Body mass index is associated with type 2 diabetes mellitus in Chinese elderly

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Introduction

Morbidity and prevalence of type 2 diabetes mellitus (DM) are increasing in elderly population. The prevalence of type 2 DM in elderly is approximately 22.7% at present in China.1 Global elderly population of type 2 DM has been estimated to increase from 106 million in 2010 to 200 million in 2030.2 Type 2 DM is a chronic progressive metabolic disease caused by various pathogenic factors. However, insulin resistance and deficiency of insulin secretion from β-cells are the main pathogenesis of type 2 DM.3 Type 2 DM usually coexists with other components of metabolic syndrome such as high body mass index (BMI), hypertension, hypercholesterolemia, hypertriglyceridemia and fatty liver4–6 and increases the risk of all-cause and cardiovascular mortality.7–9 High BMI is a predictor of an onset of type 2 DM in older persons aged 65–96 years.10 However, a study reported that high BMI was associated with a lower mortality risk in very elderly population aged ≥80 years with type 2 DM.11 Some recent studies have demonstrated that a J-shaped association exists between BMI and mortality; high BMI was associated with increased mortality among subjects with type 2 DM.8,9 It is not well known if various metabolic syndrome components such as BMI are related to type 2 DM in Chinese elderly. Therefore, we collected recently diagnosed type 2 DM elderly patients retrospectively in a cross-sectional study in order to investigate the correlation between metabolic syndrome components including BMI and type 2 DM in Chinese elderly.

Background: There is limited information on the association between metabolic syndrome components including body mass index (BMI) and type 2 diabetes mellitus in elderly Chinese population. Therefore, we investigated whether components of metabolic syndrome are associated with type 2 diabetes mellitus in elderly.

Methods: A total of 479 hospitalized patients (aged 65–95 years) with recently diagnosed type 2 diabetes mellitus were studied retrospectively in a cross-sectional study and compared with 183 subjects with prediabetes and 62 subjects without glucose metabolism abnormalities.

Results: BMI (24.69±3.59 versus 23.92±3.08 and 23.56±3.25 kg/m2), blood pressure, cholesterol, triglyceride, liver enzymes and prevalence of fatty liver were higher in patients with type 2 diabetes mellitus as compared with elderly subjects with prediabetes or normal glucose metabolism separately (all P<0.05). Multivariable regression analysis showed that BMI was associated positively with insulin resistance and inversely with insulin sensitivity in type 2 diabetes mellitus group (all P<0.05).

Conclusion: Higher BMI was associated with increased insulin resistance and decreased insulin sensitivity in elderly Asian population with type 2 diabetes mellitus.

Keywords: body mass index, type 2 diabetes, elderly, aging

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Methods

Patients

Seven hundred twenty-four elderly patients aged 65–95 years (370 males, 354 females) were hospitalized due to comorbidities of diabetes and prediabetes without the use of antidiabetic drugs. The patients’ blood glucose concentration was found to be elevated accidentally after hospitalization. Then, they underwent standard 75 g oral glucose tolerance and insulin release tests from December 2012 to February 2016. Among them, 479 subjects were firstly diagnosed with type 2 DM, 183 with prediabetes and 62 with normal glucose metabolism. Data were collected retrospectively in a cross-sectional study from the First Affiliated Hospital of Chongqing Medical University, Chongqing, China.

We excluded patients with type 1 and other types of DM, alcoholic fatty liver, viral hepatitis, hepatic cirrhosis, glomerulonephritis, pyelonephritis, carcinoma, glucocorticoid use, bleeding, acute cardio- or cerebrovascular disease, acute and chronic infection or trauma.

This study was approved by the ethics committee of the First Affiliated Hospital of Chongqing Medical University, Chongqing, China. All participants provided written informed consent.

Diagnosis of type 2 DM and prediabetes

Diagnosis of type 2 DM and prediabetes was confirmed by oral glucose tolerance and insulin release tests described as follows. After 8 h fasting period, plasma glucose (fasting plasma glucose [FPG]) and insulin concentrations (fasting plasma insulin [FPI]) were measured. Then, the patients were made to drink 300 mL syrup containing 75 g glucose. Postprandial plasma glucose (PPG) and postprandial insulin (PPI) concentrations at 30, 60 and 120 min were determined by glucose oxidase method and radioimmunoassay, respectively. DM, prediabetes and normal glucose metabolism were diagnosed according to the World Health Organization criteria 1998.12 DM is defined as FPG ≥7.0 mmol/L and/or 120 min PPG ≥11.1 mmol/L. Prediabetes refers to impaired fasting glucose (7.0 mmol/L >FPG ≥6.1 mmol/L and 120 min PPG <7.8 mmol/L) and/or impaired glucose tolerance (FPG <6.1 and 11.1 mmol/L >120 min PPG ≥7.8 mmol/L). Normal glucose metabolism refers to 6.1 mmol/L >FPG ≥3.9 and 7.8 mmol/L >120 min PPG ≥3.9 mmol/L.12

FPI was normal or high and PPI increased to varying degrees compared with baseline, and there was no autoimmune antibody against islet β-cells and insulin in the recruited elderly with type 2 DM and prediabetes.

Measurement of insulin resistance parameters:
homeostasis model assessment (HOMA) and LogHOMA

HOMA = FPG mmol/L × FPI μU/mL + 22.513
LogHOMA = Logarithm of HOMA14

Measurement of insulin sensitivity parameters:
HOMA−1, quantitative insulin sensitivity check index (QUICKI) and Gutt’s insulin sensitivity index (ISI0,120)

HOMA−1 = Reciprocal of HOMA14
QUICKI = 1 + (LogFPI μU/mL + Log [FPG mmol/L × 18.015])15
ISI0,120 = (75,000 + [FPG mmol/L - 120 min PPG mmol/L] × 0.19 × body weight kg) + (120 × [(FPG mmol/L + 120 min PPG mmol/L] + 2] × Log [(FPI μU/mL + 120 min PPI μU/mL] + 2)16

Measurement of estimated glomerular filtration rate (eGFR)

For male, serum creatinine (Scr) >80 μmol/L: eGFR = 141 × (Scr μmol/L + 88.4 + 0.9)−1.209 × 0.993age, years17
For male, Scr ≤80 μmol/L: eGFR = 141 × (Scr μmol/L + 88.4 + 0.9)−0.411 × 0.993age, years17
For female, Scr >62 μmol/L: eGFR = 144 × (Scr μmol/L + 88.4 + 0.7)−1.209 × 0.993age, years17
For female, Scr ≤62 μmol/L: eGFR = 144 × (Scr μmol/L + 88.4 + 0.7)−0.329 × 0.993age, years17

Measurement of BMI

BMI = Body weight kg + (Height m)2

Measurement of blood lipids

Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and triglyceride (TG) were determined by cholesterol oxidase, magnesium sulfate precipitation and three color methods, respectively. Low-density lipoprotein cholesterol (LDL-C) = TC – HDL-C – (TG + 2.19). Apolipoprotein B (apoB) was determined by immune transmission turbidity method.

Measurement of fatty liver and liver enzymes

Fatty liver was diagnosed by color Doppler ultrasound.18 Alanyl aminotransferase (ALT), alkaline phosphatase (ALP),
\(\gamma\)-glutamyltransferase (\(\gamma\)-GT) and cholinesterase were determined by rate method.

**Statistical analysis**

Continuous parameters were expressed as mean values ± standard deviation. The statistical differences were evaluated by one-way analysis of variance, followed, in case of significance, by a two-sided Fisher’s least significant difference test for multiple comparisons. Categorical data were summarized as percentages and compared using chi-square test. Pearson univariate linear correlation and logistic multivariate regression models were utilized for data analysis. Statistical analysis was performed by SPSS 21.0 software package (IBM Corporation, Armonk, NY, USA). A two-tailed value of \(P<0.05\) was considered to be statistically significant.

**Results**

**Clinical characteristics**

The age and BMI of the enrolled 724 subjects were 74±6 years and 24.39±3.46 kg/m\(^2\), respectively. Compared with prediabetes and normal groups, the insulin resistance index HOMA and LogHOMA were increased and the insulin sensitivity index HOMA\(^{-1}\), QUICKI and ISI\(_{0.120}\) were decreased in the recently diagnosed type 2 DM group (Table 1). There were no differences in age, sex, smoking, drinking, prevalence of coronary heart disease, stroke, hyperthyroidism and gout, and the use of medicines among the three groups (Table 1).

**Metabolic syndrome components**

Compared with prediabetes and normal groups, BMI, resting heart rate (HR), prevalence of primary hypertension, systolic and diastolic blood pressure, TC, LDL-C, TG, apoB, prevalence of fatty liver, ALT, ALP, \(\gamma\)-GT and cholinesterase were higher and HDL-C was lower in patients with recently diagnosed type 2 DM (Table 2).

In univariate correlation analysis, BMI and ALT were correlated positively with insulin resistance index HOMA, and BMI and fatty liver were correlated positively with insulin resistance index LogHOMA among patients with recently diagnosed type 2 DM. While BMI and fatty liver were correlated inversely with insulin sensitivity index HOMA\(^{-1}\), BMI was correlated inversely with insulin sensitivity index QUICKI and ISI\(_{0.120}\) respectively (Table 3).

Furthermore, in multivariate regression analysis, BMI was only independently directly associated with the insulin resistance index HOMA and LogHOMA (Table 4; Figures 1 and 2) and inversely with sensitivity index HOMA\(^{-1}\), QUICKI and ISI\(_{0.120}\) respectively, among patients with recently diagnosed type 2 DM (Table 4; Figures 3–5).

However, BMI was not associated independently with the insulin resistance and sensitivity index in prediabetes and normal subject groups.

**Discussion**

Higher BMI was associated with increased insulin resistance and decreased insulin sensitivity in elderly with recently diagnosed type 2 DM. This study shows that higher BMI may be the most important pathogenic factor and associated with type 2 DM in elderly Asian population. These findings were consistent with conclusions from European elderly and Asian population studies.\(^{10,19,20}\) They showed that overweight Asian people are still more susceptible to type 2 DM.\(^{20}\) Our study confirmed that slightly increased BMI was associated with type 2 DM in elderly Asian population. It could be useful for initiating early interventional measures including balanced diet and regular physical exercise to prevent overweight, obesity and type 2 DM in the elderly population.\(^{8}\)

Middle-aged adults with elevated resting HR have been reported to have higher risk of incident type 2 DM when they enter old age.\(^{21}\) Our present study found that high resting HR was associated with increased insulin resistance and decreased insulin sensitivity in the elderly with recently diagnosed type 2 DM. However, we did not observe an association between resting HR and type 2 DM in this elderly population, suggesting that increased resting HR is not a determinant of type 2 DM among elderly.

A previous meta-analysis concluded that hypertension could predict the risk of incident type 2 DM in adults aged 30–90 years.\(^{22}\) This study showed that elevated blood pressure was related to high insulin resistance and low insulin sensitivity in the elderly Chinese population with recently diagnosed type 2 DM. However, the independent association of hypertension with type 2 DM has not been found.

High apoB, LDL-C and TG and low HDL-C have been demonstrated to be associated with the risk of incident type 2 DM.\(^{23}\) Previous population studies have shown that hypertriglyceridemia can predict the future risk of incident type 2 DM.\(^{24,26}\) We found that TC, LDL-C, TG and apoB were increased among patients with recently diagnosed type 2 DM, while HDL-C was decreased significantly and was related to high insulin resistance and low insulin sensitivity. Nevertheless, this study found that there was no independent association between the abnormal lipid profile and the risk of type 2 DM in elderly, indicating that lipid abnormalities were not risk markers for type 2 DM.
Table 1 Comparison of clinical characteristics among type 2 diabetes mellitus, prediabetes and normal subject groups

|                          | Type 2 diabetes mellitus (n=479) | Prediabetes (n=183) | Normal (n=62) | P-value |
|--------------------------|----------------------------------|----------------------|---------------|---------|
| Age, years               | 73.83±6.15                       | 73.35±5.68           | 73.08±5.36    | 0.484   |
| Sex (M/F) n              | 238/241                          | 99/84                | 33/29         | 0.563   |
| FPG, mmol/L              | 6.98±1.68ab                      | 5.67±0.59p           | 5.16±0.42     | <0.001  |
| 30 min PPG, mmol/L       | 12.36±2.94ab                     | 10.06±1.61b          | 8.80±1.41     | <0.001  |
| 60 min PPG, mmol/L       | 14.91±3.19ab                     | 10.80±1.06p          | 8.47±2.27     | <0.001  |
| 120 min PPG, mmol/L      | 15.81±3.95ab                     | 9.27±1.18h           | 6.50±0.91     | <0.001  |
| FPI, μU/mL               | 7.35±4.96a                       | 4.64±4.54            | 4.95±2.63     | 0.083   |
| 30 min PPI, μU/mL        | 34.63±32.64ab                    | 48.78±32.04          | 63.1±47.01    | <0.001  |
| 60 min PPI, μU/mL        | 48.03±45.47p                     | 59.84±42.51          | 70.83±58.34   | 0.046   |
| 120 min PPI, μU/mL       | 69.76±57.25                      | 72.76±55.49          | 44.58±47.42   | 0.173   |
| Glycated hemoglobin, %   | 7.05±1.73ab                      | 6.09±0.53            | 6.00±0.40     | <0.001  |
| HOMA                     | 2.28±1.55ab                      | 1.63±1.26            | 1.13±0.62     | <0.001  |
| LogHOMA                  | 0.27±0.27ab                      | 0.12±0.28            | -0.01±0.243   | <0.001  |
| HOMA-1                   | 0.67±0.56ab                      | 0.96±0.89            | 1.18±0.75     | <0.001  |
| QUICKI                   | 0.35±0.05ab                      | 0.37±0.04            | 0.38±0.03     | 0.002   |
| ISL,120                  | 39.95±11.32ab                    | 57.81±13.75a         | 104.56±40.35  | <0.001  |
| Smoking, n (%)           | 144 (30.1)                       | 53 (29.0)            | 18 (29.0)     | 0.956   |
| Drinking, n (%)          | 90 (18.8)                        | 37 (20.2)            | 9 (14.5)      | 0.612   |
| CHD, n (%)               | 79 (16.5)                        | 37 (20.2)            | 15 (24.2)     | 0.054   |
| COPD, n (%)              | 57 (11.9)                        | 25 (13.7)            | 11 (17.7)     | 0.404   |
| Stroke, n (%)            | 183 (38.2)                       | 81 (44.3)            | 23 (37.1)     | 0.331   |
| Hypothyroidism, n (%)    | 41 (8.9)                         | 16 (16.0)            | 9 (27.3)      | 0.359   |
| Hyperthyroidism, n (%)   | 8 (1.7)                          | 3 (3.0)              | 1 (3.0)       | 0.945   |
| TSH, μU/mL               | 3.57±9.14                        | 2.38±2.04            | 5.60±17.09    | 0.189   |
| Gout, n (%)              | 10 (2.1)                         | 3 (1.6)              | 1 (1.6)       | 0.916   |
| Uric acid, μmol/L        | 341.26±110.35                    | 335.39±109.73        | 322.96±81.2   | 0.427   |
| Creatinine, μmol/L       | 80.62±27.72                      | 81.88±24.84          | 79.74±23.18   | 0.819   |
| eGFR, mL/min/1.73 m²     | 79.36±19.44                      | 78.60±17.58          | 80.10±16.75   | 0.838   |
| Hemoglobin, g/L          | 130.03±17.39                     | 128.62±14.82         | 129.10±15.22  | 0.608   |
| Albumin, g/L             | 39.24±4.33                      | 39.61±4.72           | 40.46±4.39    | 0.115   |
| Fibrinogen, g/L          | 3.28±1.03                       | 3.19±0.95            | 3.12±0.85     | 0.376   |
| Antiplatelet agents, n (%)| 273 (57.1)                      | 117 (63.9)           | 38 (61.3)     | 0.343   |
| Warfarin, n (%)          | 24 (5.0)                         | 7 (3.8)              | 5 (8.0)       | 0.863   |
| ACEI, n (%)              | 157 (32.8)                       | 47 (25.7)            | 16 (25.8)     | 0.148   |
| ARB, n (%)               | 94 (19.6)                        | 38 (20.8)            | 16 (25.8)     | 0.552   |
| α1-blockers, n (%)       | 9 (1.9)                          | 7 (3.8)              | 1 (1.6)       | 0.310   |
| β1-blockers, n (%)       | 130 (27.1)                       | 56 (30.6)            | 19 (30.6)     | 0.619   |
| CCB, n (%)               | 187 (39.0)                       | 70 (38.3)            | 18 (29.0)     | 0.311   |
| Diuretics, n (%)         | 86 (18.0)                        | 29 (15.9)            | 9 (14.5)      | 0.636   |
| Spironolactone, n (%)    | 19 (4.0)                         | 8 (4.4)              | 5 (8.1)       | 0.337   |
| Statins, n (%)           | 313 (65.3)                       | 122 (66.7)           | 42 (67.7)     | 0.594   |
| Fibrates, n (%)          | 8 (1.7)                          | 3 (1.6)              | 0 (0)         | 0.594   |
| Nitrates, n (%)          | 77 (16.1)                        | 36 (19.7)            | 12 (19.4)     | 0.496   |
| Trimetazidine, n (%)     | 52 (10.9)                        | 21 (11.5)            | 8 (12.9)      | 0.882   |
| Digitals, n (%)          | 17 (3.5)                         | 6 (3.3)              | 2 (3.2)       | 0.981   |
| Finasteride, n (%)       | 14 (2.9)                         | 6 (3.3)              | 0 (0)         | 0.390   |
| Allopurine, n (%)        | 2 (0.4)                          | 0 (0)                | 0 (0)         | 0.600   |
| Ncarcin, n (%)           | 2 (0.4)                          | 2 (1.1)              | 0 (0)         | 0.479   |
| Bicarbonate, n (%)       | 7 (1.5)                          | 3 (1.6)              | 2 (3.2)       | 0.614   |
| Thyroxine, n (%)         | 10 (2.1)                         | 0 (0)                | 2 (3.2)       | 0.102   |

**Notes:** Values are presented as mean ± SD unless otherwise stated. All the figures are based on nonmissing data. *P*<0.05 versus prediabetes group; **P**<0.05 versus normal group.

**Abbreviations:** ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin II receptor inhibitor; CCB, calcium channel blocker; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; FPG, fast plasma glucose; FPI, fasting plasma insulin; HOMA, homeostasis model assessment, an insulin resistance index; HOMA-1, reciprocal of HOMA, an insulin sensitivity index; ISL,120, Gutt’s insulin sensitivity index; LogHOMA, logarithm of HOMA, an insulin resistance index; PPG, postprandial plasma glucose; PPI, postprandial plasma insulin; QUICKI, quantitative insulin sensitivity check index; SD, standard deviation; TSH, thyroid stimulating hormone; F, female; M, male.
Table 2 Comparison of metabolic syndrome components among type 2 diabetes mellitus, prediabetes and normal subject groups

| Value                  | Type 2 diabetes mellitus (n=479) | Prediabetes (n=183) | Normal (n=62) | P-value |
|------------------------|----------------------------------|---------------------|---------------|---------|
| BMI, kg/m²              | 24.69±3.59 a                     | 23.92±3.08         | 23.56±3.25    | 0.029   |
| HR, beats/min           | 80.28±4.147 a                    | 78.93±4.15         | 75.6±4.14     | 0.047   |
| Hypertension, n (%)     | 354 (73.9)                       | 121 (66.1)         | 39 (62.9)     | 0.049   |
| SBP, mmHg               | 144.67±23.58 b                   | 137±22.00          | 132.21±18.09  | <0.001  |
| DBP, mmHg               | 79.57±13.01 b                    | 76.81±13.19        | 75.4±12.76    | 0.008   |
| TC, mmol/L              | 4.55±1.07                        | 4.32±1.07          | 4.37±1.11     | 0.048   |
| LDL-C, mmol/L           | 2.80±0.90 a                      | 2.6±0.91           | 2.65±0.98     | 0.056   |
| HDL-C, mmol/L           | 1.18±0.34 a                      | 1.24±0.30          | 1.30±0.05     | 0.014   |
| TG, mmol/L              | 1.81±1.45 a                      | 1.54±1.38          | 1.29±0.91     | 0.008   |
| ApoB, g/L               | 0.91±0.27 a                      | 0.83±0.25          | 0.84±0.27     | 0.002   |
| FL, n (%)               | 194 (40.6) a                     | 31 (17.1)          | 14 (24.0)     | 0.001   |
| ALT, U/L                | 24.06±17.29 a                    | 21.74±16.11        | 18.8±10.47    | 0.035   |
| ALP, U/L                | 81.41±31.99 a                    | 74.90±26.98        | 73.07±20.08   | 0.014   |
| γ-GT, U/L               | 46.38±69.79 p                    | 35.99±42.49        | 27.99±22.7    | 0.028   |
| CE, U/L                 | 7,678.98±1,938.23 a              | 7,307.64±651.60    | 7,517.77±2,289.30 | 0.047   |

Notes: Values presented as mean ± SD unless otherwise stated. *P<0.05 versus prediabetes group; #P<0.05 versus normal group.

Abbreviations: BMI, body mass index; CE, cholinesterase; DBP, diastolic blood pressure; FL, fatty liver; HDL-C, high-density lipoprotein cholesterol; HR, resting heart rate; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; SD, standard deviation; TC, total cholesterol; TG, triglyceride.

Table 3 Pearson univariate correlation analysis of metabolic syndrome components with insulin resistance and sensitivity index in type 2 diabetes mellitus

| Value                  | HOMA | LogHOMA | HOMA⁻¹ | QUICKI | ISI₅,₁₂₀ |
|------------------------|------|---------|--------|--------|----------|
| BMI                    | 0.407| 0.000⁰ | -0.328 | -0.277 | -0.262   |
| HR                     | 0.003| 0.965   | 0.043  | 0.000⁰ | 0.016    |
| HT                     | 0.015| 0.841   | 0.050  | 0.000⁰ | 0.016    |
| SBP                    | 0.036| 0.618   | 0.008  | 0.000⁰ | 0.016    |
| DBP                    | -0.005| 0.945  | -0.022 | 0.000⁰ | 0.016    |
| TC                     | 0.004| 0.963   | 0.010  | 0.000⁰ | 0.016    |
| LDL-C                  | 0.006| 0.935   | 0.022  | 0.000⁰ | 0.016    |
| HOMA                   | 0.006| 0.935   | 0.022  | 0.000⁰ | 0.016    |
| QUICKI                 | 0.006| 0.935   | 0.022  | 0.000⁰ | 0.016    |
| ISI₅,₁₂₀               | 0.006| 0.935   | 0.022  | 0.000⁰ | 0.016    |

Note: *P<0.05.

Abbreviations: γ-GT, γ-glutamyl transferase; ALP, alkaline phosphatase; ALT, alanine aminotransferase; apoB, apolipoprotein B; BMI, body mass index; CE, cholinesterase; DBP, diastolic blood pressure; FL, fatty liver; HDL-C, high-density lipoprotein cholesterol; HR, resting heart rate; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; SD, standard deviation; TC, total cholesterol; TG, triglyceride.

Table 4 Logistic multivariate regression analysis of metabolic syndrome components with insulin resistance and sensitivity index in type 2 diabetes mellitus

| Value                  | β     | SE    | Wald  | P-value | Exp (β) | 95% CI    |
|------------------------|-------|-------|-------|---------|---------|-----------|
| HOMA                   | -0.491| 0.222 | 4.890 | 0.027²  | 1.634   | 1.057–2.524 |
| HOMA⁻¹                 | -0.003| 0.026 | 0.013 | 0.909  | 0.997   | 0.948–1.049 |
| LogHOMA                | -0.364| 0.119 | 9.432 | 0.002⁰ | 0.695   | 0.551–0.877 |
| LogHOMA⁻¹              | 0.415 | 1.103 | 0.142 | 0.707  | 1.514   | 0.174–13.161 |
| HOMA⁻¹                 | -0.357| 0.126 | 7.990 | 0.005⁰ | 0.700   | 0.547–0.896 |
| QUICKI                 | -0.254| 1.432 | 0.031 | 0.859  | 0.776   | 0.047–12.844 |
| ISI₅,₁₂₀               | -0.300| 0.107 | 7.918 | 0.005⁰ | 0.741   | 0.601–0.913 |

Note: *P<0.05.

Abbreviations: ALT, alanine aminotransferase; BMI, body mass index; CI, confidence interval; FL, fatty liver; HOMA, homeostasis model assessment, an insulin resistance index; HOMA⁻¹, reciprocal of HOMA, an insulin sensitivity index; LogHOMA, logarithm of HOMA, an insulin resistance index; LogHOMA⁻¹, logarithm of HOMA, an insulin resistance index; ISI₅,₁₂₀, Gutt’s insulin sensitivity index; QUICKI, quantitative insulin sensitivity check index; SE, standard error.
Increased liver enzymes have been found to predict the risk of incident type 2 DM in the elderly. Our present study identified that the prevalence of fatty liver and liver enzymes including ALT, ALP, γ-GT and cholinesterase were increased significantly with high insulin resistance and low insulin sensitivity in elderly patients with recently diagnosed type 2 DM. But this study revealed that fatty liver and liver enzymes were not independently associated with type 2 DM in the elderly.

The major limitation of the present study is that the data were obtained retrospectively in a cross-sectional study by reviewing the patients’ medical records. The confounding factors arising from the study setting, population selection, use of medications, exercise and dietary habits could not be completely excluded. The number of type 2 DM patients among the elderly was quite limited. Although a previous study reported the association of higher BMI with...
BMI and type 2 DM in the elderly

prediabetes,28 our study did not support this conclusion. Therefore, large prospective study settings would be needed to confirm these findings.

Conclusion
Higher BMI was associated with increased insulin resistance and decreased insulin sensitivity in the elderly with type 2 DM.

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Disclosure
The authors report no conflicts of interest in this work.

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