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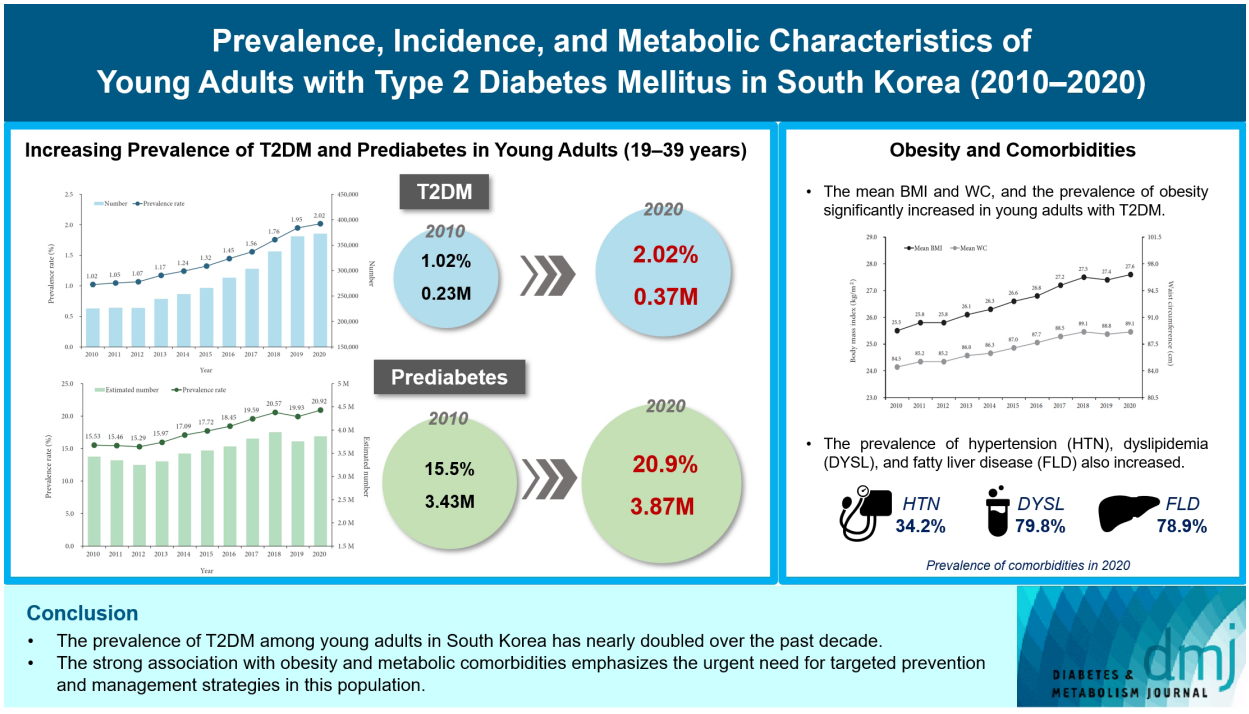

Highlights

- **This study analyzed trends in T2DM among young adults in Korea, 2010–2020.**
- **T2DM prevalence in young adults rose from 1.02% to 2.02%, sharply in ages 30–39.**
- **In 2020, among young adults with T2DM, 67.8% had BMI ≥25 kg/m², and 31.6% had BMI ≥30 kg/m².**
- **Hypertension, dyslipidemia, and fatty liver prevalence were 34.2%, 79.8%, and 78.9%.**
- **SGLT2 inhibitor and GLP-1RA use rose among young adults, but treatment stayed low.**

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Prevalence, Incidence, and Metabolic Characteristics of Young Adults with Type 2 Diabetes Mellitus in South Korea (2010–2020)

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Background: This study aimed to examine trends in the prevalence, incidence, metabolic characteristics, and management of type 2 diabetes mellitus (T2DM) among young adults in South Korea.
Methods: Young adults with T2DM were defined as individuals aged 19 to 39 years who met the diagnostic criteria for T2DM. Data from the Korean National Health Insurance Service-Customized Database (2010–2020, $n=225,497–372,726$) were analyzed to evaluate trends in T2DM prevalence, incidence, metabolic profiles, comorbidities, and antidiabetic drug prescription. Additional analyses were performed using the Korea National Health and Nutrition Examination Survey.
Results: The prevalence of T2DM in young adults significantly increased from 1.02% in 2010 to 2.02% in 2020 ($P<0.001$), corresponding to 372,726 patients in 2020. Over the same period, the incidence rate remained stable within the range of 0.36% to 0.45%. Prediabetes prevalence steadily increased from 15.53% to 20.92%, affecting 3.87 million individuals in 2020. The proportion of young adults with T2DM who were obese also increased, with 67.8% having a body mass index (BMI) ≥25 kg/m² and 31.6% having a BMI ≥30 kg/m² in 2020. The prevalence of hypertension, dyslipidemia, and fatty liver disease also increased, reaching 34.2%, 79.8%, and 78.9%, respectively, in 2020. Although the overall pharmacological treatment rate remained low, the prescription of antidiabetic medications with weight-reducing properties increased over the study period.
Conclusion: The prevalence of T2DM among young adults in South Korea nearly doubled over the past decade. The strong association with obesity and metabolic comorbidities emphasizes the urgent need for targeted prevention and management strategies tailored to this population.

Keywords: Diabetes mellitus, type 2; Disease management; Epidemiology; Obesity; Young adult

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease that affects multiple organs and leads to vascular complications if not adequately managed [1]. Traditionally, DM—particularly type 2 diabetes mellitus (T2DM)—has been considered a disease that predominantly affects middle-aged and older individuals. However, the prevalence of T2DM in younger populations is increasing worldwide [2,3]. While definitions of early-onset T2DM vary, it is generally accepted that a diagnosis made before the age of 40 years represents a distinct clinical entity compared to later-onset T2DM [2,4]. Early-onset T2DM is further

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subdivided into T2DM diagnosed in childhood (age ≤18 years) and early adulthood (age 19 to 39 years) [2]. Young people with T2DM often have difficulty achieving adequate glycemic control and are at increased risk of developing complications [5], highlighting the need for targeted interventions.

Globally, the estimated number of people with T2DM aged 20 to 39 years increased from 63 million in 2013 to 260 million in 2021 [2]. The incidence and prevalence of T2DM in younger populations show regional and ethnic variations [6,7]. In particular, Asian countries have reported a marked increase in T2DM prevalence among younger individuals, in part due to a greater susceptibility to developing T2DM at lower body mass index (BMI) levels compared to Western populations [8-10]. Despite the global increase in T2DM among young adults, the epidemiology and clinical characteristics of this population in South Korea remain understudied.

To address this gap, we collaborated with the Korean Diabetes Association to estimate the prevalence and incidence of T2DM among young adults (aged 19 to 39 years) in South Korea. In addition, we assessed the changes in metabolic characteristics, comorbidities, vascular complications, and antidiabetic medication prescriptions among young adults with T2DM.

METHODS

Data sources

To obtain reliable and representative estimates of young adults (aged 19 to 39 years) with T2DM in South Korea, data from 2010 to 2020 in the Korean National Health Insurance Service (NHIS)-Customized Database were analyzed. The NHIS database covers almost all South Korean citizens, and provide a longitudinal data set that includes demographic information, disease diagnoses based on the International Classification of Diseases, 10th Revision (ICD-10), prescription records, hospital admissions, procedure details, and health examination results including laboratory tests and anthropometric measurements [11-17]. As supporting information, we further analyzed data from the Korea National Health and Nutrition Examination Survey (KNHANES, from 2012 to 2022), a series of cross-sectional surveys designed to assess the health status of the Korean population using a multistage clustered probability sampling design [18,19].

This study received ethical approval from the Institutional Review Board (IRB) of Korea University Anam Hospital (IRB number: 2022AN0531). Informed consent was not required because the databases used did not contain personally identifiable information.

Definition of diabetes mellitus and patient selection

In the NHIS-Customized Database, T2DM was defined as the presence of ICD-10 codes E11–E14 or a fasting plasma glucose (FPG) level ≥126 mg/dL. Individuals who subsequently received an ICD-10 code E10 with insulin prescriptions was considered to have type 1 diabetes mellitus (T1DM) and were excluded. We allocated at least 1 year for the exclusion process. The database identified all individuals aged 19 to 39 years who met the aforementioned diagnostic criteria for T2DM, with 225,497 in 2010 and 372,726 in 2020. The evaluation of the prevalence, incidence, metabolic characteristics, comorbidities, vascular complications, and pharmacological treatment rate was based on these populations. The number of total population aged 19 to 39 years in South Korea was determined using data from the National Statistical Office.

Prediabetes was defined as an FPG level of 100 to 125 mg/dL in the absence of ICD-10 codes E10–E14 or use of antidiabetic medications. Individuals aged 19 to 39 years who met the criteria for prediabetes were identified among those who underwent a national health examination, tailoring 3,498,371 in 2010 and 4,087,713 in 2020. Of these, 543,437 met the definition of prediabetes in 2010 and 855,310 in 2020.

In additional analyses using the KNHANES database, DM was defined as having an FPG level ≥126 mg/dL, or a glycosylated hemoglobin (HbA1c) level ≥6.5%, or a previous diagnosis of DM in the questionnaire, or the use of antidiabetic medication [20-23]. The number of patients meeting these criteria was 30 out of a total population of 1,474 in 2012 and 26 out of 1,222 in 2022. The type of DM was not specified in this database. Prediabetes was defined as having an FPG level of 100 to 125 mg/dL or an HbA1c level of 5.7% to 6.4% without meeting the criteria for DM.

Metabolic parameters, comorbidities, and vascular complications

We examined changes in BMI, waist circumference (WC), and the prevalence of comorbidities including hypertension, dyslipidemia, fatty liver disease and vascular complications including myocardial infarction (MI), ischemic stroke, heart failure, end-stage kidney disease (ESKD), and proliferative diabetic retinopathy (PDR), in young adults with T2DM over a 10-year period (2010 to 2020). Additionally, we investigated

the trends in the characteristics of individuals newly diagnosed with T2DM at the time of diagnosis.

BMI was categorized using cut-off points of 23.0, 25.0, 30.0, 35.0, and 40.0 kg/m² [24,25]. Central obesity was defined as a WC ≥90 cm in men or ≥85 cm in women. Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, a diastolic blood pressure ≥90 mm Hg, or the use of antihypertensive medication. Dyslipidemia was defined as a low-density lipoprotein cholesterol level ≥100 mg/dL or the use of lipid-lowering medications [26]. Fatty liver disease was determined by a fatty liver index (FLI) ≥30. The FLI was calculated as follows [27,28]:

$$[e^{0.953\times\log e(\text{triglycerides})+0.139\times\text{BMI}+0.718\times\log e(\text{gamma-glutamyl transpeptidase})+0.053\times\text{WC}-15.745}]/$$
$$[1+e^{0.953\times\log e(\text{triglycerides})+0.139\times\text{BMI}+0.718\times\log e(\text{gamma-glutamyl transpeptidase})+0.053\times\text{WC}-15.745}]\times 100.$$

MI was defined as hospitalization with ICD-10 codes I21–I22. Ischemic stroke was identified as hospitalization with ICD-10 codes I63–I64 accompanied by brain imaging studies. Heart failure was defined as hospitalization with a diagnosis of heart failure (ICD-10 code I50). ESKD was defined by the receipt of special exemption codes V001 (hemodialysis), V003 (peritoneal dialysis), or V005 (kidney transplant). PDR was defined as undergoing photocoagulation (procedure codes S5160 or S5161) and having an ICD-10 diagnosis code of H36.0 (diabetic retinopathy) within the year prior to the procedure.

Use of antidiabetic medication

Antidiabetic medication prescription among young adults with T2DM was evaluated from 2010 to 2020. We examined the pharmacological treatment rate, defined as the proportion of individuals taking antidiabetic medications. Further analyses were conducted among those receiving antidiabetic medications. The classes of antidiabetic medications were categorized as follows: insulin, metformin, sulfonylurea (SU), meglitinide, thiazolidinedione (TZD), α-glucosidase inhibitor, dipeptidyl peptidase-4 (DPP-4) inhibitor, sodium-glucose cotransporter-2 (SGLT2) inhibitor, and glucagon-like peptide-1 receptor agonist (GLP-1RA). Insulin was counted if it was prescribed at least three times during the year, while the other medications were counted if prescribed at least once during the year. In addition, patterns of combination therapy excluding insulin were examined and categorized as monotherapy, dual combination, triple combination, and quadruple or higher combinations.

Statistical analysis

The prevalence and incidence rates of T2DM were calculated annually, and trend tests were performed to evaluate changes over time. Analyses focused on individuals aged 19–39 years, stratified into two age groups (19–29 and 30–39 years) and by sex (men and women). We examined whether the two age groups and sex groups exhibited different patterns of change over time, with the results presented as *P* values for interactions. Annual assessments of metabolic parameters, the prevalence of comorbidities and vascular complications, and antidiabetic drug prescription among young adults with T2DM were also performed. Additionally, the trends in characteristics at the time of diagnosis of incident T2DM were investigated. Statistical analyses were performed with SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

The characteristics of the incident T2DM patients are summarized in the Supplementary Table 1. Over the study period, the mean age at diagnosis of T2DM decreased (33.2 years in 2010 and 32.3 years in 2020, $P<0.001$). The male-to-female ratio consistently showed that approximately twice as many men were diagnosed with T2DM. The mean BMI at diagnosis increased significantly over time (25.4 kg/m² in 2010 and 28.3 kg/m² in 2020, $P<0.001$), accompanied by increasing rates of general and abdominal obesity. The prevalence of comorbid hypertension, dyslipidemia, and fatty liver disease increased over time. Fatty liver disease, as indicated by the FLI, had the highest prevalence, affecting 83.1% of young people with newly diagnosed T2DM in 2020.

Prevalence and incidence of T2DM in young adults

Between 2010 and 2020, the prevalence rate of T2DM among young adults increased significantly, from 1.02% to 2.02% ($P<0.001$), and the number of affected individuals increased from 225,497 to 372,726 (Fig. 1A, Supplementary Table 2). Throughout the period, prevalence rates were consistently higher in men than in women, increasing from 1.22% to 2.30% in men and from 0.81% to 1.71% in women (Fig. 1B). When stratified by age, the prevalence of T2DM in individuals aged 19–29 years increased from 0.73% to 1.54%, whereas the prevalence in individuals aged 30–39 years increased from 2.09% to 3.90%, resulting in a prevalence more than doubled in the 30–39 years age group by 2020 (Fig. 1C).

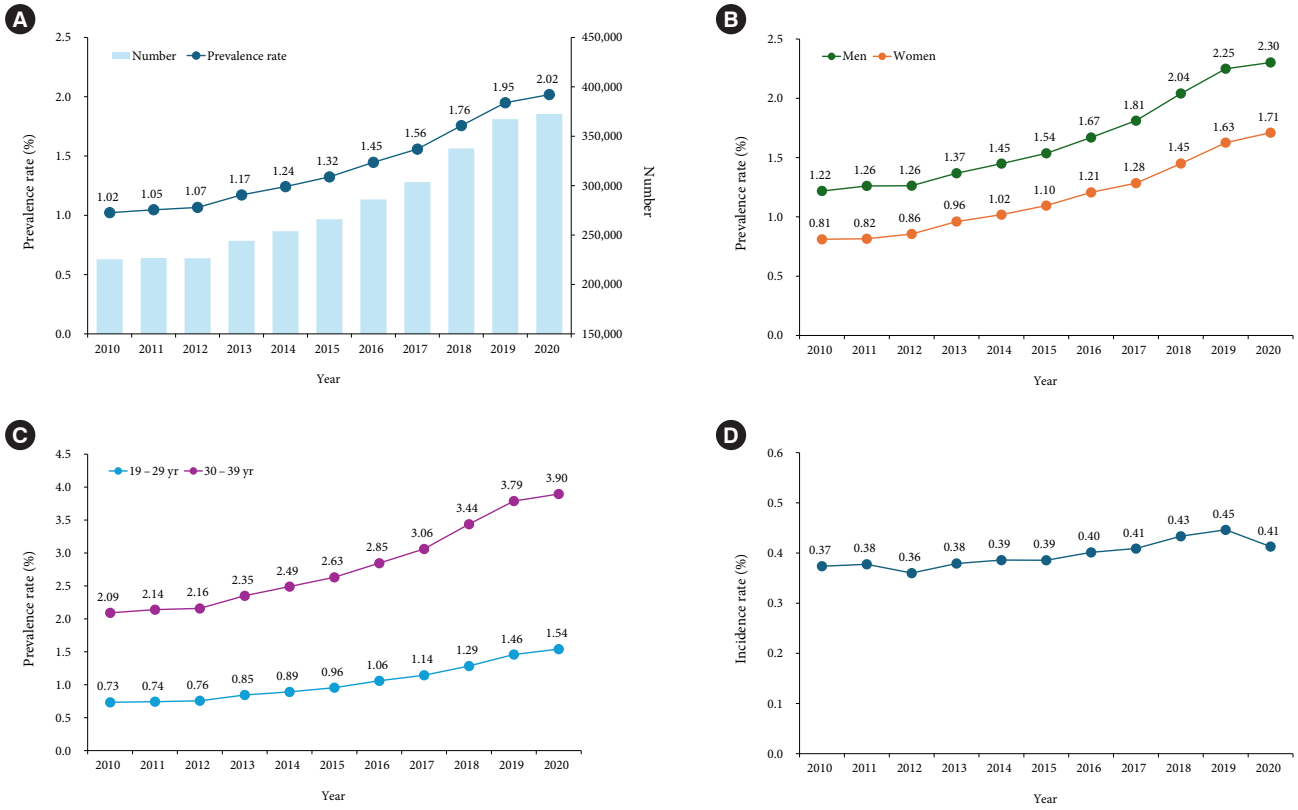

Fig. 1. Prevalence and incidence rate of type 2 diabetes mellitus (T2DM) in young adults (2010 to 2020). (A) Trends in number and prevalence rate of T2DM in young adults. (B) Trends in the prevalence rate of T2DM in young adults by sex. (C) Trends in the prevalence rate of T2DM in young adults by age group. (D) Trends in the incidence rate of T2DM in young adults.

The incidence rate of T2DM among young adults remained relatively stable, ranging from 0.36% to 0.45% annually between 2010 and 2020 (Fig. 1D, Supplementary Table 3). Similar to prevalence trends, incidence rates were higher in men than in women and more than twice as high in individuals aged 30–39 years compared with those aged 19–29 years.

Trends in the prevalence of DM was also estimated from the KNHANES database, although the type of DM was not specified in this dataset. The prevalence of DM showed fluctuations between 1.5% and 2.5% from 2012 to 2022, probably due to small sample sizes (Supplementary Fig. 1A). From the most recent integrated KNHANES database from 2019 to 2022, the prevalence of DM in young adults was 2.2%. As in the NHIS-Customized Database, the prevalence rate of DM was higher in men (2.7%) compared with women (1.7%) (Supplementary Fig. 1B). In addition, the prevalence in individuals aged 30–39 years (3.4%) was more than three times higher than that observed in those aged 19–29 years (1.1%).

Prevalence of prediabetes in young adults

From NHIS-Customized Database (2010 to 2020), the prevalence of prediabetes among young adults aged 19–39 years who underwent national health examinations steadily increased from 15.53% to 20.92%, with an estimated 3,865,194 affected individuals in 2020 (Fig. 2). Analysis of the KNHANES database (2019–2022) revealed a prediabetes prevalence of prediabetes of 21.8%, with higher rates in men (26.5%) compared with women (16.7%) (Supplementary Fig. 2). The prevalence of prediabetes was more than twice as high in the 30–39 age group (29.8%), compared to those aged 19–29 years (14.3%).

Obesity in young adults with T2DM

Between 2010 and 2020, the mean±standard deviation (SD) BMI of young adults with T2DM increased from 25.5±4.3 to 27.6±5.6 kg/m^2, while the mean±SD WC increased from 84.5±10.9 to 89.1±14.0 cm (P<0.001 for both) (Fig. 3A, Supplementary Table 4). Throughout the study period, the mean BMI of men was consistently higher than that of women. In

men, the mean BMI increased from 26.0±4.0 in 2010 to 28.4±5.1 kg/m² in 2020, whereas in women, it increased from 23.7±4.9 to 26.0±6.2 kg/m² (Fig. 3B). The proportion of young adults with obesity also increased significantly over this period (Fig. 3C). The percentage of patients with stage 1 obesity or higher (BMI ≥25 kg/m²) increased from 53.8% to 67.8%, while stage 2 obesity or higher (BMI ≥30 kg/m²) increased from 14.8% to 31.6%. The prevalence of stage 3 obesity (BMI ≥35 kg/m²) reached 10.1% in 2020, and 2.6% of patients had a BMI of ≥40 kg/m². When the proportion of obesity in young adult with T2DM was analyzed separately by sex, the proportion of stage 1 obesity or higher increased from 58.5% to 75.1% in men and from 36.2% to 52.4% in women (Fig. 3D). The prevalence of stage 2 obesity or higher (BMI ≥30 kg/m²) increased from 15.5% to 34.1% in men and from 12.6% to 26.4% in women.

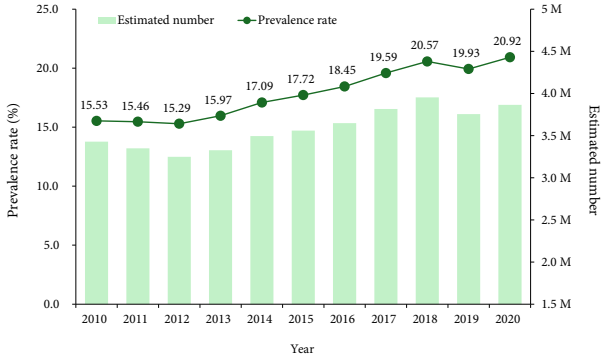

Fig. 2. Prevalence rate and estimated number of prediabetes in young adults (2010 to 2020). M, million.

Comorbidities and vascular complications

Between 2010 and 2020, the prevalence rates of hypertension, dyslipidemia, and fatty liver disease in young adults with T2DM showed an increasing trend, reaching 34.2%, 79.8%, and 78.9%, respectively, by 2020 (P<0.001 for all) (Fig. 4A, Supplementary Table 5). The prevalence of vascular complica-

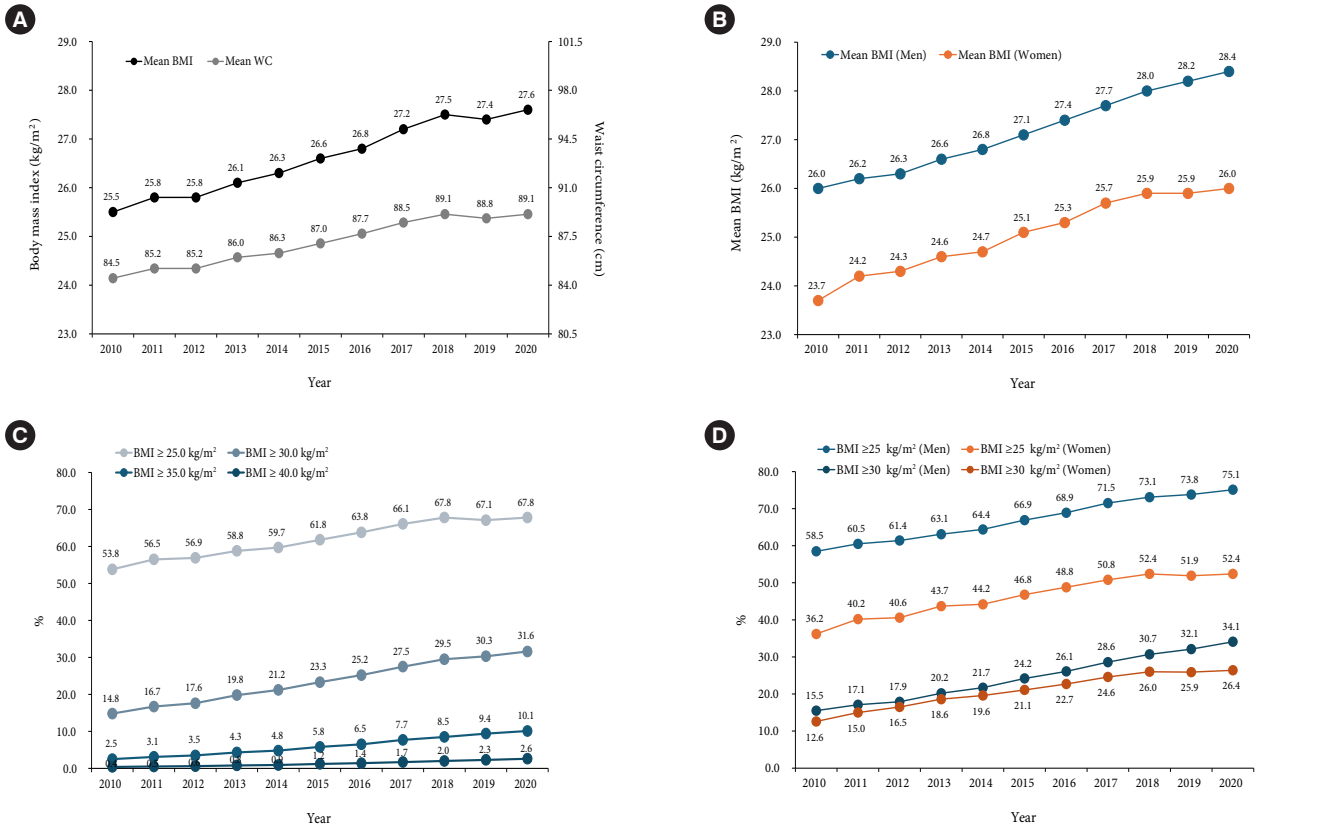

Fig. 3. Obesity in young adults with type 2 diabetes mellitus (T2DM). (A) Trends in mean body mass index (BMI) and waist circumference (WC) in young adults with T2DM. (B) Trends in mean BMI by sex. (C) Trends in the proportion of individuals with a BMI of ≥25, ≥30, ≥35, and ≥40 kg/m² among young adults with T2DM. (D) Trends in the proportion of individuals with a BMI of ≥25 and ≥30 kg/m² among young adults with T2DM, analyzed by sex.

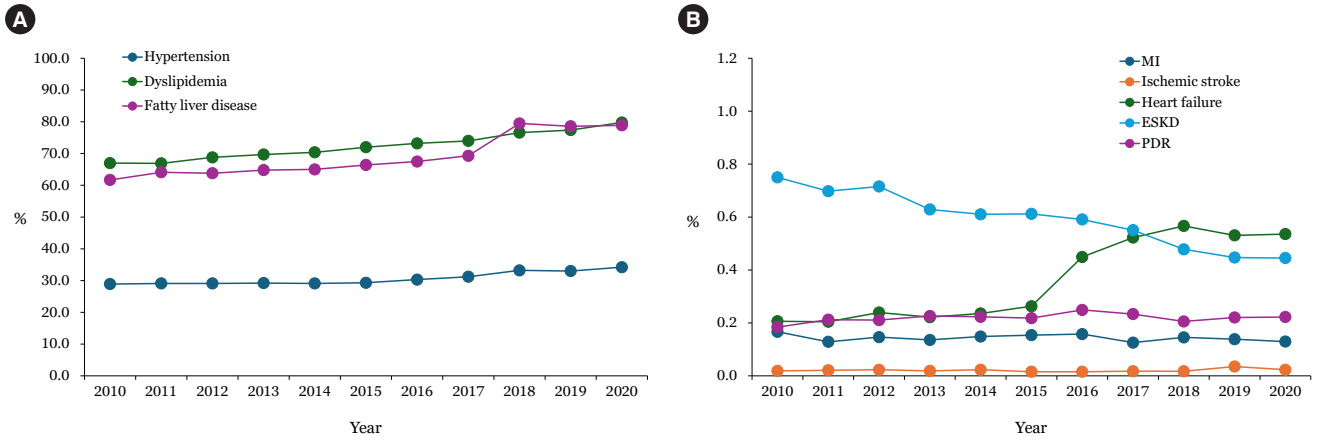

Fig. 4. Trends in comorbidities and vascular complications in young adults with type 2 diabetes mellitus (2010 to 2020). (A) Prevalence of hypertension, dyslipidemia, and fatty liver disease. (B) Prevalence of vascular complications. MI, myocardial infarction; ESKD, end-stage kidney disease; PDR, proliferative diabetic retinopathy.

tions is displayed in Fig. 4B, Supplementary Table 5. The prevalence of vascular complications among young adults with T2DM was less than 1%. While the prevalence of ESKD has been gradually decreasing, the prevalence of heart failure has shown an increasing trend. The most common comorbid vascular disease in 2020 was heart failure, followed by ESKD, PDR, MI, and ischemic stroke.

Antidiabetic medication patterns in young adults with T2DM

Fig. 5A shows the pharmacological treatment rate of young adults with T2DM, the proportion of patients receiving antidiabetic medication. The treatment rate was very low at 28.7% in 2010, increasing slightly to 33.0% in 2020. Among those receiving antidiabetic medication, Fig. 5B shows the prescription patterns of pharmacologic treatments. There has been an increase in the prescription rates of metformin, SGLT2 inhibitors, and GLP-1RA since 2015. In particular, the prescription rate for SGLT2 inhibitors showed the most significant increase, with 32.0% of patients using these agents by 2020. Metformin remained the most commonly prescribed medication throughout the study period, with a steady increase in used to reach 91.2% of patients in 2020. While the prescription rate of DPP-4 inhibitors declined after 2016, it remained the second most commonly prescribed medication in 2020. Conversely, the prescription rates of SU and TZD showed a gradual decline over time. Fig. 5C highlights the patterns of drug regimen combinations excluding insulin. A notable trend was the decrease in the use of monotherapy and the increase in the use of triple and quadruple or higher combination therapies. Specifically, the proportion of patients receiving triple combination therapy increased from 17.8% in 2010 to 32.4% in 2020, while those receiving quadruple or higher combination therapy increased from 4.0% to 8.8% over the same period.

DISCUSSION

This study demonstrated an increasing prevalence of T2DM among young adults in South Korea, and unique characteristics of affected individuals with distinct disease phenotypes. In the decade from 2010 to 2020, the prevalence of T2DM among individuals aged 19 to 39 years nearly doubled, with approximately 400,000 young adults affected by 2020. One of the most notable findings was the significant increase in obesity rates among young adults with T2DM, reflected in a mean BMI of 27.6 kg/m^2 in 2020. This increase in obesity correlates with increased prescribing of antidiabetic medications that promote weight loss, such as SGLT2 inhibitors and GLP-1RAs.

The increasing prevalence of T2DM in Korean young adults is consistent with global trends, particularly in the Western Pacific and Southeast Asian regions, where the burden of early-onset T2DM is substantial [4]. Reports from the Joint Asia Diabetes Evaluation (JADE) program estimate that 10% to 25% of T2DM patients in Asia are diagnosed before the age of 40 [29]. In South Korea, previous studies using sample-based databases such as KNHANES and NHIS-National Sample Cohort have shown similar trends [30]. In a study using the KNHANES database, the prevalence of T2DM increased from 0.5% in 2005

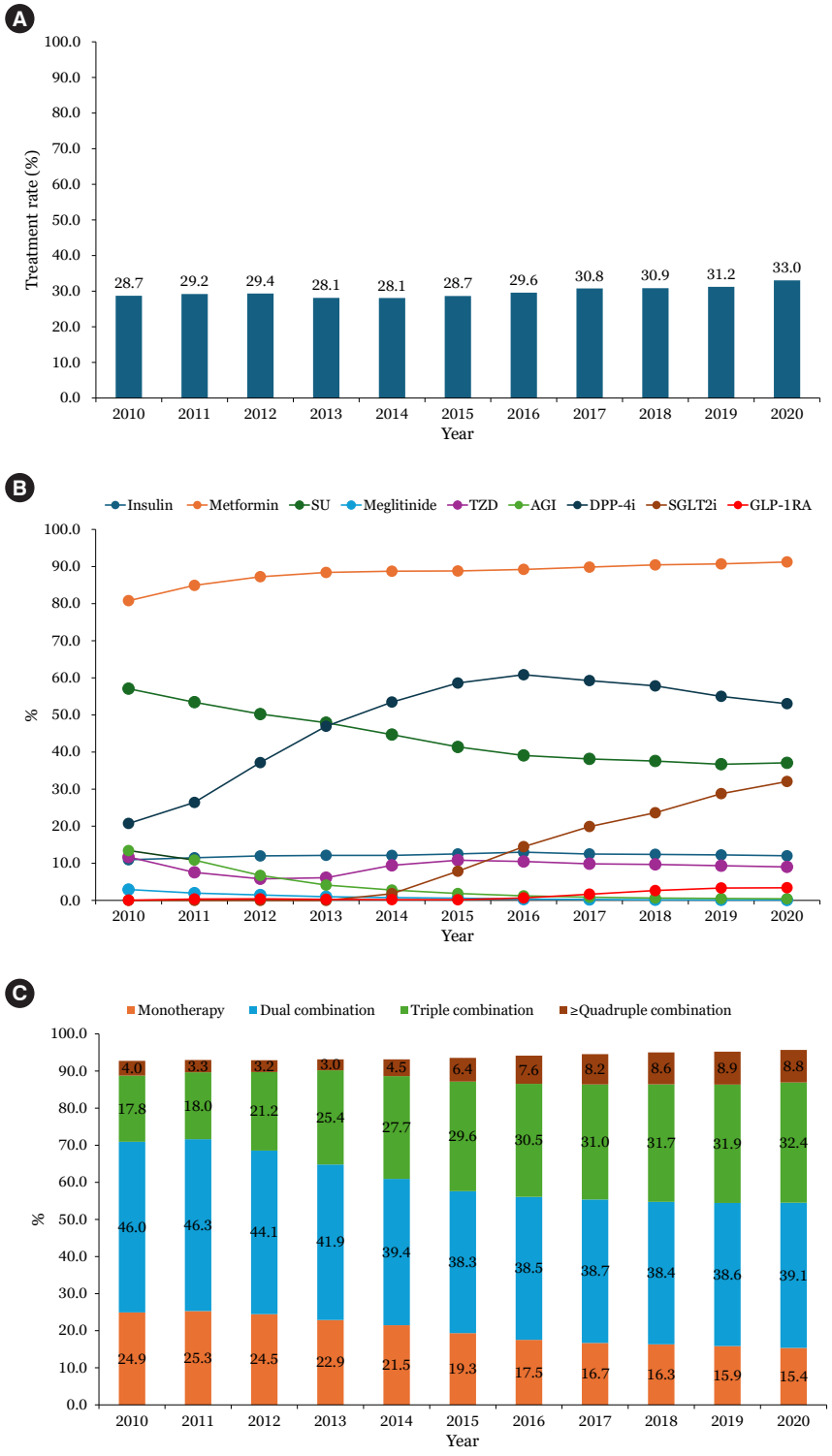

Fig. 5. Trends in antidiabetic medication use among young adults with type 2 diabetes mellitus. (A) Pharmacological treatment rate. (B) Prescription patterns for pharmacological treatments among those receiving antidiabetic medications. (C) Patterns of drug regimen combinations excluding insulin among those receiving antidiabetic medications. SU, sulfonylurea; TZD, thiazolidinedione; AGI, alpha-glucosidase inhibitor; DPP-4i, dipeptidyl peptidase-4 inhibitor; SGLT2i, sodium-glucose cotransporter-2 inhibitor; GLP-1RA, glucagon-like peptide-1 receptor agonist.

to 1.0% in 2016–2018 among individuals aged 20–29 years, and from 1.2% to 2.4% among individuals aged 30–39 years. A NHIS-National Sample Cohort (2006 to 2015) analysis showed that DM prevalence increased from 0.3% to 0.4% and from 1.1% to 1.4% among individuals aged 20–29 and 30–39 years, respectively. Our study, based on the NHIS-Customized Database with an actual number of affected individuals, provided a comprehensive view and showed that the prevalence of T2DM increased from 1.02% in 2010 to 2.02% in 2020 among individuals aged 19 to 39 years. In particular, prevalence increased more rapidly in the 30 to 39 age group, reaching 3.90% in 2020. Despite limitations in the KNHANES data due to small sample sizes, the estimated DM prevalence of 2.2% during 2019 to 2022 are consistent with findings from the NHIS-Customized Database, strengthening the validity of our findings. Gender differences in T2DM prevalence were consistently observed, with higher rates in men compared to women. This disparity is likely influenced by the higher prevalence of obesity in men, as well as systematic health screening during mandatory physical examinations for military enlistment.

While the prevalence of T2DM has increased, the incidence rate among young adults has remained relatively stable. It increased steadily from 0.36% to 0.45% between 2012 and 2019, but decreased to 0.41% in 2020, likely due to reduced healthcare utilization during the coronavirus disease 2019 (COVID-19) pandemic. In an earlier study, there was a gradual increase in DM incidence from 2006 to 2015 [30].

Obesity is an established risk factor for T2DM [31]. The association between T2DM and obesity is particularly pronounced in younger populations, with earlier age of diagnosis associated with higher BMI. For example, a United States study reported that patients diagnosed with DM in their 30s or younger had a mean BMI of 38.3 kg/m², compared with 28.8 kg/m² in those diagnosed at age 70 or older [32]. Similarly, previous South Korean data showed that the proportion of young diabetic patients with a BMI ≥25 kg/m² increased from 51.4% in 2006 to 72.4% in 2015 [30]. In our study, 67.8% of young adults with T2DM had a BMI ≥25 kg/m², 31.6% had a BMI ≥30 kg/m², and 10.1% had a BMI ≥35 kg/m² in 2020. The prevalence of obesity observed in our study was relatively lower compared to that reported in a previous study [30], likely due to differences in the operational definition of T2DM. Specifically, our study included both individuals who were on antidiabetic medications and those who were not, whereas the previous study included only those receiving antidiabetic medications. When we applied a similar definition, including only individuals with ICD-10 codes E11 to E14 and concurrent use of antidiabetic medications, the mean BMI increased to 29.3 kg/m², and the prevalence of obesity increased to 80.4% in 2020 (Supplementary Fig. 3). However, regardless of the operational definition of T2DM, it is evident that the prevalence of obesity is increasing among young adults with T2DM. In addition, the prevalence of central obesity, as reflected by increased WC, further underscores the metabolic risk in this population. Moreover, the prevalence of obesity and central obesity also increased among those newly diagnosed with T2DM (Supplementary Table 1). These findings suggest both rising obesity rates among newly diagnosed young T2DM patients and inadequate obesity management in prevalent cases.

The striking prevalence of obesity provides insight into the management and prevention of T2DM in young adults, emphasizing the need to prioritize obesity treatment. Although there was an increasing trend in the prescription of antidiabetic drugs with weight-reducing benefits, the proportion of young adults with T2DM treated with GLP-1RAs still remained low (3.4% in 2020). Clinicians should consider the impact of antidiabetic medications on weight when prescribing them while actively encouraging patients to adopt lifestyle modifications [24,25]. Moreover, when counseling obese young adults who have not yet been diagnosed with T2DM, it is essential to actively screen for T2DM [21] and aggressively manage obesity to prevent T2DM. Considering that anti-obesity drugs are currently not covered by insurance and the use of antidiabetic drugs with weight-reducing effects is largely limited by current insurance coverage criteria, policies expanding insurance coverage for young adults with T2DM and morbid obesity may be needed.

Another important finding of this study is the high prevalence of metabolic comorbidities in young adults with T2DM. Approximately 80% had dyslipidemia and fatty liver disease, and 34.2% had hypertension. The co-occurrence of these conditions increases the risk of cardiovascular disease and other long-term complications, underscoring the need for a comprehensive, multidisciplinary approach to diabetes management. Among vascular complications, the prevalence of heart failure has substantially increased, becoming the most common complication in 2020. Incorporating routine screening for comorbidities and complications, along with early intervention, could mitigate the progression of these conditions.

Analysis of pharmacological treatment patterns has revealed

a shift over the past decade toward newer antidiabetic agents, such as SGLT2 inhibitors and GLP-1RAs. These medications, which offer cardiovascular and renal protection [33-37], have gained prominence in treatment regimens, reflecting adherence to evolving clinical guidelines [21]. In particular, the prescription rate for SGLT2 inhibitors has increased significantly, reaching 32.0% in 2020. Despite these advances, metformin remained the most commonly prescribed drug throughout the study period, with 91.2% of patients using it in 2020. The increasing use of metformin, SGLT2 inhibitors and GLP-1RAs—all of which are associated with weight management benefits—appears to reflect growing clinical recognition of the interplay between DM and obesity in this population. However, the proportion of patients receiving antidiabetic agents was low, at 33.0% in 2020. Analysis of the KNHANES database from 2019 to 2022 revealed a similar treatment rate of 34.6%, consistent with findings from the NHIS-Customized Database. The low pharmacological treatment rate among young patients with T2DM warrants attention and further intervention.

To the best of our knowledge, this is the largest study investigating the epidemiology of young adults with T2DM in South Korea, encompassing nearly the entire population using the NHIS-Customized Database. While the KNHANES dataset has commonly been used to evaluate diabetes prevalence, the number of young adults with T2DM in KNHANES was low, with approximately 30 cases per year. Therefore, we utilized the NHIS-Customized Database, presenting data from KNHANES as supporting information. The NHIS-Customized Database allows us to report the actual number of young adults with T2DM and comprehensively analyze their characteristics, including metabolic features, comorbidities, vascular complications, and use of antidiabetic medications.

This study has several limitations. First, the accuracy of T2DM diagnoses in the NHIS database may be compromised because diagnoses were based on corresponding codes and FPG levels without mandatory confirmation by antidiabetic medication use. This approach was chosen because of the low awareness and treatment rates of DM in young adults, which remain below 50%. Additionally, we excluded patients who received an ICD-10 code E10 (T1DM) diagnosis with insulin prescriptions after initially being assigned ICD-10 codes E11 (T2DM) to E14. As a result, individuals with an unclear diabetes type may have been excluded from the current analysis. However, without this exclusion process, we believed that a substantial portion of the study population would have included T1DM patients, given their age. Second, the prevalence estimates of prediabetes may be imprecise because they were derived only from individuals undergoing national health examinations, potentially excluding a significant portion of the population. Third, the vascular complications identified in this study should be interpreted as comorbid conditions rather than true complications, as they were assessed cross-sectionally each year.

In conclusion, the results of this study highlight a worrisome increase in T2DM prevalence among young adults in South Korea, which is strongly associated with increasing obesity and related metabolic comorbidities. Although the pharmacological treatment rate was low, the evolving treatment patterns and increasing complexity of therapeutic regimens reflect the challenges of managing this condition in younger populations. These findings underscore the need for multifaceted strategies that include prevention, early diagnosis, and comprehensive management to address the growing burden of T2DM in young adults.

SUPPLEMENTARY MATERIALS

Supplementary materials related to this article can be found online at https://doi.org/10.4093/dmj.2024.0826.

CONFLICTS OF INTEREST

Seung-Hyun Ko has been the executive editor of the *Diabetes & Metabolism Journal* since 2022. Sung Hee Choi has been an associate editor of the *Diabetes & Metabolism Journal* since 2022. They were not involved in the review process of this article. Otherwise, there was no conflict of interest.

AUTHOR CONTRIBUTIONS

Conception or design: J.Y.K., N.H.K.
Acquisition, analysis, or interpretation of data: all authors.
Drafting the work or revising: J.Y.K., N.H.K.
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Supplementary Table 1. Characteristics at diagnosis of incident type 2 diabetes mellitus among young adults

Characteristic	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	*P* for trend
Number	82,470	81,805	75,377	78,990	78,905	77,451	79,368	79,674	83,344	84,079	76,277	
Age, yr	33.2±4.8	33.1±4.8	33.0±4.9	32.9±4.9	32.8±5.0	32.7±5.1	32.7±5.2	32.7±5.2	32.7±5.2	32.5±5.3	32.3±5.4	<0.001
Sex												<0.001
Men, %	65.7	66.5	65.3	64.8	64.7	64.5	64.5	65.0	65.6	63.5	63.5	
Women, %	34.3	33.5	34.7	35.2	35.3	35.5	35.5	35.0	34.4	36.5	36.5	
BMI, kg/m^2	25.4±4.4	25.6±4.5	25.7±4.6	26.1±4.8	26.3±4.9	26.7±5.1	27.0±5.2	27.5±5.4	27.8±5.4	28.0±5.7	28.3±5.8	<0.001
BMI ≥25, %	50.6	53.0	53.5	55.8	57.4	60.7	62.9	65.9	68.1	68.3	69.8	<0.001
BMI ≥30, %	14.2	16.0	16.9	19.4	21.2	23.8	26.1	29.0	31.6	33.0	35.4	<0.001
BMI ≥35, %	2.5	3.1	3.6	4.6	5.2	6.4	7.1	8.9	9.9	11.2	12.6	<0.001
WC, cm	84.2±10.9	84.8±11.1	84.9±11.3	85.9±11.8	86.3±12.8	87.6±22.2	88.6±26.3	89.3±19.1	89.9±15.7	90.0±16.5	90.6±14.1	<0.001
Central obesity, %	31.2	33.3	34.2	37.7	39.5	43.2	46.0	49.1	51.6	52.8	55.2	<0.001
Hypertension, %	24.8	25.2	25.2	25.6	25.3	26.1	27.0	28.1	31.0	31.1	32.6	<0.001
Dyslipidemia, %	64.1	63.1	64.9	66.3	67.3	68.7	70.4	70.9	72.6	73.0	77.7	<0.001
FLI	48.6±31.7	50.5±31.8	50.8±31.9	52.8±32.1	53.7±32.2	55.9±32.2	57.3±32.1	59.0±32.0	65.1±29.1	54.9±29.6	65.8±29.4	<0.001
Fatty liver disease, %	64.7	66.7	66.9	68.8	69.9	72.0	73.4	75.0	82.5	82.0	83.1	<0.001
House income												<0.001
Lower third, %	26.2	26.4	25.9	25.4	25.6	25.4	25.6	25.4	25.0	26.5	26.9	
Middle third, %	40.9	42.3	42.1	43.0	43.2	43.9	43.0	43.1	43.3	42.8	42.1	
Upper third, %	32.9	31.3	32.0	31.7	31.2	30.7	31.4	31.5	31.8	30.7	31.0	

Values are presented as mean±standard deviation or percentages.
BMI, body mass index; WC, waist circumference; FLI, fatty liver index.

Supplementary Table 2. Trends in prevalence and number of young adults (19–39 years) with type 2 diabetes mellitus

Variable	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	*P* for trend	*P* for interaction
All subjects													
Prevalence rate[a]	1.02	1.05	1.07	1.17	1.24	1.32	1.45	1.56	1.76	1.95	2.02	<0.001	
Number	225,497	226,701	226,575	244,158	253,867	265,936	286,108	303,616	337,664	367,302	372,726		
According to sex													0.067
Men													
Prevalence rate[a]	1.22	1.26	1.26	1.37	1.45	1.54	1.67	1.81	2.04	2.25	2.30	<0.001	
Number	139,346	141,617	139,078	147,876	153,679	160,143	171,368	183,292	203,574	220,052	220,887		
Women													
Prevalence rate[a]	0.81	0.82	0.86	0.96	1.02	1.10	1.21	1.29	1.45	1.63	1.71	<0.001	
Number	86,151	85,084	87,497	96,282	100,188	105,793	114,740	120,324	134,090	147,250	151,839		
According to age													<0.001
19–29 years													
Prevalence rate[a]	0.73	0.74	0.76	0.85	0.89	0.96	1.06	1.14	1.29	1.46	1.54	<0.001	
Number	50,391	50,002	50,169	55,715	59,256	64,017	71,670	77,945	87,698	99,375	104,911		
30–39 years													
Prevalence rate[a]	2.09	2.14	2.16	2.35	2.49	2.63	2.85	3.06	3.44	3.79	3.90	<0.001	
Number	175,106	176,699	176,406	188,443	194,611	201,919	214,438	225,671	249,966	267,927	267,815		

[a]Per 100 persons.

Supplementary Table 3. Trends in incidence and number of young adults (19–39 years) with type 2 diabetes mellitus

Variable	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	*P* for trend	*P* for interaction
All subjects													
Incidence rate[a]	0.37	0.38	0.36	0.38	0.39	0.39	0.40	0.41	0.43	0.45	0.41	0.905	
Number	82,470	81,805	75,377	78,990	78,905	77,451	79,368	79,674	83,344	84,079	76,277		
According to sex													0.196
Men													
Incidence rate[a]	0.47	0.48	0.45	0.47	0.48	0.48	0.50	0.51	0.55	0.55	0.51	0.531	
Number	54,142	54,383	49,258	51,203	51,062	49,941	51,162	51,778	54,700	53,394	48,405		
Women													
Incidence rate[a]	0.27	0.26	0.26	0.28	0.28	0.29	0.30	0.30	0.31	0.34	0.31	0.100	
Number	28,328	27,422	26,119	27,787	27,843	27,510	28,206	27,896	28,644	30,685	27,872		
According to age													0.001
19–29 years													
Incidence rate[a]	0.27	0.27	0.25	0.27	0.28	0.28	0.29	0.30	0.31	0.34	0.32	<0.001	
Number	18,419	18,188	16,773	18,025	18,395	18,505	19,765	20,143	21,276	22,982	21,818		
30–39 years													
Incidence rate[a]	0.77	0.77	0.72	0.76	0.78	0.77	0.79	0.81	0.85	0.86	0.79	0.056	
Number	64,051	63,617	58,604	60,965	60,510	58,946	59,603	59,531	62,068	61,097	54,459		

[a]Per 100 persons.

Supplementary Table 4. Obesity in young adults with type 2 diabetes mellitus

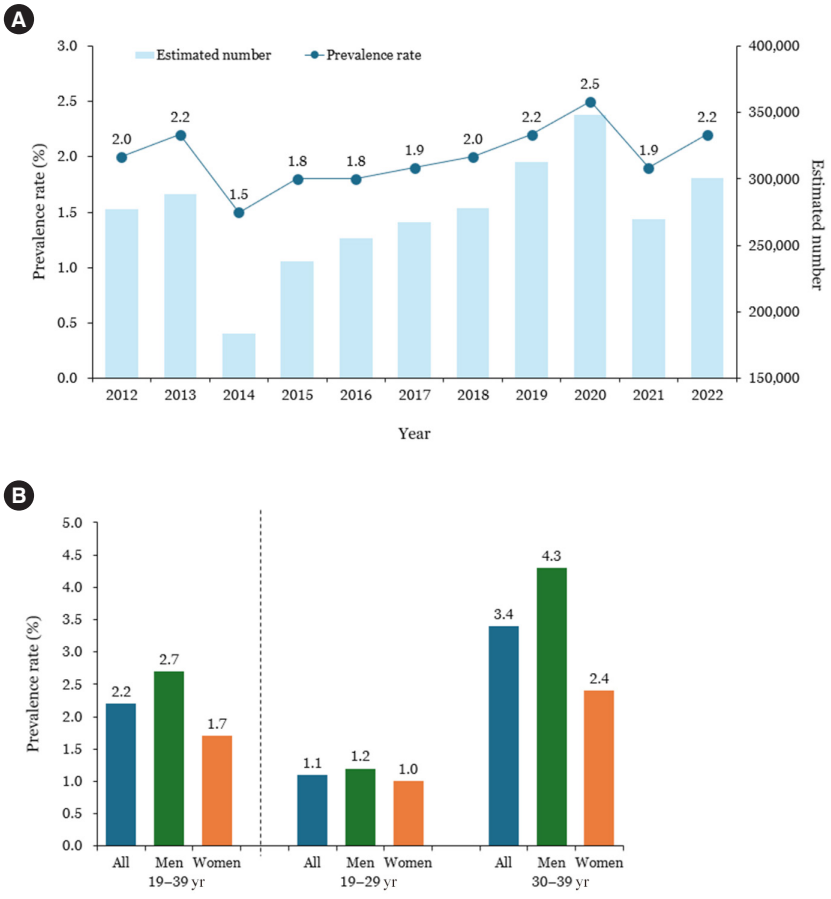
Variable	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	*P* for trend
Men and women												
Number[a]	86,508	88,878	86,344	91,424	98,259	101,248	106,789	112,824	133,704	156,432	150,807	
BMI, kg/m^2	25.5±4.3	25.8±4.4	25.8±4.5	26.1±4.7	26.3±4.8	26.6±5.0	26.8±5.1	27.2±5.2	27.5±5.3	27.4±5.5	27.6±5.6	<0.001
Proportion of patients in each BMI (kg/m^2) categories, %												<0.001
18.5–22.9	27.1	25.0	25.1	23.8	23.4	21.9	20.6	19.2	18.0	19.2	18.8	
23.0–24.9	19.0	18.6	18.0	17.3	16.9	16.2	15.5	14.7	14.2	13.8	13.4	
25.0–29.9	39.0	39.8	39.3	39.0	38.5	38.5	38.6	38.6	38.3	36.8	36.2	
30.0–34.9	12.3	13.6	14.1	15.5	16.4	17.5	18.7	19.8	21.0	20.9	21.5	
35.0–39.9	2.1	2.6	2.9	3.5	3.9	4.6	5.1	6.0	6.5	7.1	7.5	
≥40	0.4	0.5	0.6	0.8	0.9	1.2	1.4	1.7	2.0	2.3	2.6	
Number[b]	89,357	91,449	89,015	94,221	101,212	104,134	109,730	115,487	136,478	160,260	154,398	
WC, cm	84.5±10.9	85.2±11.0	85.2±11.3	86.0±11.7	86.3±12.0	87.0±12.3	87.7±12.6	88.5±12.9	89.1±13.1	88.8±13.7	89.1±14.0	<0.001
Proportion of patients with central obesity, %[c]	32.4	34.9	35.6	38.5	40.1	42.8	45.2	47.8	49.9	49.8	51.2	<0.001
Men												
Number[a]	68,807	71,293	67,874	71,423	75,636	76,236	80,156	84,104	99,941	107,921	102,313	
BMI, kg/m^2	26.0±4.0	26.2±4.1	26.3±4.2	26.6±4.3	26.8±4.4	27.1±4.5	27.4±4.6	27.7±4.7	28.0±4.8	28.2±5.0	28.4±5.1	<0.001
Proportion of patients in each BMI (kg/m^2) categories, %												<0.001
18.5–22.9	21.5	20.0	19.7	18.6	18.0	16.2	14.9	13.3	12.3	12.1	11.4	
23.0–24.9	20.1	19.5	18.9	18.3	17.6	17.0	16.3	15.2	14.6	14.2	13.6	
25.0–29.9	43.0	43.4	43.5	42.9	42.7	42.7	42.8	42.9	42.4	41.7	41.0	
30.0–34.9	13.1	14.2	14.7	16.2	17.2	18.6	19.9	21.2	22.4	22.8	23.7	
35.0–39.9	2.0	2.4	2.7	3.3	3.7	4.5	5.0	5.9	6.5	7.2	7.9	
≥40	0.4	0.5	0.5	0.7	0.8	1.1	1.2	1.5	1.8	2.1	2.5	
Number[b]	69,880	72,288	68,863	72,434	76,632	77,098	81,092	84,892	100,781	108,845	103,101	
WC, cm	86.7±9.6	87.2±9.8	87.4±10.0	88.2±10.4	88.7±10.6	89.5±10.9	90.2±11.1	91.1±11.4	91.8±11.6	92.3±12.0	93.0±12.2	<0.001
Proportion of patients with central obesity, %[c]	35.3	37.4	38.4	41.4	43.1	46.2	49.1	52.0	54.2	55.8	57.9	<0.001
Women												
Number[a]	17,701	17,585	18,470	20,001	22,623	25,012	26,633	28,720	33,763	48,511	48,494	
BMI, kg/m^2	23.7±4.9	24.2±5.1	24.3±5.3	24.6±5.5	24.7±5.5	25.1±5.7	25.3±5.9	25.7±6.1	25.9±6.1	25.9±6.1	26.0±6.2	<0.001
Proportion of patients in each BMI (kg/m^2) categories, %												<0.001
18.5–22.9	48.7	44.9	44.7	42.5	41.4	39.2	38.0	36.2	34.9	35.0	34.6	
23.0–24.9	15.1	14.8	14.6	13.7	14.4	13.9	13.2	13.1	12.7	13.0	12.9	
25.0–29.9	23.6	25.2	24.1	25.1	24.6	25.7	26.1	26.2	26.4	26.0	26.0	
30.0–34.9	9.4	11.2	11.9	13.1	13.7	14.2	15.1	15.8	16.7	16.5	16.7	
35.0–39.9	2.6	3.1	3.5	4.2	4.5	5.1	5.6	6.3	6.6	6.8	6.8	
≥40	0.6	0.7	1.1	1.3	1.4	1.8	2.0	2.5	2.7	2.6	2.9	
Number[b]	19,477	19,161	20,152	21,787	24,580	27,036	28,638	30,595	35,697	51,415	51,297	
WC, cm	76.5±11.5	77.5±12.0	77.7±12.2	78.7±12.8	79.1±13.0	79.8±13.3	80.3±13.6	81.0±13.9	81.4±14.0	81.4±14.1	81.4±14.3	<0.001
Proportion of patients with central obesity, %[c]	22.2	25.3	26.0	29.0	30.5	32.8	34.3	36.2	37.6	37.2	37.7	<0.001

Values are presented as mean±standard deviation or percentages.
BMI, body mass index; WC, waist circumference.
[a]Number of participants with available BMI data, [b]Number of participants with available WC data, [c]WC ≥90 cm (men), ≥85 cm (women).

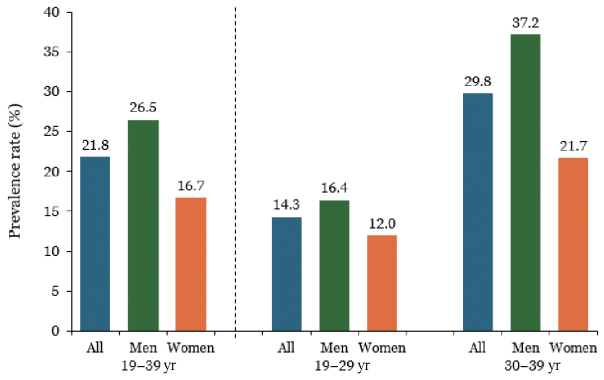
Supplementary Table 5. Comorbidities and vascular complications in young adults with type 2 diabetes mellitus

Prevalence rate/100 persons, %	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	*P* for trend
Comorbidities												
Hypertension	28.9	29.1	29.1	29.2	29.1	29.3	30.3	31.2	33.2	33.0	34.2	<0.001
Dyslipidemia	67.0	66.9	68.8	69.7	70.4	72.0	73.2	74.0	76.6	77.4	79.8	<0.001
Fatty liver disease	61.7	64.1	63.8	64.8	65.0	66.4	67.5	69.3	79.5	78.6	78.9	<0.001
Vascular complications												
MI	0.17	0.13	0.15	0.14	0.15	0.15	0.16	0.13	0.15	0.14	0.13	0.022
Ischemic stroke	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.020
Heart failure	0.21	0.20	0.24	0.22	0.24	0.26	0.45	0.52	0.57	0.53	0.54	<0.001
ESKD	0.75	0.70	0.72	0.63	0.61	0.61	0.59	0.55	0.48	0.45	0.45	<0.001
PDR	0.18	0.21	0.21	0.23	0.22	0.22	0.25	0.23	0.21	0.22	0.22	0.028

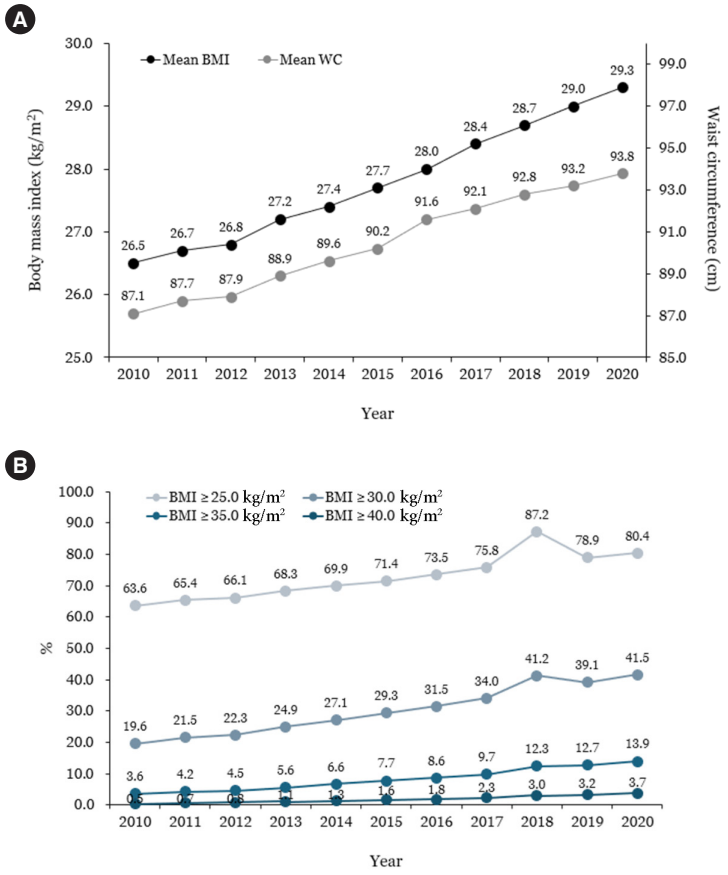
MI, myocardial infarction; ESKD, end-stage kidney disease; PDR, proliferative diabetic retinopathy.



Supplementary Fig. 1. Prevalence rate of diabetes mellitus in young adults from the Korea National Health and Nutrition Examination Survey database. (A) Trends in number and prevalence rate of diabetes mellitus in young adults (2012–2022). (B) Prevalence rate of diabetes mellitus in young adults according to sex and age group (2019–2022).



Supplementary Fig. 2. Prevalence rate of prediabetes in young adults from the Korea National Health and Nutrition Examination Survey database (2019–2022).



Supplementary Fig. 3. Obesity in young adults with type 2 diabetes mellitus defined as receiving International Classification of Diseases, 10th Revision codes E11 to E14 along with antidiabetic medications. (A) Trends in mean body mass index (BMI) and waist circumference (WC). (B) Trends in the proportion of young adults with BMI ≥25, ≥30, ≥35, and ≥40 kg/m^2.