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ORIGINAL ARTICLE

An assessment of the impact of type 2 diabetes on the quality of life based on age at diabetes diagnosis

Jin Ook Chung · Dong Hyeok Cho · Dong Jin Chung · Min Young Chung

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Abstract
Aims This study aimed to determine whether Korean adults diagnosed with type 2 diabetes before the age of 40 have a different perception of the impact of diabetes on their quality of life (QoL) compared with that of patients diagnosed at an older age.
Methods A total of 236 patients were investigated in this cross-sectional study. The patients were classified into two groups based on their age at diagnosis: early type 2 diabetes (age at diagnosis <40 years) and typical type 2 diabetes (age at diagnosis ≥40 years). The QoL was assessed using the latest version of the audit of diabetes-dependent quality of life (ADDQoL).
Results The average weighted impact (AWI) of diabetes on QoL was significantly lower in adults with early type 2 diabetes than those diagnosed later. Patients with early type 2 diabetes reported a greater negative impact of diabetes on specific life domains "close personal relationship," "sex life," "self-confidence," "motivation to achieve things," "feelings about the future," "freedom to eat," and "freedom to drink" than patients with typical type 2 diabetes. In multivariate analysis adjusted for demographic and medical variables, a diagnosis of diabetes before the age of 40 was significantly associated with a lower ADDQoL AWI score [OR 3.60 (95 % CI: 1.12–11.55), $P < 0.05$].
Conclusions Younger age at type 2 diabetes diagnosis is significantly associated with a poor diabetes-related QoL.

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J. O. Chung · D. H. Cho · D. J. Chung · M. Y. Chung (✉)
Division of Endocrinology and Metabolism, Department of Internal Medicine, Chonnam National University Medical School, 8 Hak-Dong, Dong-Gu, Gwangju 501-757, Republic of Korea
e-mail: mychung@chonnam.ac.kr

Keywords Aging · Quality of life · Type 2 diabetes mellitus

Introduction

Diabetes mellitus is a chronic metabolic disorder that influences a patient's quality of life (QoL) as well as health [1]. Although efforts are made to improve a patient's physical health, including glycemic control and diabetic complications, these approaches may be inadequate in managing the full burden of diabetes [1, 2]. Patients with diabetes might exhibit a diminished QoL [1]. The QoL of patients with diabetes is recognized as an important health outcome; therefore, it is important to identify diabetes patients with high risk for lower diabetes-related QoL and improve QoL in such patients. Various methods have been used to assess the diabetes-related QoL in patients with type 2 diabetes. While generic health status and health-related QoL measures have been widely, they cannot determine the impact of diabetes on QoL, which requires the respondent to attribute a QoL rating to their diabetes and its management. Thus, diabetes-specific QoL measures are preferable [1]. Among the diabetes-specific QoL methods available, the audit of diabetes-dependent quality of life (ADDQoL) is a widely used measure of diabetes-specific QoL that evaluates the patient's perspective of the impact of diabetes on their QoL [3].

Type 2 diabetes is an epidemic, and the burden of diabetes is significant [4]. While type 2 diabetes is more prevalent in older adults, there is mounting evidence that onset of type 2 diabetes is increasing in younger adults [5, 6]. However, despite this change in demographics, little is known about the diabetes-related QoL in patients who are younger at type 2 diabetes onset, although younger adults

with type 2 diabetes have been recently reported to have impaired emotional well-being and physical health [7].

The objective of this study was to determine whether Korean adults diagnosed with type 2 diabetes before 40 years of age have a different perception of their diabetes-related QoL compared with patients diagnosed at an older age.

Patients and methods

Subjects

This cross-sectional study was conducted from January 2013 to December 2013. A total of 240 patients with type 2 diabetes (>20 years of age) were randomly selected from patients who visited the diabetes clinic in our hospital. The patient sample size was calculated on the basis that 5–10 patients per criterion were required for a psychometric assessment [8]. For the 19-item ADDQoL, a sample of at least 95–190 patients would be required. A diagnosis of type 2 diabetes mellitus was made based on the following criteria from the "Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus" [9]: fasting plasma glucose ≥7.0 mmol/l, 2-h plasma glucose ≥11.1 mmol/l during a 75-g oral glucose tolerance test, or patients taking medication to treat diabetes. To minimize the inclusion of individuals with type 1 diabetes mellitus in the study, patients with a history of diabetic ketoacidosis or fasting serum C-peptide <0.33 mmol/l were excluded [10], and patients diagnosed with diabetes before the age of 20 were excluded. Patients presenting with any of the following characteristics were also excluded: positive glutamic acid decarboxylase (GAD) autoantibodies, glucocorticoid use, active liver disease, renal insufficiency (serum creatinine ≥133 μmol/l), malignancy, an acute coronary or cerebrovascular event, and a cognitive or physical condition that would preclude participation.

Patient history was taken, and a physical examination, which included measurements of blood pressure, height, and body weight, was conducted. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m^2). Hypertension was diagnosed if the patient had blood pressure ≥140/90 mmHg or if antihypertensive drugs were administered. Educational background, marital status, occupation, duration of diabetes, cigarette smoking, familial history of diabetes in their first-degree relatives, and treatment mode were evaluated. The insulin-use group included patients treated with a combination of insulin and oral hypoglycemic agents, as well as those treated only with insulin. The level of exercise was characterized as follows: no exercise, ≤2 days per week of physical activity lasting at least 30 min per day, and ≥3 days per week of physical activity lasting at least 30 min per day.

The study subjects consisted of two groups based on the age at diabetes diagnosis: early type 2 diabetes (age at diagnosis <40 years) and typical type 2 diabetes (age at diagnosis ≥40 years) randomly selected and matched by sex. This dichotomization was based on the previous findings of differential impacts of diabetes on health status by age in this range [11–14]. In exploratory analyses, we also treated age at diabetes diagnosis as a continuous variable. The study was approved by the local ethics committee. All participants gave informed consent.

Measurements

Symptoms of depression were investigated using the Beck Depression Inventory (BDI), which consists of 21 items related to cognitive and somatic symptoms [15]. Depression was defined as a BDI score ≥16. The overall BDI measure yielded good internal constancy (Cronbach's $\alpha = 0.92$).

The impact of diabetes on QoL was assessed using the ADDQoL questionnaire [3]. The latest version of the ADDQoL includes 19 life domains [16]. The two overview items assess the present global QoL (range +3 to −3) and the impact of diabetes on QoL (range −3 to +1). For both items, lower scores reflect poorer QoL. Respondents also rate the impact of diabetes (range −3 to +1) on 19 items and rate the importance (range 3–0) of each to their QoL. The 19 items are as follows: leisure activities, working life, local or long-distance journeys, holidays, physical health, family life, friendship and social life, close personal relationship, sex life, physical appearance, self-confidence, motivation to achieve things, people's reaction, feelings about the future, financial situation, living conditions, dependence on others, freedom to eat, and freedom to drink. The impact score is multiplied by the importance rating to yield a weighted impact score for each domain, resulting in score ranging from −9 to +3. The weighted impact scores for domains are divided by the number of applicable domains to produce an average weighted impact (AWI) score (range −9 to +3), where a more negative score indicates worse QoL and a more negative impact of diabetes on QoL. The overall reliability coefficient (Cronbach's α) of the ADDQoL survey was 0.96, indicating a very high level of internal consistency.

Glycated hemoglobin (HbA_{1c}) level was determined using ion exchange liquid chromatography with an HLC-723-GHbV apparatus (Tosoh, Tokyo, Japan). Serum C-peptide (Biosource Europe S.A., Nivelles, Belgium) level was measured using radioimmunoassay. Urinary albumin excretion was determined in random urine samples using urinary albumin: creatinine (Cr) ratio (UACR). Urinary

Table 1 Demographic and clinical characteristics of the study population

Variables	*N* (%)	AWI score	*P* value
Number (*n*)	236	−3.33 (2.13)	
Age at diagnosis (years)			
<40	116 (49.2)	−3.75 (2.15)	0.001
≥40	120 (50.8)	−2.93 (2.04)	
Gender			
Male	133 (56.4)	−3.35 (2.19)	0.857
Female	103 (43.6)	−3.32 (2.07)	
Current smoking			
Yes	49 (20.8)	−3.26 (2.20)	0.830
No	187 (79.2)	−3.35 (2.12)	
Education			
High school or more	159 (67.4)	−3.63 (2.28)	0.190
Middle school or less	77 (32.6)	−3.18 (1.92)	
Employment			
Full- or part-time	106 (44.9)	−3.78 (2.40)	0.773
None	130 (55.1)	−3.88 (2.10)	
Family history of diabetes			
Yes	127 (53.8)	−3.24 (2.13)	0.426
No	109 (46.2)	−3.44 (2.14)	
Marital status			
Married	184 (78.0)	−3.37 (2.13)	0.377
Unmarried and not living as married	52 (22.0)	−3.62 (2.16)	
Hypertension			
Yes	123 (52.1)	−3.21 (2.03)	0.357
No	113 (47.9)	−3.47 (2.16)	
Diabetes duration (years)			
≥5	135 (57.2)	−3.60 (2.09)	0.015
<5	101 (42.8)	−2.98 (2.15)	
BMI (kg/m^2)			
≥25	83 (35.2)	−3.03 (2.05)	0.146
<25	153 (64.8)	−3.51 (2.17)	
Exercise			
None	68 (28.8)	−3.42 (1.98)	0.501
≤2 per week	45 (19.1)	−3.60 (2.58)	
≥3 per week	123 (52.1)	−3.20 (2.07)	
HbA_{1c} (%)			
≥8	138 (58.5)	−3.64 (2.18)	0.009
<8	98 (41.5)	−2.91 (2.01)	
Treatment			
Insulin use	65 (27.5)	−3.87 (2.08)	0.010
Noninsulin use	171 (72.5)	−3.16 (2.13)	
Microvascular complications			
None	104 (44.1)	−2.94 (1.86)	0.015
One	74 (31.4)	−3.60 (2.32)	
Two or more	58 (24.6)	−3.99 (1.97)	
BDI ≥ 16			
Yes	76 (32.2)	−4.05 (1.97)	<0.001
No	160 (67.8)	−3.01 (2.13)	

Reported values are mean values (standard deviation). The numbers in parentheses are the percentage

AWI score average weighted impact score, *BMI* body mass index, *HbA_{1c}* glycated hemoglobin, *BDI* Beck Depression Inventory

Table 2 Demographic and clinical characteristics of the study population according to the age at which type 2 diabetes was diagnosed

Variables	Early type 2 diabetes ($n = 116$)	Typical type 2 diabetes ($n = 120$)	P value
Current age (years)	46.3 (11.9)	63.3 (10.4)	<0.001
Men, *n* (%)	66 (56.9)	67 (55.8)	0.973
Current smoking, *n* (%)	28 (24.1)	21 (17.5)	0.273
Education, *n* (%)			
High school or more	79 (68.1)	80 (66.7)	0.923
Middle school or less	37 (31.9)	40 (33.3)	
Employment, *n* (%)			
Full- or part-time	66 (56.9)	40 (33.3)	<0.001
None	50 (43.1)	80 (66.7)	
Family history of diabetes, *n* (%)	65 (56.0)	62 (51.7)	0.588
Marital status, *n* (%)			
Married	80 (69.0)	104 (86.7)	0.002
Unmarried and not living as married	36 (31.0)	16 (13.3)	
Hypertension, *n* (%)	51 (44.0)	72 (60.0)	0.020
Diabetes duration (years), *n* (%)			
≥5	74 (63.8)	61 (50.8)	0.060
<5	42 (36.2)	59 (49.2)	
BMI (kg/m^2), *n* (%)			
≥25	44 (37.9)	39 (32.5)	0.461
<25	72 (62.1)	81 (67.5)	
Exercise, *n* (%)			
None	32 (27.6)	36 (30.0)	0.147
≤ 2 per week	28 (24.1)	17 (14.2)	
≥ 3 per week	56 (48.3)	67 (55.8)	
HbA_{1c}, *n* (%)			
≥8	81 (69.8)	57 (47.5)	0.001
<8	35 (30.2)	63 (52.5)	
Fasting C-peptide (mmol/l)	0.83 (0.63)	0.83 (0.64)	0.889
Treatment, *n* (%)			
Insulin use	44 (37.9)	21 (17.5)	0.001
Noninsulin use	72 (62.1)	99 (82.5)	
Microvascular complications, *n* (%)			
None	58 (50.0)	46 (38.3)	0.090
One	29 (25.0)	45 (37.5)	
Two or more	29 (25.0)	29 (24.2)	
BDI ≥ 16, *n* (%)	40 (35.1)	36 (30.0)	0.490
Score on the overview items			
Present global QoL	0.13 (1.40)	0.28 (1.22)	0.091
Impact of diabetes on QoL	−1.89 (1.04)	−1.64 (0.99)	0.029
AWI score	−3.75 (2.15)	−2.93 (2.04)	0.001

Reported values are mean values (standard deviation). The numbers in parentheses are the percentage

AWI score average weighted impact score, *BMI* body mass index, *HbA_{1c}* glycated hemoglobin, *BDI* Beck Depression Inventory

albumin concentration was measured using an immunoturbidimetric commercial kit (Randox, Antrim, UK). The estimated glomerular filtration rate (eGFR) was calculated using the equation reported in the Modification of Diet in Renal Disease study (MDRD) [17]. Nephropathy was defined as UACR ≥ 300 mg/gCr or eGFR < 60 ml/min per 1.73 m^2. To evaluate retinopathy, an ophthalmologist performed fundoscopy following pupil dilation. Peripheral neuropathy was scored using a clinical examination (Achilles tendon reflexes, sensory perception by a 10-g Semmes–Weinstein monofilament, and vibration sensation by a 128-Hz vibration fork at the hallux) and a neuropathy symptom score. Scores from the clinical examination and neuropathy symptom assessment ranged from 0 to 10 and from 0 to 9, respectively. Peripheral neuropathy was defined as moderate signs (score ≥6) with or without symptoms, or mild signs (score 3–5) with moderate symptoms (score ≥5) [18]. Four subjects who could not perform complete evaluation for microvascular complications were excluded. A total of 236 patients were analyzed.

Statistical analyses

Data were expressed as mean (standard deviation) or frequency distribution, unless otherwise stated. For statistical analysis, the Chi-square test was used for categorical variables, while the Mann–Whitney *U* test was used for continuous variables. The relationships between ADDQoL AWI score and age at diabetes diagnosis or other variables were examined by Spearman's rank correlation analyses. Variables with skewed distributions were log-transformed before analysis. Multiple linear regression models were used to determine the association between ADDQoL AWI score and age at diabetes diagnosis. The odds ratio (OR) for an ADDQoL score in the lower quartile of the distribution was estimated using multivariate logistic regression with adjustment of identified independent variables and factors previously reported to have independent associations. Age at the time of the study was not directly included in the same model as it is a function of age at diagnosis and duration of diabetes [19]. A test of interaction was conducted between age <40 years at diagnosis and other covariates using the multivariable model. There was no significant interaction between age <40 years at diagnosis and any of the covariates (P for interaction >0.05). Statistical analysis was performed using SPSS version 17.0 software (SPSS, Chicago, IL USA). A P value <0.05 was considered statistically significant.

Results

The clinical characteristics of the study subjects are summarized in Table 1. The mean age of the subjects was 55.3

Table 3 Audit of diabetes-dependent quality of life (ADDQoL) weighted impact score of each life domain according to the age at which type 2 diabetes was diagnosed

Domain	Weighted impact score		*P* value
	Early type 2 diabetes ($n = 116$)	Typical type 2 diabetes ($n = 120$)	
Leisure activities	−3.36 (3.06)	−2.71 (2.68)	0.229
Working life	−3.84 (3.14)	−3.18 (2.73)	0.239
Local or long-distance journey	−2.93 (3.01)	−2.63 (2.46)	0.900
Holidays	−3.02 (2.74)	−2.49 (2.30)	0.335
Physical health	−3.10 (3.15)	−2.82 (2.68)	0.780
Family life	−4.14 (3.14)	−3.42 (2.89)	0.126
Friendship and social life	−3.17 (2.90)	−3.20 (2.67)	0.756
Close personal relationship	−4.15 (3.20)	−2.93 (2.80)	0.015
Sex life	−3.54 (2.98)	−2.08 (2.50)	0.004
Physical appearance	−3.10 (2.79)	−2.58 (2.52)	0.226
Self-confidence	−4.64 (3.04)	−3.44 (2.77)	0.008
Motivation to achieve things	−4.66 (3.01)	−3.36 (2.81)	0.003
People's reaction	−2.23 (2.60)	−2.22 (2.50)	0.834
Feelings about the future	−4.12 (2.80)	−3.29 (2.58)	0.020
Financial situation	−3.27 (3.02)	−2.56 (2.73)	0.132
Living conditions	−3.49 (2.81)	−2.82 (2.62)	0.150
Dependence on others	−2.58 (2.89)	−1.99 (2.54)	0.278
Freedom to eat	−5.33 (3.05)	−4.07 (2.82)	0.014
Freedom to drink	−5.22 (3.31)	−3.81 (3.10)	0.013

Reported values are mean values (standard deviation)

(14.0) years. Diabetes duration and the HbA_{1c} levels were 10.3 (9.3) years and 9.0 (2.4) %, respectively. The mean weighted impact ADDQoL score was −3.33, indicating an overall negative impact of diabetes on QoL (Table 1). The AWI of diabetes on QoL was significantly lower in the patients on insulin, those with longer durations of diabetes, those with higher HbA_{1c} levels, those with one or more diabetes-related complications, and those with depressive symptoms.

The patients with early type 2 diabetes had significantly poorer scores on the overall item about the impact of diabetes on QoL (Table 2). In addition, the AWI of diabetes on QoL was significantly lower in patients with early type 2 diabetes compared with those diagnosed at an older age. The patients with early type 2 diabetes were more likely to be younger at the time of the study, employed, and unmarried or not living as married compared with those diagnosed at an older age. The patients with early type 2 diabetes presented with a lower prevalence of hypertension, higher prevalence of insulin use, and higher HbA_{1c} compared to those in patients with typical type 2 diabetes.

In the early type 2 diabetes group, the most negative impacts of diabetes were observed for the items "freedom to eat" (mean = −5.33) and "freedom to drink" (mean = −5.22), while the least negative weighted impacts were reported for "people's reaction" (mean = −2.23) and "dependence on others" (mean = −2.58; Table 3). In patients with typical type 2 diabetes, the most negatively impacted ADDQoL item was "freedom to eat" (mean = −4.07), while the least negative impacts of diabetes were observed for the domains "dependence on others" (mean = −1.99) and "sex life" (mean = −2.08). Patients with early type 2 diabetes reported a greater negative impact of diabetes on their QoL with specific reference to "close personal relationship," "sex life," "self-confidence," "motivation to achieve things," "feelings about the future," "freedom to eat," and "freedom to drink" than those with typical type 2 diabetes.

Logistic regression analysis was performed for the ADDQoL score in the lower quartile according to age at diagnosis (Table 4). After adjustments for sex, BMI, hypertension, family history of diabetes, employment, education, marital status, symptoms of depression, HbA_{1c}, diabetes duration, insulin use, and chronic complications, being diagnosed with type 2 diabetes before the age of 40 was significantly associated with a lower ADDQoL score [OR 3.60 (95 % CI: 1.12–11.55), $P < 0.05$].

We next conducted analyses treating age as a continuous variable. A positive correlation was found between age at diabetes diagnosis and ADDQoL AWI score ($\rho = 0.255$, $P < 0.001$). ADDQoL AWI score was also inversely associated with diabetes duration ($\rho = -0.130$, $P = 0.046$), HbA_{1c} ($\rho = -0.233$, $P < 0.001$), number of chronic complications ($\rho = -0.209$, $P = 0.013$), insulin use ($\rho = -0.170$, $P = 0.009$), and BDI score ($\rho = -0.289$, $P < 0.001$). In a multivariable linear regression analysis adjusted for sex, BMI, hypertension, family history of diabetes, employment, education, marital status, symptoms of depression, HbA_{1c}, diabetes duration, insulin use, and chronic complications, age at diabetes diagnosis was significantly associated with ADDQoL AWI score ($\beta = 0.152$, $P = 0.024$).

Discussion

In this study, being younger at diabetes diagnosis was associated with a more negative impact on QoL related to

Table 4 Odds ratio (OR) of age at diagnosis (<40 years) for the ADDQoL score in the lower quartile in patients with type 2 diabetes

	Model 1	Model 2	Model 3
Age at diagnosis (years)			
<40	2.80 (1.50–5.21)†	3.58 (1.47–8.69)†	3.60 (1.12–11.55)*
≥40 (referent)	1.0 (–)	1.0 (–)	1.0 (–)

Model 1: unadjusted

Model 2: adjusted by gender (0: female, 1: male), BMI (0: <25 kg/m^2, 1: ≥25 kg/m^2), hypertension (0: no, 1: yes), family history of diabetes (0: no, 1: yes), employment (0: none, 1: full- or part-time), education (0: middle school or less, 1: high school or more), marital status (0: unmarried and not living as married, 1: married), and depression (0: BDI < 16, 1: BDI ≥ 16)

Model 3: adjusted by model 2 plus HbA_{1c} (0: <8 %, 1: ≥8 %), diabetes duration (0: <5 years, 1: ≥5 years), microvascular complication (0: no, 1: one or more), and insulin use (0: noninsulin use, 1: insulin use)

Values are shown as OR (95 % CI).* $P < 0.05$, † $P < 0.01$

diabetes than being older at diagnosis in Korean patients with type 2 diabetes. Furthermore, being younger when diagnosed with diabetes was independently associated with a poor diabetes-related QoL after adjustment for demographic and medical variables. Patients with early type 2 diabetes reported a greater negative impact of diabetes on their QoL with particular reference to the effects on close personal relationship, sex life, self-confidence, motivation to achieve things, feelings about the future, freedom to eat, and freedom to drink compared to that in those diagnosed with diabetes at an older age.

Previous studies have focused on differences in clinical characteristics between early onset type 2 diabetes and usual or elderly onset type 2 diabetes, although the cutoff value for age at diagnosis differs from study to study [11, 13, 19, 20]. Several studies reported that patients diagnosed with type 2 diabetes at younger age have poorer glycemic control during their management of diabetes compared with those diagnosed at an older age [11, 13, 19, 21]. Patients diagnosed with type 2 diabetes at younger age might be more likely to begin insulin therapy than those diagnosed at an older age [13]. In addition, several studies have reported that patients with early onset type 2 diabetes may have a different disease course compared to that in those with onset at an older age [21, 22]. However, it has not been fully understood how the perceived diabetes-related QoL assessed by diabetes-specific measures may differ according to age at diagnosis in patients with type 2 diabetes. The mean weighted impact ADDQoL score calculated from the scores of all the patients in this study indicated an overall negative impact of diabetes on patient QoL, consistent with previous studies [2, 23, 24]. In addition, the AWI of diabetes on QoL was significantly lower in patients diagnosed with type 2 diabetes at a younger age than in those diagnosed at an older age. This suggests that a younger age at diabetes diagnosis might be a strong factor driving poor diabetes-related QoL.

The ADDQoL is an individualized questionnaire that permits respondents to evaluate the impact of diabetes on the factors they are concerned about and assess the relative importance of these factors relating to their QoL [3]. In the present study, we found that patients diagnosed with type 2 diabetes at a younger age were significantly more likely to report a greater negative impact of diabetes on their QoL for seven items compared with patients with typical type 2 diabetes: close personal relationship, sex life, self-confidence, motivation to achieve things, feelings about the future, freedom to eat, and freedom to drink. Thus, our findings suggest that patients diagnosed with diabetes at a younger age might be more affected by problems relating to these factors compared with typical type 2 diabetes. Furthermore, in the present study, "freedom to eat" and "freedom to drink" were the most negatively impacted factors in patients with early type 2 diabetes. These findings might suggest that dietary restrictions strongly influence diabetes-related QoL [2, 23], and patients with early type 2 diabetes might be particularly affected by the need for dietary restrictions beginning at a younger age. Therefore, an intervention to improve dietary flexibility might be an effective way of improving QoL in this group [2]. And this has been demonstrated in several studies [25, 26].

Many factors have been reported to impact QoL in patients with type 2 diabetes. Depression is a frequent comorbidity in patients with type 2 diabetes. Depression in patients with diabetes may contribute to poor adherence to diet, exercise, and medications. Previous studies have demonstrated that symptoms of depression are related to poor QoL in patients with type 2 diabetes [27, 28], although there are conflicting data regarding relationships between depressive symptoms and insulin use in patients with type 2 diabetes [29, 30]. Several studies have reported the inverse relationship between glycemic control and the QoL assessed by generic or diabetes-specific measures [27, 31]. In addition, insulin therapy may affect the QoL in patients with diabetes. Sundaram et al. [27] reported a greater negative impact of diabetes on the QoL in insulin-treated patients. Collins et al. [23] showed an inverse

relationship between insulin use and higher ADDQoL scores adjusted for age and gender, although there was no longer a significant association after further adjustment for other covariates, including education, marital status, diabetes complications, and diabetes care models. Previous studies have also suggested the close relationships between QoL and diabetic chronic complications [32–34]. In addition, marital status and diabetes duration might be related to QoL [35, 36]. In the present study, the diabetes-related QoL was significantly lower in the patients on insulin, those with longer durations of diabetes, those with higher HbA_{1c} levels, those with diabetes-related complications, and those with depressive symptoms, consistent with the findings of previous studies [23, 27, 31–35]. In addition, the patients diagnosed with diabetes at a younger age were associated with poorer glycemic levels as reflected by their HbA_{1c} levels and a higher prevalence of insulin use compared with those with typical type 2 diabetes. These patients also tended to be more unmarried or not living as married. Thus, this different distribution between the two groups might contribute, in part, to different perceptions regarding diabetes-related QoL because these factors are also associated with worse QoL in patients with diabetes. However, results from multivariate analysis showed that being diagnosed with type 2 diabetes at a younger age was strongly associated with a lower ADDQoL score, even after adjusting for factors such as gender, BMI, hypertension, HbA_{1c}, diabetes duration, family history of diabetes, insulin use, chronic complications, depression, employment, education, and marital status [OR 3.60 (95 % CI: 1.12–11.55), $P < 0.05$]. This indicates that these factors did not significantly influence the relationship between age at diabetes diagnosis and QoL.

This study has some limitations. First, as our study was conducted in a single center and the subjects were confined to one ethnic group, the results might not be representative of people with diabetes around the world. Second, as this study was a cross-sectional one, the causative natures of the associations cannot be established. Finally, fasting C-peptide levels were measured in addition to medical history to exclude severe insulin deficiency, although serum C-peptide levels are widely used as an indirect measure of β-cell function in practice [37]. Despite these limitations, the present findings might provide important information regarding the relationship between age at diabetes diagnosis and QoL.

In conclusion, our results show that patients diagnosed with type 2 diabetes at a younger age report a greater negative impact of diabetes on their QoL compared with patients diagnosed at an older age. These findings suggest that patients diagnosed with type 2 diabetes at a younger age need more support to help them cope with diabetes. Further longitudinal studies of these associations are necessary.

Conflict of interest Jin Ook Chung, Dong Hyeok Cho, Dong Jin Chung, and Min Young Chung declare they have no conflict of interest.

Ethical standard All the authors declare that there is no ethical problem associated with this manuscript.

Human and Animal Rights disclosure All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Declaration of Helsinki of 1975, as revised in 2008.

Informed consent disclosure Informed consent was obtained from all patients for being included in the study.

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