THE CARDIOVASCULAR FACTORS AND METABOLIC SYNDROME IN AN ELDERLY MALE CHINESE OCCUPATIONAL POPULATION

Pei-En Chen1,2, Hsi-Che Shen3, Yi-Chun Hu3,4, Yu-Fen Chen5–7, Tao-Hsin Tung2
1Taiwan Association of Health Industry Management and Development, Taipei, Taiwan
2Department of Medical Research and Education, Cheng Hsin General Hospital, Taipei, Taiwan
3Taipei Medical University, Taipei, Taiwan
4Health Promotion Administration, Ministry of Health and Welfare
5Oriental Institute of Technology, Taipei, Taiwan
6Division for Disease Control and Prevention, Department of Health, Taipei City Government, Taipei, Taiwan
7Institute of Health and Welfare Policy, National Yang-Ming University, Taipei, Taiwan

Corresponding Author: Dr. Tao-Hsin Tung: ch2876@chgh.org.tw

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ABSTRACT

Purpose
This study was conducted to explore the prevalence of metabolic syndrome and identify associated risk factors in an elderly male occupational population in Taipei, Taiwan.

Methods
A total of 2734 healthy subjects over age 65 voluntarily presented to a teaching hospital for a physical check-up in 2010. Demographic data and blood test results were collected. Metabolic syndrome was diagnosed according to NCEP ATP III criteria.

Results
The mean age of study participants was 74.4±6.6 years. The prevalence of metabolic syndrome was estimated at 29.9% (95%CI: 28.2%-31.6%). After adjustment for confounding factors, higher body-mass index (OR=1.50, 95%CI 1.41–1.62), higher mean body fat (% of total mass, OR=1.11, 95%CI: 1.04–1.20), elevated serum uric acid (OR=1.13, 95%CI: 1.02–1.26), and elevated alanine aminotransferase (OR=1.01, 95%CI: 1.00–1.02), and sedentary lifestyle (yes vs. no, OR=1.22, 95%CI: 1.09–1.37) were identified as the most significant risk factors associated with metabolic syndrome.
Conclusion
The prevalence of metabolic syndrome is related to several cardiovascular risk factors. Health initiatives directed towards preventing and treating metabolic syndrome could significantly reduce the prevalence of diabetes and cardiovascular disease in this older population.

Key Words: male, metabolic syndrome, occupational population, elderly

Metabolic syndrome (MetS), a consequence of obesity and sedentary lifestyle, significantly increases the risk of cardiovascular disease (CVD) and diabetes.\textsuperscript{1-3} The prevalence of MetS increases with age. It is estimated that 40\% of individuals over age 60, and 10\% of individuals ages 20–60 have MetS.\textsuperscript{4} Early detection and treatment of this syndrome would significantly reduce the prevalence of associated poor health outcomes, including diabetes and CVD.

In Taiwan, the number of people entering the sector was estimated between 23,000 and 33,000 in 2002 by the Council of Agriculture. The agricultural population as a ratio of Taiwan’s total employed workforce dropped from 10.1\% in 1996 to 7.5\% in 2002, with the average age of farm workers rising slightly from aged 49 to 50. Those over age 60 accounted for over 25\%, a mild increase from the preceding year and an indication that Taiwan’s agricultural population is relatively elderly. In addition, the rise of the tourism industry in Taiwan has increased the country’s commercial fishing population, which is turning to recreational fishing for an economic turnaround. The generally low esteem of fishermen and the perceived lack of public respect for their occupation makes it difficult for the aging generation.\textsuperscript{5} Little is known about the prevalence of MetS, especially among elderly males.

From the preventive medicine viewpoint, it is not only essential to be cognizant of the prevalence of MetS regionally, but to explore the spectrum of demographic and biological markers which may be related to MetS levels. Regarding the uncertainty on whether the prevalence of and the associated risk factors with MetS amongst a male elderly occupational population. This study was conducted to identify the prevalence of and associated factors for a MetS, among an elderly male agricultural and fishing population in Taipei, Taiwan.

METHODS

Study Design and Data Collection
In this cross-sectional study a total of 2,734 elder males from agricultural and fishing occupations voluntarily presented to one teaching hospital in Northern Taiwan for an annual physical check-up between January, 1, 2010 and December, 31, 2010. All procedures were performed in accordance with the guidelines of our institutional ethics committee and adhered to the tenets of the Declaration of Helsinki. All patients’ information remained anonymous.

The medical histories and measurements of the participants were obtained by well-trained nurses. Personal and family histories of hypertension, type 2 diabetes, CVDs, and other chronic diseases were obtained by a questionnaire. The participants were asked to remove their shoes and any other belongings that could possibly add weight when they were weighed. Body-mass index (BMI) were evaluated based on height and weight. Waist circumference was measured at the level of the iliac processes and the umbilicus with a soft tape measure to evaluate abdominal obesity. Blood pressures were measured twice in the sitting position with an interval of 15 minutes between the measurements, by means of standard sphygmomanometers of appropriate width, after a rest period for 30 minutes. Those taking antihypertensive therapy were considered to be hypertensive.

Fasting blood samples were drawn via venipuncture from study participants by clinical nurses. Overnight-fasting serum and plasma samples (from whole blood preserved with EDTA and NaF) were kept frozen (−20°C) until ready for analysis. MetS was diagnosed according to NCEP ATP III criteria., At least 3 of the following 5 parameters were required for diagnosis: (1) abdominal obesity (waist circumference ≥ 90 cm), (2) hypertension (SBP>130 mm Hg and/or DBP>85 mm Hg)
or history of antihypertensive medication, (3) hypertriglyceridemia (≥150 mg/dL) or treatment for this disorder, (4) low HDL-C (<40 mg/dL in males) or treatment for this disorder, and (5) elevated fasting plasma glucose (>100 mg/dL) or the diagnosis of type 2 diabetes.6,7

Physical activity was gauged as moderate (60 minutes or more per day in activities such as brisk walking/domestic chores/carrying or moving loads up to 20 kg) and vigorous (running/cycling/swimming/carrying or moving loads above 20 kg). Anything short of moderate physical activity was considered sedentary.8

**Statistical Analysis**

Statistical analysis was performed using SPSS for Windows, (SPSS version 18.0; Chicago, IL, USA). The one-way ANOVA method was adopted to assess differences in the mean value of continuous variables. The χ²-trend test was used to determine significant differences in proportions among categorical variables. Multinomial logistic regression is the extension for the (binary) logistic regression when the categorical dependent outcome has more than 2 levels.9 This method was also performed to provide a set of coefficients for each of the 2 comparisons of MetS and to investigate the independence of factors associated with the prevalence of MetS.

A p-value of <0.05 was considered to represent a statistically significant difference between 2 test populations.

**RESULTS**

Table 1 indicates the demographic characteristics of the participants of the study. There were significant differences in SBP, DBP, BMI, waist circumference, triglycerides, total cholesterol, and alanine aminotransferase (ALT) among different age subgroups. In addition, the prevalence of sedentary lifestyle among

| TABLE 1 Demographic Characteristic of Participants with and Without Metabolic Syndrome among Male Study Population (n=2734) |
|---|---|---|---|---|---|
| Variables | General (n=2734) | Age | Metabolic Syndrome |
| | mean±SD | 65–74 (n=1519) mean±SD | 75–84 (n=1020) mean±SD | ≥85 (n=195) mean±SD | p-value for F-test | No (n=473) mean±SD | One or two (n=1443) mean±SD | More than three (n=818) mean±SD | p-value for F-test |
| Age | 74.4±6.6 | 69.7±2.9 | 78.8±2.8 | 88.7±4.6 | - | 74.7±6.9 | 74.5±6.5 | 74.5±6.5 | 0.10 |
| SBP (mm Hg) | 137.0±22.1 | 135.9±22.1 | 138.2±22.0 | 138.8±22.3 | 0.01 | 115.5±12.2 | 139.1±21.0 | 139.1±21.0 | <0.001 |
| DBP (mm Hg) | 78.6±12.1 | 88.6±12.0 | 76.6±11.7 | 73.9±12.8 | <0.001 | 69.3±8.0 | 79.3±11.6 | 79.3±11.6 | <0.001 |
| BMI (kg/m²) | 24.9±3.5 | 25.3±3.5 | 24.6±3.4 | 23.7±3.6 | <0.001 | 22.1±2.5 | 24.5±3.1 | 24.5±3.1 | <0.001 |
| Waist circumference (cm) | 88.5±10.2 | 89.1±10.1 | 88.1±10.1 | 85.8±11.7 | 0.04 | 79.4±6.4 | 87.1±9.1 | 87.1±9.1 | <0.001 |
| Fasting blood glucose (mg/dL) | 99.5±27.0 | 100.6±29.0 | 98.6±25.3 | 95.0±15.3 | 0.65 | 86.3±6.5 | 95.1±18.7 | 95.1±18.7 | <0.001 |
| Triglycerides (mg/dL) | 128.5±82.0 | 135.9±92.0 | 120.6±69.1 | 111.7±50.1 | 0.020 | 83.8±6.5 | 105.4±7.5 | 105.4±7.5 | <0.001 |
| HDL-C (mg/dL) | 51.9±14.5 | 52.0±14.7 | 51.8±14.3 | 52.1±13.5 | 0.11 | 61.1±13.8 | 54.2±13.5 | 54.2±13.5 | <0.001 |
| Uric acid (mg/dL) | 6.5±1.5 | 6.4±1.5 | 6.6±1.5 | 6.6±1.5 | 0.15 | 6.1±1.3 | 6.4±1.4 | 6.4±1.4 | <0.001 |
| ALT (U/L) | 32.4±26.0 | 34.5±32.2 | 30.1±14.6 | 25.1±9.4 | 0.01 | 28.3±11.8 | 31.6±27.2 | 31.6±27.2 | <0.001 |
| Mean body fat (% of total mass) | 24.1±7.4 | 24.5±8.5 | 23.7±5.0 | 22.9±8.0 | 0.17 | 20.3±4.4 | 23.6±6.6 | 23.6±6.6 | <0.001 |

ALT = alanine aminotransferase; BMI = body-mass index; DBP = diastolic blood pressure; HDL = high-density lipoprotein; SBP = systolic blood pressure.
Study subjects was 33.1% (95% CI: 31.3–34.9%). The prevalence of sedentary lifestyle and no MetS criteria, one or 2 criteria, and 3 or more criteria were 29.6% (95% CI: 25.5–33.7%), 31.8% (95% CI: 29.4–34.2%), and 37.4% (95% CI: 34.1–40.7%), respectively ($\chi^2 = 53.04, p < 0.001$).

The proportion of Chinese elderly men with MetS is shown in Figure 1. The prevalence of MetS among the study participants was 29.9% (95% CI: 28.2–31.6%). The prevalence of MetS revealed significant negative relationship with metabolic components when applying the $\chi^2$ trend test ($p = 0.04$). Figure 2 demonstrated the age-specific prevalence of each metabolic component of MetS. The prevalence of each metabolic component also revealed significant negative relationship with increased age when applying the $\chi^2$ trend test ($p < 0.001$). The most common component among the different age subgroups in this survey was elevated blood pressure, which involved 57.0% (95% CI: 55.1–58.9%) of all the participants. Hypertriglyceridemia (26.2%, 95% CI: 24.6–27.9%) and low HDL-C (21.9%, 95% CI: 20.3–23.4%) were relatively low. There were the same ranks in the 5 components for each age group.

The effect of independent associated risk factors upon MetS was examined using the multinomial logistic regression model. As is depicted in Table 2, subsequent to adjustment for confounding factors, higher BMI (OR = 1.19, 95% CI: 1.12–1.27), higher mean body fat (% of total mass, OR = 1.07, 95% CI: 1.02–1.14), higher ALT (OR = 1.01, 95% CI: 1.00–1.02), and sedentary lifestyle (yes vs. no, OR = 1.17, 95% CI: 1.02–1.33) appeared to be statistically significantly related to subjects with one or 2 metabolic factors. In addition, higher BMI (OR = 1.50, 95% CI: 1.41–1.62), higher mean body fat (% of total mass, OR = 1.11, 95% CI: 1.04–1.20), higher serum uric acid (OR = 1.13, 95% CI: 1.02–1.26), higher ALT (OR = 1.01, 95% CI: 1.00–1.02), and sedentary lifestyle (yes vs. no, OR = 1.22, 95% CI: 1.09–1.37) appeared to be statistically significantly related to subjects with MetS.

**DISCUSSION**

**Factors Associated with Metabolic Syndrome**

Interestingly we observed that the prevalence of MetS diminished with age (see Figure 1). Previous studies have indicated that prevalence of MetS increases with age until after age 70 when it tends to decrease. This may be related to a higher prevalence of chronic disorders and related complications such as malnutrition, dementia, etc. that increase with age.\textsuperscript{10,11} Another possible explanation may be related to the healthy worker effect (self-selection bias), whereby healthier working individuals may be more likely to volunteer for a physical check-up compared with unhealthier individuals who cannot work. In addition, we observed a higher prevalence of MetS in the sedentary lifestyle group. The relationship between regular moderate-to-vigorous physical activity and the prevention of chronic

**FIG. 1** Age-specific prevalence of number of metabolic components in the study participants ($n=2,734$).
FIG. 2 Age-specific prevalence of each metabolic component in the study participants (n=2,734).

(a) Elevated blood pressure

(b) Central obesity

(c) Hypertriglyceridemia

(d) Hyperglycemia

(e) Low High-Density Lipoprotein-C
TABLE 2 Multinominal Logistic Regression of Associated Factors for Metabolic Syndrome Among Male Elderly Screened Subjects (n=2,734)

|                                | One or two metabolic factors vs. no metabolic factors | Three or more metabolic factors vs. no metabolic factors |
|--------------------------------|------------------------------------------------------|--------------------------------------------------------|
|                                | OR         | 95%CI       | OR           | 95%CI       |
| Age (yrs)                      | 1.01       | 0.97–1.07   | 1.01         | 0.99–1.04   |
| BMI (Kg/m²)                    | 1.19       | 1.12–1.27   | 1.50         | 1.41–1.62   |
| Mean body fat (% of total mass) | 1.07       | 1.02–1.14   | 1.11         | 1.04–1.20   |
| Uric acid (mg/dl)              | 1.07       | 0.98–1.16   | 1.13         | 1.02–1.26   |
| ALT (U/L)                      | 1.01       | 1.00–1.02   | 1.01         | 1.00–1.02   |
| Irregular physical activity (yes vs. no) | 1.17       | 1.02–1.33   | 1.22         | 1.09–1.37   |

In this study, higher serum uric acid was independently associated with MetS. Serum uric acid is the final oxidation product of purine metabolism in humans. Hyperuricemia is usually caused by inadequate renal excretion of uric acid. Epidemiologic studies have shown an association between serum uric acid levels and the components of MetS, suggesting that hyperuricemia could be an additional component of MetS. The association between serum uric acid levels and CVDs might be partially due to attributable cardiovascular risk factors clustering in subjects with MetS, especially those strongly associated with waist circumference, which are also relevant in relation to MetS index – obesity. Underlying mechanisms which may explain why hyperuricemia is more commonly associated with Mets include: (1) Insulin resistance is widely recognized as a major risk factor for kidney disease and is also common in subjects with hyperuricemia and MetS. (2) Fructose is known to increase uric acid concentrations in humans, and uric acid may in turn increase the risk of MetS. However, strong intercorrelations among serum uric acid levels and the diagnostic criteria of MetS make it difficult to determine if an elevated serum uric acid level is an additional active component of MetS or just an associated link to MetS and its components.

Our results revealed that both higher BMI and higher mean body fat are strongly associated with MetS. MetS and obesity have been associated with an increased risk of diabetes and CVD morbidity and mortality, resulting in an enormous economic burden to society. Obesity adversely affects processes controlling blood glucose, blood pressure, and lipids. In addition, several investigators have shown that body fat is higher in Asian compared with white Caucasians for the similar level of BMI. Higher body fat composition, contributes to insulin resistance, dyslipidemia, hyperglycemia, and hypercoagulability seen commonly in South Asians. From the primary prevention viewpoint, obesity and sedentary lifestyle are responsible for the MetS epidemic behavioral modification to reduce weight and increase physical activity therefore should be the cornerstone of treatment.

Serum ALT was identified an important modifiable risk factor for MetS in this study. Elevated serum ALT is most closely related to liver fat accumulation, and is often used in epidemiological studies as a surrogate marker for nonalcoholic fatty liver disease. Previous studies demonstrated that serum ALT concentrations were related to hepatic insulin resistance and fatty changes in the liver. Therefore, conducting the better quality of liver function in order to prevent MetS is essential in elderly sub-population. Besides this fact, an early detection of MetS might be beneficial if accompanied with an early intervention, such as suppressing pathways for complications.

Prevalence of Metabolic Syndrome

The MetS is viewed as a constellation of cardiovascular risk factors. Table 3 presents the prevalence
TABLE 3 Prevalence of Metabolic Syndrome by ATP III Criteria in Various Populations

| Author       | Study year | Screened number | Setting  | Study age (years) | Prevalence of metabolic syndrome (%) | Associated factors                                                                 |
|--------------|------------|-----------------|----------|-------------------|--------------------------------------|----------------------------------------------------------------------------------|
| Shin MH, et al.33 | 2013       | 9260            | Korea    | Older than 50     | 40.4% (male), 53.9% (female)         | Alcohol intake                                                                    |
| Gundogan K, et al.10 | 2013       | 4309            | Turkey   | 47 ± 14           | 36.6%                                | Age, body-mass index, obesity                                                    |
| Carriere I, et al.34 | 2013       | 6141            | France   | Older than 65     | Central obesity, high triglycerides, and elevated fasting glucose and incidence of limitations in mobility and instrumental activities of daily living. |
| Li JB, et al.35 | 2010       | 1206            | China    | 59 ± 15           | 38.0%                                | Hypertension, diabetes, abdominal obesity, elevated blood glucose, life stress and anxiety |
| Chiou WK, et al.36 | 2010       | 5896            | Taiwan   | 53 ± 12           | 50.0% (male), 59.4% (female)         | Age, cardiovascular risk factor, hyperuricemia                                   |
| Zuo h, et al.37 | 2009       | 3914            | China    | 53 ± 10           | 45.2%                                | Body-mass index, hypertension, education, tea drinking, age, triglycerides        |
| Erem C, et al.11 | 2008       | 4809            | Turkey   | Older than 20     | 26.9% (female), 21.7% (male)         | Age, marital status, parity, cessation of cigarette smoking, and negatively with the level of education, alcohol consumption, current cigarette use, household income, and physical activity |
| Rho YH, et al.38 | 2008       | 1686            | Korea    | Older than 20     | 4.4% (male), 6.8% (female)           | Uric acid                                                                        |
| Gu D, et al.20  | 2005       | 15540           | China    | 35–74             | 9.8% (male), 17.8% (female)          | Age, body-mass index, overweight                                                 |
TABLE 3 Prevalence of Metabolic Syndrome by ATP III Criteria in Various Populations (Continued)

| Author       | Study year | Screened number | Setting                  | Study age (years) | Prevalence of metabolic syndrome (%) | Associated factors                              |
|--------------|------------|-----------------|--------------------------|-------------------|-------------------------------------|------------------------------------------------|
| Ford ES, et al. | 2005       | 3601            | United States           | Older than 20     | 34.5±0.9%                           | Waist circumference                               |
| Park, et al.  | 2004       | 3937(male) 4713(female) | Korea                    | 43 ± 15           | 14.2%(male), 17.7%(female)          | Obesity, body-mass index, current smoking         |
| Gupta, et al. | 2003       | 532(male) 559(female) | North India              | Older than 20     | 9.8%(male), 20.4%(female)           | Obesity, central obesity, hypertension, low high-density lipoprotein, hypertriglyceridemia |
| Azizi, et al. | 2003       | 4397(male) 5971(female) | Tehran, Iran(urban)     | Older than 20     | 24.0%(male), 42.0%(female)          | Age                                              |
| Al-Lawati, et al. | 2003   | 4723            | Oman                     | 38 ± 15           | 19.5%(male), 23.0%(female)          | Obesity, age, low high-density lipoprotein, cholesterol |
| Ford ES, et al. | 2002       | 8814            | United States           | Older than 20     | 21.8%(male), 23.7%(female)          | Age                                              |
| Misra, et al. | 2001       | 170(male) 362(female) | North India              | 35 ± 12           | 13.3%(male), 15.6%(female)          | Obesity, dyslipidaemia, diabetes                 |

and factors related to MetS in various populations. The prevalence of MetS seems to vary among different screened populations based on the results of different studies conducted in different countries.

Changes in lifestyle and diet have led to an increase in the prevalence of MetS in many parts of the world including Asia. 29 Sixty-four million people are estimated to have MetS in China alone. 20 The results provide an opportunity to elucidate the associations between putative factors and the early stage of MetS. The significant associated factors in our study are congruent with the biological plausibility that the impact of factors on the development or progression of MetS. The prevalence of MetS amongst different screened populations appears to vary according to the results of different studies conducted in different countries. 2 This disparity would likely be largely due to differences between different populations in addition to differences in the specifics of diagnostic criteria for MetS. The prevalence of MetS for our study population (29.9%) was higher than the corresponding prevalence presented in a previous population-based study conducted in general Chinese populations. 20,30–32 This might partially explain the apparently high prevalence of MetS observed in our study due to the agricultural and fishing population always face to the physical work, job stress, and reversed working and resting time. Irregular lifestyle and carelessness with their own health can result in MetS. 5 Another possible reason for such difference between the results of the general population-based studies and our results may simply have been related to the different study populations.
Limitations of This Study

Admittedly, there were several limitations in this study. Firstly, the MetS measurements were done only at a single point in time and would not be able to be used to reflect long-term exposure to various demographic or biochemical aspects or factors, which might be important influencers of MetS status. The better solution to such a quandary is to conduct a number of prospective analogous studies which would be expected to complement the cross-sectional results of this study. Secondly, the potential selection bias due to the hospital-based study design, is not representative of the whole general population. The present study only included male subjects who were aged ≥ 65 years and may have different characteristics compared with whole population. This study’s sub-population was more susceptible to be implemented with MetS. Furthermore, it can be beneficial to predict pathogenic trends and take early prevention strategies.

CONCLUSIONS

The prevalence of MetS is related to several cardiovascular risk factors. Promoting good health practices among this elderly male population is extremely important. Further studies are also needed to elucidate the temporal sequence of events that typically lead to MetS among male elderly sub-population.

CONFLICTS OF INTEREST

We certify that all the affiliations with or financial involvement in, within the past 5 years and foreseeable future, any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript are completely disclosed (e.g., employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, royalties).

REFERENCES

1. Misra A. Overnutrition and nutritional deficiency contribute to metabolic syndrome and atherosclerosis in Asian Indians. Nutrition 2002;18:702–703.
2. Misra A, Khurana L. Obesity and the metabolic syndrome in developing countries. J Clin Endocrinol Metab 2008;93:S9–S30.
3. Liu M, Wang J, Bin J, et al. Increasing prevalence of metabolic syndrome in a Chinese elderly population: 2001-2010. PloS ONE 2013;8:e66233.
4. Nevajda B, Mestrovic AH, Bilic M, et al. Prevalence of the metabolic syndrome in the old institutionalized people in Zagreb, Croatia. Coll Antropol 2013;31:203–206.
5. Chen YF, Hu YC, Chen HC, et al. Clinical implications in the prevalence and associated cardiovascular factors of elevated serum alanine aminotransferase levels among the elderly agricultural and fishing population in Taipei, Taiwan: Experience at a teaching hospital. J Invest Med 2014;62:88–96.
6. Jang SY, Kim IH, Ju EY, et al. Chronic kidney disease and metabolic syndrome in a general Korean population: The Third Korea National Health and Nutrition Examination Survey (KNHANES III) Study. J Public Health 2010;32:538–6.
7. Grundy SM, Cleeman JI, Daniels SE, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005;112:2735–52.
8. Sachdeva S, Khan Z, Ansari MA, et al. Lifestyle and gallstone disease: Scope for primary prevention. Indian J Community Med 2011;36:263–7.
9. Chan YH. Multinomial logistic regression. Singapore Med J 2005;46:259–9.
10. Gundogan K, Bayram F, Gedik V, et al. Metabolic syndrome prevalence according to ATP III and IDF criteria and related factors in Turkish adults. Arch Med Sci 2013;9:243–53.
11. Erem C, Hacihasanoglu A, Deger O, et al. Prevalence of metabolic syndrome and associated risk factors among Turkish adults: Trabzon MetS study. Endocrine 2008;33:9–20.
12. Clarke J, Janssen I. Sporadic and bouted physical activity and the metabolic syndrome in adults. Med Sci Sports Exerc 2014;46:76–83.
13. Levine JA. Nonexercise activity thermogenesis-liberating the life-force. J Int Med 2007;262:273––87.
14. Tremblay MS, Warburton DER, Janssen I, et al. New Canadian physical activity guideline. Appl Physiol Nutr Metab 2011;36:36–46.
15. See LC, Kuo CF, Chuang FH, et al. Serum uric acid is independently associated with metabolic syndrome in subjects with and without a low estimated glomerular filtration rate. J Rheumatol 2009;36:1691–98.
16. Lim JH, Kim YK, Kim YS, et al. Relationship between serum uric acid levels, metabolic syndrome, and arterial stiffness in Korean. Korean Circ J 2010;40:314–20.
17. Yoo TW, Sung KC, Shin HS, et al. Relationship between serum uric acid concentration and insulin resistance and metabolic syndrome. Circ J 2005;69:928–33.
18. Nakagawa T, Cirillo P, Sato W, et al. The conundrum of hyperuricemia, metabolic syndrome, and renal disease. Intern Emerg Med 2008;3:313–18.
19. Nakagawa T, Hu H, Zharikov S, et al. A causal role for uric acid in fructose-induced metabolic syndrome. Am J Physiol Renal Physiol 2006;290:F625–F631.
20. Gu D, Reynolds K, Wu X, et al. Prevalence of the metabolic syndrome and overweight among adults in China. Lancet 2005;365:1398–405.
21. Misra A, Vikram NK. Insulin resistance syndrome (metabolic syndrome) and obesity in Asian Indians: evidence and implications. Nutrition 2004;20:482–91.
22. Misra A, Vikram NK. Clinical and pathophysiological consequences of abdominal adiposity and abdominal adipose tissue depots. Nutrition 2003;19:457–66.
23. Dickinson S, Colagiuri S, Faramus E, et al. Post-prandial hyperglycemia and insulin sensitivity differ among lean young adults of different ethnicities. J Nutr 2002;132:2574–79.
24. Liu Z. Obesity and metabolic syndrome. North Am J Med Sci 2009;2:88–89.
25. The Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive Summary of The Third Report of The National Cholesterol Education Program (NECP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486–97.
26. Chen ZW, Chen LY, Dai HL, et al. Relationship between alanine aminotransferase levels and metabolic syndrome in nonalcoholic fatty liver disease. Zhejiang Univ Sci B 2008;9:616–22.
27. Fu CC, Chen MC, Li YM, et al. The risk factors for ultrasound-diagnosed non-alcoholic fatty liver disease among adolescents. Ann Acad Med Singapore 2009;38:15–17.
28. Oh SY, Cho YK, Kang MS, et al. The association between increased alanine aminotransferase activity and metabolic factors in nonalcoholic fatty liver disease. Metabolism 2006;55:1604–609.
29. Kitiyakara C, Yamwong S, Cheepudomwit S, et al. The metabolic syndrome and chronic kidney disease in a Southeast Asian cohort. Kidney Int 2007;71:693–700.
30. Tan CE, Ma S, Wai D, et al. Can we apply the national cholesterol education program adult treatment panel definition of the metabolic syndrome to Asians? Diabetes Care 2004;27:1182–86.
31. Fan JG, Zhu J, Li XJ, et al. Fatty liver and the metabolic syndrome among Shanghai adults. J Gastroenterol Hepatol 2005;20:1825–32.
32. Ko GT, Tang JS. Metabolic syndrome in the Hong Kong community: the United Christian Nethersole Community Health Service primary healthcare programme, 2001-2002. Singapore Med J 2007;48:1111–16.
33. Shin MH, Kweon SS, Choi JS, et al. Average volume of alcohol consumed, drinking patterns, and metabolic syndrome in older Korean adults. J Epidemiol 2013;23:122–31.
34. Carriere I, Pérès K, Ancelin ML, et al. Metabolic syndrome and disability: Findings from the Prospective Three-City Study. J Gerontol A Biol Sci Med Sci 2013 Jul 5.
35. Li JB, Wang X, Zhang JX, et al. Metabolic syndrome: prevalence and risk factors in southern China. J Int Med Res 2010;38:1142–48.
36. Chiou WK, Wang MH, Huang DH, et al. The relationship between serum uric acid level and metabolic syndrome: Differences by sex and age in Taiwanese. J Epidemiol 2010;20:219–24.
37. Zuo h, Shi Z, Hu X, et al. Prevalence of metabolic syndrome and factors associated with its components in Chinese adults. Metabolism 2009;58:1102–108.
38. Rho YH, Woo JH, Choi SJ, et al. Association between serum uric acid and the Adult Treatment Panel III-defined metabolic syndrome: Results from a single hospital database. Metabolism 2008;57:71–76.
39. Ford ES. Prevalence of the metabolic syndrome defined by the International Diabetes Federation among adults in the U.S. Diabetes Care 2005;28:2745–49.
40. Park HS, Oh SW, Cho SI, et al. The metabolic syndrome and associated lifestyle factors among South Korean adults. Int J Epidemiol 2004;33:328–36.
41. Gupta A, Gupta R, Sarna M, et al. Prevalence of diabetes, impaired fasting glucose and insulin resistance
syndrome in an urban Indian population. Diabetes Res Clin Pract 2003;61:69–76.
42. Azizi F, Salehi P, Etemadi A, et al. Prevalence of metabolic syndrome in an urban population: Tehran Lipid and Glucose Study. Diabetes Res Clin Pract 2003;61:29–37.
43. Al-Lawati JA, Mohammed AJ, Al-Hinai HQ, et al. Prevalence of the metabolic syndrome among Omani adults. Diabetes Care 2003;26:1781–85.
44. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. JAMA 2002;287:356–59.
45. Misra A, Pandey RM, Devi JR, et al. High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India. Int J Obes Relat Metab Disord 2001;25:1722–29.