ORIGINAL ARTICLE

Prevalence and factors associated with non-high density lipoprotein cholesterol among Thai adults in Khon Kaen Province of Northeastern Thailand

Pornpimon Chupanit[1], Benja Muktabhant[2] and Frank Peter Schelp[3]

[1] *Dr.P.H. Candidate. Faculty of Public Health, Khon Kaen University, Thailand*
[2] *M.Sc. (Nutrition), Faculty of Public Health, Khon Kaen University, Thailand*
[3] *D.med.Sc. (Hon), D.T.M &H., Faculty of Public Health, Khon Kaen University, Thailand*

Corresponding author: *Benja Muktabhant* ***E-mail:*** *benja@kku.ac.th*
Received: *19 March 2017* ***Revised:*** *17 April 2017* ***Accepted:*** *30 April 2017*
Available online: *April 2017*

Abstract

Chupanit P, Muktabhant B and Schelp FP.
Prevalence and factors associated with non-high density lipoprotein cholesterol among Thai adults in Khon Kaen Province of Northeastern Thailand
J Pub Health Dev.2017;15(1):49-61

The presence of elevated non-high density lipoprotein cholesterol (non-HDL-C) is considered to indicate a risk for cardiovascular diseases. The purpose of this study was to determine the prevalence of high non-HDL-C level and to explore factors associated with non-HDL-C among northeastern Thai adults. A cross-sectional study was carried out among 444 Thai adults aged 35 to 60 years living in Khon Kaen Province, Northeastern Thailand. A cluster random sampling was used to select subjects. The lipid blood parameters measured were total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). The level of non-HDL-C was calculated by subtracting HDL-C from TC. The Pearson's correlation was used to examine the correlation between non-HDL-C levels with metabolic risk factors and multiple logistic regressions were used to define factors associated with non-HDL-C.

The results showed that the mean age of the participants was 49.1 years and that 70.5% of the participants were women. The proportion of participants with high non-HDL-C (≥ 160 mg/dL) was 40.1%. Non-HDL-C level was positively correlated with metabolic risk factors including waist circumference, systolic and diastolic blood pressure, triglyceride, and LDL-C level. Multiple logistic regression showed that high non-HDL-C were significantly correlated with increasing age (Adj.OR = 2.15, 95% CI = 1.42 – 3.25), high body mass index (Adj.OR = 1.98, 95% CI =1.33 – 2.96), and abdominal obesity (Adj.OR = 1.93, 95% CI =1.28 – 2.90).

These findings confirm that obesity is commonly associated with the risk indicator of high non-HDL-C. Further research is needed to find effective prevention programmes for reducing obesity and increasing healthy lifestyles.

Keywords: non-high density lipoprotein cholesterol, prevalence, factors, Thai adults, Northeastern

วารสารสาธารณสุขและการพัฒนา
ปีที่ 15 ฉบับที่ 1 มกราคม-เมษายน 2560

ความชุกและปัจจัยที่สัมพันธ์กับระดับไขมันคอเลสเตอรอลอื่นที่ไม่ใช่ชนิดเอชดีแอลในผู้ใหญ่ไทย จังหวัดขอนแก่น ภาคตะวันออกเฉียงเหนือ ประเทศไทย

พรพิมล ชูพานิช[1], เบญจา มุกตพันธุ์[2] และฟรังค์ เพเทอร์ เชลพ์[3]

[1] *Dr.P.H. Candidate. คณะสาธารณสุขศาสตร์ มหาวิทยาลัยขอนแก่น, ประเทศไทย*
[2] *M.Sc. (Nutrition), คณะสาธารณสุขศาสตร์ มหาวิทยาลัยขอนแก่น, ประเทศไทย*
[3] *D.T.M &H., D.Sc. (Hon), คณะสาธารณสุขศาสตร์ มหาวิทยาลัยขอนแก่น, ประเทศไทย*

บทคัดย่อ

พรพิมล ชูพานิช, เบญจา มุกตพันธุ์ และฟรังค์ เพเทอร์ เชลพ์
ความชุกและปัจจัยที่สัมพันธ์กับระดับไขมันคอเลสเตอรอลอื่นที่ไม่ใช่ชนิดเอชดีแอลในผู้ใหญ่ไทย
จังหวัดขอนแก่น ภาคตะวันออกเฉียงเหนือ ประเทศไทย
ว สาธารณสุขและการพัฒนา. 2560;15(1):49-61

การมีระดับไขมันคอเลสเตอรอลอื่นที่ไม่ใช่ชนิดเอชดีแอลในเลือดสูง (non-HDL-C) ทำให้เกิดความเสี่ยงต่อโรคหัวใจและหลอดเลือด การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อหาความชุกของระดับไขมัน non-HDL-C ในเลือดสูง และวิเคราะห์หาปัจจัยที่สัมพันธ์กับระดับไขมัน non-HDL-C ในเลือดสูง รูปแบบการศึกษาแบบภาคตัดขวางในกลุ่มตัวอย่างผู้ใหญ่ 444 คน อายุระหว่าง 35 ถึง 60 ปี ที่อาศัยอยู่ในจังหวัดขอนแก่น ภาคตะวันออกเฉียงเหนือของประเทศไทย การเลือกกลุ่มตัวอย่างโดยวิธีสุ่มแบบแบ่งกลุ่ม การตรวจวัดไขมันในเลือด ได้แก่ คอเลสเตอรอลรวม ไตรกลีเซอไรด์ และเอชดีแอลคอเลสเตอรอล สำหรับ non-HDL-C ได้มาจากการคำนวณโดยการนำค่าเอชดีแอลคอเลสเตอรอลหักลบออกจากค่าคอเลสเตอรอลรวม หาค่าสัมประสิทธิ์สหสัมพันธ์ของเพียร์สันระหว่างระดับไขมัน non-HDL-C กับปัจจัยเสี่ยงทางเมตาบอลิก และใช้การวิเคราะห์ถดถอยโลจิสติกพหุคูณหาปัจจัยที่สัมพันธ์กับระดับไขมัน non-HDL-C ในเลือดสูง

ผลการศึกษาพบว่ากลุ่มตัวอย่างมีอายุเฉลี่ยที่ 49.1 ปีและส่วนใหญ่เป็นผู้หญิง ร้อยละ 70.5 สัดส่วนกลุ่มตัวอย่างที่มีระดับไขมันแบบ non-HDL-C ในเลือดสูง (≥ 160 มิลลิกรัม / เดซิลิตร) พบร้อยละ 40.1 ระดับไขมันแบบ non-HDL-C ในเลือดมีความสัมพันธ์เชิงบวกกับปัจจัยเสี่ยงทางเมตาบอลิก ได้แก่ เส้นรอบวงเอว ความดันโลหิตซิสโตลิคและไดแอสโตลิค ระดับไตรกลีเซอไรด์ และระดับแอลดีแอลคอเลสเตอรอล เมื่อวิเคราะห์ด้วยการถดถอยโลจิสติกพหุคูณพบว่าปัจจัยที่มีความสัมพันธ์กับระดับไขมันแบบ non-HDL-C ในเลือดสูง อย่างมีนัยสำคัญทางสถิติ ได้แก่ อายุ (Adj.OR = 2.15, 95% CI = 1.42 – 3.25) ดัชนีมวลกายที่เพิ่มมากขึ้น (Adj.OR = 1.98, 95% CI =1.33 – 2.96) และโรคอ้วนแบบลงพุง (Adj.OR = 1.93, 95% CI =1.28 – 2.90).

การศึกษานี้ยืนยันว่าโรคอ้วนเกี่ยวข้องกับความเสี่ยงของระดับไขมันแบบ non-HDL-C ในเลือดสูง ในการวิจัยครั้งต่อไปควรศึกษาเพิ่มเติมเกี่ยวกับโปรแกรมการป้องกันที่มีประสิทธิภาพในการลดความอ้วนและเพิ่มวิถีสุขภาพที่ดี

คำสำคัญ: คอเลสเตอรอลอื่นที่ไม่ใช่ชนิดเอชดีแอล ความชุก ปัจจัย ผู้ใหญ่ไทย ภาคตะวันออกเฉียงเหนือ

Introduction

Dyslipidemia is associated with a major risk of cardiovascular diseases (CVDs)[1]. A high prevalence and inadequate management of dyslipidemia has been reported[2-3]. The prevalence of dyslipidemia differs by gender, ethnicity and geographic region. Recently it was suggested that non-high density lipoprotein cholesterol (non-HDL-C) is a more valid indicator for the risk of CVDs than low-density lipoprotein cholesterol (LDL-C)[4-5]. Non-HDL-C represents all atherogenic lipoprotein particles, consisting of small dense LDL-C, very low-density lipoprotein cholesterol (VLDL-C), intermediate-density lipoprotein cholesterol (IDL-C), and lipoprotein (a) as well as chylomicrons remnants[6]. Non-HDL-C can be easily assessed without further costs simply by subtracting high density lipoprotein cholesterol (HDL-C) from total cholesterol (TC) levels.

The Thai National Health Examination Survey IV in 2009 reported a high prevalence of dyslipidemia within the Thai population, especially in the north and northeast regions, with a high prevalence of low HDL-C (47.1%), elevated triglyceride (38.6%), and elevated non-HDL-C (32.6%)[7]. In addition, a retrospective cohort study with patients after an acute myocardial infarction (AMI) indicated that high non-HDL-C was associated with long-term major adverse cardiovascular events[4]. Recent studies showed that non-HDL-C levels varied according to sex, age, ethnicity, and obesity status measured by the body mass index (BMI) and waist circumference (WC)[8-10]. In Thailand, blood lipid levels including high non-HDL-C levels differed significantly according to sex, living in urban or rural areas, and between geographic regions[7, 11]. However, very few studies were conducted to evaluate factors correlated with high non-HDL-C in Thai adults. The working hypothesis of this study assumed that age, sex, physical activity, obesity status, smoking status, and family history are associated with high non HDL-C in Thai adults. The aim of this investigation was to determine the prevalence of high non-HDL-C level and to explore factors associated with high non-HDL-C among a randomly selected group of Thai adults from one district from the northeastern province Khon Kaen.

Methods

Study design and subjects

This was a cross-sectional study of Thai adults aged 35 – 60 years living in Nam Phong District, Khon Kaen Province, in the northeast of Thailand. Nam Phong , a semi-urban district, is located about 43 km north of the Khon Kaen municipality. A two-stage cluster random sampling was conducted to select study participants. At the first stage, simple random sampling was used to choose 50 villages from 12 sub-districts. At the second stage, the subjects were recruited from those villages based on a probability proportional to size sampling method. Individuals under lipid-lowering therapy and suffering from cardiovascular disease or other serious health conditions were excluded. A total of 444 individuals were included into this investigation. The study protocol was approved by the Ethical Committee for human research at the Khon Kaen University (HE552143). Participants willingly signed a consent form before enrolment into the study.

Data collection

Demographic variables such as age, gender, physical activity, smoking status, and family history of diabetes mellitus (DM), hypertension (HT), or dyslipidemia for a first-degree relative were recorded. Anthropometric measurements included weight, height, and WC. The BMI was calculated by weight in kilograms divided by height squared in meters. WC was measured in the horizontal plane midway between the lower lib margin and the iliac crest. Abdominal obesity was defined as WC 90 cm and more for men and 80 cm and more for women. Blood pressure (BP) was measured two times by using a standardized automatic blood pressure device after the participant rested for at least 5 minutes. Physical activity (PA) was assessed by using the Global Physical Activity Questionnaire (GPAQ) and PA was categorized as low, moderate, or vigorous level according to the guidelines[12].

Blood specimens were drawn after an overnight fasting, and all specimens were analyzed by a central laboratory at the Faculty of Medicine, Srinagarind Hospital, Khon Kaen University to determine levels of total cholesterol (TC), triglyceride (TG), and HDL-C. TC, TG and HDL-C were measured by using an automatic analyzer (Roche Diagnostics, Mannheim, Germany). An estimation of LDL-C level was calculated by using the Friedewald formula based on TG ≤ 400 mg/dL. Non-HDL-C was calculated by total cholesterol minus HDL-C. The cutoff point for high non-HDL-C was defined as non-HDL-C ≥ 160 mg/dL according to The National Cholesterol Education Program Adult Treatment Panel III (the NCEP ATP III) guidelines[13]. Fasting blood glucose (FBG) was measured and categorized as impaired FBG (≥ 100 mg/dL).

Statistical analysis

All statistical analyses were performed using software Stata version 13 (Stata Corp, College Station, TX, USA). For baseline characteristics, the categorical variables were summarized in numbers and percentages and the continuous variables as means and standard deviations.

The Pearson correlation coefficient was used to assess the linear correlation of non-HDL-C with metabolic risk factors. Statistical significance was set as p-value < 0.05. Non-HDL-C levels were classified to the dependent binary variables. The Chi-square was performed to evaluate the association between potential related factors with non-HDL-C. To control confounding factors, variables significant at the p < 0.25 (two-sided) level from the Chi-square test were included in a multiple logistic regression using backward elimination. Statistical significance in the multiple logistic regressions was set at p < 0.05. The magnitude of association was presented in the form of odds ratios and 95% confidence intervals (95% CI).

Results

The baseline characteristics for all participants are shown in Table1. The mean age of the participants was 49.1 ± 6.4 years: 38.1% were aged 35 – 47 years, and 61.9% were aged 48 – 60 years. The majority were women (70.5%). The proportions of obesity and abdominal obesity were moderately high (46.2% and 53.2%, respectively). Over half of the participants had a vigorous level of physical activity (53.6%), almost 20% were smokers, and 45.9% reported that they had a first-degree family member with a history of diabetes mellitus, hypertension, or dyslipidemia.

Table 1 Distribution of the 444 participants by baseline characteristics

Characteristics	Number (%)	Mean (SD)	Median (QD)
Gender			
Men	131 (29.5)	-	-
Women	313 (70.5)	-	-
Age		49.1 (6.4)	50 (5)
35 – 47 yrs	169 (38.1)	-	-
48 – 60 yrs	275 (61.9)	-	-
Blood pressure (mmHg)			
Systolic BP	-	127.7 (17.6)	124.5 (11.6)
Diastolic BP	-	75.8 (9.8)	75.3 (6)
BMI (kg/m^2)		25.1 (4.0)	24.6 (2.6)
BMI < 25 kg/m^2	239 (53.8)	-	
BMI ≥ 25 kg/m^2	205 (46.2)	-	
Waist circumference (cm.)		84.3 (10.4)	84.3 (7.9)
Normal	208 (46.9)	-	-
Abdominal obesity	236 (53.2)	-	-
Physical activity			
Low	95 (21.4)	-	-
Moderate	111 (25.0)	-	-
Vigorous	238 (53.6)	-	-
Smoking status			
No	360 (81.1)	-	-
Yes	84 (18.9)	-	-
Family history of DM, HT, or dyslipidemia			
No	240 (54.1)	-	-
Yes	204 (45.9)	-	-

The prevalence of individuals with high non-HDL-C was 40% (Table 2). The proportions in terms of other lipid parameters were 43.7% for high TC, 38.5% for high TG, 41.2% for high LDL-C, and 61.3% for low HDL-C. Impaired fasting blood glucose was found for 10% of the participants.

Table 2 Lipid profiles and fasting blood glucose of the 444 participants

Blood samples	Number (%)	Mean (SD)	Median (QD)
Non-HDL-C		152.7 (46.0)	148.3 (30.1)
< 160 mg/dL	266 (59.9)		
≥ 160 mg/dL	178 (40.1)		
Total cholesterol		196.6 (49.2)	193.9 (31.6)
< 200 mg/dL	250 (56.3)		
≥ 200 mg/dL	194 (43.7)		
Triglyceride		145.3 (70.0)	128.6 (44.4)
< 150 mg/dL	273 (61.5)		
≥ 150 mg/dL	171 (38.5)		
LDL-C		123.6 (42.4)	120.5 (27.4)
< 130 mg/dL	261 (58.8)		
≥ 130 mg/dL	183 (41.2)		
HDL-C		43.9 (12.2)	42.9 (8.2)
men ≥ 40 mg/dL and women ≥ 50 mg/dL	172 (38.7)		
men < 40 mg/dL and women < 50 mg/dL	272 (61.3)		
Fasting blood glucose		90.2 (25.7)	84.9 (7.9)
< 100 mg/dL	382 (86.0)		
≥ 100 mg/dL	62 (14.0)		

The correlations of non-HDL-C with metabolic risk factors are shown in Table 3. Non-HDL-C was positively correlated with waist circumference, systolic and diastolic BP, TG levels, and LDL-C levels, but was not significantly associated with FBG.

Table 3 Correlations of non-HDL-C with metabolic risk factors

Factors	r*	p-value*
Waist circumference	0.1470	< 0.002
Systolic BP	0.1817	< 0.001
Diastolic BP	0.2579	< 0.001
FBG	-0.0347	0.466
TG	0.3983	< 0.001
LDL-C	0.9531	< 0.001

* Pearson's correlation coefficient

Without adjusting for covariates, statistically significant associations with elevated non-HDL-C levels were found for age, BMI and waist circumference (Table 4). The age group of 48 – 60 yrs was 2.07 times more likely than the younger age group to have an increased risk of elevated non-HDL-C levels (95% CI: 1.38 to 3.11). The risk of having high non-HDL-C was 1.97 times (95% CI: 1.34 to 2.89) higher for Thai adults with a BMI of 25 kg/m^2 or greater than those with a BMI lower than 25 kg/m2. Abdominal obesity increased the risk of elevated non-HDL-C level by 1.94 times (95% CI: 1.32 to 2.86).

Table 4 Factors associated with non-HDL-C

Factors	Non-HDL-C		Crude OR	95% CI	p-value
	High n (%)	Normal n (%)			
Age					
35 – 47 yrs	50 (29.6)	119 (70.4)	1.00		
48 – 60 yrs	128 (46.6)	147 (53.4)	2.07	1.38 – 3.11	< 0.001
Gender					
Men	49 (37.4)	82 (62.6)	1.00		
Women	129 (41.2)	184 (58.8)	1.17	0.77 – 1.78	0.455
Body mass index					
BMI < 25 kg/m^2	78 (32.6)	161 (67.4)	1.00		
BMI ≥ 25 kg/m^2	100 (48.8)	105 (51.2)	1.97	1.34 – 2.89	< 0.001
Waist circumference					
Normal	65 (31.7)	142 (68.3)	1.00		
Abdominal obesity	113 (47.5)	124 (52.5)	1.94	1.32 – 2.86	< 0.001
Physical activity					
Low	44 (46.3)	51 (53.7)	1.00		
Moderate	44 (36.6)	67 (63.4)	0.76	0.44 – 1.32	0.335
Vigorous	90 (37.8)	148 (62.2)	0.70	0.44 – 1.14	0.154
Smoking status					
No	144 (40.0)	216 (60.0)	1.00		
Yes	34 (40.5)	50 (59.5)	1.02	0.63 – 1.66	0.936
Family history of DM, HT, or dyslipidemia					
No	88 (36.7)	152 (63.3)	1.00		
Yes	90 (44.1)	114 (55.9)	1.36	0.93 – 2.00	0.111

The results after adjusting for potential confounders are shown in Figure 1. The age group of 48 – 60 yrs were significantly associated with elevated non-HDL-C levels (adjusted OR 2.15; 95% CI = 1.42 to 3.25), those with a BMI of ≥ 25 kg/m^2 had an approximately two times higher risk for elevated non-HDL-C levels than non-obese participants (adjusted OR 1.98; 95% CI = 1.33 to 2.96), and similarly, participants with abdominal obesity were nearly twice as likely to be at risk for high non-HDL-C than those with a normal waist circumference (adjusted OR 1.93; 95% CI = 1.28 to 2.90).

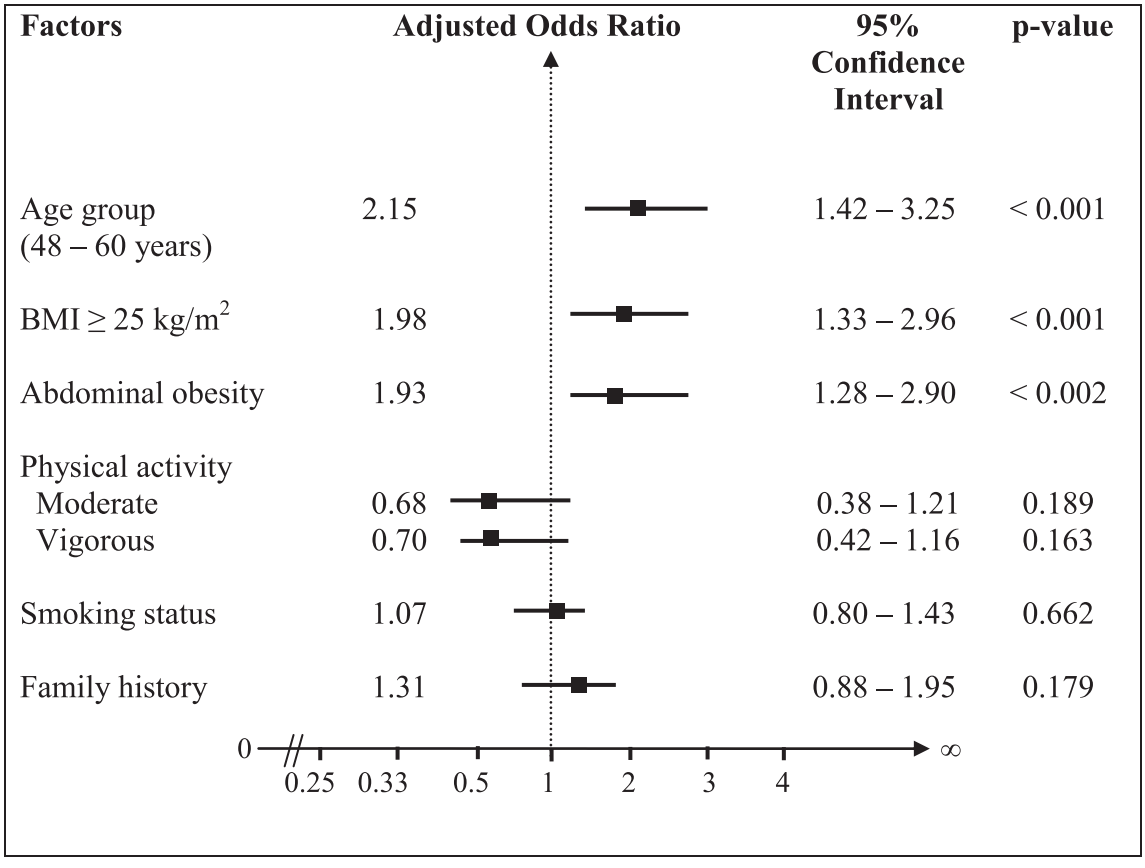

Figure 1 The association between factors and high non-HDL-C after adjusting for age, physical activity, smoking status, and family history of DM or HT or dyslipidemia.

Discussion

In this study, factors strongly associated with elevated non HDL-C levels were higher for the age range above 47 years and obesity. Non HDL-C value was positively correlated with various metabolic risk factors, namely waist circumference, systolic and diastolic BP, TG levels, and LDL-C levels.

Several population-based studies have indicated that blood cholesterol concentration is likely to increase with age[14-15], and that is confirmed here. The results in the present study are similar to those obtained by an epidemiologic study conducted at the Khon Kaen Province, which found that the prevalence of dyslipidemia increased with advancing age[16]. The association between increasing age and dyslipidemia are controversially discussed. It was argued that cholesterol metabolism declines in older age and this results in high blood cholesterol concentrations. It was also suggested that age-related obesity due to lifestyle changes might be to blame for increasing cholesterol levels. Lifestyle changes appear to have arisen as a consequence of the social and economic effects of urbanization and a more sedentary lifestyle with an oversupply of energy intake going along with changes in patterns of food consumption resulting in a rapidly increasing burden of non-communicable

diseases (NCDs)[17]. However, this study was not assessed dietary consumption of participants which it might be associated factors with non-HDL-C.

The association of obesity with CVDs is partly due to atherogenic dyslipidemia, for instance high TG and low-HDL-C. The results presented here indicated that general and abdominal obesity are associated with the risk of elevated non HDL-C levels. This finding is consistent with those of previous studies which reported that in both Thai adults[18] and Thai children[19] increasing BMIs and waist circumferences were associated with higher lipid concentrations, but not with HDL-C levels. In addition, a large multi-national study of 27 different populations found that increasing BMI was associated with high TC while the obesity indicators, BMI and waist circumference, were strongly associated with low HDL-C[20]. Non-HDL-C can be directly calculated from HDL-C and TC, and it is a comprehensive measure of atherogenic lipoproteins[21]. Our study found a high proportion of elevated TC (43.75%) and a high proportion of low HDL-C (61.7%) resulting in an increasing of high non-HDL-C (40.1%). It is known that obesity is associated with an increase in cholesterol synthesis and a decrease in intestinal absorption[22]. In particular, abdominal obesity has been closely associated with metabolic abnormalities. A strong relationship of abdominal fat accumulation with hypertriglyceridemia and reduced HDL-C has been reported[23]. Studies in adults[24] and also in children[9] have shown that abdominal obesity is associated with the increasing non-HDL-C levels.

Data on the prevalence of high non-HDL-C in Thailand are scarce. This study showed that the distribution of high non-HDL-C was higher than the result of Thai National Health Examination Survey IV in 2009 based on the northeast region (40.1% vs. 26.2%)[7]. The effect of urbanization and nutritional transition may be related to the high prevalence of elevated non-HDL-C level. The finding of the InterASIA study in 2000, a survey undertaken in five regions of Thailand, showed a high prevalence of high TG and low HDL-C in the northeast region of the country whereas the prevalence of high non-HDL-C was lower than other regions[25]. The present study found that non-HDL-C was associated with cardiovascular risk factors. This is consistent with several studies which have demonstrated the relationship of non-HDL-C to adverse CVD events[4, 26]. It may imply that non-HDL-C could be an additional screening lipid parameter for the risk of CVDs.

Some limitations in this study need to be mentioned. In Thailand there are regional differences due to dissimilar traditional and cultural backgrounds, lifestyles as well as living conditions. This applies to the food habits of the northeastern Thai adults having a high consumption of carbohydrate from glutinous rice that is not the case in the central or southern region. Care should therefore be taken when extrapolating our findings to the population of other Thai regions. In addition, a cross-sectional study as this one cannot establish the variation of the factors under investigation over time.

Conclusions and Recommendations

The present study demonstrated a high prevalence of elevated non-HDL-C level among Thai adults at the Khon Kaen Province. This finding confirms that increasing age and obesity are associated with the risk of high non-HDL-C. However, these findings need

to be confirmed in Thai populations living in other regions. Further research is needed to find out an effective prevention programme for reducing obesity and increasing healthy lifestyles.

Acknowledgements

The authors would like to appreciate the support of Research Group on Prevention and Control of Diabetes Mellitus in the Northeast of Thailand, Khon Kaen University. Assistance with the English language presentation of this paper was provided by a native English speaker with a background in the biomedical sciences. We also gratefully thank all participants and all assistants for helping to accomplish this study.

References

1. Anderson TJ, Grégoire J, Hegele RA, Couture P, Mancini GBJ, McPherson R, et al. 2012 Update of the Canadian Cardiovascular Society Guidelines for the Diagnosis and Treatment of Dyslipidemia for the Prevention of Cardiovascular Disease in the Adult. Canadian Journal of Cardiology. 2013;29(2):151-67.
2. Ghandehari H, Kamal-Bahl S, Wong ND. Prevalence and extent of dyslipidemia and recommended lipid levels in US adults with and without cardiovascular comorbidities: the National Health and Nutrition Examination Survey 2003-2004. Am Heart J. 2008;156(1):112-9.
3. Luo JY, Ma YT, Yu ZX, Yang YN, Xie X, Ma X. Prevalence, awareness, treatment and control of dyslipidemia among adults in northwestern China: the cardiovascular risk survey. Lipids Health Dis. 2014;13.
4. Wongcharoen W, Sutthiwutthichai S, Gunaparn S, Phrommintikul A. Is non-HDL-cholesterol a better predictor of long-term outcome in patients after acute myocardial infarction compared to LDL-cholesterol? : a retrospective study. BMC Cardiovascular Disorders. 2017;17:10.
5. Liu J, Sempos C, Donahue RP, Dorn J, Trevisan M, Grundy SM. Joint distribution of non-HDL and LDL cholesterol and coronary heart disease risk prediction among individuals with and without diabetes. Diabetes Care. 2005;28(8):1916-21.
6. Robinson JG. Are you targeting non-high-density lipoprotein cholesterol? J Am Coll Cardiol. 2009;55(1):42-4.
7. Aekplakorn W, Taneepanichskul S, Kessomboon P, Chongsuvivatwong V, Putwatana P, Sritara P, et al. Prevalence of Dyslipidemia and Management in the Thai Population, National Health Examination Survey IV, 2009. J Lipids. 2014;2014:249584. Available from: https://www.hindawi.com/journals/jl/2014/249584/pdf/ [Accessed 2017 February 2]
8. Abe Y. Difference in Serum Non-High-Density Lipoprotein Cholesterol Levels in terms of Sex, Age, and Physique in Children and Adolescents. J Atheroscler Thromb. 2016;23(12):1311-2.
9. Srinivasan SR, Myers L, Berenson GS. Distribution and correlates of non-high-density lipoprotein cholesterol in children: the Bogalusa Heart Study. Pediatrics. 2002;110(3):e29.
10. Dai S, Yang Q, Yuan K, Loustalot F, Fang J, Daniels SR, et al. Non-high-density lipoprotein cholesterol: distribution and prevalence of high serum levels in children and adolescents: United

States National Health and Nutrition Examination Surveys, 2005-2010. J Pediatr. 2014;164(2):247-53.

11. Pongchaiyakul C, Hongsprabhas P, Pisprasert V. Rural-urban difference in lipid levels and prevalence of dyslipidemia: a population-based study in Khon Kaen province, Thailand. J Med Assoc Thai. 2006;89(11):1835-44.
12. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. J Phys Act Health. 2009;6(6):790-804.
13. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). JAMA. 2001;285(19):2486-97.
14. Gostynski M, Gutzwiller F, Kuulasmaa K, Doring A, Ferrario M, Grafnetter D, et al. Analysis of the relationship between total cholesterol, age, body mass index among males and females in the WHO MONICA Project. Int J Obes Relat Metab Disord. 2004;28(8):1082-90.
15. Wang S, Xu L, Jonas JB, You QS, Wang YX, Yang H. Prevalence and associated factors of dyslipidemia in the adult Chinese population. PLoS One. 2011;6(3):e17326.
16. Pongchaiyakul C, Pratipanawatr T. Prevalence of dyslipidemia in rural Thai adults: an epidemiologic study in Khon Kaen province. J Med Assoc Thai. 2005;88(8):1092-7.
17. Kosulwat V. The nutrition and health transition in Thailand. Public Health Nutr. 2002;5(1A):183-9.
18. Aekplakorn W, Kosulwat V, Suriyawongpaisal P. Obesity indices and cardiovascular risk factors in Thai adults. Int J Obes (Lond). 2006;30(12):1782-90.
19. Rerksuppaphol S, Rerksuppaphol L. Metabolic Syndrome in Obese Thai Children: Defined Using Modified 'The National Cholesterol Education Program/Adult Treatment Panel III' Criteria. J Med Assoc Thai. 2015;98 Suppl 10:S88-95.
20. Wietlisbach V, Marques-Vidal P, Kuulasmaa K, Karvanen J, Paccaud F. The relation of body mass index and abdominal adiposity with dyslipidemia in 27 general populations of the WHO MONICA Project. Nutrition, Metabolism and Cardiovascular Diseases. 2013;23(5):432-42.
21. Blaha MJ, Blumenthal RS, Brinton EA, Jacobson TA. The importance of non-HDL cholesterol reporting in lipid management. J Clin Lipidol. 2008;2(4):267-73.
22. Klop B, Elte JWF, Castro Cabezas M. Dyslipidemia in Obesity: Mechanisms and Potential Targets. Nutrients. 2013;5(4):1218-40.
23. Carr MC, Brunzell JD. Abdominal Obesity and Dyslipidemia in the Metabolic Syndrome: Importance of Type 2 Diabetes and Familial Combined Hyperlipidemia in Coronary Artery Disease Risk. The Journal of Clinical Endocrinology & Metabolism. 2004;89(6):2601-7.
24. Tangvarasittichai S, Tangvarasittichai O, Teeraputon S, Maneemaroj R, Boonlert W, Jongjitwimol J, et al. Non-HDL-Cholesterol and Total Cholesterol to HDL-C Ratio in Abdominally Obese Adults in Phitsanulok. Siriraj Medical Journal. 2009;61(2):82-87.

25. Chongsuvivatwong V, Yipintsoi T, Suriyawongpaisal P, Cheepudomwit S, Aekplakorn W, Faramnuayphol P, et al. Comparison of cardiovascular risk factors in five regions of Thailand: InterASIA data. J Med Assoc Thai. 2010;93(1):17-26.

26. Boekholdt S, Arsenault BJ, Mora S, Pedersen PR, LaRosa JC, Nestel PJ, et al. Association of ldl cholesterol, non–hdl cholesterol, and apolipoprotein b levels with risk of cardiovascular events among patients treated with statins: A meta-analysis. JAMA. 2012;307(12):1302-9.