secretion in the postmenopausal period affect lipid metabolism, or lipid levels may be related to hereditary characteristics, degenerative processes, and lifestyle [26].

The results of some recent studies are consistent with ours [24,25]. In addition, the conclusion of an analysis of three large epidemiologic data sets, involving approximately 8000 individuals, was that TC/HDL-C was a better predictor of subsequent coronary heart disease (CHD) than LDL-C [27]. In our study (Figure 2), people over 60 years of age, especially females, with a high TC/HDL-C were at greater risk for CHD.

Hyperlipidemia is a major risk factor for cardiovascular disease [1,2]. As shown in Table 1, the prevalence of hypertension, central obesity, ALD, NALD, DM and MS was higher in serum lipid abnormality groups than in the non-dyslipidemia group ($p < 0.001$ in all cases). As abnormalities in lipid parameters increased, a significantly higher proportion of metabolic diseases occurred, accompanied by underlying pathophysiology related to insulin resistance. A study by Soda [28] showed that insulin resistance (especially hepatic insulin resistance) plays a critical and central role in the development of dyslipidemia and atherosclerosis.

However, plasma lipid and lipoprotein levels are also influenced by biological indices (age, gender, FBG, hypertension and so on) as well as environmental and lifestyle factors [29]. Our analysis using binary logistic regression showed that hyperlipidemia was positively correlated, to a significant degree, with age, being

male, hypertension, high BMI, and fatty liver disease. There were negative correlations with being female and education level. Abnormally high TC/HDL-C was more prevalent among those of greater age, fatty liver and males, and was less prevalent among females, those who were more physically active, high school or university graduates and those who consumed alcohol. All of the above risk factors (hypertension, high BMI, fatty liver, male, age and exercise levels) have also been identified as risk factors for CHD.

The OR for dyslipidemia was significantly greater among males in this logistic regression analysis model. Most studies state that dyslipidemia is more prevalent among men than women [17], but there are also studies indicating that the prevalence is greater among women than men [31]. The variation may be explained by differential distributions in risk factors (genetic predisposition, dietary factors, smoking, alcohol consumption, lack of physical activity) between women and men across populations. However, being male is an independent risk factor for CVD [30,32], and age is also strongly associated with dyslipidemia. Many studies have reported that the prevalence of dyslipidemia increases with age [31,33]. In our study, prevalence increased dramatically with age in both sexes.

Dyslipidemia exhibited a strong inverse association with levels of education in our study. These results are in agreement with other studies in the literature [34]. Low education levels were an independent risk factor for dyslipidemia in the present study. The high prevalence of dyslipidemia in the group with the lowest education level may result from risk factors such as stress, poor working conditions, and poor nutritional habits or these individuals may have greater difficulties in securing access to health care services [35].

5. Conclusion

Overall this study was the first to examine the clustering of various risk factors for dyslipidemia in a large number of adults in China. Dyslipidemia is a major risk factor for premature coronary artery diseases and an important public health issue in the northeastern part of China. Dyslipidemia is more frequent than expected based on previous studies. To control dyslipidemia, routine evaluations in clinics and community centers are needed, as well as effective public health education.

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