Short Communication

Metabolic syndrome among non-obese adults in the teaching profession in Melaka, Malaysia

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Abstract

Background: Non-obese individuals could have metabolic disorders that are typically associated with elevated body mass index (BMI), placing them at elevated risk for chronic diseases. This study aimed to describe the prevalence and distribution of metabolically obese, non-obese (MONO) individuals in Malaysia.

Methods: We conducted a cross-sectional study involving teachers recruited via multi-stage sampling from the state of Melaka, Malaysia. MONO was defined as individuals with BMI 18.5–29.9 kg/m² and metabolic syndrome. Metabolic syndrome was diagnosed based on the Harmonization criteria. Participants completed self-reported questionnaires that assessed alcohol intake, sleep duration, smoking, physical activity, and fruit and vegetable consumption.

Results: A total of 1168 teachers were included in the analysis. The prevalence of MONO was 17.7% (95% confidence interval [CI], 15.3–20.4). Prevalence of metabolic syndrome among the normal weight and overweight participants was 8.3% (95% CI, 5.8–11.8) and 29.9% (95% CI, 26.3–33.7), respectively. MONO prevalence was higher among males, Indians, and older participants and inversely associated with sleep duration. Metabolic syndrome was also more prevalent among those with central obesity, regardless of whether they were normal or overweight. The odds of metabolic syndrome increased exponentially from 1.9 (for those with BMI 23.0–24.9 kg/m²) to 11.5 (for those with BMI 27.5–29.9 kg/m²) compared to those with BMI 18.5–22.9 kg/m² after adjustment for confounders.

Conclusions: The prevalence of MONO was high, and participants with BMI ≥23.0 kg/m² had significantly higher odds of metabolic syndrome. Healthcare professionals and physicians should start to screen non-obese individuals for metabolic risk factors to facilitate early targeted intervention.

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1. Introduction

The prevalence of metabolic syndrome in Malaysia is higher than in other Asian countries, mainly due to the high prevalence of obesity. However, there are many individuals who are not categorized as obese based on body mass index (BMI) but are predisposed to metabolic disorders. Screening for metabolic disorders among these non-obese individuals is often ignored, as they are assumed to be healthy. The literature shows that normal weight individuals could have metabolic disorders, placing them at elevated risk for chronic diseases that are typically associated with elevated BMI. Evidence also suggests that an abnormal metabolic profile, rather than high BMI, is associated with higher risk of diabetes and cardiovascular disease.

Individuals who are normal-to over-weight with metabolic syndrome have been broadly classified as metabolically obese, non-obese (MONO). However, the classification of MONO was complicated by the limitations associated with utilizing BMI in the definition. MONO was previously defined as individuals with BMI <27.0 kg/m² or <25.0 kg/m² who have metabolic syndrome. However, based on World Health Organization (WHO) classification, the definition of non-obese is BMI 18.5–29.9 kg/m². Malaysia has the highest prevalence of overweight population in the Southeast Asia, so knowing the metabolic risk among this group is crucial for public health action and clinical practice.
MONO offers insight into the risks of metabolic syndrome independent of obesity. Several studies have reported that non-obese individuals with metabolic risk factors display characteristic such as insulin resistance and higher visceral adiposity and plasma triglyceride, which together may confer an increased risk of cardiometabolic disease. Moreover, identifying MONO may be more important among Asians, who are generally less obese but have relatively higher body fat than Westerners with the same BMI.

Therefore, the aim of this study was to describe the prevalence and distribution of MONO using a BMI criterion of 18.5–29.9 kg/m² among the adult population in the state of Melaka, Malaysia.

2. Methods

This was a cross-sectional study carried out using multi-stage sampling in a school setting. A total of 51 public secondary schools were randomly selected. All permanent school teachers from the selected schools were invited to participate. Teachers who had psychiatric illnesses, were pregnant, or had a BMI < 18.5 or ≥ 30.0 kg/m² were excluded. Data collection was carried out from October 2013 until February 2014. Information on socio-demographic characteristics and lifestyle behaviours were enquired using self-administered questionnaires. Anthropometric measurements and metabolic risk assessments were conducted by trained research assistants as per protocol. This study is part of a cohort study on clustering of lifestyle risk factors and understanding its association with stress on health and wellbeing among school teachers in Malaysia (CLUSTer).

This study was approved by the University Malaya Medical Ethics Committee (Ref No. 950.1) and written permission was granted from the Ministry of Education, the Education Department, and the school principals. Informed consent was obtained from all participants.

2.1. Definition of metabolic syndrome

Metabolic syndrome was defined using the Harmonization criteria as having any three or more of the following risk factors: (1) central obesity (waist circumference [WC] ≥ 80 cm in women or ≥ 90 cm in men); (2) elevated triglyceride (TG; ≥ 1.7 mmol/L); (3) low high-density lipoprotein cholesterol (HDL-C; ≤ 1.3 mmol/L in women or < 1.0 mmol/L in men); (4) high blood pressure (BP; ≥ 130/85 mm Hg or on antihypertensive treatment); and (5) high fasting blood glucose (FBG; ≥ 5.6 mmol/L or on treatment for elevated glucose).

2.2. Definition of MONO

MONO was defined as individuals with BMI 18.5–29.9 kg/m² with metabolic syndrome. These individuals were subdivided into four BMI categories (18.5–22.99, 23.00–24.99, 25.00–27.49, and 27.50–29.99 kg/m²) according to the BMI cut-off points as defined by WHO.

2.3. Statistical analyses

Data entry and analysis were undertaken using the IBM SPSS Statistic version 21.0 (IBM Corp, Armonk, NY, USA). Samples were weighted to account for unequal probabilities of selection and non-response rate. Complex sample multivariate logistic regression

| Table 1 |
| Socio-demographic characteristics and lifestyle risk factors of participants. |
| --- |
| **Total** n | **MONO** | **P value** |
| **Age group, years** | **Yes (n = 218) n (weighted %)** | **No (n = 950) n (weighted %)** |
| 20–29 | 113 | 6 (5.6) | 107 (94.4) | <0.001 |
| 30–39 | 319 | 32 (10.5) | 287 (89.5) |
| 40–49 | 430 | 87 (17.5) | 343 (82.5) |
| 50–59 | 306 | 92 (29.4) | 214 (70.6) |
| **Gender** | | | |
| Male | 280 | 72 (25.9) | 208 (74.1) | 0.004 |
| Female | 888 | 146 (15.2) | 742 (84.8) |
| **Ethnicity** | | | |
| Malay | 897 | 165 (17.7) | 732 (82.3) | 0.005 |
| Chinese | 216 | 34 (14.9) | 182 (85.1) |
| Indian | 40 | 16 (39.3) | 24 (60.7) |
| Others | 15 | 2 (7.8) | 13 (92.2) |
| **Level of education** | | | |
| Diploma | 37 | 5 (19.1) | 32 (80.9) | 0.451 |
| Degree | 1035 | 1868 (17.2) | 847 (82.8) |
| Master/PhD | 96 | 25 (23.3) | 71 (76.7) |
| **Level of physical activity** | | | |
| Low | 103 | 21 (15.2) | 82 (84.8) | 0.617 |
| Moderate | 453 | 84 (18.6) | 369 (81.4) |
| High | 275 | 59 (20.0) | 216 (80.0) |
| **Smoking status** | | | |
| Current | 28 | 7 (21.5) | 21 (78.5) | 0.870 |
| Former | 43 | 9 (19.2) | 34 (80.8) |
| Never | 955 | 177 (17.6) | 778 (82.4) |
| **Alcohol consumption** | | | |
| Yes | 34 | 10 (25.7) | 24 (74.3) | 0.219 |
| No | 1020 | 186 (17.2) | 834 (82.8) |

| **Mean (SE)** | **Mean (SE)** | **P value** |
| --- | --- | --- |
| Age, years | 42.51 (0.49) | 46.72 (0.72) | 41.60 (0.50) | <0.001 |
| Servings of fruits and vegetables/day | 2.35 (0.04) | 2.39 (0.10) | 2.34 (0.05) | 0.644 |
| Sleep, hours per day | 6.26 (0.05) | 5.97 (0.08) | 6.32 (0.06) | 0.001 |

MONO, metabolically obese, non-obese; SE, standard error.
analysis was conducted to estimate the odds ratio (OR) with 95% confidence interval (CI) of metabolic syndrome among non-obese individuals (MONO) adjusted for modifiable and non-modifiable confounders.

3. Results

A total of 1511 teachers were recruited, yielding a response rate of 36.0%. After excluding the underweight and obese, 1168 participants (78.4%) were included in the analysis. The majority of participants were females, Malays, and had tertiary education, with a mean age of 42.5 years (Table 1). The prevalence of MONO was 17.7% (95% CI, 15.3–20.4), whereas the prevalence of metabolic syndrome among the normal weight and overweight participants was 8.3% (95% CI, 5.8–11.8) and 29.9% (95% CI, 26.3–33.7), respectively (Table 2). The prevalence of MONO was higher among males (P = 0.004) and Indians (P = 0.006) and increased with age (P < 0.001). Participants with metabolic syndrome were

Table 2
The proportion of metabolic syndrome according to fatness categories.

| Fatness categories | Metabolic syndrome | P value |
|--------------------|--------------------|---------|
|                    | Yes (weighted %)   | No (weighted %) |
| Normal weight      | 55 (8.3)           | 577 (91.7) | <0.001 |
| Central obesity    | 35 (24.6)          | 92 (75.4)  | <0.001 |
| Non-central obesity| 20 (4.2)           | 485 (95.8) | <0.001 |
| Overweight         | 163 (29.9)         | 373 (70.1) | <0.001 |
| Central obesity    | 140 (40.7)         | 212 (59.3) | <0.001 |
| Non-central obesity| 14 (8.4)           | 161 (91.6) | <0.001 |
| Total (MONO)       | 218 (17.7)         | 950 (82.3) | <0.001 |
| Central obesity    | 184 (36.2)         | 304 (63.8) | <0.001 |
| Non-central obesity| 34 (5.3)           | 646 (94.7) | <0.001 |

MONO, metabolically obese, non-obese.

- Male ≥90 cm; female ≥80 cm.
- BMI 18.5–24.9 kg/m².
- BMI 25.0–29.9 kg/m².
- BMI 18.5–29.9 kg/m².

Fig. 1. The proportion of number of metabolic risk factors according to BMI categories. MetS, metabolic syndrome.
significantly older (by approximately five years) and had shorter sleep duration (by approximately half an hour). There was no significant difference in the prevalence of metabolic syndrome according to the levels of education, physical activity, smoking status, alcohol consumption, or fruits and vegetables intake (Table 1).

Regardless of BMI status (normal and/or overweight), participants with central obesity were more likely to have metabolic syndrome compared to those without central obesity \((P < 0.001)\), whereas, among participants without central obesity, only 4–8% were diagnosed with metabolic syndrome (Table 2).

The number of metabolic risk factors according to BMI categories is shown in Fig. 1. The proportion of participants with no metabolic risk factors reduced with BMI \((P_{\text{trend}} < 0.001)\), while the proportion of participants with two to four metabolic risk factors increased significantly with BMI. There were no participants with five metabolic risk factors in the normal BMI categories. The proportion of participants with metabolic syndrome increased with BMI \((P_{\text{trend}} < 0.001)\).

The associations between BMI categories and metabolic syndrome are presented in Table 3. Higher BMI categories conferred higher crude and adjusted OR for metabolic syndrome. The unadjusted odds of metabolic syndrome increased exponentially from 2.5 \((\text{at BMI } 23.0–24.9 \text{ kg/m}^2)\) to 10.3 \((\text{at BMI } 27.5–29.9 \text{ kg/m}^2)\) compared to those with BMI 18.5–22.9 kg/m\(^2\). The adjusted odds of metabolic syndrome in models 1 and 2 were comparable those in the unadjusted model.

### Table 3

| BMI categories, kg/m\(^2\) | n  | Unadjusted | Model 1 | Model 2 |
|---------------------------|----|------------|---------|---------|
|                           |    | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| 18.5 to 22.9              | 376| 1          | 1       | 1       |
| 23.0 to 24.9              | 256| 2.49 (1.46, 4.25) | 2.22 (1.23, 4.01) | 1.94 (1.06, 3.55) |
| 25.0 to 27.4              | 312| 5.714 (3.48, 9.39) | 5.66 (3.43, 9.34) | 6.47 (3.53, 11.88) |
| 27.5 to 29.9              | 224| 10.32 (5.64, 18.89) | 10.95 (5.43, 21.93) | 11.47 (5.11, 25.75) |

BMI, body mass index; CI, confidence interval; OR, odds ratio. Model 1: Adjusted for non-modifiable confounders: age, gender, ethnicity. Model 2: Adjusted for all factors in Model 1 and modifiable confounders: education, physical activity, smoking, alcohol consumption, fruit and vegetable consumption, and sleep duration.

4. **Discussion**

The prevalence of MONO among our participants was about 18%, with male predominance. Previous studies have shown that the prevalence of metabolic syndrome among Taiwanese with BMI <27.0 kg/m\(^2\) was 18.7%\(^6\) and that the prevalence among South Indians with BMI <25.0 kg/m\(^2\) was 15.1%\(^8\).

MONO was more prevalent among our participants of Indian ethnicity, as they had higher tendency to develop central obesity, hypertension, dyslipidemia, hyperinsulinemia, and glucose intolerance, as has been reported elsewhere.\(^{15,16}\) Older age participants also had higher prevalence of MONO, so it is important to screen the older population for metabolic risk factors even if they are non-obese. Lifestyle risk factors, such as physical activity, smoking, alcohol, fruit and vegetable consumption, and sleep duration were reported to contribute to metabolic syndrome.\(^{17,18}\) However, in our study, only sleep duration was found to be significantly associated with MONO; an inverse relationship between sleep and metabolic syndrome has also been reported in a recent meta-analysis.\(^{19}\)

Central obesity is not compulsory in diagnosing metabolic syndrome using the Harmonization criteria. However, our results showed that those with central obesity had higher risk of metabolic syndrome regardless of being normal weight or overweight. One possible explanation might be because central obesity was the most frequently reported metabolic risk factor among our participants (data not shown), and central obesity could be a proxy for insulin resistance, which would increase the risk of developing metabolic syndrome.\(^{20,21}\)

Our study showed that the prevalence of metabolic syndrome and the number of metabolic risk factors increased with BMI, findings that have been similarly reported by others.\(^{6,22–24}\) These findings support the notion that weight gain is detrimental to metabolic health. We found that the adjusted odds of metabolic syndrome increased exponentially from a BMI of 23.0 kg/m\(^2\), in agreement with the recommendations,\(^9\) where BMI 23.0 kg/m\(^2\) was identified as an additional trigger point for public health action among Asians.

There were several limitations in our study that need to be addressed. First, the prevalence of MONO is difficult to quantify, as there is presently no standardized definition for MONO, resulting in a wide variation in its prevalence. Our results may not be generalizable to the general population, as the majority of our participants were females, Malays, and had tertiary education, representing the characteristics of the secondary school teachers in our country. In addition, the cross-sectional design does not allow us to establish causal relationships. Finally, recall bias could not be ruled out, as lifestyle behaviours were self-reported.

However, to the best of our knowledge, this is the first study to investigate the prevalence of MONO in Malaysia. In addition, the BMI categories were based on WHO cut-off points,\(^9\) unlike other studies where cut-off points were chosen arbitrarily.\(^{6,8}\) It is now clear that MONO is prevalent among our participants and they are susceptible to developing diabetes and cardiovascular disease, which may lead to cardiovascular or all-cause mortality.\(^{25–29}\) Detection of MONO individuals might be particularly noteworthy, since they might be more responsive to dietary and lifestyle interventions, which may reduce their subsequent risk of cardiovascular complications.\(^3,30\) Furthermore, it is practical, cost-effective, and feasible to identify MONO individuals in a large population using our already established health care system.

In conclusion, the prevalence of MONO was high and increased with BMI among our participants. Participants with BMI ≥23.0 kg/m\(^2\) had significantly higher odds of metabolic syndrome after adjustment. MONO was more prevalent among males, Indians, and those of older age, and was inversely associated with sleep duration. Healthcare professionals should start screening normal weight and overweight individuals for metabolic risk factors. Health promotion programs should be targeted on MONO individuals to increase their awareness of cardiometabolic risks and gear them towards taking preventive measures. Future studies should be conducted among populations from more diverse occupations, with a more nationally representative ethnic and gender distribution. Longitudinal studies should also be carried out to establish causal relationship between metabolic syndrome and its risk factors.
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Conflicts of interest

None declared.

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References

1. Mohamud WN, Ismail AA, Sharifuddin A, et al. Prevalence of metabolic syndrome and its risk factors in adult Malaysians: results of a nationwide survey. Diabetes Res Clin Pract. 2011;91:239–245.
2. Cornier MA, Dabelea D, Hernandez TL, et al. The metabolic syndrome. Endocr Rev. 2008;29:777–822.
3. Ruderman N, Chisholm D, Pi-Sunyer X, Schneider S. The metabolically obese, normal-weight individual revisited. Diabetes. 1998;47:699–713.
4. Wildman RP, Muntner P, Reynolds K, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). Arch Intern Med. 2008;168:1617–1624.
5. Meng J, Wilson PW, Fox CS, et al. Body mass index, metabolic syndrome, and risk of type 2 diabetes or cardiovascular disease. J Clin Endocrinol Metab. 2006;91:2906–2912.
6. Tsai CH. Metabolic syndrome in non-obese Taiwanese: new definition of metabolically obese, normal-weight individual. Chin Med J. 2009;122:2534–2539.
7. Peppa M, Koliaki C, Papaefstathiou A, et al. Body composition determinants of metabolic phenotypes of obesity in nonobese and obese postmenopausal women. Obesity (Silver Spring). 2013;21:1807–1814.
8. Geetha L, Deepa M, Anjana RM, Mohan V. Prevalence and clinical profile of metabolic obesity and phenotypic obesity in Asian Indians. J Diabetes Sci Technol. 2011;5:439–446.
9. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157–163.
10. World Health Organization. Noncommunicable Diseases Country Profiles; 2011 [updated September 2011; cited 4th December 2015]. Available from: http://www.who.int/nmh/publications/ncd_profiles2011/en/.
11. Karelis AD, St-Pierre DH, Conus F, Rahasa-Lhouet R, Poehlman ET. Metabolic and body composition factors in subgroups of obesity: what do we know? J Clin Endocrinol Metab. 2004;89:2569–2575.
12. Park YW, Allison DB, Heymsfield SB, Gallagher D. Larger amounts of visceral adipose tissue in Asian Americans. Obes Res. 2001;9:381–387.
13. Moey FM, Hoe VC, Hairi NW, et al. Cohort study on clustering of lifestyle risk factors and understanding its association with stress on health and wellbeing among school teachers in Malaysia (CLUSTER)—a study protocol. BMC Public Health. 2014;14:611.
14. Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; american heart association; World heart federation; international atherosclerosis society; and international association for the study of obesity. Circulation. 2009;120:1640–1645.
15. Yusuf S, Reddy S, Oumpuu S, Anand S. Global burden of cardiovascular diseases: Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. Circulation. 2001;104:2855–2864.
16. Misra A, Khurana L. The metabolic syndrome in South Asians: epidemiology, determinants, and prevention. Metabol Syndr Relat Res Dis. 2009;7:497–514.
17. Santos AC, Ebrahim S, Barros H. Metabolic syndrome: contribution to global cardiometabolic risk. Arterioscler Thromb Vasc Biol. 2008;28:1039–1049.
18. Geetha L, Deepa M, Anjana RM, Mohan V. Prevalence and clinical profile of metabolic obesity and phenotypic obesity in Asian Indians. J Diabetes Sci Technol. 2011;5:439–446.
19. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157–163.
20. World Health Organization. Noncommunicable Diseases Country Profiles; 2011 [updated September 2011; cited 4th December 2015]. Available from: http://www.who.int/nmh/publications/ncd_profiles2011/en/.
21. Tabata S, Yoshimito S, Hanachi T, Ahe H, Ohnaka K, Kono S. Waist circumference and insulin resistance: a cross-sectional study of Japanese men. BMC Endocr Disord. 2009;9:1–7.
22. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988–1994. Arch Intern Med. 2003;163:437–436.
23. St-Onge MP, Janssen I, Heymsfield SB. Metabolic syndrome in normal-weight Americans: new definition of the metabolically obese, normal-weight individual. Diabetes Care. 2004;27:2222–2228.
24. Lamon-Fava S, Wilson PWF, Schaefer EJ. Impact of body mass index on coronary heart disease risk factors in men and women: the framingham offspring study. Arterioscler Thromb Vasc Biol. 1996;16:1509–1515.
25. Batnij JA, Sahaykan RR, Rodriguez-Escudero JP, Bartels SJ, Somers VR, Lopez-Jimenez F. Normal weight obesity and mortality in United States subjects >60 years of age from the third national health and nutrition examination survey. Am J Cardiol. 2013;112:1592–1598.
26. Choi KM, Cho HJ, Choi HY, et al. Higher mortality in metabolically obese normal-weight people than in metabolically healthy obese subjects in elderly Koreans. Clin Endocrinol. 2013;79:364–370.
27. Fan J, Song Y, Chen Y, Hui R, Zhang W. Combined effect of obesity and cardiometabolic abnormality on the risk of cardiovascular disease: a meta-analysis of prospective cohort studies. Int J Cardiol. 2013;168:4761–4768.
28. Aung K, Lorenzo C, Hinojosa MA, Huffner SM. Risk of developing diabetes and cardiovascular disease in metabolically unhealthy normal-weight and metabolically healthy obese individuals. J Clin Endocrinol Metab. 2014;99:462–468.
29. Rhee EJ, Lee MK, Kim JD, et al. Metabolic health is a more important determinant for diabetes development than simple obesity: a 4-year retrospective longitudinal study. PLoS One. 2014;9:e8369.
30. Bradshaw PT, Monda KL, Stevens J. The metabolic syndrome in healthy obese, overweight, and normal weight individuals: the Atherosclerosis Risk in Communities Study. Obesity (Silver Spring). 2013;21:203–209.