Prevalence of the Metabolic Syndrome, and Its Association Factors between Percentage Body Fat and Body Mass Index in Rural Thai Population Aged 35 Years and Older

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Objectives: *To obtain the prevalence of metabolic syndrome (MS) and its associated socioeconomic factors, and also to evaluate the association between percentage body fat (BF) and body mass index (BMI) in a rural Thai population.*

Material and Method: *MS defined by the National Cholesterol Education Program Adult Treatment Panel III criteria. The prevalence of the MS was then determined using the NCEP III criteria with and without the modified waist circumference criteria. BMI indicating normal weight, overweight and obesity as re-defined for the Asian by International Association for the Study of Obesity (IASO), WHO. Four-hundred and four rural Thai men and women aged 35 years and older were evaluated. Data on anthropometry, blood pressure, socioeconomic status, lifestyle-related information, blood studies, and bioelectrical impedance (BIA) values had been collected.*

Results: *The prevalence of the MS in the rural Thai people was 18%, but increased to 23% with the modified Asian criteria. High BMI, female gender, and older age were associated with increased odds of the MS. Household income, dietary composition, smoking and drinking status were not associated with increased odds of the MS. There was significant association between percent BF and BMI in men and women in rural Thai population.*

Conclusion: *The MS was present in about 18% of the rural Thai population and was significantly influenced by body mass index, gender and age. Metabolic syndrome becomes an important problem in rural Thai populations who even live basic lifestyle in the non-urbanized and non-industrialized areas. Identification and clinical management of this high-risk group is an important strategy for coronary heart disease prevention.*

Keywords: *Metabolic syndrome, Body mass index, Percentage body fat, Bioelectrical impedance analysis*

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The metabolic syndrome (MS) is an important cluster of coronary heart disease risk factors including central obesity, glucose intolerance, insulin resistance, low HDL cholesterol, high triglyceride and hypertension[1]. The prevalence and the mortality of coronary heart disease (CHD) and cerebrovascular disease (CVD) in association with the metabolic cluster are greater than that of its individual MS components.

In the past, the syndrome has had a variety of names, such as insulin resistance syndrome, deadly quartet, syndrome X (plus), dysmetabolic syndrome (X), Reaven's syndrome, chronic cardiovascular risk factor clustering syndrome[2,3]. Researchers have used various terms to describe the cluster of abnormalities that make up the MS. Recently a number of expert groups have attempted to develop a unifying definition for the metabolic syndrome. The most accepted of these definitions are by the WHO and the National Cholesterol Education Program - Third Adult Treatment Panel (NCEP/ ATP III). The two resulting definitions agree on the essential components - obesity, hypertension, and dyslipidemia, but the NCEP/ATP III definition is perhaps the most straightforward and clinically amenable to implement because the 5 criteria are clearly defined[4]. When using the NCEP ATP III criteria, about 23% of the US populations meet the criteria for the MS[5]. The age-specific prevalence was highest in Mexican Americans and lowest in black, ethnic differences persisted even after adjusting for age, BMI, and socioeconomic status[5].

Local and regional data have shown that the same level of BMI connotes a greater degree of obesity in Asians compared with Caucasians, perhaps leading to the greater prevalence of cardiovascular disease risk factors at lower BMI in Asian populations than in Western populations[6-9]. In response to these findings, the Western Pacific regional office of the WHO, the International Obesity Task Force (IOTF) collaborated in the creation of new recommendations for BMI and waist circumference cutoffs among Asian populations, overweight is defined as a BMI >23, and waist circumference cutoffs are 90 cm for men and 80 cm for women[10]. Currently, using the original NCEP ATP III criteria, the prevalence of the MS in Singapore is 12.1%, but increases to 18.2% with the modified Asian criteria[11]. In Thailand, especially in a rural population, limited information is available about MS.

To assess the pubic health implications of the MS in Thailand, the important issue must be concerned. The recommended cut off for waist circumference in the NCEP ATPIII definition is inappropriate for a Thai population because Asians had a higher percentage body fat at the lower BMI compared with Caucasians[12-14]. Therefore, the aims of the present study were 1) to determine the prevalence of the MS and associated risk factors in the rural Thai population and 2) to demonstrate the quantitative link between percentage BF and BMI in the rural Thai population.

Material and Method

The authors invited all of the population aged 35 years and older in Baan Nayao district in Chacheongsao province (which is located about 300 kilometers from Bangkok in the southeast coastal region of Thailand) to participate. The subjects who had prosthetic heart valves, cardiac pacemakers, aneurysmal clips, paraplegic, pregnant or lactating due primarily to the possible technical interference with total body water and thereby cause an error to our analytical instrument of the percentage body fat were excluded. A total of 404 eligible participants were enrolled in the present study. The Institute review board at the Phramongkutklao Hospital approved the present study. Informed consent was obtained from all subjects before data collection.

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Anthropometric measurements

Data collections were done at the local health station in the participant's residential area. Questionnaire assessing lifestyle, socioeconomic, medical history including 24 hour food recall was administered by trained medical cadets under the supervision of medical staff. Economic status was divided into 2 categories according to the subject's household income for the previous year: <$ 500 (20,000 baht), and >$ 500 (20,000 baht). Smoking status was categorized as current and non-current smoker. Drinking status was categorized as current and non-current drinker. Non-current smokers or drinkers were those who reported they had smoked or drunk but stopped smoking or drinking for at least 6 months before the present study or those who had not smoked or drank. The percentage of total caloric intake from carbohydrates, was categorized as high if caloric intake more than 60%.

Physical examination and anthropometric measurements including weight, height, and waist circumference (at the umbilicus level in standing position) were performed. BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Blood specimens were collected from all subjects after overnight fast to quantitatively assess for their fasting plasma glucose, and lipid profile. A body composition analyzer for bioelectrical impedance (Bioscan 916 Maltron®, England) was used for the measurement of whole body electrical resistance and impedance. During the BIA procedure subjects lay in the supine position on a nonconductive examination table without a pillow under their head. Electrodes were attached to the right wrist, hand, ankle, and foot after being cleaned with alcohol and gauze. The subject was instructed to remain motionless and relaxed with their arms and legs slightly apart and not touching any other part of the body. Resistance and reactance values (in ohms) were recorded from the BIA unit. All subjects were requested to not eat or drink anything except water during the fasting period. Detailed information on the BIA procedure is presented elsewhere[15]. The %BF estimates were derived from prediction equations for fat-free mass that were validated for men and women[16]. High %BF was defined as the following: that is greater than 25 percent in men and greater than 30 percent in women.

Laboratory methods

After the subjects had fasted overnight, blood samples were drawn by venipuncture to measure serum total cholesterol, HDL cholesterol, triglyceride, and glucose. Blood specimens were processed at the Phramongkutklao Hospital. Total cholesterol, HDL cholesterol, and triglyceride were measured by emzymatic, calorimetric method (Integra 800, Roche Diagnostic).

LDL- cholesterol concentrations were calculated by using the Friedewald equation for the participants who had triglyceride concentrations < 400 mg/dL: LDL cholesterol = Total cholesterol - HDL cholesterol - (triglyceride/5)[17]. Glucose was analyzed by emzymatic reference method with hexokinase (Integra 800, Roche Diagnostic). The coefficient of variation for this assay was 1.7% at a mean glucose value of 96 mg/dL.

Definition of metabolic syndrome

Metabolic syndrome was defined according to the criteria of the National Cholesterol Education Program criteria that required the presence of ≥ 3 of the following 5 risk factors[4]: abdominal obesity [waist circumference > 102 cm (> 40 inches) in men, and > 88 cm (≥ 35 inches)] in women (modified Asian criteria for waist circumference > 90 cm in men, and > 80 cm in women), high triglycerides concentrations ≥ 150 mg/dL, low High-density lipoprotein cholesterol (< 40 mg/dL for men, and < 50 mg/dL for women), high Blood pressure (systolic ≥ 130 mmHg and diastolic ≥ 85 mmHg) or known treatment of hypertension, and high

fasting glucose (≥ 110 mg/dL) or known treatment of diabetes.

Statistical analyses

Data analysis was undertaken using SPSS statistical software. The level of significance was determined by p value <0.05. Data were presented as mean ± standard deviation. Multiple logistic regression analysis models was formulated to estimate the odds ratios of the MS and to identify the strongest determinant of the condition. The correlation between %BF and BMI was elucidated using linear regression. Dietary data were analyzed by the Food Composition Database Program (Immucal software, Maidol University, Thailand).

Results

The baseline characteristics and anthropometric of the participants are shown in Tables 1 and 2. Four hundred and four people were enrolled, 169 were men and 235 were women. The majority of the participants were women, younger than sixty years old, and had a household income of less than twenty thousand baht per year. In addition, in terms of smoking and drinking status, less than half were current smokers and drinkers. The authors assumed that most of the participants had a non sedentary lifestyle because nearly 70% of the subjects' occupation was farmers. Dietary intake pattern, nearly 92% had less than 30 percent of fat consumption while around 70% and 61% consumed greater than 60 percent of carbohydrate and 15% of protein intake (Table 1).

The mean BMI in men and women were 23 ± 3.5 kg/m^2 and 24.7 ± 6.3 kg/m^2 respectively, and the mean %BF in men and women were 27.1 ± 5.4% and 37.6 ± 5.2% respectively (Table 2). The mean BMI among each gender are characteristically of "overweight" not "obesity", but their corresponding mean %BF values have readily gone one step beyond and are characteristic of obesity. This finding maybe support that Asians had a higher percentage body fat at the lower BMI compared with Caucasians.

Table 1. Baseline characteristic of the participants

Characteristic	Percent (%)
Gender	
Men (n = 169)	41.8
Women (n = 235)	58.2
Age, yr	
<60	75.7
≥60	24.3
Household income, baht/yr	
≤20,000 (500 $US)	58.66
>20,000	36.14
Smoking	
Current	27.7
Non-current	69.8
Drinking	
Current	42.1
Non-current	55.9
Daily carbohydrate intake, %	
≤60	29.9
>60	70.1
Daily fat intake, %	
≤30	91.6
>30	8.4
Daily protein intake, %	
≤15	39.7
>15	60.3
Occupation	
Farmer	69.5
Non-farmer	30.5

The prevalence of the MS when using the original NCEP ATP III was 10.6 and 21.2 percent in men and women, respectively. But when using the criteria for Asians, the prevalence of MS was 12.3 and 30.8 percent in men and women, respectively (Table 3).

The prevalence of the MS by 10 year age groups (except 35-39 years) was presented in Fig. 1, as age increased, the prevalence of the MS tended to get greater, from 8.3% in those aged 35-39 years to 38.8% in those aged more than 60 years. Female gender possessed a higher prevalence across all age groups (Fig.1).

Table 2. Anthropometric Characteristics and Percentage Body Fat (%BF)

Characteristics	Men (Mean±SD)	Women (Mean±SD)
Study sample (n)	169	235
Age (yr)	52.5 ± 12	50.5 ± 10.7
Height (cm)	162.3 ± 6.5	152.3 ± 5.5
Weight (kg)	60.6 ± 10.3	57.4 ± 9.3
Waist girth (cm)	77.9 ± 10	77.4 ± 9.1
BMI (kg/m2)	23 ± 3.5	24.7 ± 6.3
BF (%)	27.1 ± 5.4	37.6 ± 5.2

Table 3. Prevalence of MS by Sex

Original NCEP ATP III (%)			Modified Asian Criteria (%)		
Men	Women	Total	Men	Women	Total
10.6	21.2	17.8	12.3	30.8	23

Table 4. Multivariable Adjusted Odds Ratios for MS

Variables	Odds Ratio	p-value	95% CI
Overweight BMI (≥23 kg/m2)	5.354	<0.001	(2.804-10.221)
Female gender	2.534	0.002	(1.419-4.526)
Older age (≥ 60 yr)	2.597	<0.001	(1.445-4.667)

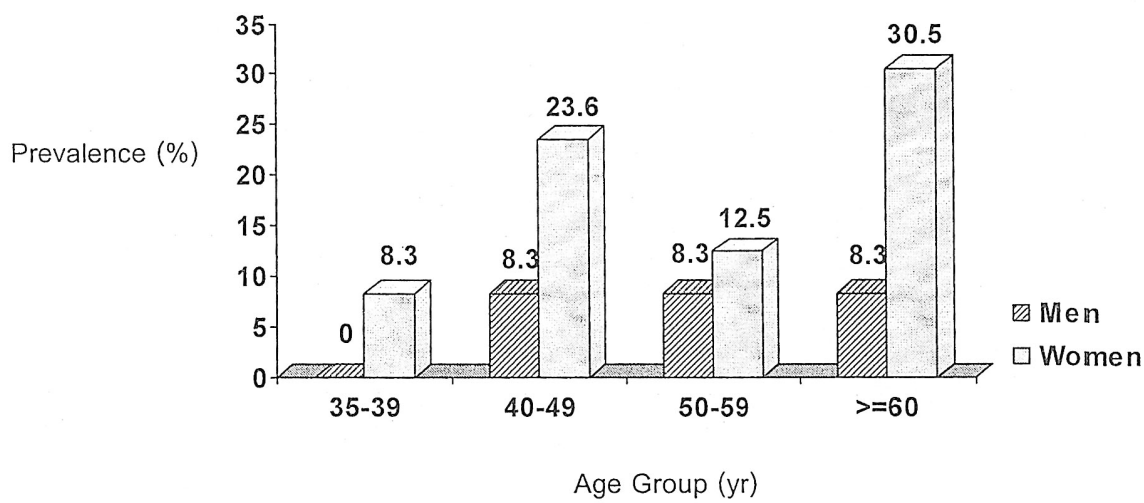

Fig. 1 Prevalence of MS according to Age and Sex

The overall relative frequency of each component of the MS is given in fig. 2. Men had a higher prevalence of high blood pressure, but lower prevalence of large waist. In women, the highest prevalence of the MS was attributed to hypertriglyceridemia, followed by low HDL level. The women were found to have a larger prevalence in any feature of the MS when compared with men.

The authors could not demonstrate the association between the prevalence of the MS and household income, dietary composition, and lifestyle factors in the present study. But the authors found the association between BMI, female gender, older

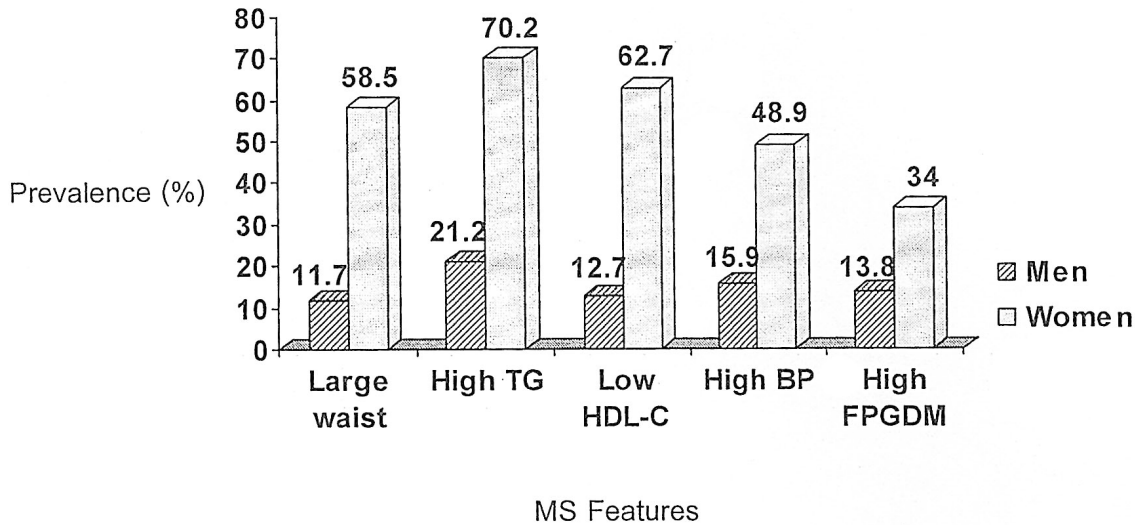

Fig. 2 Prevalence of Individual MS Component according to Sex

age with the prevalence of the MS. After adjusted the odds ratios for the MS, higher BMI, female gender, and older age, were statistically significant associated with the increased odds of the MS.

The ORs for the MS in the overweight group (BMI $\geq$ 23 kg/m^2) relative to the normal-weight group were 5.35 (95% CI 2.80 - 10.22). Female gender and elderly (age $\geq$ 60 years) showed a significantly higher OR than male gender and younger (Table 4).

In the present study, the authors demonstrated that BMI is statistically significant correlated to %BF in both men and women. In men, the linear regression was $Y = 0.7 x + 11.8$, ($r = 0.5$, $p < 0.001$), and in women, the linear regression was $Y = 0.8 x + 17.7$, ($r = 0.6$ $p < 0.001$) (Fig. 3).

Discussion

The present study found that the prevalence of the (MS) in the rural Thai people was 18% (10.6% in men, 21.2% in women) when using the original NCEP III criteria, and was considerably lower than the crude prevalence of 21.8% reported in the U.S.[18] But with modified Asian criteria (waist girth male > 90 cm, female > 80 cm), the prevalence of the MS was 23%.

The highest prevalence of the MS in the present study was attributed to hypertriglyceridemia in both men and women, but followed by low HDL level in women, high blood pressure in men. McNeill et al,[19] analysis indicated that the individual components for elevated blood pressure and low HDL cholesterol have the strongest effect on CHD risk. It is known that the MS was an important constellation of CHD risk factors. Cardiovascular mortality rates in developing countries was increasing, and cardiovascular mortality and morbidity rates in a Thai population were still high and seem to be related to the high prevalence of the various features of the MS in Thai people. Thus, when applied the NCEP III criteria in a Thai population, may underestimate the prevalence of MS.

Study from the US population from the Third National Health and Nutrition Examination Survey demonstrated that older age, postmenopausal status, Mexican Americans ethnicity, higher body

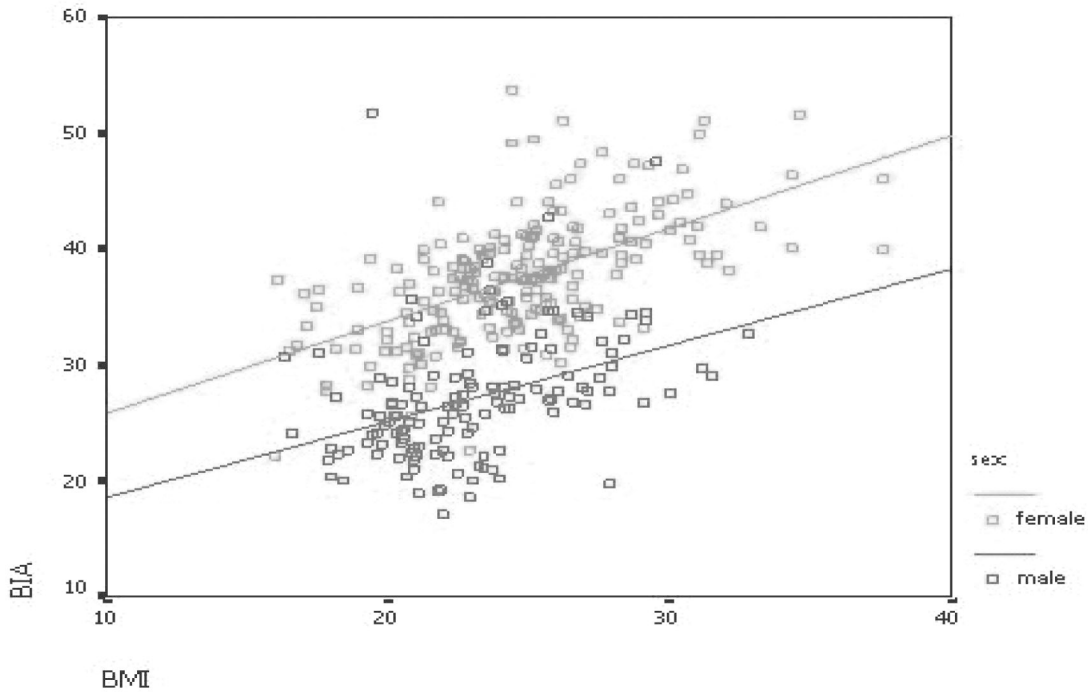

Fig. 3 Correlation between BMI and Percentage body fat in Men and Women

mass index, current smoking, high household income, high carbohydrate intake, no alcohol consumption, and physical inactivity were associated with increased odds of the MS[5].

In the present study, the authors could not demonstrate the association between low household income, high carbohydrate intake, current smoking, no alcohol consumption, and physical inactivity with increased odds of the MS. The authors assumed that most of the participants had adequate exercise because nearly 70% of the subjects' occupation was farmers. This could explain why the effect of diet, tobacco, or alcohol was not found in the present study.

Although BMI was a useful surrogate measure of adiposity, increasing interest was centering on actual measures of fatness and their link with health related processes[20,21]. Many data have shown that the same level of BMI, Asians have a greater degree of obesity than Caucasians[6-9]. Some studies have demonstrated that measurement of body fat is a more appropriate way to assess obesity in people with a BMI below 30 kg/m^2 [22] Vikram et al,[23] showed that Asian Indians have excess cardiovascular risk at BMI and waist circumference values considered normal for Caucasian populations. The risk of developing the MS in Caucasians increases strikingly above a BMI of around 25 kg/m^2 [24-26].

In the present study there was a significant association between the BMI and percentage BF. In men, the linear regression was $Y = 0.7 x + 11.8$, ($r = 0.5$, $p < 0.001$), and in women, the linear regression was $Y = 0.8 x + 17.7$, ($r = 0.6$ $p < 0.001$). Referring to the equation once the authors have substituted BMI critical cutoff values in those

two established gender-specific equations, BMI of 23 kg/m^2 the corresponding %BF would respectively be 27 percent in men, 36 percent in women. High %BF was defined as greater than 25% in men and greater than 30% in women, therefore, it is advisable that BMI $\geq$ 23 kg/m^2 be considered as overweight for the Thai population. This finding should re-emphasize the authors' concern on how the BMI and %BF are discordant, and as a consequence, a new less stringent BMI cutoff point for overweight is putatively something that needs re-considering. The principal limitation relevant to the interpretation of the present results is the use of cross-sectional data and the present investigation include only one daily food recall.

Conclusion

The MS increasingly becomes an important problem in the rural Thai population who even lives a basic lifestyle in the non-urbanized and non-industrialized area. Identification and clinical management of this high-risk MS is an important strategy for CHD prevention.

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ความชุกของภาวะกลุ่มอาการทางเมตาบอลิสม และความสัมพันธ์กับปัจจัยเศรษฐฐานะ เปอร์เซ็นต์ไขมันในร่างกาย และดัชนีมวลกาย ในประชากรที่อายุ 35 ปีขึ้นไป ในชนบทของไทย

อภัสนี บุญญาวรกุล, ฉัตรชัย ชูแสง, อุปถัมภ์ ศุภสินธุ์, สุธี พานิชกุล

บทนำ: *ภาวะดื้อต่ออินซูลินและความอ้วนลงพุง เป็นกลไกสำคัญที่ทำให้เกิดกลุ่มอาการทางเมตาบอลิสมซึ่งเป็นปัจจัยเสี่ยงที่สำคัญของโรคหลอดเลือดหัวใจ ในประเทศสหรัฐอเมริกาความชุกของกลุ่มอาการทางเมตาบอลิสมแตกต่างกันในเชื้อชาติต่าง ๆ โดยรวมพบร้อยละ 23 เมื่อใช้เกณฑ์การวินิจฉัยของ National Cholesterol Education Program III (NCEP III) ในประเทศสิงคโปร์ พบความชุกของกลุ่มอาการดังกล่าวร้อยละ 12.1 โดยใช้เกณฑ์ NCEP III และเพิ่มเป็นร้อยละ 15.2 เมื่อมีการปรับเปลี่ยนเกณฑ์การวินิจฉัย สำหรับประชากรทางเอเชีย ในประเทศไทยความชุกของภาวะดังกล่าวและความสัมพันธ์กับเศรษฐฐานะทางสังคมในประชากรที่อาศัยในชนบทยังไม่มีการศึกษา นอกจากนี้ในขณะที่ดัชนีมวลกายเท่ากัน ในคนเอเชียจะมีระดับความอ้วนมากกว่าคนทางซีกตะวันตก ดังนั้นความสนใจในปริมาณความสัมพันธ์ระหว่างเปอร์เซ็นต์ไขมันในร่างกาย และดัชนีมวลกายมีเพิ่มขึ้นเรื่อย ๆ และความสัมพันธ์ดังกล่าวในประชากรไทยยังไม่มีการศึกษา*

วัตถุประสงค์: *หาความชุกของภาวะกลุ่มอาการทางเมตาบอลิสม และความสัมพันธ์ของกลุ่มอาการดังกล่าวกับปัจจัยเศรษฐฐานะและหาความสัมพันธ์ระหว่างเปอร์เซ็นต์ไขมันในร่างกาย และดัชนีมวลกายในประชากรที่อาศัยในชนบท*

วัสดุและวิธีการ: *ใช้เกณฑ์การวินิจฉัยกลุ่มอาการทางเมตาบอลิสมตาม NCEP III และมีการปรับเปลี่ยนตามเกณฑ์ทางเอเชีย เกณฑ์การวินิจฉัยโรคอ้วนตามการปรับเปลี่ยนของเอเชีย ประชากรทั้งหมด 404 ราย ที่มีอายุตั้งแต่ 35 ปีขึ้นไป ทำการซักประวัติตรวจร่างกาย ตรวจทางห้องปฏิบัติการรวมทั้งตรวจวัดปริมาณไขมัน โดย Bioelectrial impedance*

ผลการศึกษา: *พบความชุกของกลุ่มอาการทางเมตาบอลิสมร้อยละ 18 เมื่อใช้เกณฑ์ NCEP III และเพิ่มเป็นร้อยละ 23 เมื่อปรับเกณฑ์ตามเอเชียพบความสัมพันธ์ระหว่างความชุกของกลุ่มอาการของเมตาบอลิสมกับการมีดัชนีมวลกายเพิ่มขึ้น เพศหญิง และอายุที่มากขึ้นขณะที่ไม่พบความสัมพันธ์ดังกล่าวกับเรื่องของรายได้ ส่วนประกอบของอาหารที่รับประทาน การสูบบุหรี่ หรือดื่มเหล้า นอกจากนี้พบมีความสัมพันธ์ระหว่างปริมาณไขมันในร่างกายกับดัชนีมวลกายในประชากรไทยในชนบท*

สรุป: *กลุ่มอาการทางเมตาบอลิสมพบร้อยละ 18 และมีความสัมพันธ์กับการมีดัชนีมวลกายที่มาก เพศหญิง และอายุที่มากขึ้น จะเห็นได้ว่ากลุ่มอาการดังกล่าว เป็นปัญหาสำคัญในประชากรไทย ถึงแม้จะอาศัยในชนบทที่ยังไม่ค่อยเจริญ ดังนั้นการตระหนักถึงปัญหาและให้การรักษาภาวะดังกล่าวจะช่วยลดปัจจัยเสี่ยงที่สำคัญของการเกิดโรคหลอดเลือดหัวใจ*