

## Obesity Definition Differences and Association with Coronary Artery Disease in a Rural Malaysia Population

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### Abstract

Obesity, defined conventionally by Basal Mass Index (BMI), is associated with numerous cardiac complications such as coronary heart disease, heart failure, and sudden death. However, not all obese people are affected by metabolic disturbances and a subset of normal BMI individuals suffer from metabolic syndrome (MetS). Although these phenotypes have been recognized by researchers, there is a paucity of data for obese people without MetS (MHO) (MetS+/Obe-). This study examined the prevalence of different definitions of obesity and their association with Coronary Artery Disease (CAD) in a Malay rural population.

**Method:** The group, an 18 month cross sectional, hospital based study, comprised 408 patients who were non-smokers, age 20 and above, both gender and all races. We used differing definitions of obesity based on BMI, the consequences of obesity by these different definitions and ethnic associations.

**Results:** In patients with BMI  $\geq 25$ ,  $\geq 27$ , and  $\geq 30$ , the percentages of MHO were 15.4, 10.8 and 5.7% respectively. Obese, metabolic abnormal groups (MetS+/Obe+) (MOO) defined at BMI  $\geq 25$  (1.92, CI =1.16-3.17),  $\geq 27$  (1.94, CI=1.18-3.17) and non-obese, metabolic abnormal group with BMI<30 (MetS+/Obe-) (MONO) (1.71, CI=1.04-2.80) were significantly associated with CAD.

**Conclusion:** Obese, metabolic abnormal groups (MetS+/Obe+) (with obesity defined as BMI  $\geq 25$ ,  $\geq 27$ ) and metabolic abnormal group (MetS+/Obe-) with BMI <30 (with obesity defined as BMI  $\geq 30$ ) were significantly associated with CAD but obese metabolic normal subjects (Mets+/Obe-) (MHO) with BMI <27 were not significantly associated with CAD.

**Keywords:** Obesity; Basal Mass Index; Coronary heart disease; Heart failure

### Introduction

Obesity statistics from the 2006 Malaysian National Health and morbidity Survey showed 43% of Malaysian adults were overweight or obese as was 38% of child population. The recent 2010 World Health Organization (WHO) results showed that 60% of Malaysians age 18 and older had a Basal Mass Index (BMI) over 25. Obesity is a major contributor to the global epidemic of type 2 Diabetes (DM), fatty liver disease and cardiovascular diseases (CAD) but obesity is traditionally defined only by BMI without any regard to associated abnormalities [1-3]. However, there are individuals in the population who have different phenotypes such as phenotypically obese but metabolically healthy (MHO); phenotypically not obese but metabolically unhealthy (NOMO); and other healthy in both categories.

In the last WHO Expert Consultation addressing the issue of setting different cut points for BMI in Asian populations, the committee agreed that overweight or obese Asians are generally at higher risk for diabetes mellitus and cardiovascular disease than Europeans of similar age, sex, and BMI [4]. Earlier studies suggest that MHO could represent as much as 20% of the obese population [5-9]. Conversely, there is a subset of normal weight individuals who suffer from metabolic disturbances, i.e., Non-Obese Metabolically Obese (NOMO). There are only a few studies comparing these phenotypes in the general population and their association with CAD.

This study aimed to identify prevalence of different obesity phenotypes in each category and their association with Coronary Artery Disease (CAD).

### Materials and Methods

Patients attending a rural district hospital in Malaysia were referred

by medical officers and other practitioners, or referred back from secondary and tertiary level hospitals for continued care.

This was a retrospective study with a sample size (n=408) determined using the Epi Info version 6<sub>(CDC)</sub> for population surveys. The study period was from January 15, 2010 to June 30, 2011. Samples were selected using clustered systematic randomizing. Fifteen patients were recruited every week, by randomly selecting patients from two out-patient clinics. Inclusion criterion was age 20 and above. Exclusion criteria were: patients with known causes of obesity such as Cushing's and pseudo-Cushing's syndrome, known causes of dyslipidaemia such as chronic renal failure, nephrotic syndrome, hypothyroidism, and HIV patients on antiviral drugs, and smoking.

The research purpose was explained and consent obtained from all patients interviewed and examined by the investigators. Questions asked included smoking history, alcohol intake, occupation, family income, exercise (mild=active with house chores, moderate activity=30 minute walk, jog, swimming per day for three days per week, etc., strenuous exercise=hard labour. History also included patient use of contraceptive pills, and knowledge of healthy foods, lifestyle, and hazards of obesity. Measurements of the BMI (kg/m<sup>2</sup>), Waist Circumference (WC) (cm) and Blood Pressure (mmHg) were

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carried out by the same assigned staff. Measurement of WC was standardized at the midpoint between the lower costal cartilage and the highest point of iliac crest with the patient exhaling completely. Coronary Artery Disease (CAD) was defined by patients' record: coronary angiography, angioplasty, CABG, symptoms of angina or unstable angina plus ECG changes, cardiac biomarkers with or without echocardiogram changes and response to coronary vasodilators. Blood samples for Fasting Blood Sugar (FBG), Serum Triglycerides (TG) and High-Density Lipoprotein Cholesterol (HDL-C) were taken in the early morning after an overnight fast.

Samples were defined as high waist circumference (WC ≥ 90 cm for male and WC ≥ 80 cm for female) and normal weight (BMI 18.5-22.9). Overweight was defined variably as BMI 23-29.9, 23-27.3 and 23-24.9; and obesity defined variably as BMI ≥ 25, ≥ 27 and ≥ 30 respectively for both female and male.

Three definitions for obesity, BMI ≥ 25, ≥ 27 and ≥ 30 were adopted from WHO definitions for Europeans, Southeast Asians and Far East populations [4]. In each definition we defined four groups: MetS+/Obe+ (Metabolic obese and obese: MOO), MetS-/Obe+ (Metabolic healthy and obese: MHO), MetS+/Obe- (Metabolic obese non obese: MONO) and MetS-/Obe- (normal). We adopted the basic NCEP (National Cholesterol Education Program) but used waist circumference (WC)

Variables	No. ( 408)	Malay (39.7%)	Indian (36.5%)	Chinese (23.8%)
<b>Age</b>		%	%	%
20-29	43 (15.0%)	(62.2)	(35.1)	(2.70)
30-39	40 (9.80%)	(60.0)	(37.5)	(2.50)
40-49	89 (21.8%)	(33.7)	(48.3)	(18.0)
50-59	129 (31.8%)	(40.3)	(34.7)	(25.0)
≥60	107 (26.4%)	(30.4)	(29.4)	(40.2)
Male	199 (48.8%)	(41.7)	(29.1)	(29.1)
Female	209 (51.2%)	(39.8)	(43.5)	(18.7)
BMI ≥25	268 (65.7%)	(44)	(36.6)	(19.4)
BMI ≥27	220 (45.3%)	(35)	(34.5)	(30.5)
BMI ≥30	129 (31.6%)	(44.2)	(39.2)	(16.3)
High WC	275 (67.4%)	(40.6)	(41.8)	(18.9)
Hypertension	244 (59.8%)	(31.7)	(35.4)	(32.9)
High F PG	241 (59.1%)	(39.8)	(40.2)	(19.9)
High TG	169 (41.4%)	(45.0)	(34.3)	(20.7)
Low HDL	228 (55.9%)	(31.4)	(45.5)	(23.1)
High T Cholesterol	187 (45.8%)	(47.1)	(33.7)	(19.3)
High LDL Cholesterol	281 (68.9%)	(42.3)	(37.7)	(19.9)
MetS	252 (61.8%)	(39.7)	(40.9)	(19.4)
DM	182 (44.6%)	(41.2)	(41.2)	(17.6)
CAD	80 (19.6%)	(35)	(36.3)	(28.8)

BMI: Body Mass Index; High WC: High Waist Circumference (≥ 80 cm in female & ≥ 90cm in male.) Hypertension ( Systolic Blood Pressure ≥ 130mmHg & Diastolic Blood Pressure ≥ 85 mmHg) , High FBG: High Fasting Plasma Glucose (≥ 5.6mmol/L), High TG: High Triglycerides (≥ 1.7mmol/L); Low HDLC: High Density Lipoprotein Cholesterol (≤ 1.29mmol/L in female & ≤ 1mmol/L in male); High T Cholesterol: High Total Cholesterol (≥ 5.2mmol/L), High LDL Cholesterol: High Low Density Cholesterol (≥ 2.4 mmol/L), DM: Diabetes Mellitus (Fasting Plasma Glucose ≥ 7mmol/L), CAD: Coronary Artery Disease.

Study population of 408: 48.8% female, 51.2% male.

Age group 20-29: 15%; 30-39: 9.80%; 40-49: 21.8%; 50-59: 31.8%; ≥ 60:26.4%, BMI: ≥ 30: 31.6%, ≥ 27: 45.3%, ≥ 25: 65.7%.

High LDL: 68.9, High WC: 67.4, High BP: 59.8, High fasting plasma glucose: 59.1, low HDL: 55.9, high total cholesterol: 45.8, high TG: 41.4, DM: 44.6, MetS: 61.8 and CAD 19.6%.

**Table 1:** Prevalence distribution of age groups, gender, and obesity, metabolic risks MetS, Type 2 DM and CAD with ethnicity.

criteria for both genders from International Diabetes Federation (IDF) criteria to define MetS and thus 'harmonized NCEP' because WC is ethnic specific. Other definitions used were: hypertension (systolic BP ≥ 130 mmHg, and/or diastolic BP ≥ 85 mmHg); raised fasting plasma glucose (FBG=5.6 mmol/L-6.99mmol/L; diabetes mellitus (FBG ≥ 7 mmol/L); low HDL-C <1.29 mmol/L in females and HDL-C <1.03mmol/L in males; high TG ≥ 1.7 mmol/L for both

Malays and Indians had genders. Patients were placed on therapy as needed, but only data prior to the treatment was used for analysis. Statistical analyses were performed using the SPSS version 11.5 (SPSS Inc, Chicago, IL, USA). Students' t-test was used to compare means; chi-squared test to identify the associations. Any result of p value <0.05 was considered as significant. Wilcoxon on Signed Rank test was used for non-normally distributed variables if applicable.

## Results

Table 1 shows number of total study population, percent of male and females, ethnicity (Malay, Indian and Chinese); age groups, prevalence of cardio-metabolic risks.

Significantly higher obesity than Chinese when BMI used was ≥ 25 and ≥ 30, but all ethnicities were comparable in group BMI ≥ 27. Prevalence of all the metabolic risks (DM, MetS and CAD) except hypertension was higher in Malay and Indians than Chinese. The highest prevalence of obesity was in age group 50-59 followed by age group 40-49 and ≥ 60). The youngest age group had the highest prevalence of obesity ≥ 30. Females were more obese than males in all obese BMI and nearly two fold in BMI ≥ 27 and ≥ 30, highest in Malays, followed by Indians and lowest in Chinese (Table 2).

Subjects with BMI ≥ 30 were slightly younger and those with BMI ≥ 25 slightly older. Mean BMI and WC were highest in group with BMI ≥ 30 and lowest in group with BMI ≥ 25 Mean of diastolic BP, HDLC, Total Cholesterol and LDL, TG, SBP and FBG were comparable among the all obesity groups (Table 3).

The prevalence of metabolic risk factors was comparable among obesity classes except for an increasing trend of high WC and hypertension noted from BMI ≥ 25 to BMI ≥ 30 (Table 4). The prevalence of all risk factors was significantly higher in BMI ≥ 25 than those less BMI <25, and similar for all obesity groups. In group BMI ≥ 30, the prevalence of WC and hypertension was significantly higher than those with BMI ≤ 30.

Variables	BMI ≥25 n=268 (65.7)	BMI ≥ 27 188 (46.1)	BMI ≥30 n=129 (31.6)
<b>Age groups</b>			
20-39	21 (8)	17 (9.2)	14 (11.1)
30-39	23 (8.7)	20 (10.8)	12 (9.5)
40-49	72 (27.3)	53 (28.6)	38 (30.2)
50-59	91 (34.5)	65 (35.1)	45 (35.7)
≥60	57 (21.6)	30 (16.2)	17 (7.5)
<b>Gender</b>			
Male	113 (42.8)	70 (36.8)	42 (33.3)
Female	151 (57.2)	120 (63.2)	84 (66.7)
<b>Ethnicity</b>			
Malay	120(45.5)	87 (45.8)	57 (45.2)
Indian	95 (36)	73 (38.4)	49 (38.9)
Chinese	49 (18.6)	30 (15.8)	20 (13.9)

Age group 50-59 had the highest prevalence of obesity followed by age groups 40-49 and ≥ 60. Prevalence of obesity was higher in females than males in all obese BMI and is nearly two fold in BMI ≥27.4 and ≥ 30. Obesity was highest in Malays followed by Indians and much lower in Chinese.

**Table 2:** Distribution of age groups, gender, ethnicity, in BMI ≥ 25, ≥ 27 and ≥ 30.

	Age	BMI	WC	SBP	DBP	TG	HDLC	FPG	T C	LDLC
BMI ≥25	50.3 ± 12.3	31.1 ± 6.21	98.5 ± 12.2	138 ± 18.7	84.0 ± 10.2	1.89 ± 10.41	1.11 ± 0.37	7.21 ± 2.88	5.22 ± 1.48	3.33 ± 1.20
BMI ≥ 27	48.7 ± 1.9	33.3 ± 6.10	101 ± 12.0	139 ± 8.3	84.4 ± 9.84	1.78 ± 1.27	1.11 ± 0.34	7.32 ± 2.95	5.20 ± 1.41	3.33 ± 1.13
BMI ≥ 30	47.7 ± 12.0	35.7 ± 6.18	104 ± 12.1	140 ± 16.7	84.6 ± 9.49	1.75 ± 1.30	1.13 ± 0.35	7.59 ± 3.14	5.22 ± 1.54	3.40 ± 1.25

Data expressed as means ± standard deviation, Biochemistry results as mmol/L

BMI: Body Mass Index; WC: Waist Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; FBG: Fasting Blood Glucose; FBG: Fasting Blood Glucose Raised FBG : Raised Fasting Blood Glucose; DM: Fasting Blood Glucose ≥ 7mmol/L; TG: Triglycerides; HDLC: High Density Lipoprotein Cholesterol; TC: Total Cholesterol; LDLC: Low Density Lipoprotein

Subjects in BMI ≥ 30 group were slightly younger and in group BMI ≥25 were slightly older. Mean of BMI and WC were highest in group BMI ≥ 30 and lowest in group BMI ≥ 25. Mean of diastolic BP, HDLC and Total Cholesterol and LDL, TG, SBP and FBS were comparable in all obese groups.

**Table 3:** Demographics of subjects with obesity (BMI ≥ 25 BMI ≥ 27 and BMI ≥ 30).

	BMI < 25	BMI ≥ 25	BMI ≥ 27	BMI ≥30
MetS	35%	76.8%	78.7 %	81.7 %
DM	36.4%	44.3%	51.1 %	48.4 %
CAD	17.9%	20.5%	20.7 %	19 %
High WC	28.6%	87.7%	92%	95.3%
P		0.00	0.00	0.00
High BP	39.3%	70.5%	77.1%	79.1%
P		0.00	0.00	0.00
FPG	46.4%	65.7%	66.0%	65.9%
P		0.00	0.00	0.057
Low HDLC	45.7%	61.2%	62.2%	62.8%
P		0.00	0.00	0.056
High TG	31.4%	46.6%	42.6%	42.6%
P		0.03	0.66	0.73
High TC	39.3%	49.3%	47.3%	46.5%
P		0.05	0.57	0.85
High LDL-C	67.1%	69.8%	71.3%	72.9%
P		0.58	0.33	0.23

BMI: Body Mass Index body weight kg/height by m<sup>2</sup>; High WC: High Waist Circumference ( ≥ 80 cm in female & ≥ 90cm in male;) Hypertension ( Systolic Blood Pressure ≥130mmHg & Diastolic Blood Pressure ≥85 mmHg) ; High FBG: High Fasting Plasma Glucose ( ≥ 5.6mmol/L); High TG: High Triglycerides ( ≥ 1.7 mmol/L); Low HDLC: High Density Lipoprotein Cholesterol ( ≤ 1.29mmol/L in female & ≤ 1mmol/L in male); High T Cholesterol: High Total Cholesterol ( ≥ 5.2mmol/L); High LDL Cholesterol: High Low Density Cholesterol ( ≥ 2.4 mmol/L); DM: Diabetes Mellitus (Fasting Plasma Glucose ≥ 7mmol/L); CAD: Coronary Artery Disease

Table 4 shows prevalence of metabolic abnormalities were comparable among all obesity classes with increasing trend of high WC and hypertension noted from BMI ≥ 25 to BMI ≥ 30. The prevalence of all risk factors except High LDL-C, were significantly higher in BMI ≥ 25 than those less than BMI < 25.

**Table 4:** Prevalence of high WC, hypertension, dyslipidemia, dysglycaemia, in obesity with associated outcomes of DM, MetS and CAD.

Female				Male			
Obesity	P	OR	95% CI	Obesity	P	OR	95% CI
BMI ≥ 25	0.31	0.65	0.28-1.51	≥ 25	0.97	0.98	0.49-1.99
BMI ≥ 27	0.62	1.19	0.59-2.41	≥ 27	0.73	1.14	0.55-2.33
BMI ≥ 30	0.46	1.31	0.64-2.69	≥ 30	0.41	0.72	0.33-1.58
High WC	P	OR	95% CI	High WC	P	OR	95% CI
≥ 80cm	0.90	0.94	0.38-2.83	≥ 80 cm	0.11	0.32	0.07-1.42
≥ 90cm	0.64	1.18	0.59-2.38	≥ 90 cm	0.21	0.63	0.31-1.30
≥ 100cm	0.74	1.14	0.53-2.46	≥ 100 cm	0.13	0.57	0.28-1.18

BMI=Body Mass Index (Body weight in Kg/Height cm<sup>2</sup>), WC= Waist Circumference in centimeter)

CAD risk does not increase with increase in either obesity classification or high WC categories in either gender.

**Table 5:** Association between Obesity and high WC categories with CAD in female and males.

There was no significant association between obesity categories, or WC categories with CAD (Table 5).

The prevalence of MetS+/Obe+ was highest in age group 50-59 whereas MetS+/Obe- was highest in age group ≥ 60, and MetS-/Obe+ highest in age group <30-39 among all obesity categories. Prevalence of DM was highest in MetS+/Obe-in BMI ≥ 25 and ≥ 27 whereas MetS+/Obe+ had highest DMin ≥ BMI 30. Prevalence of CAD was highest in

groups MetS+/Obe+ with BMI ≥ 25 and ≥ 27 and also MetS+/Obe- with BMI<30 (Tables 6a-6c).

MetS+/Obe+ in BMI ≥ 25 and BMI ≥ 27 and MetS+/Obe- in BMI <30 were significantly associated with CAD in. Subjects with BMI ≥ 25 and ≥ 27 without MetS were significantly less likely to develop CAD (Tables 7a-c).

**6a**

( BMI ≥25)	MetS+/Obe+ n=208 (51.5%)	MetS+/Obe- n=45 (11%)	MetS-/Obe+ n=62 (15.4%)	MetS-/Obe- n=92 (22.5%)
Age group				
20-29	9 (4.3)	1(2.2)	12 (19)	15 (16.3)
30-39	17 (8.2)	3(6.7)	6 (9.5)	14 (15.2)
40-49	49 (23.6)	7(15.6)	22 (34.9)	11 (12.0)
50-59	76 (36.5)	12(26.7)	14 (22.2)	22 (23.9)
≥ 60	48 (23.1)	18(40.0)	8 (12.7)	28 (30.4)
DM	123 (59.0)	30 (66.7)	9 (14.3)	20 (21.7)
CAD	51 (24.5)	10 (22.2)	6 (9.5)	13 (14.1)

**6b**

BMI ≥ 27	MetS+/Obe+ n=166 (40.7)	MetS+/Obe- n=91 (22.3%)	MetS-/Obe+/ n=44 (10.8%)	MetS-/Obe-/ n=109 (26.7%)
Age group				
20-29	7 (4.2)	3(3.3)	12(27.3)	15 (13.8)
30-39	16 (9.6)	4 (4.4)	4(9.1)	16 (14.7)
40-49	43 (25.9)	14 (15.4)	14 (31.8)	18 (16.5)
50-59	59 (35.5)	31(34.1)	9(20.5)	26 (23.9)
≥ 60	35 (21.1)	42(35.2)	4 (9.1)	32 (29.4)
DM	98 (59.0)	56(61.5)	6 (13.6)	22 (20.2)
CAD	43 (25.9)	20 (22.0)	5 (11.4)	14 (12.8)

**6c**

BMI ≥ 30	MetS+/Obe+ n=106(25.9%)	MetS+/Obe- n=145 (35.5%)	MetS-/Obe+ n=26 (5.70%)	MetS-/Obe- n=131 (32.3%)
Age group				
20-29	6 (5.7)	4 (2.9)	8 (30.8)	21 (15.2)
30-39	11 (10.4)	9(6.3)	1(3.8)	19 (14.8)
40-49	30(27.4)	31(21.5)	8 (30.8)	24 (18.4)
50-59	44(40.6)	49(33.8)	6 (23.1)	32 (25.4)
≥ 60	15(13.2)	52(35.5)	3 (11.5)	33 (26.2)
DM	71 (67.6)	85 (57.4)	2 (8.3)	26 (20.2)
CAD	24 (22.6)	37(25.0)	2 (8.3)	17 (13.2)

MetS-/Obe+ were highest in age group < 30-39 by all obesity categories. Prevalence of DM was highest in MetS+/Obe- and MetS+/Obe+ in all groups. Prevalence of CAD was highest in MetS+/Obe+ in BMI ≥ 25 and ≥ 27, and MetS+/Obe-in group BMI ≥30. **Tables 6a,b&c:** Age groups distribution and prevalence of DM and CAD in MetS+/Obe+, MetS-/Obe+, MetS+/Obe- and MetS-/Obe- in obesity categories. Table 6a,b &c shows prevalence of MetS+/Obe+ was highest in age group 50-59; with MetS+/Obe- highest in age group ≥60;

Figures 1-3 showed prevalence of high WC and CAD in subjects with MetS+/Obe+ and MetS+/Obe- in varying BMI threshold. It revealed that prevalence of CAD is higher in MetS+/Obe- than MetS+/Obe- in BMI ≥ 30.

Variables	p	OR	95%CI
MetS+/Obe+ ( n=208) CAD=24.5%	0.01	1.92	1.16-3.17
MetS-/Obe+ (n=63) CAD =9.5%	0.03	0.39	0.16-0.95
MetS+/Obe- (n=45) CAD=22.2%	0.64	1.20	0.57-2.53
MetS-/Obe-(n=92) CAD=14.1%	0.13	0.61	0.32-1.16

**Table 7a:** BMI ≥ 25, MetS+/Obe+ was significantly associated with and MetS-/Obe+ was significantly not associated with CAD.

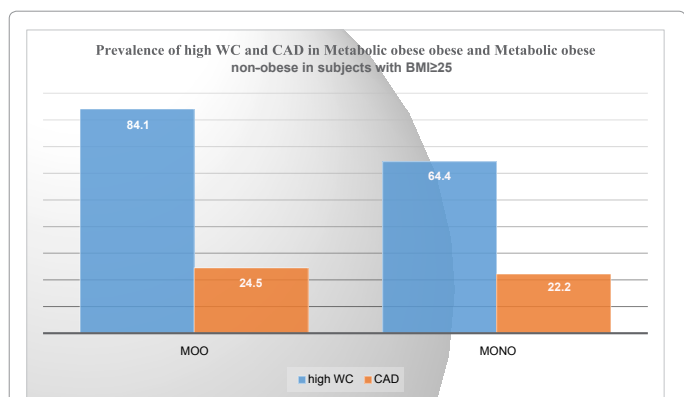
Variables	p	OR	95%CI
MetS+/Obe+ (n=164) CAD=25.0%	0.00	1.94	1.18-3.17
MetS-/Obe+ (n=41) CAD =20.6%	0.15	0.54	0.18-1.51
MetS+/Obe- (n=89) CAD= 22%	0.52	1.21	0.68-2.13
MetS-/Obe- (n=114) CAD=12.8%	0.04	0.52	0.28-0.97

**Table 7b:** BMI ≥ 27, MetS+/Obe+ was significantly associated with CAD but MetS-/Obe+ was not in this group definition. MetS-/Obe- was significantly not associated with CAD.

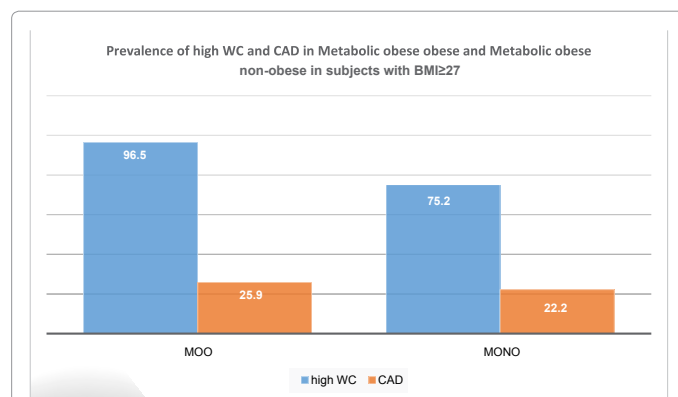
Variables	p	OR	95%CI
MetS+/Obe+/(n=106) CAD=22.6%	0.36	1.29	0.75-2.21
MetS-/Obe+ (n=26) CAD =7.7%	0.11	0.33	0.08-1.40
MetS+/Obe- (n=147) CAD= 25.2%	0.03	1.71	1.04-2.80
MetS-/Obe-(n=129) CAD=13.2%	0.03	0.52	0.29-0.93

**Table 7c:** BMI ≥ 30, MetS+/Obe-was significantly associated with and MetS-/Obe- was significantly not associated with CAD. MetS-/Obe+ was not significantly associated with CAD.

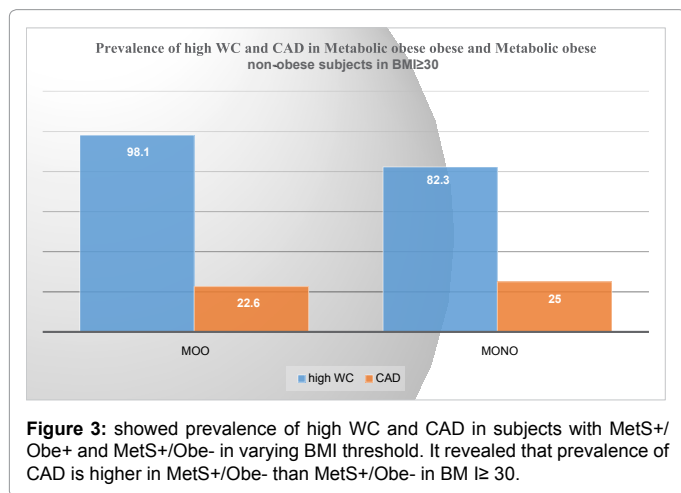
**Tables 7a,b,c:** Association between MetS+/Obe+, MetS-/Obe+, MetS+/Obe-, MetS-/Obe- and CAD where obesity is defined by BMI ≥ 25 ≥ 27 and ≥ 30.



**Figure 1:** showed prevalence of high WC and CAD in subjects with MetS+/Obe+ and MetS+/Obe- in varying BMI threshold. It revealed that prevalence of CAD is higher in MetS+/Obe- than MetS+/Obe- in BM ≥ 30.



**Figure 2:** showed prevalence of high WC and CAD in subjects with MetS+/Obe+ and MetS+/Obe- in varying BMI threshold. It revealed that prevalence of CAD is higher in MetS+/Obe- than MetS+/Obe- in BM ≥ 30.



## Discussion

The higher prevalence of obesity in our study compared to other local studies could be that our study population was hospital based (Table 1). We agree with other local studies that females are more obese than males and Malay and Indian females are more obese than Chinese females (Table 2) [10,11]. Our finding of highest prevalence of obesity in age group 50-59 is consistent with reports by others [12-14]. In age group 60 and above, obesity was noted to decrease, consistent with other studies most probably because mean body weight and BMI tend to decrease after age 60, although BMI was highest in Chinese in this age group (Table 2) [15,16].

Our finding of comparable prevalence of CAD in BMI  $\geq$  25,  $\geq$  27 and  $\geq$  30 (Table 4) and no significant association of obesity categories (BMI  $\geq$  25,  $\geq$  27 and  $\geq$  30) and high WC categories ( $\geq$  80 cm,  $\geq$  90 cm,  $\geq$  100 cm) with CAD in both sexes (Table 5) prompted a look into the association between metabolic syndrome and obesity (with different cut off points) as separate factors; MetS+/Obe+, MetS-/Obe+, MetS+/Obe- and MetS-/Obe- with CAD. We found MetS+/Obe+ to be significantly associated with CAD in BMI  $\geq$  25, BMI  $\geq$  27 and Obe-/MetS+ in BMI <30. (Tables 7a-7c). This supports other reports that obesity is independently associated with the incidence of new CAD cases possibly because of an increase in vascular resistance and high circulating blood volume adversely affecting conventional CAD risk factors such as HTN, diabetes mellitus, dyslipidemia, and the metabolic syndrome [17,18].

58.4%-89.6% of subjects with MetS+/Obe+ in BMI groups  $\geq$  25 and  $\geq$  27 respectively had high waist circumference (WC) and these groups were noted to be significantly associated with CAD (Table 7a,7b and Figures 1 and 2). However, in BMI  $\geq$  30, MetS+/Obe+ was noted to have more significant association with CAD than MetS+/Obe+ (Table 7c and Figure 3). Thus it appears that WC coupled with BMI predicts health risk better than does BMI alone. It seems reasonable to suggest that, for a given WC value, higher BMI values by itself may not necessarily indicate an increased health risk and when BMI >30, WC is irrelevant. Waist circumference and BMI are not interchangeable and waist circumference should be interpreted with regard to patient's BMI [19-22]. In addition, subjects with MetS+/Obe+ were older (age 50-59) than subjects with MetS-/Obe+, subjects with MetS+/Obe- were older (age  $\geq$  60) than subjects with MetS+/Obe+, and subjects with MetS-/Obe+ were the youngest of all groups (Tables 6a-6c). It thus appears that obese subjects develop MetS one decade earlier than those without obesity, supporting obesity being a risk factor for developing

MetS [15,16]. As age is one of the determining factor for developing MetS subjects with MetS+/Obe- were the oldest age group in our study, consistent with report by Kraja et al., that an age-related difference might exist as metabolic risk factors appear increasingly prevalent or worsen with age [23-26]. The higher number of MetS+/Obe- in BMI <30 and older age might explain the significant association with CAD.

15.5%, 10.9% and 5.70% of subjects were noted to be MetS-/Obe+ (MHO) in groups BMI  $\geq$  25,  $\geq$  27 and  $\geq$  30 respectively (Tables 6a-6c). This finding is consistent with reports by others where 10-25% of obese individuals were metabolically healthy, probably due to preserved insulin sensitivity, less visceral adipose tissue, less ectopic fat accumulation in the liver, normal to high levels of insulin sensitivity and lower inflammation state as suggested by low C-reactive protein levels [9,12,27-31]. They even seems to have a protective function, raising the possibility of a metabolically different class of subjects with this phenotype (Table 7a), as MetS-/Obe+ subjects with BMI  $\geq$  27 and BMI  $\geq$  30 were not seen to have a significant association with CAD. (Table 7b&c) This finding is consistent with reports by others [8,24,32].

Since MetS with obesity (MetS+/Obe+) is strongly associated with CAD, the risk of CAD was compared among these three subtypes of obesity. Overall, the prevalence and risk of CAD was significantly higher in the metabolically obese, obese, MetS+/Obe+, in the BMI groups  $\geq$  25 and  $\geq$  27 and in the metabolically obese, non-obese, MetS+/Obe- in the BMI <30. A possible explanation could be that, in the absence of metabolic abnormalities, phenotypic obesity alone does not increase the risk for CAD. Given that the risk of CAD is higher among the MetS+/Obe- subjects, it appears that identification and treatment of metabolic abnormalities could reduce the risk of cardiovascular disease among MONO individuals. The authors of the notion of obesity paradox may not have looked into obesity together with MetS [33]. We find that the definition of obesity by presence or absence of MetS is more important than that of high BMI (Tables 7a-7c).

Prevalence of all ethnic groups was virtually the same at BMI  $\geq$  27 but the prevalence of obesity  $\geq$  25 and  $\geq$  30 was higher among Malay and Indian (Table 2). It is necessary to study the demographic risk factors for developing obesity. Comparable mean of metabolic risks in all obese BMI groups need to redefine obesity in this study population by reflecting lower BMI cut-off than 25 in South-East Asians (Table 3).

## Conclusion

Not all obese subjects have MetS and only individuals with MetS with or without obesity have a significant association with CAD.

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