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Original article

# Relationship between age and metabolic disorders in the population of Bali

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ABSTRACT

*Background/Purpose:* The purpose of this study is to examine the association between age and metabolic disorders in the population of Bali.
*Method:* A cross-sectional study was conducted on metabolic syndrome (MS) as defined on the basis of recommended parameters for diagnosis of the syndrome in the population of seven villages of Bali comprising six villages and one suburban area. At least three of the five parameters must be present for the diagnosis. Three hundred ten elderly people aged 60 years or more, with a male:female ratio of 168:142, of 1840 subjects were recruited in the study. The criteria for obesity were based on the 2000 World Health Organization recommendations for Asia Pacific population, for prediabetes [impaired fasting glycemia (IFG) and impaired glucose tolerance] and diabetes mellitus (DM) by American Diabetes Association (2009), and for MS by a joint statement of International Diabetes Federation, National Heart, Lung, and Blood Institute, American Heart Association, World Heart Federation, International Atherosclerosis Society, and International Association for the Study of Obesity (2009).
*Results:* The prevalence of IFG and DM were twofold in the elderly as compared with those in the younger-aged groups (21.4 *vs.* 11.7; 11.7 *vs.* 4.8, respectively). Blood pressure and fasting blood sugar levels were higher in the elderly than in the younger-aged group (133/81 mmHg *vs.* 117/76 mmHg; 102.7 mg/dL *vs.* 93.0 mg/dL, respectively; $p < 0.001$). There was no statistically significant difference in triglyceride and high-density lipoprotein cholesterol levels between both groups. Waist circumferences were lower among the elderly than among younger-aged groups (75.8 cm *vs.* 80.9 cm; $p < 0.001$). The elderly, with lower waist circumference, revealed significantly higher prevalence of MS as compared with the younger-aged group {22.9% *vs.* 17.3%; $p = 0.026$; prevalence risk 1.423 [confidence interval (CI) = 1.043–1.944]}. The subjects who had 1, 2, 3, 4, and 5 components of MS were 34.6%, 23.8%, 13.0%, 4.3%, and 0.9%, respectively. The prevalence risk of each component of MS for the occurrence of MS were: elevated triglyceride [30.2 (CI = 14.5–63.1)], elevated fasting blood sugar [8.5 (CI = 4.5–15.8)], increased waist circumference [8.1 (CI = 4.3–15.0)], reduced high-density lipoprotein cholesterol [4.4 (CI = 2.4–7.9)], and elevated blood pressure [3.7 (CI = 1.9–7.2)].
*Conclusions:* It could be inferred that in comparison with the younger-age group, the elderly had higher (twice) prevalence of IFG and DM, lower prevalence of central obesity, but higher prevalence of MS. Old age (60 years and more) had 1.4-fold risk for MS as compared with that in the younger-aged group, and elevated triglyceride levels appeared to be the most important risk factor for MS.


## 1. Introduction

The number of elderly population has increased worldwide; and recently, it has been increasing sharply in the developing countries. The projection of elderly population in Indonesia by the year 2010 is 23,992. The Indonesian Central Bureau for Statistics (Badan Pusat

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Statistik) reported that Indonesia is the world's fourth in the number of elderly population after China, India, and the United States.[1] The island of Bali is one among 11 provinces in Indonesia that has a relatively high proportion of elderly population, that is, 11.02%.[2] United States Bureau of Census predicted that from 1990 to 2020, the Indonesian elderly population would increase to 41.4%.[3] The predicted increased number of elderly was ascribed to the success of health promotion and improvement of social and economic status.[3] A field study in 1990 by World Health Organization (WHO), World Bank, and Harvard University found a changing pattern of diseases caused by unhealthy lifestyle changes that may eventually lead to metabolic syndrome (MS), Type 2 diabetes mellitus (DM), coronary arterial diseases, depression, and traffic accidents. The study also predicted that cerebrovascular diseases would become the most prevalent disease, whereas human HIV infection would sharply increase in the year 2020.[4]

Metabolic disorders are closely related with aging process. Central obesity and its consequences are frequently found among the elderly. The development of insulin resistance is likely to become one of the most important risk factors for metabolic diseases in the elderly. Decline in lean body mass and increase in body fat, particularly visceral adiposity that often accompanies aging may contribute to the development of insulin resistance. As for the mechanism of Type 2 DM, it is known that aging induces decrease of insulin sensitivity and alteration or insufficient compensation of beta-cell functional mass in the face of increasing insulin resistance.[5] Related to beta-cell functions, aging correlates with decrease of beta-cell proliferation capacity and enhances sensitivity to apoptosis.[6] It has recently been proposed that an age-associated decline in mitochondrial function contributes to insulin resistance in the elderly. Mitochondrial oxidative and phosphorylation function was reduced by about 40% in association with increased intramyocellular and intrahepatocellular lipid content and decreased insulin-stimulated glucose uptake.[7] Other metabolic diseases are also frequently related with aging, such as coronary arterial disease, malignancies, cognitive disorders, and vitamin D deficiency.[8,9]

The purpose of this study was to study metabolic disorders (obesity, MS, and glucose intolerance) in the elderly in comparison with younger-aged group.

## 2. Methods

A survey (cross-sectional study) was conducted on obesity, MS and its components, and glucose intolerance (prediabetes and DM) in the populations of seven villages of Bali, Indonesia, comprising six villages and one suburban area. The villages were the village of Sangsit (seashore area, 471 subjects), Pedawa (mountainous area, aboriginal Balinese, 294 subjects), Ubud (lowland and tourism area, 301 subjects), Tenganan (highland area, aboriginal Balinese, 81 subjects), Ceningan (remote island, 305 subjects), Legian (beach and tourism area, 288 subjects), and Pengelipuran (highland, 100 subjects) (Fig. 1). Three hundred ten elderly [aged 60 years or more; male-to-female ratio (168/142)] of a total of 1840 subjects were recruited in the study.

The variables measured included age, waist circumference, body mass index (BMI), blood pressure, plasma lipids, fasting, and 2-hour postprandial blood glucose. The criteria for obesity was based on the 2000 WHO recommendation for Asia Pacific Population.[10] Classification of prediabetes [impaired fasting glycemia (IFG) and impaired glucose tolerance (IGT)] and DM was based on the guidelines set out by American Diabetes Association in 2009,[11] that is, IFG if fasting blood glucose level was 100 mg/dL or higher and below 126 mg/dL; IGT if fasting blood glucose levels was below 100 mg/dL and 2-hour postprandial blood glucose levels was between 140 mg/dL or higher and below 200 mg/dL; and diabetes if fasting blood glucose levels was 126 mg/dL or higher. The diagnosis of MS was established on the basis of criteria and parameters as set out in the joint statement of International Diabetes

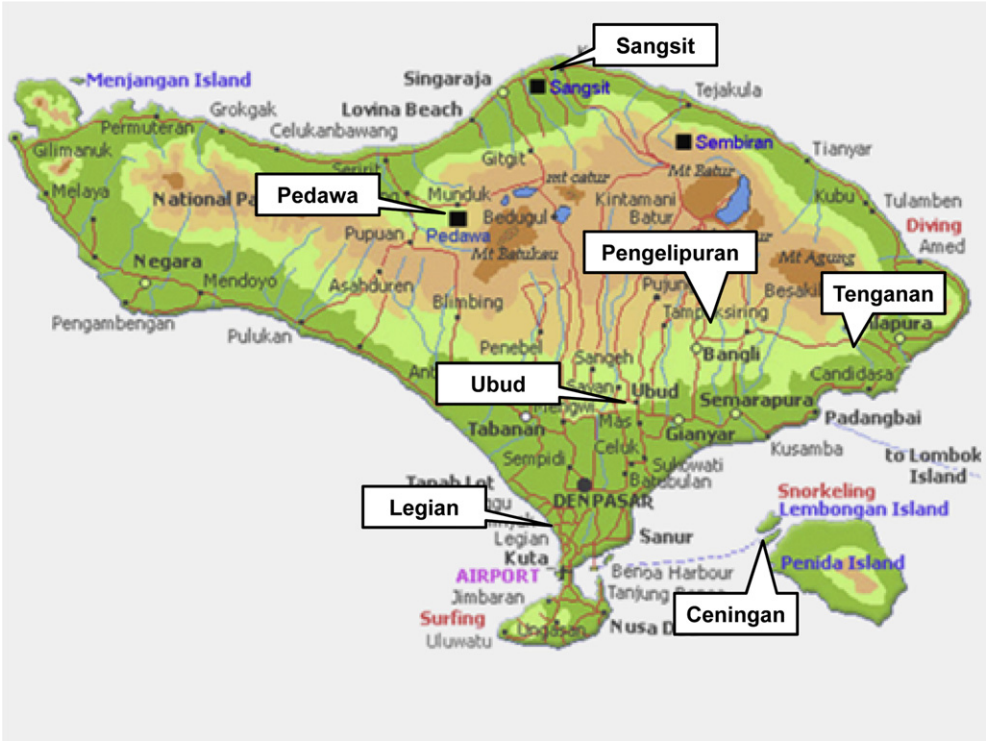


**Fig. 1.** Map of Bali Island: locations of the seven villages involved in the study.

**Table 1**
Characteristic of metabolic states in younger and elderly subjects

| Variables | <60 yr ($n = 1530$) | ≥60 yr ($n = 310$) | $p$ |
|---|---|---|---|
| Body mass index (kg/m$^2$) | 23.1 ± 4.1 | 21.0 ± 4.6 | <0.001 |
| Waist circumference (cm) | 80.9 ± 11.9 | 75.8 ± 12.5 | <0.001 |
| Systolic blood pressure (mmHg) | 117.5 ± 16.7 | 132.6 ± 23.1 | <0.001 |
| Diastolic blood pressure (mmHg) | 75.8 ± 10.3 | 81.1 ± 11.7 | <0.001 |
| Fasting blood glucose (mg/dL) | 93.0 ± 27.9 | 102.7 ± 40.0 | <0.001 |
| Postprandial blood glucose (mg/dL) | 106.7 ± 48.9 | 133.9 ± 94.0 | NS |
| Total-cholesterol (mg/dL) | 186.0 ± 37.6 | 198.8 ± 42.4 | <0.001 |
| LDL-cholesterol (mg/dL) | 120.1 ± 30.6 | 131.8 ± 35.0 | <0.001 |
| HDL-cholesterol (mg/dL) | 50.4 ± 13.3 | 49.9 ± 15.4 | NS |
| Triglyceride (mg/dL) | 120.0 ± 75.1 | 124.2 ± 66.8 | NS |

HDL = high-density lipoprotein; LDL = low-density lipoprotein; NS = not significant.

Federation (IDF), National Heart, Lung, and Blood Institute, American Heart Association, World Heart Federation, International Atherosclerosis Society, and International Association for the Study of Obesity in 2009.[12] MS was diagnosed if three of five parameters were present: increased waist circumference (male >90 cm, female >80 m), elevated triglycerides (drug treatment for elevated triglycerides is an alternate indicator; ≥150 mg/dL), reduced high-density lipoprotein (HDL) cholesterol (drug treatment for reduced HDL-cholesterol is an alternate indicator; ≤40 mg/dL in males and ≤50 mg/dL in females), elevated blood pressure (antihypertensive drug treatment in a patient with a history of hypertension is an alternate indicator; systolic ≥130 mmHg and/or diastolic ≥85 mmHg); elevated fasting glucose (drug treatment of elevated glucose is an alternate indicator; ≥100 mg/dL).[12]

Blood glucose levels was measured by the hexokinase method (Hitachi 912; Roche Diagnostic GmbH, Mannheim, Germany); total cholesterol level was measured by CHOD PAP (CHOD, cholesterol oxidase; PAP, phenol + aminophenazone) (Hitachi 912; Roche Diagnostic GmbH); low-density lipoprotein cholesterol level was measured by enzymatic/homogenous method (Hitachi 912; Roche Diagnostic GmbH); HDL-cholesterol level was measured by enzymatic/homogenous method (Hitachi 912; Roche Diagnostic GmbH); and triglyceride level was measured by GPO PAP (GPO, glycerol-3-phosphate oxidase; PAP, phenol + aminophenazone) method (Hitachi 912; Roche Diagnostic GmbH).

Statistical tests used to analyze the data in the study include descriptive presentation, independent $t$ test, cross-tab ($\chi^2$ test and prevalence risk or odds ratio), with significant value confirmed at $p$ less than 0.05.

## 3. Results

A total of 310 elderly subjects of 1840 subjects were enrolled in this study. Because of some technical difficulty in collecting data in the villages, we could only examine 268 subjects for their 2-hours postprandial blood glucose level (only subjects from Legian Village, a suburban area). Table 1 shows that although the elderly group had lower BMI and waist circumference, they had significantly higher blood pressure and higher level of cholesterol than the younger-aged group.

**Table 3**
Prevalence risk (odds ratio) of the elderly subjects for metabolic syndrome

| Age | Metabolic syndrome negative (%) | Metabolic syndrome positive (%) | Prevalence risk (odds ratio) | 95% Confidence interval | $p$ |
|---|---|---|---|---|---|
| <60 yr ($n = 1405$) | 82.7 | 17.3 | 1.423 | 1.043–1.944 | 0.026 |
| ≥ 60 yr ($n = 279$) | 77.1 | 22.9 | | | |

A tendency was noted for the increasing frequency of MS and its components with the increasing age (Table 2). Blood pressure and fasting blood sugar level were higher in the elderly than in the younger-aged group (133/81 mmHg *vs*. 117/76 mmHg; 102.7 mg/dL *vs*. 93.0 mg/dL, respectively; $p < 0.001$), whereas no difference was seen in triglyceride and HDL-cholesterol levels between the two groups. Waist circumference was lower among the elderly than the younger-aged groups (75.8 cm *vs*. 80.9 cm; $p < 0.001$); however, the elderly had a significantly higher prevalence of MS than the younger-aged group {22.9% *vs*. 17.3%; $p = 0.026$; prevalence risk 1.423 [confidence interval (CI = 1.043–1.944)]} (Table 3). The proportion of the study subjects who had 1, 2, 3, 4, and 5 components of MS were 34.6%, 23.8%, 13.0%, 4.3%, and 0.9%, respectively. The frequency of MS in the female subjects was higher significantly than in the male subjects (29.4% *vs*. 17.6%, $p = 0.021$) (Fig. 2). Of the five criteria for MS, it was obvious that elevated triglyceride was the most important risk factor in contributing the event of MS (30.2 time *vs*. normal triglyceride), followed by in the order of decreasing frequencies: elevated fasting blood glucose (8.5 time *vs*. normal fasting blood glucose), increased waist circumference (8.1 time *vs*. normal waist circumference), reduced HDL-cholesterol (4.4 time *vs*. normal HDL-cholesterol), and elevated blood pressure (3.7 time *vs*. normal blood pressure) (Table 4).

There was a tendency of increasing frequency of IFG and DM with increasing age. Because only a few data of 2-hours postprandial blood glucose levels were available from the study, the results of IGT might have not reflected the real condition (Table 5). The prevalence of IFG and DM were twofold in the elderly as compared with the younger groups (21.4 *vs*. 11.7; 11.7 *vs*. 4.8; respectively). Among the elderly, no significant difference was seen in the frequency of normoglycemia (67.3% *vs*. 66.4%), IFG (20.4% *vs*. 22.6%), and DM (12.3% *vs*. 10.9%), between male and female elderly. The summary of the frequency of MS, IFG, and DM in the elderly and in the younger-aged group is presented in Fig. 3.

## 4. Discussion

The study has clearly showed the elderly had lower BMI and waist circumference as compared with the younger-aged group, but the elderly had higher blood pressure and level of fasting blood glucose, and a tendency was noted for higher levels of triglyceride and lower levels of HDL-cholesterol. Lower BMI and waist circumference in the elderly might be because of lower food intake among them. However, lower waist circumference was not significantly related to insulin resistance causing MS and glucose intolerance in the elderly. The fact showed that the frequency of MS, IFG,

**Table 2**
Frequency of metabolic syndrome and its components by age (years)

| Metabolic syndrome and its components | ~19 (%) | 20–29 (%) | 30–39 (%) | 40–49 (%) | 50–59 (%) | 60–69 (%) | ≥70 (%) |
|---|---|---|---|---|---|---|---|
| Metabolic syndrome | 5.5 | 4.8 | 15.9 | 17.6 | 29.6 | 26.0 | 17.3 |
| Increased waist circumference | 12.5 | 24.6 | 37.9 | 40.1 | 43.6 | 29.7 | 13.8 |
| Elevated triglyceride | 1.7 | 10.3 | 24.6 | 26.1 | 31.3 | 25.9 | 18.3 |
| Reduced HDL-cholesterol | 25.9 | 31.3 | 34.2 | 27.6 | 30.2 | 33.5 | 31.4 |
| Elevated blood pressure | 12.5 | 15.1 | 19.2 | 31.5 | 45.8 | 55.1 | 60.0 |
| Elevated fasting blood glucose | 6.9 | 9.5 | 12.9 | 17.3 | 27.4 | 34.9 | 29.9 |

HDL = high-density lipoprotein.

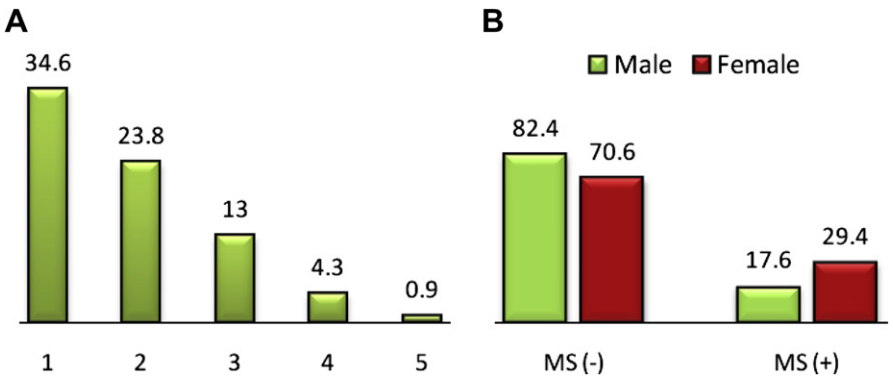


**Fig. 2.** (A) Frequency of number of components of metabolic syndrome; (B) Frequency of metabolic syndrome by sex ($p = 0.021$) in the elderly. MS = metabolic syndrome.

and DM in the elderly were higher as compared with those in the younger-aged group. Central obesity was unlikely to be the most important risk for MS and glucose intolerance in the elderly.

The Third National Health and Morbidity Survey conducted in Malaysia on 4746 individuals aged 60 years and older revealed the prevalence of overweight and obesity in men as 29.2% and 7.4% respectively; and in women as 30.3% and 13.8%, respectively. The prevalence of abdominal obesity was 21.4%, with 7.7% in men and 33.4% in women. Predictors of adiposity include the following: Malay and Indian ethnicity, higher education level, higher household income, from urban area, and being married.[13] Data from the Elderly Nutrition and Health Survey in Taiwan during 1999–2000 showed that the prevalence of obesity was 29.0% in men and 36.8% in women by obesity for Asians (BMI $\geq$ 25 kg/m$^2$). Waist circumference as risk factor for cardiovascular diseases was more sensitive than BMI and waist-to-hip ratio.[14] The prevalence of central obesity in the elderly people in Beijing was significantly higher, that is, 67.3%.[15] Survey on obesity in the urban elderly population ($\geq$ 60 years) in Barbados revealed that women had higher rates of obesity by BMI more than 30 kg/m$^2$ (31% *vs*. 11.9%), high-risk waist circumference (61.9% *vs*. 13.9%), and disease comorbidity risk (51.1% *vs*. 17.5%) compared with men.[16] A cross-sectional study was carried out in 2001 on elderly people ($\geq$ 60 years) in Spain by Gutierrez-Fisac et al.[17] The mean BMI was 28.2 kg/m$^2$ in men and 29.3 kg/m$^2$ in women. The prevalence of overweight and obesity in men was 49% and 31.5%, respectively. The corresponding percentages in women were 39.8% and 40.8%. The prevalence of central obesity was 48.4% in men and 78.4% in women.

There are different figures in the percentage of obesity both by BMI and waist circumference by countries; the difference may be because of different criteria for obesity between Asian people and Caucasian people. However, the average prevalence of obesity in the elderly people in European or American countries is higher than that in Asian Countries. Although obesity, especially central obesity, is relatively lower in Asian people as compared with Caucasian people, it has been consistently proved as a risk factor for cardiovascular diseases even in lower value.

MS in the elderly should be given proper attention because it is related with cardiovascular events beside physical dependence, cognitive dysfunction, depressive symptoms, anxiety symptoms, high psychosocial risk index, and poorer health-related quality of life.[18] Aging is an important factor that affects the metabolic abnormality, and aging of the population would lead to increase in the prevalence of MS.[19] As this study has shown, the frequency of MS and its components increased with the increase of age. Elevated blood pressure was the most frequent contributor for MS in the elderly (Table 2). Age more than 60 years was 1.4 times higher risk for MS than that below 60 years. Although blood pressure was the most frequent variable found as the component of MS, actually elevated triglyceride level was the most important predictor for MS event, with 30 times greater risk prevalence. This means that an elderly individual who has triglyceride level above 150 mg/dL has risk for MS 30 times greater than those who have lower level of triglyceride.

The prevalence of MS in elderly people in Beijing by the National Cholesterol Education Program was 30.5% (17.6% in men, 39.2% in women); but based on the new IDF definition, the prevalence significantly increased to 46.3% (34.8% in men, 54.1% in women). Individuals with MS are defined by significant elevated odds ratios for coronory heart disease, stroke, and peripheral arterial disease.[15] By using Modified ATP III, a study on MS in Japan showed that the prevalence of MS in men was 19.0% in middle-aged people (40–64 years) and 21.4% in the elderly (not significantly different), and in women 9.0% in middle-aged people (40–64 years) and 26.8% in the

**Table 4**
Prevalence risk (odds ratio) of component of metabolic syndrome on the metabolic syndrome event in the elderly

| Component of metabolic syndrome | Metabolic syndrome event | | |
|---|---|---|---|
| | Prevalence risk (odds ratio) | 95% Confidence interval | *p* |
| Elevated triglyceride | 30.2 | 14.5–63.1 | <0.001 |
| Elevated fasting blood glucose | 8.5 | 4.5–15.8 | <0.001 |
| Elevated waist circumference | 8.1 | 4.3–15.0 | <0.001 |
| Reduced HDL-cholesterol | 4.4 | 2.4–7.9 | <0.001 |
| Elevated blood pressure | 3.7 | 1.9–7.2 | <0.001 |

HDL = high-density lipoprotein.

**Table 5**
Frequency of impaired fasting glycemia diabetes mellitus by age (years)

| Classification | ~19 ($n = 59$) | 20–29 ($n = 201$) | 30–39 ($n = 454$) | 40–49 ($n = 490$) | 50–59 ($n = 304$) | 60–69 ($n = 199$) | ≥70 ($n = 111$) |
|---|---|---|---|---|---|---|---|
| Normoglycemia | 93.1 | 90.5 | 87.1 | 82.7 | 72.6 | 65.1 | 70.1 |
| Impaired fasting glycemia | 6.9 | 7.0 | 10.9 | 11.7 | 16.9 | 23.4 | 17.8 |
| Diabetes mellitus | 0 | 2.5 | 2.0 | 5.6 | 10.5 | 11.5 | 12.1 |

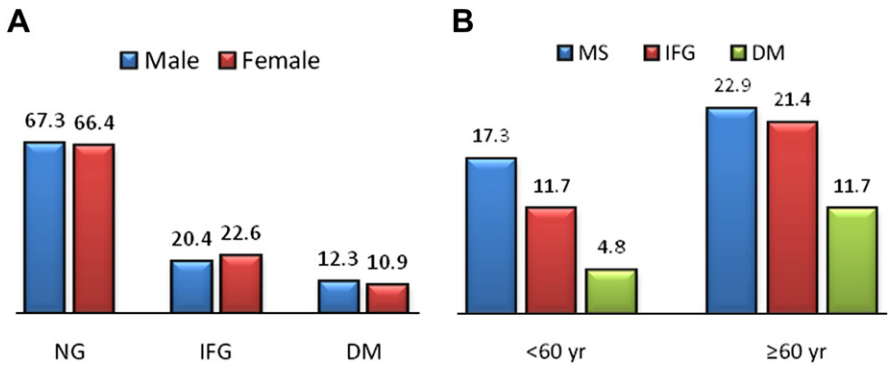


**Fig. 3.** (A) Frequency of normoglycemia (NG), impaired fasting glycemia (IFG), diabetes mellitus (DM) by sex in elderly; (B) Frequency of metabolic syndrome (MS), impaired fasting glycemia, and diabetes mellitus in the younger-aged and elderly. DM = diabetes mellitus; IFG = impaired fasting glycemia; MS = metabolic syndrome; NG = normoglycemia.

elderly ($p < 0.01$).[18] A study on Italian elderly people by Ravaglia et al[20] revealed that the prevalence of MS was 27.2% and higher in women (33.3%) than in men (19.6%). Based on Kooperative gesundheitsforschung in der Region Augsburg (KORA) Survey 2000, the prevalence of MS by the National Cholesterol Education Program, WHO, and IDF were 24%, 38%, and 46% among women, respectively and 28%, 50%, 57% among men, respectively.[21]

In general, the prevalence of MS in Asian and Caucasian elderly people is very similar. Most studies have revealed that the prevalence of MS, including that in this study, was higher in women than in men. But, KORA Survey has found the opposite that the prevalence of MS was higher in men. The frequencies of components of MS found in this study were lower if compared with the findings of the study done by He et al[15] in Beijing.

Similar to MS, the prevalence of IFG and DM increased with rising age. Unfortunately, there was limitation of the study in which there was only limited subjects who were examined for their 2-hours postprandial glucose levels. Trend of prevalence of IGT by age was not seen in the study. It caused by the technical difficulty faced in assessing blood glucose levels after glucose loading in the villages. The prevalence of IFG and DM were higher in the elderly than in the younger-aged group (nearly twofold and more than twofold, respectively). By sex, no difference was found in the prevalence of normoglycemia, IFG, and DM in the elderly (between male and female).

Data from rural Taiwan showed that the prevalence of DM was 16.9% and IFG was 25.5% among elderly Chinese in 2000. During a 5-year follow up, cumulative prevalence of DM and IFG were 23.7% and 27.9%, respectively. The 5-year cumulative incidence of newly onset diabetes was 6.8%. Hypertension, overt proteinuria, IFG, and high total cholesterol were independent risk factors for new onset diabetes.[22] The MEDIS (MEDiterranean ISlands) Study on the prevalence of DM among elderly living in Mediterranean Islands has found that 21% males and 23% females had DM. Diabetic individuals had higher prevalence of hypertension (80% *vs.* 64%) and hypercholesterolemia (63% *vs.* 51%) and reported to have lower physical activity compared with nondiabetic participants.[23] In United States, the annual incidence of diabetes increased by 23% between 1994–1995 and 2003–2004, and the prevalence increased by 62%. It therefore has increased the burden of financing for provision of health care for people older than 65 years.[24]

The prevalence of DM among elderly Balinese was lower than among those in other countries. Lower prevalence of obesity, lower food intake, more physical activity especially in the rural areas, might have some influence on the results. The difference criteria for obesity (by BMI and waist circumference) and for the elderly between Asian population and Caucasian population might also be because of the difference in ethnicity between our study and other studies, especially those conducted in Western countries might also cause the difference in results.

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