นิพนธ์ต้นฉบับ **Original Article**

ผู้ที่มีน้ำหนักเกินหรืออ้วนมีความสัมพันธ์อย่างชัดเจนกับค่าซี-รีแอคทีฟโปรตีนระดับความเสี่ยงสูง

Individuals with overweight and obesity are firmly associated with high-risk level of C-reactive protein

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DOI: 10.14456/dcj.2021.19
Received: April 23, 2020 | **Revised:** July 22, 2020 | **Accepted:** July 22, 2020

บทคัดย่อ

ค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูงเป็นตัวบ่งชี้ทางชีวภาพที่มีประโยชน์ในการคัดกรองด้านสุขภาพเพื่อแสดงถึงการอักเสบในร่างกาย การศึกษาเพื่อตรวจสอบถึงความสัมพันธ์ระหว่างปัจจัยเสี่ยงทางคลินิกกับค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูงในคนไทยยังมีข้อมูลจำกัด การศึกษานี้มีเป้าหมายเพื่อศึกษาถึงความสัมพันธ์ระหว่างปัจจัยทางคลินิกกับค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูง วัสดุและวิธีการวิจัย : งานวิจัยนี้เป็นการวิจัยโดยการสังเกตเชิงวิเคราะห์แบบภาคตัดขวาง โดยการเก็บข้อมูลด้านผลเลือดค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูง ในศูนย์ตรวจสุขภาพจากผู้ที่มารับบริการตรวจสุขภาพ โรงพยาบาลมหาวิทยาลัยแม่ฟ้าหลวง กรุงเทพ มีการทบทวนและเก็บข้อมูลด้าน ข้อมูลทั่วไปทางคลินิก ประวัติการเจ็บป่วยในอดีต ข้อมูลผลเลือดทางห้องปฏิบัติการ และการวัดสัดส่วนร่างกายในวันเดียวกันกับที่ได้ตรวจเลือดวัดค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูง ผลการวิจัย : ความชุกของค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูงระดับความเสี่ยงสูงเท่ากับร้อยละ 46.1 สำหรับข้อมูลทางคลินิก ได้แก่ ข้อมูลอายุ เพศ ข้อมูลผลทางโลหิตวิทยา ภาวะกลุ่มอาการเมตาบอลิก ระดับไขมันในเลือด ค่าระดับน้ำตาลสะสม พบว่าไม่มีความแตกต่างกันระหว่างสองกลุ่ม จากการวิเคราะห์การถดถอยลอจิสติคแบบพหุ พบว่า ผู้ที่มีค่าดัชนีมวลกายมากกว่าหรือเท่ากับ 25.0 กก./ตร^2 มีความเสี่ยง 5.14 เท่าที่จะมีค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูงระดับความเสี่ยงสูง (มากกว่า 3.0 มก./ลิตร) เมื่อเทียบกับผู้ที่มีค่าดัชนีมวลกายน้อยกว่า 25.0 กก./ตร ตร^2 อย่างมีนัยสำคัญ สรุป : ผู้ที่มีน้ำหนักเกินหรืออ้วนมีความสัมพันธ์กับค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูงระดับความเสี่ยงสูง โดยแนะนำให้เพิ่มการตรวจหาค่าซี-รีแอคทีฟโปรตีนที่มีระดับความไวสูงในโปรแกรมการตรวจสุขภาพประจำปี

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Abstract

Objective: High sensitivity C-reactive protein (hs-CRP) is a biomarker useful for health screening for body inflammation. The study to determine the association between clinical risks and hs-CRP level in the Thai cohort is limited. This study aimed to determine the association between clinical factors and hs-CRP level. Materials and Methods: This study was a cross-sectional, analytic, observational study. The results of high sensitivity C-reactive protein (hs-CRP) level of the participants visiting health care check-up clinic at Mae Fah Luang University Hospital were collected. Clinical demographics, past medical history, laboratory testing, and anthropometric measurements on the same day of hs-CRP blood draw were reviewed and collected. Results: The prevalence rate of high-risk hs-CRP was 46.1%. The clinical factors including age, gender, abnormal hematologic parameters, metabolic syndrome, lipid profiles, and HbA1C level were not different between the two groups. Based on Multivariate and Logistic Regression model, people with BMI> 25.0 kg/m^2 significantly demonstrated 5.14 times greater to have high-risk hs-CRP (hs-CRP>3.0 mg/L) than those with BMI<25.0 kg/m^2. Conclusion: Individuals with overweight and obesity or BMI>25.0 kg/m^2 are associated with high-risk levels of hs-CRP. The recommendation to add hs-CRP level to the package of annual health check-up is required.

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Keywords
C-reactive protein, biomarker, risk factor, overweight and obesity

Introduction

In the Internet of Things (IoT) era, our life is easy such as daily living lifestyle, workplace, education, and particularly, communications and social information. The aspects of the health care system, treatment, and continuing care are also improving over time. This is reflected by an improved average age of the people living a longer life and having an improved quality of life. This has been confirmed by a report released by the National Statistical Office Thailand, which states that Thai citizens had longer life expectancy than the previous decade with the mean age of 80.4 years in female and 73.2 years in male in 2019.[1]

Non-Communicable Diseases (NCDs), also known as chronic medical conditions, are currently presenting as a frontline health care problem because the incidence rate of these diseases is increasing over the past 20 years and being one of the global leading causes of death. A report from the World Health Organization (WHO) found an overall incidence of non-communicable diseases has consistently increased and associated with the leading causes of death involving 41 million people worldwide.[2] Important non-communicable diseases affecting the world population, for instance, cardiovascular disease, cerebrovascular disease and stroke, malignancy, diabetes, and hypertension. Main aetiology and risk factors of NCDs include aging condition, being a male, genetic

factor and family history, poor nutritional diet, obesity, biohazard exposure such as cigarette and polluted air and alcohol consumption.[3]

Health prevention by clinical screening by annual check-up visit is a good screening tool for early detection and diagnosis of subclinical disease. This is because the faster the disease is diagnosed, the better treatment outcome would be. Not only clinical parameters could score the risk, but also biological or molecular markers would help to detect the future risk for NCD.[4] A study to determine serum homocysteine level and serum biomarker which are associated with NCD, found that elevated serum homocysteine level has been associated with coronary artery disease and myocardial infarction.[5] Another biomarker study reported that elevated serum brain natriuretic peptide (BNP) has been associated with an increased risk of developing cerebral ischemic stroke when compared with a normal BNP level.[6]

High sensitivity C-reactive protein (hs-CRP), which is an acute-phase reactant, is an effective screening biomarker. A previous study strongly suggested that elevated hs-CRP levels have had an association with ischemic heart disease, autoimmune disease, diabetes, hypertension, and obesity.[7] A previous cohort study to follow-up those with a high level of hs-CRP found that hs-CRP level was a biomarker capable of predicting a long-term risk of NCDs.[8] According to the American Heart Association and the US Centers for Disease Control and Prevention (CDC), high sensitivity CRP can be classified into 3 levels based on the cardiovascular risk category: low risk<1.0 mg/L, moderate risk=1.0 to 3.0 mg/L and high risk>3.0 mg/L.[8]

As reported by a previous literature review, a laboratory-confirmed high hs-CRP level is crucial. Currently, the study to determine the association between clinical risks and its magnitude of that risk with hs-CRP level in Thai cohort is still limited. This study aimed to determine the association between clinical factors and hs-CRP in health care check-up and wellness centers.

Materials and Methods

This study was a retrospective, cross-sectional, analytic and observational study. The participants who attended the health care check-up and wellness clinic at Mae Fah Luang University Hospital from 1 January 2018-31 December 2019 were required to have a laboratory test to determine a high sensitivity C-reactive protein (hs-CRP) level. The sample size was estimated by using the different means (+SD) of hs-CRP level between those with or without high BMI>25 kg/m^2; was 0.07+0.09 mg/dL and with type I error (α) of 5%, type II error of 10%, and adding 30% missing data. Therefore, a total of 50 participants per group was initially planned in this study. The inclusion criteria were male or female, aged between 18-50 years, had a test result of high sensitivity, and C-reactive protein (hs-CRP) level from the blood sample taken during 1 January 2018-31 December 2019. Exclusion criteria were underlying health conditions or chronic infection, laboratory-confirmed acute febrile illness, underlying malignancy, current on medications including systemic corticosteroid, Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), immunosuppressive agents and immunotherapy.

Study process:

This study utilized a cross-sectional, retrospective and open-chart review method to collect the clinical and laboratory data in a single time-point.

Data collection was performed after receiving ethical committee approval from Mae Fah Luang University. The investigator would contact the head of the laboratory unit to explore and categorize for hs-CRP level summary reports. Then the investigator selected and enrolled only those subjects who met the inclusion and exclusion criteria to participate in this study. The hs-CRP summary report was collected. The outpatient medical record was reviewed and explored. Clinical demographics, past medical history, laboratory findings and anthropometric measurements on the same day of hs-CRP blood draw were reviewed and collected.

Data collection

1. High sensitivity C-reactive protein level and the date of specimen collection

2. Demographic data including age, gender, body weight, height, systolic and diastolic blood pressure

3. Past medical histories such as arterial hypertension, diabetes, dyslipidemia and chronic illnesses

4. Current medications

5. Laboratory findings at the same day of hs-CRP level collection-glycated hemoglobin (HbA1C), total cholesterol, triglyceride, high-density lipoprotein cholesterol and Low-density lipoprotein cholesterol

6. Anthropometric measurements including body mass index (BMI), waist circumference, waist-hip ratio (WHR), fat mass, body fat percentage

Statistical analysis

- Descriptive data analysis

Continuous data with normal distribution was reported by mean and standard deviation. Continuous data with non-normal distribution was reported by median and interquartile range. For categorical data was reported by frequency and percentage.

- Inferential data analysis

Univariate analysis to determine the association between hs-CRP level with risk factors

Continuous data with normal distribution and non-normal distribution were analysed by Student's t-test and Wilcoxon Rank-Sum (Mann-Whitney) test respectively. Categorical data was analysed by Pearson's chi-squared or Fisher's exact test. The factors in continuous data included age, body weight, blood pressure, body mass index, fat mass, body fat percentage, waist circumference, waist-hip ratio (WHR), HbA1C level, and lipid profiles. Categorical data included gender, history for hypertension, **diabetes, metabolic syndrome.**

- Multivariate data analysis

Continuous data was processed and transformed into dichotomous data. Multiple logistic regression model was used to compare the high-risk hs-CRP (>3.0 mg/L) group versus non-high-risk hs-CRP group (<3.0 mg/L) by adding significant factors from univariate analysis (p<0.10) to the model for multivariate analysis using a backward-stepwise method. Crude and adjusted Odds ratio (OR) with 95% confidence intervals (CI) of odds value were reported to illustrate the significant factors associated with a high-risk hs-CRP level. P value with less than 0.05 was defined as statistical significance. All data analysis involved in this current study was tested by IBM Statistical Package for Social Sciences (SPSS program), version 23.0.

Results

This study was approved by IRB/EC of Mae Fah Luang University with EC approval number 072/2020. Data collection was performed after receiving an EC approval. The results of serum hs-CRP level from the laboratory unit database were explored and verified, the blood specimen to test for the hs-CRP level was required to be drawn and obtained during hospital visits from 1 January 2018-31 December 2019. Seventy-six participants attending the health care clinic at Mae Fah Luang University Hospital, Bangkok, who met the inclusion criteria, were enrolled in this current study. The mean (standard deviation, SD) age was 39.9 (8.3) years. This vast majority of participants were female, 88.1% (n=67).

- High sensitivity, C-reactive protein, hs-CRP level

The mean (SD), hs-CRP level of all study participants (n=76) was 3.53 (2.79) mg/L. There were 7 cases (9.2%) with low-risk hs-CRP level (< 1.0 mg/L), 34 cases or 44.7% with moderate-risk hs-CRP level (1.0- 3.0 mg/L), and 35 cases or 46.1% with high-risk hs-CRP level of greater than 3.0 mg/L (Table 1).

Table 1: hs-CRP level and risk category

hs-CRP, risk category	n (%)	Mean (SD), hs-CRP level, mg/L
Overall	76 (100)	3.53 (2.79)
o Low risk, <1.0 mg/L, n (%)	7 (9.2)	0.71 (0.16)
o Moderate risk, 1.0-3.0 mg/L, n (%)	34 (44.7)	1.97 (0.56)
o High risk, >3.0 mg/L, n (%)	35 (46.1)	5.61 (2.89)

Abbreviation: SD=standard deviation, hs-CRP=high sensitivity C-reactive protein

- A comparison of clinical characteristics between the high-risk and non-high-risk hs-CRP groups

There were 35 cases with hs-CRP level >3.0 mg/L, or "high-risk group," and 41 cases with hs-CRP<3.0 mg/mL, as "non-high-risk group."

The mean age, gender, systolic and diastolic blood pressure were not different between the groups. There were 34.3% in the high-risk group and 46.3% in the non-high-risk group who had abnormal high blood pressure or known case of hypertension with no difference between the groups, p=0.286. There was no a significant difference in the prevalence rate of metabolic syndrome between the high-risk and non-high-risk group, 34.3% versus 39.0%, p= 0.669 (Table 2).

- A comparison of blood chemistry profiles between high-risk and non-high-risk hs-CRP groups

The average total cholesterol, triglyceride, HDL-cholesterol, and LDL-cholesterol is summarized with no difference between the two groups (p>0.05). The mean (SD), glycated hemoglobin (HbA1C) level was 5.7(1.41) % in the high-risk group, which was slightly higher than the non-high-risk hs CRP group with a mean of 5.4(0.45) % but did not differ between the 2 groups (p=0.430). There were 3 cases (8.6%) in the high-risk group with an HbA1C level greater than 6.5 % (Table 3).

Table 2: Comparison of clinical characteristics between high-risk and non-high-risk hs-CRP groups

Clinical characteristics	High-risk group hs-CRP>3 (n=35)	Non-high-risk group hs-CRP<3 (n=41)	*p*-value*
Age, mean (SD), years	40.1 (8.9)	39.7 (7.9)	0.806
o Age>40, n (%)	21 (60.0)	23 (36.1)	0.730
Gender			
o Male, n (%)	5 (14.3)	4 (9.8)	0.542
o Female, n (%)	30 (85.7)	37 (90.2)	
SBP, mean (SD), mmHg	123.8 (13.2)	124.2 (14.4)	0.895
o SBP>130 mmHg, n (%)	10 (28.6)	19 (46.3)	0.112
DBP, mean (SD), mmHg	75.9 (9.6)	76.9 (9.8)	0.662
o DBP>85 mmHg, n (%)	7 (20.0)	9 (21.9)	0.835
Abnormal BP or known of hypertension, n (%)	12 (34.3)	19 (46.3)	0.286
Diabetes, n (%)	3 (8.6)	-	0.210
Metabolic syndrome, n (%)	12 (34.3)	16 (39.0)	0.669

Abbreviation: SD=standard deviation, SBP=systolic blood pressure, DBP=diastolic blood pressure, abnormal BP=SBP>130 mmHg, DBP>85 mmHg

*Continuous data with normal distribution and non-normal distribution were analysed by Student's t-test and Wilcoxon Rank-Sum (Mann-Whitney) test respectively. Categorical data was analysed by Pearson's chi-square or Fisher's exact test

-A comparison of anthropometric measurements between high-risk and non-high-risk hs-CRP groups

The high-risk hs-CRP group had a significantly higher body mass index (BMI), with a mean (SD) of 30.2 (4.9) kg/m^2, than the non-high-risk hs-CRP group with 26.8 (4.5) kg/m^2, p=0.0012. The high-risk hs-CRP group had a higher proportion (85.7%) of those who had BMI>25.0 kg/m^2 (Overweight or obesity) than the non-high-risk hs-CRP group with only 51.2 %, p=0.002. The average mean (SD) waist circumference of the high-risk hs-CRP group was significantly longer than the non-high-risk hs-CRP group, 97.1 (3.2) cm vs. 88.9 (10.8) cm, respectively, (p=0.0036). For those with truncal obesity by waist circumference of>80 cm in female, or>90 cm in male, there were 94.3% of truncal obesity in the high-risk hs-CRP group that is in a remarkably greater percentage than the non-high-risk hs-CRP group (75.6%) (p=0.026). This study also reported that average fat mass and body fat percentage were also significantly greater in high risk group than non-high-risk hs-CRP group (p=0.0006 and 0.0032, respectively) (Table 3).

Table 3: Comparison of blood chemistry profiles and anthropometric measurements between high-risk and non-high-risk hs-CRP groups

Results	High-risk group hs-CRP>3 (n=35)	Non-high-risk group Hs-CRP<3 (n=41)	*p*-value*
Total Chol, mean (SD), mg/dL	192.8 (37.6)	192.3 (36.6)	0.947
o Total Chol≥200 mg/dL, n (%)	15 (42.9)	17 (41.5)	0.902
TG, mean (SD), mg/dL	121.3 (56.8)	126.3 (90.2)	0.588
o TG≥150 mg/dL, n (%)	5 (14.3)	10 (24.4)	0.27
LDL-Chol, mean (SD), mg/dL	136.3 (31.1)	134.5 (32.7)	0.808
o LDL-Chol≥100 mg/dL, n (%)	18 (51.4)	22 (53.7)	0.846
HDL-Chol, mean (SD), mg/dL	50.6 (12.2)	51.9 (11.7)	0.639
o LDL-Chol<40 mg/dL (male), <50 mg/dL (female), n (%)	16 (45.7)	15 (36.6)	0.42
HbA1C, mean (SD), %	5.7 (1.41)	5.4 (0.45)	0.43
o Normal, HbA1C<5.7 %, n (%)	25 (71.4)	31 (75.6)	0.208
o Prediabetes, HbA1C=5.7-6.4 %, n (%)	7 (20.0)	10 (24.4)	
o Diabetes, HbA1C≥6.5 %, n (%)	3 (8.6)	-	
Body weight, mean (SD), kg	78.1 (16.1)	69.0 (13.7)	0.009
BMI, mean (SD), kg/m^2	30.2 (4.9)	26.8 (4.5)	0.0012
o BMI<23.0 kg/m^2, n (%)	1 (2.9)	2 (4.9)	0.002
o BMI=23.0-24.9 kg/m^2, n (%)	4 (11.4)	18 (43.9)	
o BMI≥25.0 kg/m^2, n (%)	30 (85.7)	21 (51.2)	
Waist circumference (WC), mean (SD), cm	97.1 (3.2)	88.9 (10.8)	0.0036
o Truncal obesity	30 (94.3)	31 (75.6)	0.026
Waist Hip Ratio (WHR), mean (SD)	0.87 (0.07)	0.85 (0.06)	0.1919
Abnormal WHR>0.95 male, >0.85 female, n (%)	18 (51.4)	20 (48.8)	0.818
Fat mass, mean (SD), kg	33.2 (8.5)	27.1 (7.1)	0.0006
Body fat percentage, mean (SD)	42.7 (4.6)	39.3 (4.9)	0.0032
o Body fat percentage>25% male, 32% female, n (%)	34 (97.1)	36 (87.8)	0.166

Abbreviation: SD=standard deviation, Total Chol=total cholesterol, TG=triglyceride, HDL-Chol=high-density lipoprotein-cholesterol, LDL-Chol=Low-density lipoprotein-cholesterol, HbA1C=Glycated haemoglobin, BMI=body mass index, WHR=Waist Hip Ratio, Truncal obesity=WC>80 cm (female) or >90 cm (male)

*Continuous data with normal distribution and non-normal distribution were analysed by Student's t-test and Wilcoxon Rank-Sum (Mann-Whitney) test respectively. Categorical data was analysed by Pearson's chi-square or Fisher's exact test.

- Determination of the association between high-risk hs-CRP and clinical factors

Backward-stepwise, a multiple logistic regression model was tested to compare between high-risk hs-CRP and non-high-risk hs-CRP groups by entering the clinical factors from univariate analysis with $p<0.10$ to the model for multivariate analysis. The significant factors including BMI>25.0 ($p=0.002$) and truncal obesity ($p=0.026$) were included in the final analysis. From the final model

of multivariate analysis, overweight or obese individuals with BMI>25.0 kg/m^2 significantly predicted a 5.14 times greater correlation with high-risk hs-CRP or hs-CRP>3.0 mg/L than those with BMI<25.0 kg/m^2. (Adjusted Odds ratio, OR, 95% CI; 5.14, 1.65-15.98, p=0.005) (Table 4).

Table 4: Univariate and Multivariate analysis to identify the association between high-risk hs-CRP and clinical factors

Variables	Univariate analysis			Multivariate analysis		
	Crude Odds ratio (OR)	95% crude ORs	p-value	Adjusted OR	95% Adjusted ORs	p-value
BMI > 25.0 kg/m^2	5.71	1.85-17.64	0.002	5.14	1.65-15.98	0.005*
Waist circumference: >80 cm (Female), >90 cm (Male)	5.32	1.07-26.2	0.026			

Abbreviation: OR=Odds ratio (OR), BMI=body mass index

Discussion

Our study reported that the prevalence rate of the high risk of hs-CRP was 46.1%. The clinical factors including age, gender, abnormal blood pressure or hypertension, metabolic syndrome were not different between the two groups. The lipid profiles and HbA1C level were summarized with no difference between the two groups (p>0.05). The high-risk hs-CRP group had a higher proportion of those who had BMI >25.0 kg/m^2 and for subjects with truncal obesity than the non-high-risk hs-CRP group, p=0002 and 0.026, respectively in univariate analysis. In the final analysis, BMI>25.0 kg/m^2 or overweight or obesity significantly demonstrated 5.14 times greater to have high-risk hs-CRP or hs-CRP>3.0 mg/L than those with BMI<25.0 kg/m^2.

High sensitivity C-reactive protein (hs-CRP) is an acute-phase protein responding to body inflammation. It is commonly utilized as a biomarker to screen the further risk of disease or to rate the disease activity of inflammatory disorder. A previous study by Chong Y et al. enrolled healthy volunteers over 40 years of age and found that elevated hs-CRP level and Lipoprotein-associated phospholipase A2 (LP-PLA-2) level strongly related to ischemic heart disease.[9] Obesity is an example of a chronic inflammatory disorder condition, explained by adipose tissues, which could release excessive pro-inflammatory cytokines such as interleukin-6 (IL-6)[10-11] that further stimulate acute phase reactant hs-CRP.[12-13] A meta-analysis enrolled 7 cohort studies and concluded that elevated serum hs-CRP level is associated with ischemic heart disease in the future and long-term death from cardiovascular events in healthy population. And if a value of hs-CRP level> 1.0 mg/dL, it could lead to a 2-3 times greater risk of cardiovascular atherosclerosis and myocardial infarction than those with less than 1.0 mg/dL of the hs-CRP level.[14] Another study also confirmed excess hs-CRP levels had higher cardiovascular death and incidence rate of cerebral ischemic stroke in advance than the normal hs-CRP levels in both male and female subgroups.[15-16]

Moreover, a study conducted by Visser and team (1999) determined 16,616 participants with age over 17 years found that the prevalence rate of

hs-CRP level>0.22 mg/dL was 27.6% and 6.7% if hs-CRP level greater than 1.0 mg/dL. An increase in CRP level positively correlated with a higher body mass index (BMI). Individuals with overweight or obesity with BMI≥25.0 kg/m^2 were 2.1 times more likely in male and 6.2 times more likely in female to detect high CRP level than BMI<25.0 kg/m^2 that our study confirmed with the same result.[17] Importantly, a Chinese report by Ding Ding, et al. published in Plos One (2015), also supported an evidence that elevated CRP level>3.0 mg/dL had 3.4 times (Odds ratio, OR=3.4) greater mortality rate than the normal hs-CRP level group. The study result indicated this greater risk was commonly found in those individuals with BMI >_28.0 kg/m^2 subgroup.[18] A study by Farooq, et al. (2017) indicated high CRP level directly correlated with enlarged waist circumference (WC) and waist-hip ratio (WHR), which was different from our study that did not confirm this association.[19] A Taiwanese cohort study by Cheng-Chiech Lin, et al. (2010), which enrolled 1,669 healthy volunteers with age older than 40 years, found that high hs-CRP level directly correlated with high body fat percentage, body mass index and waist-hip ratio (WHR), and the female group was more strongly associated with those conditions than their male counterparts.[20]

Limitations of this study mainly caused by the study design with cross-sectional analytic study, which makes it difficult to determine whether the factors or outcomes coming to the first or temporal relationship and systematic error or technical bias may occur when collecting the data and interpreting the study results.

Conclusion

High sensitivity C-reactive protein (hs-CRP) is a robust data to be utilized as a biomarker for a screening tool to evaluate further risk of the chronic inflammatory disorder including NCDs. The prevalence rate of the high risk of hs-CRP is common in the Thai population (with 46.1 percent of prevalence rate). Individuals with overweight or obesity indicated by their BMI>25.0 kg/m^2 are 5.14 times more likely to have a high cardiovascular risk level of hs-CRP (>3.0 mg/L). Our study recommends adding hs-CRP level to the package of annual health check-ups for high-risk populations, especially individuals with overweight or obesity.

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