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Original Article

Exploration of dyslipidemia prevalence and its risk factors in a coastal city of China: a population-based cross-sectional study

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Abstract: Compared with inland inhabitants, coastal area residents have commonly owned specific customs that have been associated with dyslipidemia occurrence. However, few studies have been conducted on the field of dyslipidemia in coastal areas of China. Therefore, the present comprehensive field investigation was conducted in Ningbo, a coastal city located in the Southeast of China, aiming to explore the prevalence of dyslipidemia and its risk factors among residents aged 15-74 years. In this population-based cross-sectional study, a representative sample of 5,280 permanent participants was obtained. All selected participants were required to finish three items, including face-to-face questionnaires, physical indicator measurements, and blood specimen collection. Prevalence of dyslipidemia was 29.86% in this study. Male group and rural residents had a significantly higher risk for occurrence of dyslipidemia (male 36.55% vs female 24.32%; rural 31.90% vs urban 28.18%). Moreover, dyslipidemia prevalence presented an obvious upward trend with increasing age. Multivariate logistic regression analysis indicated that risk factors associated with dyslipidemia in diverse genders were inconsistent. For males, current smoking, diabetes patients, and residents with high BMIs were easily susceptible to occurrence of dyslipidemia. For females, hypertension patients and subjects with central obesity were more likely to suffer from dyslipidemia. Present results revealed that almost one third of the residents suffered from dyslipidemia in Ningbo City. Targeted interventions, such as controlling risk factors and strengthening dyslipidemia screening, should be conducted to prevent and control dyslipidemia.

Keywords: Dyslipidemia, risk factors, prevalence, epidemiology, coastal city of China

Introduction

Cardiovascular disease (CVD), a common chronic disease, presents a serious threat to human health, leading to severe disease burden for the whole family. Evidence from a Global Burden of Disease Study showed that nearly 17.6 million CVD deaths occurred and an estimated 353 million disability-adjusted life-years loss (DALYs) with CVD worldwide in 2016 [1, 2]. CVD has also contributed to serious disease burdens in Asian populations, particularly in China. According to findings of CVD in China, CVD has accounted for 45.01% of all diseases, reaching an estimated 38 million people [3].

Dyslipidemia is one of the important and modifiable risk factors significantly correlated with CVD occurrence [4, 5]. Previous studies have reported that effective management of patients with dyslipidemia can reduce incidence, mortality, and disease burden of CVD [6-9]. In China, due to the rapid development of economic levels and changes in eating habits and lifestyle, dyslipidemia prevalence has increased rapidly. Available studies have shown that dyslipidemia prevalence in China was 18.6% in 2002 [10]. It became 33.97% in 2010 [11] and in 2012 it had already reached 40.4% [12].

People living in coastal areas share specific customs that differ from inland inhabitants. However, few studies have examined dyslipidemia in the coastal areas of China. Therefore, the present comprehensive field survey was conducted in Ningbo, a coastal city located in the Southeast of China. This study aimed to explore epidemiological features of dyslipidemia and to provide basis for dyslipidemia control and prevention in coastal areas in China.

Materials and methods

Study population

In this survey, the age limit of the respondents was 15-74 years. Only permanent residents living in the local area for at least 6 months were eligible for this survey. Subjects with cognitive disorders or language disabilities and pregnant women were excluded from the survey. All respondents provided informed consent before conducting the investigation. This survey was approved by the Ethics Committee of the Ningbo Municipal Center for Disease Control and Prevention.

Sampling method

A multi-phase stratified cluster random sampling method was applied to select study subjects in all 10 counties of Ningbo municipality. Details of the sampling method were divided into 4 phases. Phase I: Ranked by the size of the population in each county, 3 towns were selected using the systematic sampling method in each part. Phase II: Two villages were further selected in included towns with the same method of Phase I. Phase III: In each sample village, every 105 households were categorized into one group based on their geographical location and the cluster sampling method was utilized to randomly select one group. A total of 80 households were randomly selected. Phase IV: Members with ages between 15-74 in each household, whose birthday was closest to the number of "15", were eligible respondents. The sample size of this survey was 4,752. In view of the 10% non-response rate, the planned sample size was 5,281. Finally, 5,280 permanent residents participated in the survey and 5,160 residents completed all items, with a response rate of 97.73%.

Data collection and measurements

Before the investigation, investigators attended the training sessions. Only those that passed the final test were be recruited into the investigation team. Training included introducing the purpose of this investigation, uniform requirements of the questionnaire survey, and a review of standardized methods of physical measurement and specimen collection. Data was collected through face-to-face interviews. Questionnaire information consisted of demographic characteristics, personal health-related behaviors and lifestyles, and occurrence of chronic diseases, such as hypertension, diabetes, and dyslipidemia. Physical measurements were adopted according to the recommendations of Chinese Center for Disease Control and Prevention. Measurements of height and weight were achieved via using the TZG model body height meter and the electronic weight scale of TANITA for HD-390 model, respectively. Waist circumference (WC) was measured twice at the midpoint of the horizontal position between the lower edge of the rib arch at the mid-axillary line and the upper edge iliac crest, with mean values calculated. Electronic sphygmomanometer of OMRON for HBP1300 model was utilized for blood pressure measurements. Each object was repeatedly measured 3 times, with an interval of 1 minute. The mean value was taken as the blood pressure. Venous blood specimens were collected after at least 10 hours of fasting in all subjects. Corresponding test items of all blood specimens included fasting blood glucose and four blood lipid items, involving total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG). These were assayed by Medical System Biotechnology Company, a professional testing company located in Ningbo City.

Definitions of variables

According to definitions of the 2007 Chinese Guidelines for the Prevention and Treatment of Dyslipidemia in adults, dyslipidemia was diagnosed as using lipid-lowering drugs or having one or more item of the followings: (a) High TC was defined as having TC levels $\geq$ 6.22 mmol/L; (b) Low HDL-C was defined as having HDL-C levels < 1.04 mmol/L; (c) High LDL-C was defined as having LDL-C levels $\geq$ 4.14 mmol/L; (d) High TG was defined as having TG levels $\geq$ 2.26 mmol/L [13]; (e) The calculation formula of non-high-density lipoprotein cholesterol (non-HDL-C) was the value of the TC minus the value of the HDL-C and non-HDL-C $\geq$ 4.9 mmol/L was judged as high non-HDL-C [14].

Statistical analysis

Two individuals recorded data, independently, using EpiData 3.0 software. A descriptive analysis was peformed to depict the general characteristics and to illustrate serum lipid levels in

Table 1. General characteristics of all study subjects

Characteristics	Male (n=2339)	Female (n=2821)	t (χ^2) value	*P* value
Waist circumference (cm)	84.78±8.91	79.16±9.11	22.67	<0.001
Age (years)	46.27±15.53	47.34±14.46	-2.57	0.011
FPG (mmol/L)	5.22±1.33	5.13±1.17	2.67	0.008
Glycosylated hemoglobin (%)	4.72±0.93	4.98±0.77	-11.13	<0.001
HDL-C (mmol/L)	1.27±0.31	1.38±0.30	-13.19	<0.001
LDL-C (mmol/L)	2.87±0.78	2.88±0.80	-0.17	0.863
TC (mmol/L)	4.83±0.97	4.89±0.98	-2.19	0.029
TG (mmol/L)	1.60±1.37	1.34±0.82	8.39	<0.001
SBP (mmHg)	132.23±16.9	127.97±18.13	8.66	<0.001
DBP (mmHg)	81.4±10.00	77.63±9.80	13.62	<0.001
BMI (kg/m^2)	23.99±3.20	23.40±3.38	6.46	<0.001
Non-HDL-C (mmHg)	3.57±0.95	3.52±0.96	1.97	0.049
Region, n (%)				
Urban	1281 (54.77)	1537 (54.48)	0.41	0.839
Rural	1058 (45.23)	1284 (45.52)		
Education level, n (%)				
Primary school and below	658 (28.13)	1043 (36.97)	46.23	<0.001
Junior and Senior school	1146 (49)	1240 (43.96)		
College and above	535 (22.87)	538 (19.07)		
Current drinking state, n (%)				
No	1160 (49.59)	2487 (88.16)	917.75	<0.001
Yes	1179 (50.41)	334 (11.84)		
Current smoking state, n (%)				
No	1114 (47.63)	2796 (99.11)	1846.15	<0.001
Yes	1225 (52.37)	25 (0.89)		
Hypertension[a], n (%)				
No	1358 (58.06)	1788 (63.38)	15.22	<0.001
Yes	981 (41.94)	1033 (36.62)		
Diabetes[B], n (%)				
No	2066 (88.33)	2523 (89.44)	1.59	0.207
Yes	273 (11.67)	298 (10.56)		
Central obesity[c], n (%)				
No	1702 (72.77)	1563 (55.41)	168.85	<0.001
Yes	637 (27.23)	1258 (44.59)		

[a]Hypertension was defined as self-reported history of hypertension diagnosis, or the mean of three times resting SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg. [B]Diabetes was defined as FBG ≥ 7.0 mmol/L and/or diagnosed of diabetes. [c]Central obesity referred to waist circumference ≥ 80 cm for female and ≥ 90 cm for male.

all participants with diverse characteristics. Student's t-test was utilized to examine differences between continuous variables and Chi-squared test was applied to evaluate differences in categorical variables. Multivariate logistic regression was used to identify potential influential factors associated with dyslipidemia. R software (version 3.4.1, The R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analyses and two-sided *P* values <0.05 indicate statistical significance.

Results

General characteristics of all study subjects

A total of 5,280 residents, aged 15-74 years, participated in the final investigation. A total of 5,160 residents completed all survey items, with a response rate of 97.73%. Mean values of glycosylated hemoglobin, HDL-C, and TC were significantly lower in males, contrasted with females, whereas the others seven indicators, including WC, fasting blood glucose (FPG), TG, systolic blood pressure (SBP), diastolic blood pressure (DBP), body mass index (BMI), and non-HDL-C, were prominently higher in males, compared with females. In addition, males had a higher proportion of current smoking, current drinking, and hypertension, while females displayed a higher proportion of central obesity. Information regarding general characteristics of study subjects is shown in **Table 1**.

Serum lipids levels of all study subjects

Average levels of five serum lipids, involving HDL-C, LDL-C, TC, TG, and non-HDL-C, among participants were 1.33±0.31, 2.88±0.79, 4.87±0.98, 1.46±1.11, and 3.54±0.96, respectively. Current smokers, hypertension patients, diabetes patients, residents with obesity, and central obesity patients had notably

Table 2. Serum lipids levels in all subjects with different characteristics in Ningbo

Characteristics	HDL-C (mmol/L)	LDL-C (mmol/L)	TC (mmol/L)	TG (mmol/L)	Non-HDL-C (mmol/L)
Region					
Urban	1.34±0.31**	2.89±0.80	4.88±0.99	1.44±1.11	3.54±0.98
Rural	1.31±0.31	2.86±0.77	4.86±0.96	1.49±1.11	3.55±0.94
Gender					
Male	1.38±0.30**	2.88±0.80	4.89±0.98*	1.34±0.82**	3.52±0.96*
Female	1.27±0.31	2.87±0.78	4.83±0.97	1.60±1.37	3.57±0.95
Age					
<35	1.34±0.31	2.67±0.78**	4.58±0.93**	1.19±0.83**	3.24±0.93**
35-44	1.30±0.30	2.79±0.77	4.73±0.96	1.43±1.16	3.43±0.94
45-54	1.33±0.31	2.95±0.78	4.97±0.96	1.56±1.26	3.65±0.96
55-64	1.31±0.31	3.05±0.75	5.11±0.93	1.62±1.27	3.80±0.90
≥65	1.33±0.32	2.99±0.78	5.04±0.97	1.61±0.92	3.71±0.95
Education level					
Primary school and below	1.33±0.32**	2.99±0.78**	5.05±0.98**	1.58±1.12**	3.72±0.96**
Junior and Senior school	1.31±0.30	2.85±0.78	4.82±0.96	1.47±1.18	3.50±0.94
College and above	1.35±0.32	2.74±0.79	4.69±0.96	1.24±0.89	3.34±0.95
Current drinking state					
Yes	1.32±0.32	2.88±0.76	4.90±0.95**	1.62±1.37	3.58±0.93
No	1.33±0.3	2.87±0.8	4.85±0.99	1.39±0.98	3.52±0.97
Current smoking state					
Yes	1.26±0.33**	2.93±0.78*	4.92±0.97*	1.73±1.54**	3.66±0.96**
No	1.35±0.30	2.86±0.79	4.85±0.98	1.37±0.91	3.50±0.96
Hypertension					
Yes	1.30±0.31**	3.00±0.79**	5.05±0.98**	1.72±1.36**	3.75±0.97**
No	1.34±0.31	2.79±0.78	4.75±0.96	1.29±0.88	3.41±0.93
Diabetes					
Yes	1.24±0.29**	2.97±0.80**	4.98±1.01**	1.86±1.49**	3.74±0.99**
No	1.34±0.31	2.86±0.79	4.85±0.97	1.41±1.04	3.52±0.95
BMI					
<18.5	1.50±0.34**	2.45±0.71**	4.47±0.91**	0.97±1.25**	2.97±0.83**
18.5≤BMI<24	1.38±0.31	2.79±0.78	4.78±0.95	1.26±0.78	3.40±0.92
24≤BMI<28	1.26±0.29	3.01±0.76	5.01±0.97	1.71±1.25	3.75±0.94
BMI≥28	1.20±0.27	3.08±0.84	5.04±1.06	1.95±1.66	3.84±1.04
Central obesity					
Yes	1.27±0.28**	3.04±0.79**	5.05±1.00**	1.75±1.37**	3.78±0.98**
No	1.36±0.32	2.78±0.77	4.76±0.95	1.29±0.88	3.40±0.92

*p<0.05 and **p<0.01 in comparison of serum lipids levels among participants with different characteristics.

higher lipids levels for LDL-C, TC, TG, and non-HDL-C, but had significantly lower HDL-C levels. Details are presented in **Table 2**.

Gender, region, and age diversity in prevalence of dyslipidemia

In Ningbo, prevalence of dyslipidemia from the included population was 29.86%. Male group and rural residents were more likely to suffer from dyslipidemia. Dyslipidemia prevalence presented an obvious upward trend with increasing age. Additionally, prevalence of low HDL-C, high LDL-C, high TC, high TG, and high non-HDL-C was 12.40%, 6.28%, 8.90%, 13.08%, and 7.93% in this study, respectively. Prevalence of five lipids subtypes grouped by gender, region, and age are depicted in **Table 3** and **Figure 1**. Regarding diverse genders, the proportion of high TG and low HDL-C was significantly higher in males than in females, while high LDL-C was significantly higher in females,

Table 3. Prevalence of dyslipidemia and its subtypes in all participants by gender, region and age

Characteristics	Low HDL-C	High LDL-C	High TC	High TG	High Non-HDL-C	Dyslipidemia
Total	640 (12.40)	324 (6.28)	459 (8.90)	675 (13.08)	409 (7.93)	1541 (29.86)
Age-gender standardized	12.47	5.35	7.44	11.48	6.86	28.27
Gender						
Male	419 (17.91)	129 (5.52)	189 (8.08)	368 (15.73)	187 (7.99)	855 (36.55)
Female	221 (7.83)	195 (6.91)	270 (9.57)	307 (10.88)	222 (7.87)	686 (24.32)
X^2 value	119.58	4.24	3.51	26.46	0.03	91.41
P value	<0.001	0.039	0.061	<0.001	0.868	<0.001
Region						
Urban	302 (10.72)	183 (6.49)	252 (8.94)	348 (12.35)	214 (7.59)	794 (28.18)
Rural	338 (14.43)	141 (6.02)	207 (8.84)	327 (13.96)	195 (8.33)	747 (31.90)
X^2 value	16.25	0.49	0.02	2.93	0.94	8.45
P value	<0.001	0.485	0.896	0.087	0.332	0.004
Age						
<35	153 (10.56)	54 (3.73)	68 (4.69)	98 (6.76)	71 (4.90)	320 (22.08)
35-44	91 (13.66)	36 (5.41)	52 (7.81)	89 (13.36)	42 (6.31)	207 (31.08)
45-54	179 (13.18)	100 (7.36)	130 (9.57)	206 (15.17)	114 (8.39)	424 (31.22)
55-64	129 (13.33)	82 (8.47)	122 (12.60)	151 (15.60)	110 (11.36)	338 (34.92)
≥65	88 (12.24)	52 (7.23)	87 (12.10)	131 (18.22)	72 (10.01)	252 (35.05)
X^2 value	7.04	28.63	58.85	78.22	40.95	64.57
P value	0.134	<0.001	<0.001	<0.001	<0.001	<0.001

compared to males. Concerning distinctive regions, rural residents had a higher risk for occurrence of low HDL-C. In various age groups, the upward trend was only discovered for the prevalence of high TG with increasing age.

Analysis of influence factors related to dyslipidemia by gender

After adjusting for confounding factors, multivariate logistic regression analysis was conducted to examine related risk factors of dyslipidemia among male and female residents in Ningbo City (**Table 4**). Results indicated that some features, like living in the rural region, current smoking, diabetes patients, and residents with high BMI, were easily susceptible to occurrence of dyslipidemia in male. Male residents that drank currently had lower risk for occurrence of dyslipidemia. For females, hypertension patients and subjects with central obesity were more likely to suffer from dyslipidemia. Current drinking was negatively associated with dyslipidemia.

Discussion

Prevalence of dyslipidemia has risen rapidly in China. Previous studies have implied that prevalence of dyslipidemia increased from 18.6% in 2002 to 40.4% in 2012 [10, 12]. However, dyslipidemia studies undertaken in coastal areas of China have been limited. This current investigation provides a comprehensive analysis of the prevalence and its influencing factors of dyslipidemia in coastal areas. Results showed that the age-gender standardized prevalence of dyslipidemia was 28.27% in Ningbo, lower than national survey results [12] and lower than available findings reported by several other Chinese cities [15-18]. This phenomenon might be related to the diversity of economic levels and dietary patterns in coastal areas. According to the per capita GDP, the economic level of Ningbo has reached the level of a developed country. Along with the economic level, Ningbo residents have abundant health resources and have an increased health awareness. In addition, the dietary patterns of people in Ningbo are close to the Mediterranean diet, consuming ample seafood.

Interestingly, prevalence of high TG was 13.08%, which was highest among the five dyslipidemia subtypes. Higher levels of TG could cause atherosclerosis and several chronic diseases like myocardial infarction, ischemic stroke, and ischemic heart disease [19-24]. Thus, focus should be shifted to prevention and control of this principal subtype. In

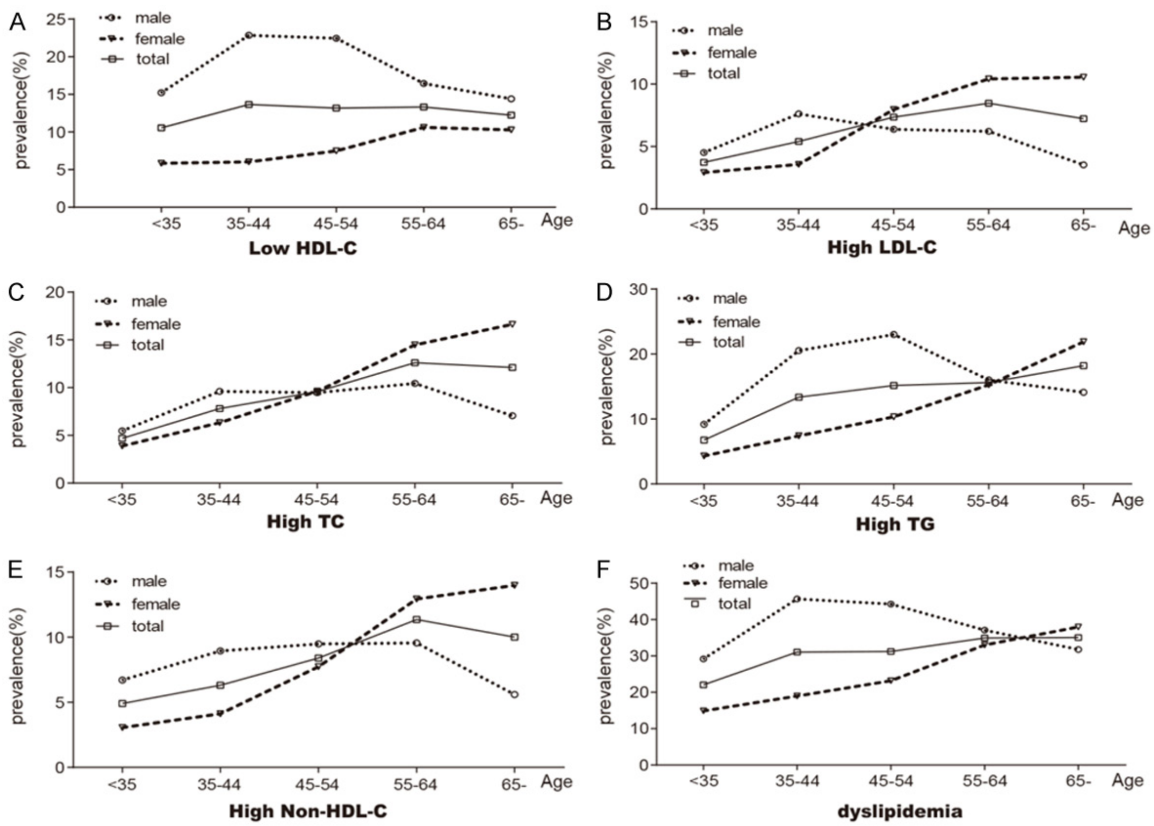

Figure 1. Trends in age-gender specific prevalence of dyslipidemia and its subtypes in all participants.

addition, guidelines at home and abroad have emphasized that LDL-C plays a vital role in the development of atherosclerotic cardiovascular disease [14, 25-28]. Fortunately, the prevalence of high LDL-C was the lowest among the five subtypes of dyslipidemia in Ningbo City.

Compared with urban residents, rural residents showed a significantly higher prevalence of dyslipidemia. This might be explained by the fact that rural residents have poorer health consciousness and unhealthy lifestyles. Males had a higher prevalence of dyslipidemia because the prevalence of the top two subtypes of dyslipidemia, high TG and low HDL-C, was significantly higher in males than in females. Age analysis indicated that residents over 55 had the peak prevalence for four subtypes of dyslipidemia, except Low HDL-C. In view of these findings, rural residents, male residents, and residents over 55 years are targeted populations for dyslipidemia intervention.

The current study found that prevalence of high LDL-C, high TC, high TG, high non-HDL-C, and total dyslipidemia in females exceeded that of males with age, especially for people aged 65 and above. Only prevalence of low HDL-C was higher in men than in women in all age groups. This outcome indicates that, although males were more likely to suffer from dyslipidemia than females, more attention should be paid to elderly females for dyslipidemia intervention.

Multivariate logistic regression analyses showed that male obesity residents and female central obesity residents were more likely to suffer from dyslipidemia. Thus, BMI and WC could be applied as the simple screening indicators to examine dyslipidemic individuals among Ningbo residents. This study found that hypertension patients and current smokers in male and female diabetic patients had greater odds ratios (OR) of having dyslipidemia. Previous studies have reported that the aggregative phenomenon of combinations of risk factors for cardiovascular disease, involving hypertension, diabetes, obesity, and smoking, was discovered, especially in the elderly [29-31]. Prior studies have also indicated that controlling risk factors could reduce the risk of cardio-

Table 4. Identification of related influence factors leading to dyslipidemia by gender in Ningbo City by multivariate logistic regression analysis

Characteristics	Male		Female	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Region				
Urban	1	0.034	1	0.073
Rural	1.226 (1.016-1.479)		1.185 (0.984-1.426)	
Age				
<35	1		1	
35-44	1.787 (1.325-2.41)	<0.001	1.034 (0.722-1.479)	0.856
45-54	1.635 (1.232-2.17)	0.001	1.057 (0.768-1.455)	0.733
55-64	1.224 (0.882-1.7)	0.226	1.392 (0.973-1.99)	0.070
≥65	0.976 (0.676-1.409)	0.899	1.542 (1.045-2.276)	0.029
Education level				
Primary school and below	1		1	
Junior and Senior school	1.010 (0.796-1.28)	0.937	0.806 (0.650-1.000)	0.050
College ane above	1.495 (1.075-2.079)	0.017	0.616 (0.423-0.896)	0.011
Current drinking state				
No	1		1	
Yes	0.819 (0.679-0.988)	0.037	0.607 (0.449-0.819)	0.001
Current smoking state				
No	1		1	
Yes	1.560 (1.280-1.901)	<0.001	1.59 (0.674-3.752)	0.290
Hypertension				
No	1		1	
Yes	1.056 (0.859-1.298)	0.605	1.352 (1.095-1.67)	0.005
Diabetes				
No	1		1	
Yes	1.599 (1.212-2.109)	0.001	1.098 (0.833-1.448)	0.507
BMI				
<18.5	1		1	
18.5≤BMI<24	2.068 (1.072-3.991)	0.030	1.427 (0.78-2.611)	0.249
24≤BMI<28	4.341 (2.229-8.453)	<0.001	1.935 (1.027-3.646)	0.041
BMI≥28	5.875 (2.849-12.115)	<0.001	2.028 (1.025-4.012)	0.042
Central obesity				
No	1		1	
Yes	1.212 (0.960-1.531)	0.106	1.578 (1.260-1.975)	<0.001

vascular disease morbidity and mortality [32-34]. Therefore, comprehensive prevention and control measures, targeting common risk factors, should be taken to decrease cardiovascular disease risks [35, 36].

There were, however, several limitations to the current study. This was a cross-sectional study. The causal relationship between dyslipidemia and influencing factors could not be derived. This present study did not include the content of detailed dietary status, thus it was unable to analyze the correlation between dietary status and dyslipidemia. Diagnostic criteria for dyslipidemia were based on domestic diagnostic criteria. Therefore, present results could not be compared with results of other countries. Finally, due to a low proportion of partial dyslipidemia subtypes, analysis of combined dyslipidemia subtypes could not be carried out.

Conclusion

In summary, present results show that nearly one third of the residents suffer from dyslipidemia in Ningbo City. Prevalence of high TG was highest among the five dyslipidemia subtypes. Current smoking, diabetes, and obesity in males and hypertension and central obesity in females were modifiable risk factors for dyslipidemia. Targeted interventions, such as controlling modifiable risk factors and strengthening dyslipidemia screening, should be conducted to prevent and control dyslipidemia.

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Disclosure of conflict of interest

None.

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