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Rising Incidence of Diabetes in Young Adults in South Korea: A National Cohort Study

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We investigated the incidence of diagnosed diabetes in South Korean adults (aged ≥20 years) by analyzing data for the National Health Insurance Service–National Sample Cohort. From 2006 to 2015, the overall incidence rate of diagnosed diabetes decreased by approximately 0.1% per year until 2015. Although, this trend was observed in individuals aged 40 years or over, the rate increased slightly in the 20–29 and 30–39 years age groups, from 0.5 to 0.7 and 2.0 to 2.6 per 1,000 individuals, respectively. The proportion of obese young adults with diabetes increased remarkably, from 51.4% in 2006 to 72.4% in 2015. Thus, young adults need early identification and weight-control strategies to prevent diabetes.

Keywords: Diabetes mellitus; Epidemiology; Incidence

INTRODUCTION

In recent decades, the prevalence of diabetes has increased worldwide [1,2]. In South Korea, the prevalence of diabetes has also increased with age and economic development [3]. However, little has been published on current trends in the overall- and age-specific incidence of diabetes in South Korea. Therefore, we investigated the incidence of diagnosed diabetes in South Korean adults (aged ≥20 years) by analyzing the National Health Insurance Service–National Sample Cohort (NHIS-NSC) data.

METHODS

The NHIS-NSC enrolled 1,021,208 individuals (2.2% of all eligible South Koreans in 2006) using a systematic sampling method. Details on the NHIS-NSC can be found elsewhere [4]. Our study protocol was approved by the Institutional Review Board of Ajou University Hospital, Suwon, South Korea (approval no. AJIRB-MED-EXP-17-511) and the requirement for informed consent was waived.

Diagnosed diabetes was defined as an individual newly diagnosed with codes E10–E14 (10th edition of the International Classification of Diseases [ICD-10]), with a simultaneous prescription for glucose-lowering medications (Anatomical Therapeutic Chemical code A10).

For each calendar year, the incidence rate of diagnosed diabetes was calculated by dividing the number of newly diagnosed individuals by the population for that year. Incidence rates were expressed as age-standardized rates per 1,000 individuals. The age-standardized rates were adjusted through direct standardization using the South Korean mid-year population in 2011 across sexes and 5-year age groups from 20–24 to 85 years and older.

The baseline sex, household income, type of diabetes, and body mass index (BMI) were extracted from the year of diabe-

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tes diagnosis. Household income was categorized into three groups: lowest 30%, middle 40%, and highest 30%. Type of diabetes was classified by ICD-10 code as types 1 (E10) and 2 (E11–E14) diabetes. BMI was classified according to Korean Society for the Study of Obesity [5] as underweight (<18.5 kg/m²), normal-weight (18.5–22.9 kg/m²), pre-obese (23.0–24.9 kg/m²), obese class I (25.0–29.9 kg/m²), obese class II (30.0–34.9 kg/m²), and obese class III (≥35.0 kg/m²). Descriptive statistics are presented as percentages. We compared the proportion according to characteristics using the chi-square test. All statistical analyses were performed using SAS Enterprise Guide 7.1 (SAS Institute, Cary, NC, USA).

RESULTS

Incidence of diagnosed diabetes

Fig. 1 and Supplementary Table 1 show the diagnosed diabetes incidence rates from 2006 to 2015 by age group. The overall diagnosed diabetes incidence rate decreased by approximately 0.1% per year until 2015. This trend was observed in individuals aged 40 years or over, particularly a remarkable decline in the 70- to 79-year age group from 20.2 per 1,000 individuals in 2006 to 13.7 per 1,000 individuals in 2015. By contrast, the diagnosed diabetes incidence rates slightly increased in the 20–29- and 30–39-year age groups, from 0.5 to 0.7 and 2.0 to 2.6 per 1,000 individuals, respectively. These trends were observed in both men and women, although the slopes of change were more pronounced in men (Supplementary Table 1 and Supplementary Fig. 1). The proportion of newly diagnosed diabetes in the 20- to 39-year age group also increased slightly in both men and women (Supplementary Fig. 2).

Change in the characteristics in young-onset diabetes

We defined a diagnosis of diabetes at the age of 20 to 40 years as young-onset. In young-onset diabetes in 2015, the proportion of men increased compared with 2006, but not significant ($P>0.05$). During the same time, when classified by household income levels, the proportion of the high-income group decreased from 32.1% to 26.4%, while the proportion of the middle-income group increased from 46.0% to 51.8% ($P=0.06$). The proportion of type 2 diabetes mellitus (T2DM) in young-onset diabetes increased significantly from 93.3% to 97.2% ($P=0.02$). The proportion of obesity in young-onset diabetes increased remarkably, from 51.4% in 2006 to 72.4% in 2015 ($P<0.001$). In particular, young-onset diabetes with BMI ≥30.0 kg/m² increased dramatically during the same period (Fig. 2).

DISCUSSION

From 2006 to 2015, the overall incidence of diagnosed diabetes in South Korea decreased. This decline in incidence is consistent with a previous study using the entire South Korean NHIS database between 2004 and 2012. Over this period, the num-

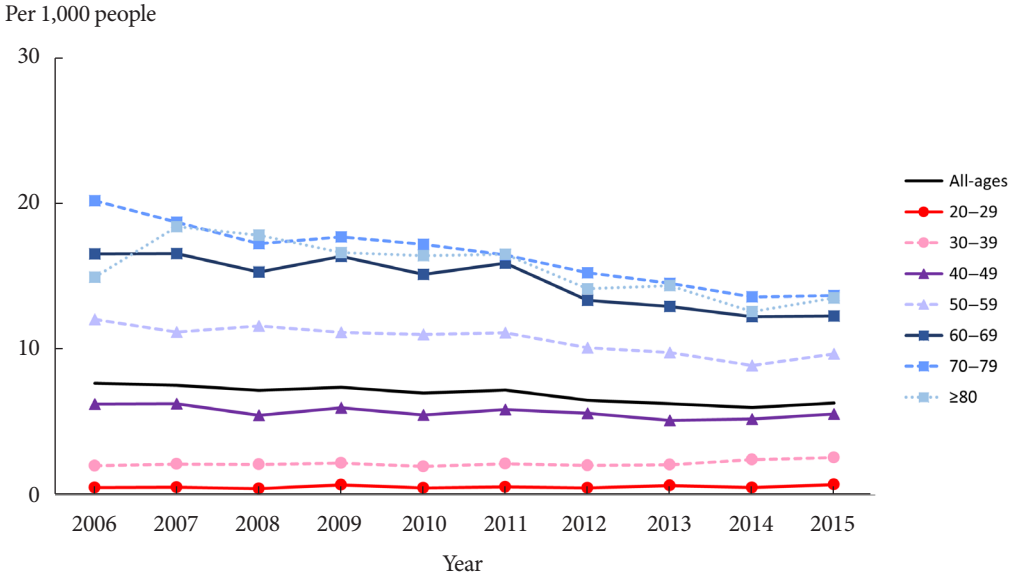

Fig. 1. Incidence rate of diagnosed diabetes by age group.

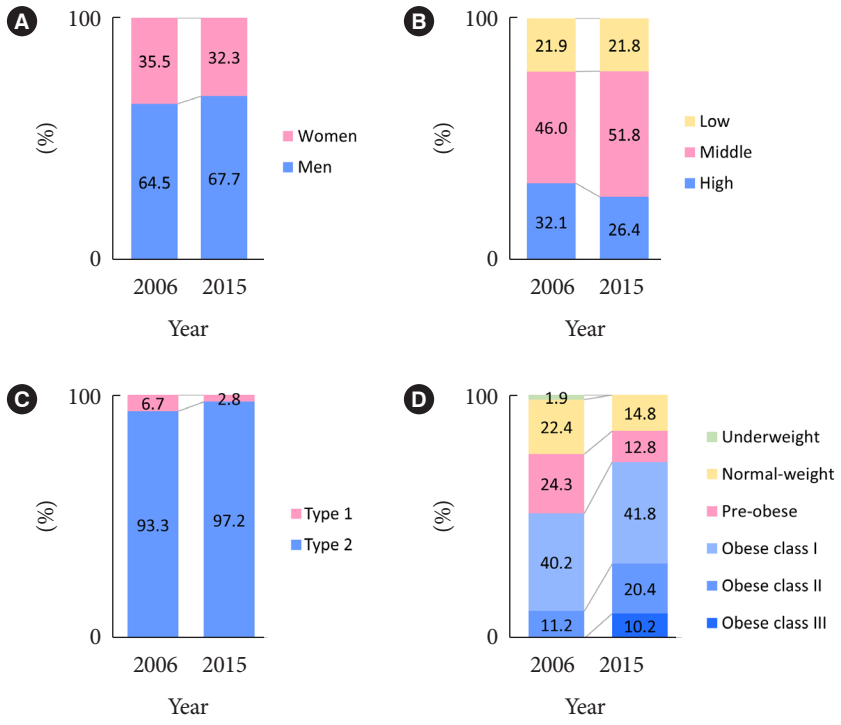

Fig. 2. Change in the characteristics of young-onset diabetes. (A) Sex, (B) household income, (C) type of diabetes, and (D) body mass index.

ber and proportion of cases of diagnosed diabetes (ICD-10 codes, E10–E14) decreased from 562,440 (1.2%) to 423,935 (0.8%) [6]. A recent study of 21 countries, including South Korea, also reported that the incidence of diagnosed diabetes was stable or had declined in mainly high-income countries [7]. By contrast, Lin et al. [8] reported that the incidence rate increased from 1990 to 2017 using the Global Burden of Disease Study 2017. The increase in incidence rate was higher in low-income countries. However, the Global Burden of Disease Study 2017 had selection bias by relying heavily on clinical data, given the lack of other sources such as representative studies and uncertainty arising from the widely varied data sources and assumptions.

Over the past 10 years, the obesity prevalence in South Korea have increased, while we have observed a decline in the incidence rate of diagnosed diabetes [9]. Diabetes incidence may be reduced by active efforts to prevent diabetes in the prediabetes or individuals at high-risk for diabetes. Also, it is possible that changes in other diabetes risk factors, including increased physical activity, reduced energy intake and change to healthy food, smoking cessation and reduced alcohol intake are contributing to the decline of diabetes incidence.

Although we have observed a decline in the incidence rate of diagnosed diabetes in individuals aged 40 years or over, the rate increased slightly in individuals aged 20 to 39 years. We found an increasing proportion of diagnosed diabetes in individuals aged 20 to 39 years. The increasing incidence estimates in young adults is consistent with that in other economically developed regions, such as the United States and Hong Kong [10,11].

In South Korea, the prevalence of obesity increased from 2009 to 2018, especially in individuals aged 20 to 39 years. In this group, severe obesity (BMI ≥30.0 kg/m^2) became much more prevalent unlike other age groups [9]. We found that >70% of people diagnosed with diabetes in the age group of 20 to 40 years were obese. We also observed an increasing proportion of obesity in young-onset diabetes, with steep increases in obese classes II (BMI 30.0 to 34.9 kg/m^2) and III (BMI ≥35.0 kg/m^2). The increase in severe obesity in young adults seems to be causing an increase in diabetes incidence because there is a relatively lack of awareness that obesity increase the risk of diabetes. We also reported that young adults with T2DM had the greatest BMI and the insulin secretion defects associated with severe insulin resistance using clinical data from 83 primary

care clinics and hospitals [12]. We suggested that in early-onset diabetes, clinic-based recruitment is limited to individuals with severe symptoms because young adults may not be aware of diabetes until symptoms appear [13]. Severe obesity in young adults in the current study may also be a characteristic of diagnosed diabetes. However, using the Korea National Health and Nutrition Examination Survey (KNHANES), we found similar trends of steep increase in severe obesity (mean BMI; from 24.9 in 2005 to 29.7 kg/m^2 in 2016–2018) in young adults with diabetes (Supplementary Fig. 3). In the United States, Hillier and Pedula [14] found a striking inverse linear relation between BMI and age at diagnosis of T2DM among adults using the Kaiser Permanente Northwest Division Diabetes Registry. Using the KNHANES 2013, our findings were similar [3]. Thus, obesity may be a powerful factor contributing to the development of diabetes in young adults, although it is unlikely to be causal.

During the same period, diabetes prevalence has increased in all age groups (Supplementary Tables 2, 3 and Supplementary Fig. 4). However, in particular, the incidence of diabetes continues to decline in the age group over 60 years. Globally, especially in high-income countries, the prevalence and incidence of diabetes are changing in the opposite direction [7]. The increase of prevalence rate may be due to a decrease in mortality in the elderly. We have shown that mortality is decreasing in people with diabetes in the period 2007 to 2015 [15]. Another explanation is that national and individual activities including education and campaigns to prevent diabetes for people at high-risk of diabetes might have led to decrease of diabetes incidence [16,17].

Because the definition of diabetes considered the ICD-based diagnosis and drug prescription simultaneously, people who do not take medication excluded. The incidence of diabetes may have been underestimated because the overall diabetes awareness rate was 65% in South Korea, and it is relatively lower in young adult population [18]. However, the definition may provide a reliable estimate as approximately 90% of adults with diagnosed diabetes were being treated with glucose-lowering drugs [18].

In South Korea, although the overall diagnosed diabetes incidence rate is decreasing, the incidence in young adults is increasing. The proportion of obesity in young-onset diabetes has also increased dramatically. The onset of diabetes at a younger age increases the risk for diabetes complications due to longer lifetime exposure to hyperglycemia. Thus, young adults need early identification and weight-control strategies to prevent diabetes.

SUPPLEMENTARY MATERIALS

Supplementary materials related to this article can be found online at https://doi.org/10.4093/dmj.2021.0236.

CONFLICTS OF INTEREST

Dae Jung Kim was editorial board member of the *Diabetes & Metabolism Journal* from 2020 to 2021. He was not involved in the review process of this article. Otherwise, there was no conflict of interest.

AUTHOR CONTRIBUTIONS

Conception or design: K.H.H., D.J.K.
Acquisition, analysis, or interpretation of data: H.H.C., G.C., H.Y., K.H.H., D.J.K.
Drafting the work or revising: H.H.C., K.H.H., D.J.K.
Final approval of the manuscript: K.H.H., D.J.K.

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