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# Factors influencing quality of life in adolescents with type 1 diabetes mellitus: A cross-sectional study in South Korea

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## Abstract

**Background:** The promotion of quality of life for adolescents with type 1 diabetes mellitus enables them to achieve physical, psychological, and social development. Improving quality of life positively influences their well-being in adulthood.

**Objective:** This study aimed to identify the factors influencing quality of life in adolescents with type 1 diabetes mellitus.

**Methods:** Data were collected from April 2022 to February 2023. The quality of life of 146 adolescents with type 1 diabetes mellitus was analyzed. The data were analyzed using IBM SPSS Statistics 25.0, with *t*-tests, ANOVA, Pearson's correlation, and stepwise multiple regression.

**Results:** The quality of life of adolescents with type 1 diabetes was significantly correlated with depression ($r$ = -0.31, $p$ <0.001) and diabetes distress ($r$ = -0.42, $p$ <0.001). Stepwise multiple regression analysis identified diabetes distress ($\beta$ = -0.38, $p$ <0.001) and insulin treatment ($\beta$ = 0.15, $p$ = 0.048) as factors influencing quality of life.

**Conclusion:** Periodic education and nursing interventions to improve self-care capacity for adolescents with type 1 diabetes mellitus are essential for reducing diabetes distress. Additionally, it is important to promote the use of insulin pump at the national level, include expanding insurance coverage and offering personalized insulin pump education.

## Keywords

diabetes mellitus, type 1; adolescent; quality of life; psychological distress; insulin infusion system

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## Background

The prevalence of diabetes mellitus (DM) is rapidly increasing worldwide. In Korea, it rose from 10.1% (approximately 3.2 million people) in 2012 (Korean Diabetes Association, 2023) to 13.8% (approximately 5.3 million people) in 2022 (Korean Diabetes Association, 2024). Additionally, the prevalence of type 1 diabetes mellitus (T1DM) has also increased. The annual incidence of T1DM increased from 1.4 per 100,000 between 1995 and 2001 to 3.2 per 100,000 between 2012 and 2014. Age-specific prevalence shows an incidence of 1.7 per 100,000 among those aged 0–4 years, 3.2 among those aged 5–9 years, and 4.5 per 100,000 among those aged 10–14 years, with a higher prevalence in adolescents than in children (Korean Diabetes Association, 2023).

T1DM is a chronic disease with no known cure. If not managed, it can result in significant disturbances in carbohydrate, protein, and fat metabolism. To prevent this, lifelong self-care is necessary, including periodically monitoring blood glucose, insulin injections, diet therapy, and physical activity (Korean Diabetes Association, 2023). Adolescents diagnosed with chronic diseases such as T1DM often undergo substantial lifestyle changes. Managing T1DM is particularly challenging (Eddy & Cruz, 2007), and uncertainty surrounding the disease persists (Haase et al., 2014). They are exposed to various physical and psychological stressors. In severe cases, it can cause permanent physical disability and a fear of death (Kanner et al., 2003). Consequently, adolescents with chronic diseases exhibit lower self-esteem compared to the peers. They also experience more negative emotions (Bennett et al., 2015). Notably, a longitudinal study tracking 92 adolescents with T1DM over a decade revealed that 47.6% were diagnosed with depression or generalized anxiety disorder. Depression occurs at a significantly higher prevalence than other psychiatric disorders (Kovacs et al., 1997). Depression in patients with T1DM is related to quality of life (QOL) (Korean Diabetes Association, 2023).

Adolescents spend considerable time in school and cultivate relationships with peers outside of academic settings. For adolescents with chronic diseases like T1DM, restrictions on external activities may hinder social interactions, making it imperative to foster quality relationships within the school (Suk et al., 2004). However, adolescents with T1DM often encounter difficulties in establishing friendships due to diabetes distress (DD), leading to social withdrawal (Kim, 2014). Additionally, DD is negatively associated with QOL (Hoogendoorn et al., 2020).

The negative emotions experienced by adolescents with chronic diseases such as T1DM during the treatment process affect their QOL (Blaiss, 2008). QOL is based on subjective experience and awareness of daily life, as well as physical, social, and psychological well-being (Calvert & Freemantle, 2003). The overarching management goal for patients with chronic diseases extends beyond mere symptom alleviation; it aims to enhance QOL throughout the duration of the illness (Oh & Bang, 2007). Consequently, improving QOL is vital to health management (Eiser & Morse, 2001).

In recent years, advancements in medical technologies related to diabetes have progressed rapidly, leading to increased utilization rates. Among these technologies, insulin pump (continuous subcutaneous insulin infusion) have gained significant attention. Insulin pump deliver insulin subcutaneously in a manner that closely mimics physiological insulin secretion (Korean Diabetes Association, 2023). Initiating insulin pump therapy at the time of T1DM diagnosis has been shown to facilitate effective blood glucose management and reduce the incidence of acute complications, such as severe hypoglycemia and diabetic ketoacidosis (DKA) (American Diabetes Association, 2020; Korean Diabetes Association, 2023). Furthermore, insulin pump have a positive impact on the QOL not only for adolescents with T1DM but also for their families (Gu, 2020). Promoting QOL among adolescents with chronic diseases enables them to achieve physical, social, and psychological development. Moreover, enhancing QOL positively influences their well-being in adulthood (Sihn, 2012). However, a study indicates that the QOL of adolescents with chronic diseases is lower than that of their peers (Lee et al., 2013).

In South Korea, participants in studies on the QOL for chronic patients are primarily elderly (Kim & Lee, 2020; Sihn, 2012), and studies on the QOL for adolescents are limited to those with respiratory diseases (Oh & Bang, 2007) or cancer (Lee et al., 2013). There is a lack of study examining the QOL of South Korea adolescents with T1DM (Sohn et al., 2015).

Therefore, this study aimed to 1) examine the characteristics, depression, self-esteem, DD, and QOL; 2) compare QOL based on the general characteristics; 3) analyze the correlations for depression, self-esteem, DD, and QOL; and 4) identify the factors influencing the QOL in adolescents with T1DM.

# Methods

### Study Design

A descriptive study design was conducted aimed at identifying the factors influencing QOL in adolescents with T1DM.

### Sample/Participants

Participants in this study were adolescents diagnosed with T1DM by a pediatric endocrinologist. The specific inclusion criteria were as follows: 1) Adolescents aged 13 to 18 years; 2) Members of the Korean Insulin Dependent Diabetes Association; 3) Participants whose parents or legal guardians provided informed consent; 4) Individuals capable of reading, understanding, and responding to the questionnaire; 5) Individuals who understand the study's objectives and voluntarily agree to participate; and 6) Individuals without restrictions on internet access. The exclusion criteria for this study were as follows: 1) Individuals diagnosed with a psychiatric disorder; and 2) Those who have taken anti-anxiety medications, anticonvulsants, or sleep aids.

The sample size was determined using G*Power version 3.1.1.0. The significant level for the regression analysis was 0.05, with a power of 0.80, an effect size of 0.15, and 11 variables. The sample size was 123 participants. To account for a dropout rate of 20%, an online questionnaire was distributed to 148 individuals. However, two questionnaires with incomplete responses were excluded, resulting in a final analysis of 146 participants.

### Instruments

***General Characteristics:*** The general characteristics of the participants, including gender, age, height, weight, age at onset of T1DM, duration of T1DM, most recent glycosylated hemoglobin type A1C (HbA1c), blood glucose measurements, insulin treatment, hospitalization for T1DM in the past year, and experience of DKA, were collected. Body mass index (BMI) was calculated by dividing weight (in kg) by height (in m) squared. Percentiles were subsequently determined using the 2017 Growth Chart for Children and Adolescents, categorized as follows: underweight (<5th percentile), normal weight (5–84th percentile), overweight (85–94th percentile), and obesity (≥95th percentile) (Korea Centers for Disease Control and Prevention, 2018).

***Depression:*** The depression of the participants was assessed using the Beck Depression Inventory-II (BDI-II) (Beck et al., 1996). A fee was paid to the Korean Psychology Association (https://www.koreapsy.co.kr/) for permission to utilize. This scale comprises 21 items, with scores ranging from 0 to 3 assigned based on symptom severity: 0 point for mild symptoms and 3 points for severe symptoms. The total score can range from 0 to 63, with higher scores indicating greater depression. The Cronbach's α was 0.89 at the time of development (Beck et al., 1996), and was 0.91 in this study.

***Self-Esteem:*** The self-esteem of the participants was assessed using the Korean version (Jeon, 1974) of the Rosenberg Self-Esteem Scale (RESE) (Rosenberg, 1965). Rosenberg allowed it to be used without copyright. The Korean version of the tool is also freely available without copyright. This scale comprises 10 items and utilizes a four-point likert scale, with 'strongly disagree' assigned 1 point and 'strongly agree' assigned 4 point. The total score can range from 10 to 40, with higher scores indicating greater self-esteem. The Cronbach's α was 0.88 at the time of development (Rosenberg, 1965), and was 0.80 in this study.

***DD:*** DD of the participants was assessed using the Diabetes Distress Scale (DDS) developed by Polonsky et al. (2005). We obtained permission from the original author to use. This scale comprises 17 items: emotional burden (5 items), physician-related distress distress (4 items), regimen-related distress (5 items), interpersonal distress (3 items). It utilizes a six-point likert scale, with 'not a problem' assigned 1 point and 'a very serious problem' assigned 6 points. The total score can range from 17 to 102, with higher scores indicating greater DD. The Cronbach's α was 0.87 at the time of development (Polonsky et al., 2005) and was 0.90 in this study.

***QOL:*** The QOL was assessed using the PedsQL 3.2 diabetes module revised (Varni et al., 2013). Varni et al. (2013)

allowed it to be used without copyright. This scale comprises 33 items: diabetes symptoms (15 items), treatment barriers (5 items), treatment adherence (6 items), worry (3 items), and communication (4 items). It utilizes a five-point likert scale, with 'never' assigned 0 point and 'always' assigned 4 point. The items are reverse-scored and transformed to a scale from 0 to 100. The transformed scores are as follows: 0 corresponds to 100 points and 4 points correspond to 0 points. The total score is calculated by summing the transformed scores and dividing by the number of items summed. The total score can range from 0 to 100, with higher scores indicating greater QOL. The Cronbach's α was 0.87 at revision (Varni et al., 2013), and was 0.92 in this study.

### Data Collection

The data collection period was from April 20, 2022, to February 28, 2023. We recruited participants via a recruitment announcement on the Korean Insulin Dependent Diabetes Association's website. After explaining the study's objectives, participants provided online consent and completed questionnaire. Participants received an online gift certificate as compensation.

### Data Analysis

Data were analyzed with IBM SPSS Statistics 25.0 using the following methods: 1) Descriptive statistics (frequency, percentage, mean, standard deviation) for general characteristics, depression, self-esteem, DD, and QOL; 2) Independent *t*-test and ANOVA for QOL by general characteristics; 3) Pearson's correlation for depression, self-esteem, DD, and QOL; 4) Stepwise multiple regression to identify factors influencing QOL.

### Ethical Considerations

We conducted this study after obtaining approval from the Institutional Review Board of Dong-A University (2-1040709-AB-N-01-202203-HR-021-02). Before completing the questionnaire, participants signed an informed consent that detailed the objectives, procedures, and confidentiality. We informed participants that they could refuse to participate during the questionnaire. To protect participants' rights, the collected data were encrypted to ensure anonymity.

## Results

### General Characteristics of Participants

The participants comprised 50% females. The age was 15.8 (±1.9) years. According to BMI, 4.1% were underweight, 57.5% were normal weight, 15.1% were overweight, and 23.3% were obesity. The age at T1DM diagnosis was 7.8 (±4.1) years, and the duration of T1DM was 93.4 (±53.7) months. Of the participants, 26.0% used continuous glucose monitoring (CGM), and 7.5% used an insulin pump. And, 21.9% had been hospitalized due to T1DM in the past year, and 30.1% had experienced DKA (**Table 1**).

**Table 1** General characteristics of participants and QOL (*N* = 146)

| Variable | Categories | Total | QOL | | | | |
|---|---|---|---|---|---|---|---|
| | | | *n* (%) or M±SD | | | *t* or *F* | (*p*) |
| Gender | Male | 73 | (50.0) | 67.47 | ±17.28 | 1.78 | (0.077) |
| | Female | 73 | (50.0) | 61.61 | ±22.22 | | |
| Age (year) | Average | 15.8 | ±1.9 | | | | |
| | ≦15 | 62 | (42.5) | 65.08 | ±20.48 | 0.28 | (0.780) |
| | ≧16 | 84 | (57.5) | 64.14 | ±19.84 | | |
| BMI | Underweight | 6 | (4.1) | 72.22 | ±15.02 | 0.92 | (0.633) |
| | Normal weight | 84 | (57.5) | 66.22 | ±19.03 | | |
| | Overweight | 22 | (15.1) | 65.30 | ±17.10 | | |
| | Obesity | 34 | (23.3) | 58.54 | ±24.07 | | |
| Age at onset of T1DM (year) | Average | 7.8 | ±4.1 | | | | |
| | <8 | 67 | (45.9) | 65.46 | ±18.52 | 0.51 | (0.609) |
| | ≧8 | 79 | (54.1) | 63.75 | ±21.35 | | |
| Duration of T1DM (month) | Average | 93.4 | ±53.7 | | | | |
| | <60 | 42 | (28.8) | 63.25 | ±22.43 | -0.49 | (0.624) |
| | ≧60 | 104 | (71.2) | 65.06 | ±19.10 | | |
| HbA1c (%) | Average | 8.7 | ±1.7 | | | | |
| | <6.5 | 10 | (6.8) | 70.99 | ±16.79 | 1.06 | (0.293) |
| | ≧6.5 | 136 | (93.2) | 64.06 | ±20.24 | | |
| Blood glucose measurement | CGM | 38 | (26.0) | 66.24 | ±19.47 | 0.61 | (0.544) |
| | BGM | 108 | (74.0) | 63.94 | ±20.30 | | |
| Insulin treatment | Insulin pump | 11 | (7.5) | 65.54 | ±19.61 | -2.15 | (0.034) |
| | MDI | 135 | (92.5) | 52.21 | ±22.30 | | |
| Hospitalization for T1DM | Yes | 32 | (21.9) | 61.47 | ±22.46 | -0.98 | (0.329) |
| | No | 114 | (78.1) | 56.40 | ±19.34 | | |
| Experience of DKA | Yes | 44 | (30.1) | 63.89 | ±21.19 | -0.26 | (0.799) |
| | No | 102 | (69.9) | 64.82 | ±19.64 | | |

*Note:* BGM = Blood glucose meter; BMI = Body mass index; CGM = Continuous glucose monitoring; DKA = Diabetic ketoacidosis; HbA1c = glycosylated hemoglobin type A1C; MDI = Multiple-dose of insulin; M = Mean; SD = Standard deviation

### Depression, Self-Esteem, DD, and QOL

A depression score was 7.88 (±7.05), a self-esteem score was 23.69 (±6.30), a DD score was 33.56 (±11.09), and a QOL score was 64.54 (±20.05) (**Table 2**).

### QOL according to General Characteristics

The QOL showed significant differences based on insulin treatment ($t$ = -2.15, $p$ = 0.034). Insulin pump users had a higher QOL than multiple-dose insulin (MDI). Gender, age, BMI, age at onset of T1DM, duration of T1DM, HbA1c, blood glucose measurements, hospitalization for T1DM in the past year, and experience of DKA were not significantly correlated with QOL (**Table 1**).

### Correlations among Depression, Self-Esteem, DD, and QOL

QOL was significantly correlated with depression ($r$ = -0.31, $p$ <0.001) and DD ($r$ = -0.42, $p$ <0.001). DD was significantly correlated with depression ($r$ = 0.60, $p$ <0.001) and self-esteem ($r$ = -0.36, $p$ <0.001). Self-esteem was significantly correlated with depression ($r$ = -0.25, $p$ = 0.003). Adolescents with T1DM was higher QOL when depression and DD were lower (**Table 3**).

**Table 2** Depression, self-esteem, DD, and QOL of participants ($N$ = 146)

| Variables | Range of score | | M | ±SD |
|---|---|---|---|---|
| | Minimum | Maximum | | |
| Depression | 0.00 | 30.00 | 7.88 | ±7.05 |
| Self-esteem | 10.00 | 36.00 | 23.69 | ±6.30 |
| DD | 17.00 | 60.00 | 33.56 | ±11.09 |
| QOL | 11.36 | 95.45 | 64.54 | ±20.05 |

*Note:* DD = Diabetes distress; QOL = Quality of life; M = Mean; SD = Standard deviation

**Table 3** Correlation between depression, self-esteem, DD, and QOL of participants ($N$ = 146)

| Variables | Depression | Self-esteem | DD | QOL |
|---|---|---|---|---|
| | $r$ ($p$) | | | |
| Depression | 1 | | | |
| Self-esteem | -0.25 (0.003) | 1 | | |
| DD | 0.60 (<0.001) | -0.36 (<0.001) | 1 | |
| QOL | -0.31 (<0.001) | 0.08 (0.313) | -0.42 (<0.001) | 1 |

*Note:* DD = Diabetes distress; QOL = Quality of life

**Table 4** Factors influencing QOL of participants ($N$ = 146)

| Factors (ref) | $B$ | $SE$ | $\beta$ | $t$ | $p$ |
|---|---|---|---|---|---|
| (Constant) | 78.28 | 7.24 | | 10.81 | <0.001 |
| Insulin treatment (Insulin pump) | 11.49 | 5.77 | 0.15 | 1.99 | 0.048 |
| Depression | -0.16 | 0.27 | -0.06 | -0.58 | 0.561 |
| DD | -0.69 | 0.17 | -0.38 | -4.07 | <0.001 |
| $R^2$ = 0.20, $adj\ R^2$ = 0.19, $F$ = 12.13 ($p$ <0.001) | | | | | |

*Note:* DD = Diabetes distress; QOL = Quality of life

### Factors Influencing QOL of Participants

To identify the factors influencing QOL, insulin treatment, which showed significant differences, was included depression and DD. As a result, DD ($\beta$ = -0.38, $p$ <0.001) and insulin treatment ($\beta$ = 0.15, $p$ = 0.048) had significant effects on QOL. To verify the normality of the error terms, a probability-probability (P-P) plot was examined, confirming that the residuals followed a normal distribution, thereby satisfying the assumption of normality. Before conducting the regression analysis, multicollinearity among the independent variables was assessed. Tolerance values ranged from 0.62 to 0.97, indicating values above 0.1. The variance inflation factor (VIF) ranged from 1.04 to 1.61, remaining below 10, confirming the absence of multicollinearity issues among the independent variables. The Durbin-Watson statistic was 1.60, indicating a value close to 2, which satisfied the assumption of no correlation among the residuals. Therefore, as all fundamental assumptions of the regression model were met, the findings of this study can be considered reliable (**Table 4**).

## Discussion

The QOL is influenced by various factors. It is important to assess QOL to understand the issues faced by adolescents (Ozyazicioglu et al., 2017). Although study on the QOL of adolescents with T1DM is frequently conducted abroad (Barnard et al., 2008; Ozyazicioglu et al., 2017; Sabri et al., 2014), studies focusing on adolescents with T1DM in South Korea are rare. This study aimed to identify the factors influencing South Korean adolescents with T1DM, who live in environments with limited social awareness or support (Korean Diabetes Association, 2023).

In this study, the depression ranged from 0 to 30, with a score of 7.88 (±7.05). In a study by Wang et al. (2008) involving children, depression was also reported as 7.4 (±7.2). Depression in both children and adolescents with T1DM was similar and below 9 points, indicating a normal range (Beck et al., 1996). However, adolescents with T1DM experience negative emotions, such as depression, more frequently than their peers (Bennett et al., 2015). Moreover, these negative emotions increase the likelihood of treatment noncompliance and suicidal. Therefore, it is essential to assess their

depression through screening regularly and to develop and implement programs to reduce depression.

In this study, the self-esteem ranged from 10 to 36, with a score of 23.69 (±6.30). The self-esteem of adolescents with T1DM is lower than that of the peers and is negatively correlated with QOL (Sabri et al., 2014). Since self-esteem also influences metabolic control (Korean Diabetes Association, 2023), it requires careful management. The self-esteem is significantly affected by their expectations for the future (Kim & Kim, 2013). Therefore, rather than solely focusing on stress relief and confidence enhancement, it is essential to foster a positive self-image. Additionally, incorporating future planning and career-related content can help prepare them to become healthy members in community.

In this study, a correlation was found between self-esteem and QOL. Self-esteem is associated with an individual's internal beliefs (Jeon, 1974; Rosenberg, 1965), while QOL encompasses various aspects such as physical, social, and psychological well-being, and is influenced by external factors, particularly economic status and health status (Ozyazicioglu et al., 2017). In other words, even if self-esteem is high, economic difficulties or health problems may result in a lower QOL. Future studies should consider economic status, and disease severity when assessing self-esteem and QOL in adolescents with T1DM.

In this study, the DD ranged from 17 to 60, with a score of 33.56 (±11.09). A correlation was found between DD and QOL. Therefore, it is essential to conduct follow-up studies that consider factors influencing DD, such as gender, age, and economic status (Rechenberg et al., 2017). Neglecting DD can complicate blood glucose management, leading to a vicious cycle of stress and elevated blood glucose (Korean Diabetes Association, 2023). DD has a strong impact on HbA1c, so it should not be viewed as a trivial issue for adolescents with T1DM. Instead, setting long-term, actionable goals for blood glucose management is imperative. This may involve individualized interventions, such as gradually incorporating preferred foods and identifying suitable of physical activity.

The use of insulin pump among diabetes patients abroad has been increasing rapidly. However, adoption in South Korea is hindered by financial constraints and insufficient education and management systems (Gu, 2020). It is essential to recommend insulin pump, which positively impact the QOL of not only adolescents with T1DM but also their families (Barnard et al., 2008). Achieving this requires national support, such as expanding insurance coverage and providing personalized insulin pump education. Further studies on the effectiveness of insulin pump for South Korean adolescents with T1DM are necessary.

Also, education for the utilization of insulin pump data and the establishment of corresponding reimbursement codes are essential. Healthcare providers treating patients with T1DM should continuously acquire knowledge about insulin pumps to provide the best possible care. Furthermore, not only diabetes educators but also diabetes-related organizations must make ongoing efforts in this regard.

T1DM is a chronic and complex disease that causes psychological distress, leads to difficulties in daily life, and decreases QOL (Korean Diabetes Association, 2023). Additionally, in South Korea, the lack of social awareness regarding T1DM negatively impacts management for adolescents with T1DM (Sohn et al., 2015). Therefore, without improvements in public awareness about T1DM, adolescents with T1DM are likely to continue experiencing psychological difficulties and declines in QOL. This, in turn, may further hinder their self-care.

DD is influenced by factors such as blood glucose management, complications, psychological factors, developmental stage, economic status, and social support (Korean Diabetes Association, 2023). Therefore, future studies should consider potential confounding variables and conduct longitudinal research to further explore these relationships.

### Implications for Nursing Practice

The prevalence of T1DM is not high in South Korea, and adolescents with the condition are particularly marginalized. This study has helped raise awareness and generate interest in research on this population. As the study reflects the unique characteristics of adolescents with T1DM in South Korea, the findings can serve as foundational evidence for developing nursing intervention programs to improve their QOL. Nursing intervention programs should encourage adolescents with T1DM to express their emotions, such as depression, to reduce DD. Additionally, these programs should include strategies to enhance self-efficacy and promote motivation in adolescents with T1DM.

## Conclusion

This study aimed to identify the factors influencing QOL in adolescents with T1DM. DD and insulin treatment were significant factors affecting QOL. To enhance the QOL for adolescents with T1DM, it is essential to develop and evaluate the effectiveness of a continuous and comprehensive intervention program. Periodic education and nursing interventions should focus on improving self-care capacity for adolescents with T1DM, emphasizing the reduction of DD. Furthermore, promoting the use of insulin pump at the national level, including the expansion of insurance coverage, is necessary to improve the QOL for adolescents. Future studies are required to broaden the T1DM target group to include children, adults, and seniors to assess their QOL. Longitudinal studies are suggested to clarify the causal relationship between T1DM and QOL, along with exploratory studies on the QOL in adolescents with T1DM. Additionally, study is needed to develop and assess the effectiveness of ongoing and impactful intervention programs for adolescents with T1DM.

## Declaration of Conflicting Interest

There is no conflict of interest to declare.

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## Authors' Contributions

Conceptualization, Investigation, Supervision, and Project Administration: H-R. Formal Analysis, Data Curation, Writing–Review & Editing: S-Y. Methodology, Validation, Resources, Writing–Original Draft Preparation,

Visualization, Funding Acquisition: H-R and S-Y. All authors were accountable in each step of the study and approved the final version of the article to be published.

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## Data Availability

The dataset generated during and analyzed during the current study is available from the corresponding author upon reasonable request.

## Declaration of Use of AI in Scientific Writing

The authors used ChatGPT in the writing process to improve readability and remove grammatical errors. However, they took full responsibility for the content.

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