

The moderating effect of self-reported dietary adherence on the association between social eating patterns and glycemic control among older adults with diabetes: A gender-stratified analysis using the KNHANES 2022–2024

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Research Article

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Abstract

Background

Social eating is considered beneficial for older adults because it supports social interactions and dietary quality. However, among older adults with diabetes, the impact of social eating on glycemic control may depend on whether individuals actively practice dietary adherence. This study examined whether the association between social eating patterns and HbA1c differs according to self-reported dietary adherence among older adults with diabetes and whether these patterns vary by gender.

Methods

Data were obtained from the ninth Korea National Health and Nutrition Examination Survey (KNHANES, 2022–2024). A total of 1,015 participants aged 65 years and older with a physician-confirmed diagnosis of diabetes were included. Social eating was categorized into three groups: eating alone, mixed eating, and eating together. The moderating variable was self-reported dietary adherence, and the outcome was HbA1c (%). Survey-weighted hierarchical linear regression analyses were conducted followed by gender stratification analyses.

Results

In the main-effects model, dietary adherence and social eating patterns were not significantly associated with HbA1c levels. However, after adding the interaction terms, the interaction between dietary adherence and social eating patterns was significantly associated with HbA1c ($p < 0.001$). The interaction terms for eating alone ($p = 0.001$) and mixed eating ($p = 0.001$) were both significant, compared to the eating together group. Gender-stratified analyses showed that the interaction remained significant in both men ($p = 0.011$) and women ($p = 0.038$). The estimated mean HbA1c values suggested a crossing pattern; among participants not practicing dietary adherence, HbA1c was higher in the eating alone group (6.84%) than in the eating together group (6.50%), whereas among those practicing dietary adherence, HbA1c was higher in the eating together group (6.85%) than in the eating alone group (6.57%).

Conclusions

The association between social eating patterns and HbA1c levels among older adults with diabetes varied by dietary adherence. These findings suggest that social eating is neither inherently beneficial nor harmful for diabetes management. Effective dietary interventions should consider dietary adherence, social eating patterns and the broader meal context.

Clinical trial number:

not applicable.

Introduction

Globally, the number of adults with diabetes was estimated at approximately 589 million in 2024, representing 11.11% of the adult population, and is projected to increase to 853 million by 2050 [1]. Among adults aged 65 years and older, the prevalence of diabetes is 23.72%, and the number of older adults with diabetes is expected to increase more rapidly as population ageing accelerates [1]. Older adults with diabetes are vulnerable to both vascular complications and geriatric conditions, including cognitive decline, depression, functional impairment, and urinary incontinence; therefore, active and sustained glycemic control is a key public health priority [2].

The management of type 2 diabetes relies heavily on patient self-management behaviors, including diet, physical activity, and weight control, in addition to pharmacological treatment [3]. The American Diabetes Association (ADA) recommends lifestyle modifications, including healthy dietary management and regular physical activity, as core components of diabetes care [4]. Among these behaviors, dietary adherence is considered a primary self-management behavior for glycemic control; however, it is also one of the most difficult behaviors to maintain in daily life [5, 6]. Despite the well-established benefits of dietary therapy, non-adherence to dietary recommendations among people with diabetes has been documented to be high in both developed and developing countries, and dietary adherence is influenced not only by individual intentions but also by the social environment [7, 8]. In later life, factors such as cognitive decline, social isolation, and reduced physical function may restrict dietary self-management capacity. Therefore, understanding the everyday environment and social context that shape dietary adherence is particularly important [9, 10].

One environmental factor that warrants particular attention in relation to eating behavior is social eating, defined as eating with others. In later life, frequent eating alone is associated with lower diet quality, less dietary variety, and lower consumption of vegetables and meat [11–13]. Conversely, eating with others may promote social interaction, alleviate depressive symptoms and social isolation, and serve as a protective factor by improving diet quality and nutrient intake [11–13]. These findings suggest that shared meals may contribute to better nutritional status later in life.

However, among older adults with diabetes, eating with others should not be assumed to be uniformly beneficial. Because diabetes management requires sustained adherence to a therapeutic diet, social eating can sometimes hinder dietary adherence. Behavioral science studies have shown that eating with others may increase food intake (facilitation effect) and influence individuals to match their companions' eating behaviors (modeling effect) [14–16].

It has also been suggested that individual dietary self-control may be weakened when eating companions choose unhealthy foods [17, 18]. Therefore, eating with others may provide nutritional benefits for older adults with diabetes; however, it may also create circumstances that challenge adherence to a therapeutic diet.

Gender should be considered an important sociocultural factor in diabetes self-management because of its link to meal preparation and caregiving roles within the family. Previous studies on dietary management among patients with type 2 diabetes have reported that the spousal influence on dietary adherence may differ by gender, facilitating adherence in men but potentially hindering it in women [5], and that difficulties in dietary management differ between men and women [19]. Dietary practices in older adults are also shaped by meal preparation experiences accumulated throughout life. Traditionally, older women have been more likely to plan, prepare, and provide meals to family members, whereas older men often rely on spouses or family members for meal preparation [20–22]. Given these gender-related differences, examining the interaction between social eating patterns and dietary adherence only in the total sample may fail to capture the distinct patterns that emerge in male and female subgroups.

To date, studies on social eating have mainly focused on diet quality or psychosocial outcomes, and evidence examining its association with clinical indicators, such as HbA1c, among older adults with diabetes remains limited. As diabetes management requires sustained dietary adherence, the association between social eating and HbA1c levels may vary according to whether individuals practice dietary adherence. In addition, given the gender differences in meal preparation capacity and roles in later life, it is necessary to examine whether such interaction patterns are similar between men and women. To address this gap, this study used the ninth Korea National Health and Nutrition Examination Survey (KNHANES, 2022–2024) data, to examine whether the association between social eating patterns and HbA1c differs according to self-reported dietary adherence among adults aged 65 years and older with diabetes and to explore these patterns separately in male and female subgroups.

Methods

Data source

This cross-sectional study was conducted as a secondary analysis of data from the ninth KNHANES, which was conducted by the Korea Disease Control and Prevention Agency (KDCA) over three years from 2022 to 2024. KNHANES is a continuous national surveillance survey that employs a stratified, multistage probability cluster sampling design to produce nationally representative data on the health and nutritional status of the non-institutionalized Korean population [23]. The surveys included interviews, health examinations, and nutritional surveys. All data collection procedures were conducted under the supervision of the KDCA Institutional Review Board and all participants provided informed consent [23]. These data are publicly available on the KNHANES website (<https://knhanes.kdca.go.kr/knhanes/main.do>).

Participants

The study population comprised adults aged 65 years and older who reported that they had first been diagnosed with diabetes by a physician after the age of 25 years (to exclude probable type 1 diabetes). Participants with missing data on any primary study variables, including HbA1c, social eating patterns, self-reported dietary adherence, or any covariates, were excluded from the analysis. The final analytical sample included 1,015 participants (490 men and 525 women) (Fig. 1).

Variables

HbA1c

The dependent variable was HbA1c levels (%). HbA1c levels were measured as part of the health examination component of the KNHANES, using standardized venous blood sampling and laboratory analysis. HbA1c reflects the average blood glucose level over the previous 2–3 months and is a widely used biomarker for evaluating glycemic control in patients with diabetes [24].

Social eating patterns

The independent variable was the social eating patterns. This variable was assessed using items from the dietary behavior section of the KNHANES nutrition survey in which participants were asked whether they had eaten breakfast, lunch, or dinner with others in the previous year. Based on previous research [13], participants who reported eating all meals alone were categorized into the eating alone group, those who reported eating all meals with others were categorized into the eating together group, and those who reported eating some meals alone and others eaten with companions were categorized into the mixed eating group.

Self-reported dietary adherence

Self-reported dietary adherence was the moderating variable. This was assessed using a single self-reported item from the KNHANES nutrition survey, which asked whether the participants were currently practicing dietary management for disease management or weight control. Responses were classified as yes or no; in this study, participants were categorized as practicing or not practicing dietary adherence.

Covariates

Covariates were selected a priori on the basis of previous studies and clinical evidence, focusing on sociodemographic, disease-related, and health behavior factors that may influence glycemic control in older adults with diabetes [4, 25–31]. This a priori selection approach was intended to minimize omitted variable bias, independent of statistical significance, in the univariate analyses. The covariates included age, duration of diabetes, pharmacological treatment, aerobic exercise, living alone, residential area, household income, educational levels, monthly alcohol consumption, and current smoking status. Age (years) and diabetes duration (years) were treated as continuous variables. Pharmacological treatment was defined as the administration of at least one oral hypoglycemic agent or insulin injection. Aerobic exercise was defined as engaging in at least 150 minutes of moderate-intensity physical activity per week, at least 75 minutes of vigorous-intensity physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activities (1 min of vigorous activity = 2 minutes of moderate activity). Residential area was defined as urban for addresses located in a dong and rural for addresses located in an eup or myeon in Korea. Household income was based on the KNHANES household income quartile variable, which classified participants into four relative income groups: low, lower-middle, upper-middle, and high. Educational levels were classified into four groups: elementary school or lower, middle school graduate, high school graduate, and college or higher. Monthly alcohol consumption was defined as drinking alcohol at least once per month during the past year, whereas current smoking was defined as self-reported active tobacco use at the time of the survey.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics version 29.0. As the KNHANES uses a complex sample design involving stratification, clustering, and sampling weights, complex sample analysis procedures were applied. Survey weights, strata, and clusters were incorporated into all the analyses to produce nationally representative estimates.

Complex sample frequency analyses were performed to describe the general characteristics of the participants. Categorical variables were presented as unweighted frequencies and weighted percentages. Differences in HbA1c levels according to participant characteristics were examined using complex-sample general linear models, with HbA1c values reported as means $\pm$ standard errors. Survey-weighted hierarchical multiple linear regression analyses were then conducted in three steps to examine the associations of social eating patterns and self-reported dietary adherence with HbA1c levels. Model 1 included only covariates selected a priori. Model 2 included the main effects of social eating patterns and self-reported dietary adherence. Model 3 included the interaction terms between social eating patterns and self-reported dietary adherence. The same regression analyses were repeated after stratifying by gender.

Reference groups were set as follows: gender, male; aerobic exercise, no; pharmacological treatment, no; living alone, no; residential area, rural; monthly alcohol consumption, no; current smoking, no; self-reported dietary adherence, no; social eating patterns, eating together. Age, duration of diabetes, household income, and educational levels were treated as continuous variables. Overall effects of multicategory variables were evaluated using the Wald F tests. In addition, a sensitivity analysis was conducted after excluding the mixed eating group to examine whether the main findings were consistent when comparing participants who ate all meals alone with those who ate all meals with others. Statistical significance was determined using two-sided tests at $p < 0.05$.

Results

Baseline characteristics

A total of 1,015 participants were included in the final analysis. Table 1 presents the general characteristics of the study participants and the univariate analysis of HbA1c levels. Of the 1,015 participants, 490 were male (50.5%) and 525 were female (49.5%). The social eating patterns were as follows: 283 participants (27.7%) in the eating alone group, 304 (31.9%) in the mixed eating group, and 428 (40.3%) in the eating together group. In total, 445 participants (43.7%) reported practicing dietary adherence, compared with 570 (56.3%) who did not.

In the univariate analysis, HbA1c differed significantly by age group (Wald $F = 7.477$, $p = 0.006$), with participants aged 65–74 years showing higher HbA1c than those aged 75 years and older. A longer diabetes duration was associated with higher HbA1c levels (Wald $F = 23.617$, $p < 0.001$), and participants who engaged in aerobic exercise had significantly lower HbA1c levels than those who did not (Wald $F = 11.754$, $p < 0.001$). No significant differences in HbA1c were observed according to gender, self-reported dietary adherence, social eating patterns, pharmacological treatment, living alone, residential area, household income, education levels, monthly alcohol consumption, or current smoking status.

Association between social eating patterns, self-reported dietary adherence, and HbA1c: total sample

Table 2 presents the results of the survey-weighted hierarchical linear regression analysis. All variance inflation factors (VIF) were below 2.0, indicating no evidence of multicollinearity.

Model 1 (covariates only) showed statistical significance ($R^2=0.076$, Wald $F = 7.820$, $p < 0.001$). Higher age ($B = -0.032$, $p < 0.001$) and aerobic exercise ($B = -0.272$, $p < 0.001$) were associated with lower HbA1c, whereas longer diabetes duration was associated with higher HbA1c ($B = 0.025$, $p < 0.001$).

Model 2, which included the main effects of social eating patterns and dietary adherence, was statistically significant ($R^2=0.077$, Wald $F = 6.526$, $p < 0.001$). However, the main effects of dietary adherence ($p = 0.806$) and social eating patterns ($p = 0.804$) were not significant. Neither the eating alone group ($p = 0.614$) nor the mixed eating group ($p = 0.869$) showed a significant difference in HbA1c levels, compared to the eating together group.

Model 3, which included the interaction terms, was statistically significant ($R^2=0.096$, Wald $F = 6.354$, $p < 0.001$), and its explanatory power increased compared to Model 2. In Model 3, age ($B = -0.033$, $p < 0.001$), diabetes duration ($B = 0.025$, $p < 0.001$), and aerobic exercise ($B = -0.278$, $p < 0.001$) remained

significantly associated with HbA1c. In the interaction model, the main effects of dietary adherence ($p = 0.469$) and social eating patterns ($p = 0.721$) were not statistically significant. However, the interaction between dietary adherence and social eating patterns was significantly associated with HbA1c levels ($p < 0.001$).

Figure 2A visualizes the interaction pattern between social eating patterns and dietary adherence in the total sample. The estimated HbA1c was the highest in the eating alone group (6.84%), followed by the mixed eating group (6.74%) and the eating together group (6.50%) among participants not practicing dietary adherence. In contrast, among participants practicing dietary adherence, the estimated HbA1c was highest in the eating together group (6.85%), with lower values in the eating alone group (6.57%) and the mixed eating group (6.51%). The estimated means showed a crossing pattern according to the self-reported dietary adherence status.

Gender-stratified analysis

The results of the gender-stratified analyses are presented in Table 3, and the interaction patterns are depicted in Fig. 2.

The model for men was statistically significant ($R^2=0.131$, Wald $F = 4.177$, $p < 0.001$). Higher age ($B = -0.036$, $p = 0.014$) and aerobic exercise ($B = -0.239$, $p = 0.029$) were associated with lower HbA1c, whereas longer diabetes duration was associated with higher HbA1c ($B = 0.027$, $p < 0.001$). Similar to the total-sample model, the main effects of dietary adherence ($p = 0.182$) and social eating patterns ($p = 0.273$) were not significant. However, the interaction between dietary adherence and social eating patterns was statistically significant ($p = 0.011$).

The model for women was statistically significant ($R^2=0.101$, Wald $F = 3.941$, $p < 0.001$). Higher age ($B = -0.025$, $p = 0.017$) and aerobic exercise ($B = -0.259$, $p = 0.003$) were associated with lower HbA1c, whereas longer diabetes duration was associated with higher HbA1c ($B = 0.021$, $p < 0.001$). Similar to the total-sample model, the main effects of dietary adherence ($p = 0.345$) and social eating pattern ($p = 0.079$) were not significant. However, the interaction between dietary adherence and social eating patterns was also significant in women ($p = 0.038$).

Figure 2B and 2C show gender-specific interaction patterns. Among men not practicing dietary adherence, estimated HbA1c was the highest in the eating alone group (7.17%), followed by the mixed eating group (6.80%) and the eating together group (6.46%). Among men practicing dietary adherence, estimated HbA1c was highest in the eating together group (6.74%), with lower values in the eating alone (6.66%) and mixed eating groups (6.50%). Among women practicing dietary adherence, the estimated HbA1c levels was the highest in the eating together group (7.15%), with lower values in the eating alone group (6.60%) and the mixed eating group (6.62%). Among women not practicing dietary adherence, the estimated HbA1c values were relatively similar across the eating alone (6.67%), mixed eating (6.75%), and eating together (6.71%) groups.

Sensitivity analysis

Results of the sensitivity analysis, excluding the mixed eating group, are presented in Supplementary Table S1. The final sensitivity sample comprised 711 participants. In the total sample, the model was statistically significant ($R^2=0.105$, Wald $F = 4.703$, $p < 0.001$), and the interaction between self-reported dietary adherence and social eating patterns remained significant in the same direction as the main analysis ($B = -0.620$, $p = 0.001$). In gender-stratified sensitivity analyses, the interaction was also significant in both men ($B = -0.747$, $p = 0.028$) and women ($B = -0.534$, $p = 0.013$). The estimated means confirmed the crossing pattern; among participants practicing dietary adherence, HbA1c was higher in the eating together group (6.84%) than in the eating alone group (6.59%), whereas among those not practicing dietary adherence, HbA1c was lower in the eating together group (6.50%) than in the eating alone group (6.85%).

Discussion

This study found that the association between social eating patterns and HbA1c levels among older adults with diabetes differed according to self-reported dietary adherence. In the main-effects model adjusted for covariates, neither self-reported dietary adherence nor social eating patterns were significantly associated with HbA1c levels; however, the interaction between the two variables was significantly associated with HbA1c levels. A crossover interaction was observed, whereby eating with others was associated with lower HbA1c among participants not practicing dietary adherence but with higher HbA1c among those practicing dietary adherence. This interaction was consistently observed in both men and women in the sensitivity analysis, excluding the mixed eating group.

Previous studies on social eating have generally shown that eating with others is associated with better nutritional status and diet quality, and with lower levels of social isolation and fewer depressive symptoms in older adults [11–13, 32]. However, in the present study, social eating patterns were not significantly associated with HbA1c levels. The key finding of this study is that the interaction between social eating patterns and self-reported dietary adherence was significantly associated with HbA1c levels. This suggests that social eating among older adults with diabetes cannot be interpreted uniformly as either a protective or harmful factor, and that its implications may differ depending on whether individuals are practicing dietary adherence. A recent study of patients with type 2 diabetes also reported that dietary adherence is influenced not solely by individual motivation but by multiple factors, including food accessibility, social gatherings, and family and social support [33]. In later life, actual meal choices may be constrained by meal preparation capacity, economic conditions, and caregivers [34]. Therefore, efforts to improve glycemic control in older adults with diabetes should not be limited to assessing whether patients understand and follow dietary recommendations but should also account for the broader meal context, including whether eating companions support therapeutic dietary practices, who prepare meals, and whether dietary principles are maintained during dining out or family meals.

Among participants who did not practice dietary adherence, eating with others was associated with lower HbA1c levels than eating alone. This may indicate that, in this group, eating with others may have served as a social resource that supported meal regularity, food variety, meal preparation, and social

engagement [11–13, 32]. For older adults who have difficulty implementing diabetes-specific dietary principles, eating alone may increase the risk of meal skipping, inadequate food intake, reliance on convenience foods, and poor dietary variety [32, 34, 35]. These findings suggest that interventions for older adults who do not practice dietary adherence and who eat alone may be needed to support regular and nutritionally balanced meals in daily life.

In contrast, among the participants practicing dietary adherence, eating with others was associated with higher HbA1c levels. This finding suggests that eating with others does not invariably serve as a protective factor for older adults with diabetes. Participants who report practicing dietary adherence may intend to regulate food quantity and food choices for glycemic control; however, when eating with others, the atmosphere of shared meals, eating companions' food preferences, offers of food, and social etiquette may take precedence over individual therapeutic dietary principles [17, 36]. In addition, food intake and food choices may be shaped by social modeling, in which individuals adjust their intake in response to their eating companions, and by the facilitation effect, in which food intake increases when eating with others [14–16, 37]. Through these mechanisms, eating with others may undermine dietary self-regulation among older adults with diabetes attempting to adhere to a therapeutic diet [18]. Therefore, among older adults who report practicing dietary adherence but continue to have elevated HbA1c levels, it may be necessary to assess whether dining out, the atmosphere of shared meals, or the eating habits of companions interfere with dietary regulation. Additionally, family members, caregivers, and community members within the social networks of older adults with diabetes should be engaged to help create a supportive meal environment that facilitates therapeutic dietary adherence.

In this analysis, the mixed eating group showed an interaction pattern that was more similar to the eating alone group than the eating together group. However, the mixed eating group is likely to be heterogeneous depending on which meals are eaten alone, meal location, and the type of eating companion; therefore, caution is needed when interpreting the findings for this group. Nevertheless, the consistency of the interaction direction in the sensitivity analysis, excluding the mixed eating group, supported the main findings.

Gender-stratified analyses showed an interaction between social eating patterns and self-reported dietary adherence in both men and women; however, this interaction was more pronounced among men who did not practice dietary adherence and women practicing dietary adherence. Among men not practicing dietary adherence, an approximately 0.71 percentage-point difference in HbA1c levels was observed between the eating alone group (7.17%) and the eating together group (6.46%). This finding aligns with evidence that older men who eat alone tend to have lower diet quality and nutrient intake [38], and that eating with others may be associated with better survival outcomes in older men [22]. As men are more reliant on spouses or family members for meal preparation throughout their life course, eating alone may compromise both meal quality and dietary intake [20, 39–41]. From this perspective, older men who do not practice dietary adherence or eat alone may represent a particularly vulnerable subgroup for glycemic control. Interventions that incorporate practical meal preparation education, diabetes-appropriate meal planning, and community-based meal support may be particularly important for these individuals.

Among women practicing dietary adherence, an approximately 0.55 percentage-point difference in HbA1c levels was observed between the eating together (7.15%) and eating alone groups (6.60%). Among older women, eating with others may create situations in which maintaining dietary self-regulation becomes more challenging, which is consistent with evidence that women may be more susceptible to dietary lapses [38, 42], and may be more strongly influenced by modeling effects [16, 18]. In addition, because older women have often assumed responsibility for planning and preparing family meals throughout the life course, the food preferences of family members and the role of food preparer may take precedence over their own therapeutic dietary principles [19, 21, 43]. Therefore, dietary education for older women with diabetes may benefit from family involved dietary interventions that support adherence to therapeutic dietary recommendations during shared meals.

The HbA1c differences observed across the social eating patterns in this study may be clinically meaningful. Given previous evidence that each 1 percentage-point reduction in HbA1c is associated with an approximately 21% lower risk of diabetes-related death and a 37% lower risk of microvascular complications [44], the 0.5–0.7%p differences observed in this study suggest that meal context may be a relevant factor in glycemic control among older adults with diabetes. However, because this study used cross-sectional data, these differences should not be interpreted as directly translating to clinical outcomes, and their significance should be confirmed in future longitudinal studies.

This study had several limitations. First, because this was a cross-sectional study, causal relationships among eating with others, dietary adherence, and HbA1c levels could not be established. In particular, individuals with poorer glycemic control may have been more likely to report practicing dietary adherence because they had received dietary counseling or were attempting to improve their diabetes management; therefore, reverse causation cannot be ruled out. Future studies using longitudinal data are needed to clarify the temporal relationships among eating with others, dietary adherence, and changes in HbA1c levels. Second, dietary adherence was measured using a single self-reported item and did not capture the specific content, intensity, duration, or actual diet quality involved in dietary management. Therefore, even among participants classified as practicing dietary adherence, actual dietary practices may vary substantially. The dietary adherence variable should be interpreted as self-reported dietary management practices or attempts rather than as objective adherence to a therapeutic diet. Future research should assess the actual level of therapeutic dietary adherence rather than rely solely on a single item regarding dietary practices. Third, the social eating pattern variables used in this study were classified according to whether breakfast, lunch, and dinner were eaten with others and therefore did not fully capture detailed meal contexts. Eating companions may include spouses, children, friends, or caregivers and their influence on food choices and dietary adherence may differ. In addition, dining out, meal location, type of meal eaten with others, companions' eating habits, and the person responsible for meal preparation may be important factors influencing dietary regulation among patients with diabetes. However, these factors could not be considered in this study. Fourth, glycemic control in patients with diabetes may be affected by a range of factors, including cognitive function, depression, physical function, and comorbidities. Residual confounding may remain because not all potential confounders could be fully controlled.

Despite these limitations, this study had several strengths. First, KNHANES data and complex sample analyses incorporating stratification, clustering, and sampling weights enhanced representativeness and validity. Second, the dependent variable, HbA1c, was an objective biomarker measured through laboratory analysis rather than being a self-reported variable, which strengthened the reliability of the outcome measurements. Third, this study examined whether the association between social eating patterns and HbA1c differed according to self-reported dietary adherence, using gender-stratified analyses.

Conclusions

This study showed that the association between social eating patterns and HbA1c levels among older adults with diabetes in Korea may differ according to self-reported dietary adherence.

Among older adults with diabetes, eating with others was linked to lower HbA1c among non-adherent individuals but higher HbA1c among adherent individuals, highlighting the need for tailored eating recommendations that consider dietary adherence and gendered sociocultural factors.

Abbreviations

KNHANES Korea National Health and Nutrition Examination Survey

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. All data were obtained from the Korea National Health and Nutrition Examination Survey (KNHANES), a publicly available, de-identified database, and did not involve direct human experimentation, thus qualifying for exemption from Institutional Review Board (IRB) review by the Seoul National University Institutional Review Board (IRB No. E2605/002–003). As this study involved secondary analysis of de-identified data, additional informed consent was not required; all participants had provided informed consent at the time of the original KNHANES survey.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Author Contribution

JW conceived and designed the study; performed data extraction, data management, statistical analysis, visualization, and interpretation of the results; and drafted the manuscript. YH supervised the study, provided conceptual and methodological guidance, contributed to the interpretation of findings, critically revised the manuscript for important intellectual content, and acquired funding. JA contributed to the interpretation of the results and to drafting and revising the manuscript. DY contributed to data extraction, statistical analysis, visualization, and critical review of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

Data Availability

The data used in this study are publicly available from the Korea National Health and Nutrition Examination Survey (KNHANES), conducted by the Korea Disease Control and Prevention Agency. The datasets are available on the KNHANES website (<https://knhanes.kdca.go.kr/knhanes/main.do>).

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Tables

Table 1 General characteristics of study participants and mean HbA1c by participant characteristics

Variable	Total	HbA1c	Univariate analysis of HbA1c	
	n(%)	mean ± SE	Wald F	P value
Age			7.477	0.006**
65-74	613 (61.2)	6.861 ± 0.053		
≥75	402 (38.8)	6.668 ± 0.050		
Gender			0.183	0.669
Male	490 (50.5)	6.802 ± 0.061		
Female	525 (49.5)	6.770 ± 0.045		
Duration of diabetes (years)			23.617	<0.001**
0-4	277 (28.7)	6.434 ± 0.046		
5-9	184 (17.1)	6.787 ± 0.086		
10-19	321 (31.2)	6.904 ± 0.083		
≥20	233 (23.1)	7.064 ± 0.079		
Dietary adherence			0.083	0.774
No	570 (56.3)	6.777 ± 0.059		
Yes	445 (43.7)	6.798 ± 0.045		
Social eating patterns			0.036	0.965
Eating alone	283 (27.7)	6.783 ± 0.087		
Mixed	304 (31.9)	6.800 ± 0.070		
Eating together	428 (40.3)	6.777 ± 0.051		
Aerobic exercise			11.754	<0.001**
No	711 (68.6)	6.861 ± 0.052		
Yes	304 (31.4)	6.622 ± 0.048		
Pharmacological treatment			0.008	0.931
No	57 (6.2)	6.760 ± 0.313		
Yes	958 (93.8)	6.788 ± 0.036		
Living alone			2.223	0.137
No	748 (75.5)	6.813 ± 0.046		
Yes	267 (24.5)	6.702 ± 0.062		
Residential area			0.519	0.472
Rural	301 (24.0)	6.742 ± 0.064		
Urban	714 (76.0)	6.800 ± 0.047		
Household income			1.139	0.333
Low	444 (40.9)	6.705 ± 0.048		
Mid-low	277 (28.2)	6.866 ± 0.094		
Mid-high	198 (21.0)	6.800 ± 0.082		
High	96 (9.9)	6.866 ± 0.134		
Education level			0.623	0.601
≤Elementary school	497 (47.6)	6.736 ± 0.048		
Middle school grad	198 (18.8)	6.843 ± 0.075		
High school grad	212 (20.7)	6.817 ± 0.073		
≥College	108 (12.9)	6.840 ± 0.184		
Monthly alcohol consumption			0.000	0.990
No	676 (65.3)	6.786 ± 0.044		

Yes	339 (34.7)	6.785 ± 0.080		
Current smoking			0.103	0.749
No	917 (90.4)	6.790 ± 0.041		
Yes	98 (9.6)	6.753 ± 0.106		

Categorical variables were presented as unweighted frequencies and weighted percentages. HbA1c values were presented as the estimated means ± standard error from complex sample general linear models. Wald F statistics and p-values indicate differences in HbA1c levels according to each participant's characteristics in the univariate complex sample general linear models. * p<0.05; ** p<0.01

Table 2 Survey-weighted hierarchical linear regression analysis of HbA1c in the total sample

Variable	Model 1					Model 2					Model 3			
	R ² =0.076, Wald F=7.820, P value<0.001					R ² =0.077, Wald F=6.526, P value<0.001					R ² =0.096, Wald F=6.354, P value<0.001			
	B	SE	95% CI		p	B	SE	95% CI		p	B	SE	95% CI	
			lower	upper				lower	upper				lower	upper
(constant)	8.972	0.837	7.327	10.618	<0.001**	8.993	0.849	7.325	10.660	<0.001**	8.933	0.837	7.288	10.578
Age	-0.032	0.009	-0.049	-0.015	<0.001**	-0.033	0.009	-0.050	-0.015	<0.001**	-0.033	0.009	-0.051	-0.014
Gender	-0.013	0.076	-0.163	0.137	0.861	-0.013	0.076	-0.161	0.136	0.868	-0.001	0.075	-0.148	0.146
Duration of diabetes	0.025	0.004	0.018	0.032	<0.001**	0.025	0.004	0.018	0.032	<0.001**	0.025	0.004	0.017	0.033
Aerobic exercise	-0.272	0.080	-0.428	-0.116	<0.001**	-0.271	0.078	-0.423	-0.118	<0.001**	-0.278	0.077	-0.429	-0.127
Pharmacological treatment	-0.124	0.312	-0.737	0.489	0.692	-0.115	0.300	-0.705	0.475	0.702	-0.123	0.299	-0.711	0.465
Living alone	-0.056	0.076	-0.205	0.092	0.457	-0.091	0.110	-0.308	0.125	0.406	-0.111	0.108	-0.324	0.102
Residential area	0.071	0.076	-0.078	0.220	0.350	0.070	0.076	-0.080	0.219	0.360	0.065	0.076	-0.083	0.213
Household income	0.005	0.045	-0.084	0.094	0.908	0.007	0.045	-0.083	0.096	0.885	0.003	0.045	-0.085	0.091
Education level	0.018	0.046	-0.073	0.109	0.699	0.021	0.049	-0.076	0.118	0.669	0.013	0.049	-0.083	0.109
Monthly alcohol consumption	-0.016	0.094	-0.200	0.167	0.861	-0.015	0.094	-0.199	0.169	0.873	-0.008	0.092	-0.189	0.173
Current smoking	-0.183	0.130	-0.439	0.072	0.160	-0.184	0.134	-0.448	0.079	0.170	-0.202	0.134	-0.465	0.061
Dietary adherence											0.806			
Yes						-0.019	0.078	-0.171	0.133	0.806	0.343	0.110	0.127	0.559
No						Ref.					Ref.			
Social eating patterns											0.804			
Eating alone						0.072	0.143	-0.209	0.354	0.614	0.343	0.185	-0.022	0.709
Mixed eating						-0.014	0.086	-0.183	0.155	0.869	0.239	0.124	-0.005	0.488
Eating together						Ref.					Ref.			
Dietary adherence × Social eating														
Dietary adherence × Eating alone											-0.623	0.190	-0.996	-0.250
Dietary adherence × Mixed eating											-0.579	0.179	-0.931	-0.227
Dietary adherence × Eating together											Ref.			

Values are presented as B, standard error (SE), 95% CI, and p-values. Age, duration of DM, household income, and educational level were treated as continuous variables. The reference groups were as follows: gender = male; aerobic exercise = no; pharmacological treatment = no; living alone = no; residential area = rural; monthly alcohol consumption = no; current smoking = no; dietary adherence = no; and social eating patterns = eating together. For multicategory variables, p-values in the variable heading rows indicate the overall p-values from the Wald F test. Heading-row p-values indicate the overall Wald F-tests for the corresponding model terms (including any associated interaction terms), whereas category-row p-values indicate tests for individual regression coefficients relative to the reference group. For the interaction term blocks, the heading-row p-values indicate the overall Wald F-test for all associated interaction coefficients. In models that included interaction terms, the main-effect coefficients represented conditional effects at the reference level of the interacting variable. * p<0.05; ** p<0.01

Table 3 Gender-stratified survey-weighted linear regression analysis of HbA1c

Variable	Men					Women				
	R ² =0.131, Wald F=4.177, P value<0.001					R ² =0.101, Wald F=3.941, P value<0.001				
	B	SE	95% CI		p	B	SE	95% CI		p
			lower	upper				lower	upper	
(constant)	9.187	1.350	6.534	11.839	<0.001**	8.163	0.803	6.586	9.741	<0.001**
Age	-0.036	0.015	-0.065	-0.007	0.014*	-0.025	0.010	-0.045	-0.005	0.017*
Duration of diabetes	0.027	0.005	0.017	0.037	<0.001**	0.021	0.005	0.010	0.030	<0.001**
Aerobic exercise	-0.239	0.109	-0.454	-0.024	0.029*	-0.259	0.088	-0.432	-0.086	0.003**
Pharmacological treatment	-0.321	0.461	-1.228	0.585	0.486	0.170	0.154	-0.132	0.473	0.269
Living alone	-0.322	0.171	-0.658	0.014	0.061	0.097	0.124	-0.146	0.341	0.433
Residential area	0.114	0.102	-0.086	0.314	0.263	-0.030	0.104	-0.235	0.176	0.777
Household income	0.050	0.064	-0.077	0.177	0.439	-0.024	0.054	-0.130	0.081	0.652
Education level	0.006	0.073	-0.137	0.149	0.935	0.039	0.062	-0.083	0.160	0.533
Monthly alcohol consumption	-0.140	0.105	-0.346	0.066	0.182	0.168	0.122	-0.071	0.408	0.168
Current smoking	-0.236	0.152	-0.534	0.062	0.120	0.019	0.255	-0.482	0.521	0.940
Dietary adherence					0.182					0.345
Yes	0.282	0.134	0.019	0.545	0.036*	0.442	0.181	0.087	0.797	0.015*
No	Ref.					Ref.				
Social eating patterns					0.273					0.079
Eating alone	0.714	0.327	0.071	1.357	0.030*	-0.034	0.143	-0.314	0.247	0.814
Mixed eating	0.338	0.171	0.003	0.674	0.048*	0.044	0.158	-0.266	0.355	0.780
Eating together	Ref.					Ref.				
Dietary adherence × Social eating					0.011*					0.038*
Dietary adherence × Eating alone	-0.789	0.340	-1.458	-0.121	0.021*	-0.510	0.215	-0.932	-0.087	0.018*
Dietary adherence × Mixed eating	-0.576	0.228	-1.024	-0.129	0.012*	-0.574	0.258	-1.080	-0.067	0.027*
Dietary adherence × Eating together	Ref.					Ref.				

Values are presented as B, standard error (SE), 95% CI, and p-values. Age, duration of DM, household income, and educational level were treated as continuous variables. The reference groups were aerobic exercise, no; pharmacological treatment, no; living alone, no; residential area, rural; monthly alcohol consumption, no; current smoking, no; dietary adherence, no; social eating patterns, eating together. For multicategory variables, p-values in the variable heading rows indicate the overall p-values from the Wald F test. Heading-row p-values indicate the overall Wald F-tests for the corresponding model terms (including any associated interaction terms), whereas category-row p-values indicate tests for individual regression coefficients relative to the reference group. For the interaction term blocks, the heading-row p-values indicate the overall Wald F-test for all associated interaction coefficients. In models that included interaction terms, the main-effect coefficients represented conditional effects at the reference level of the interacting variable. * p<0.05; ** p<0.01

Figures

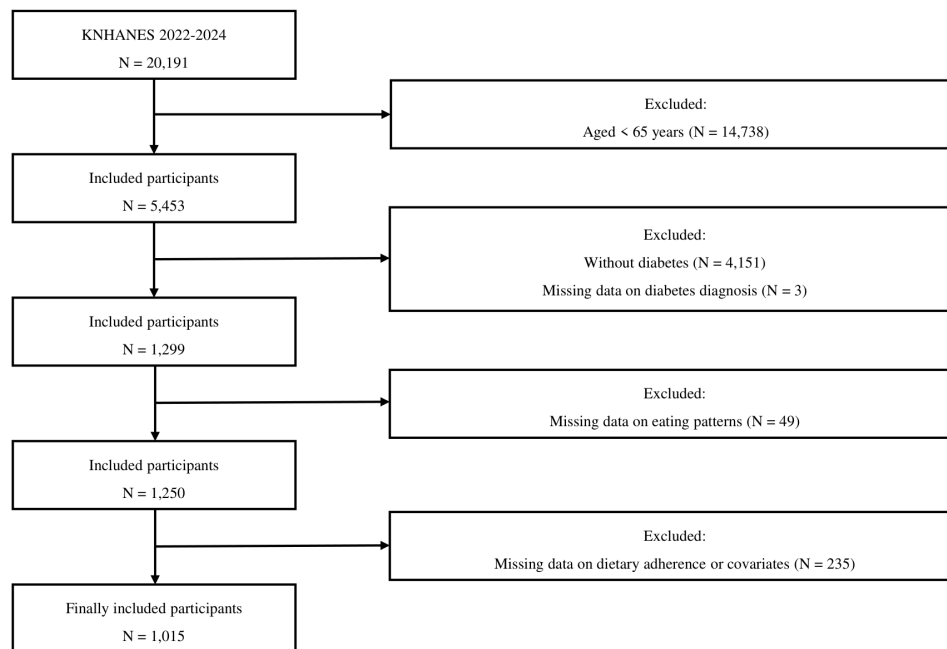


Figure 1

Flowchart of the participant selection process

Interaction of Social Eating Patterns and Self-Reported Dietary Adherence on HbA1c

Figure 2A. Overall (n=1,015)

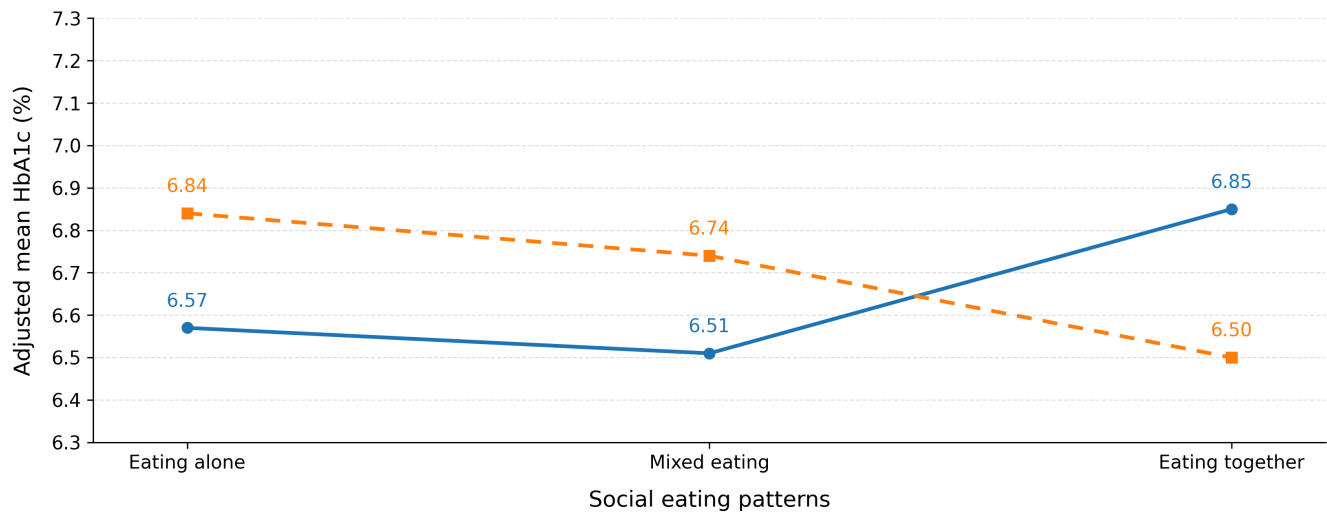


Figure 2B. Men (n=490)

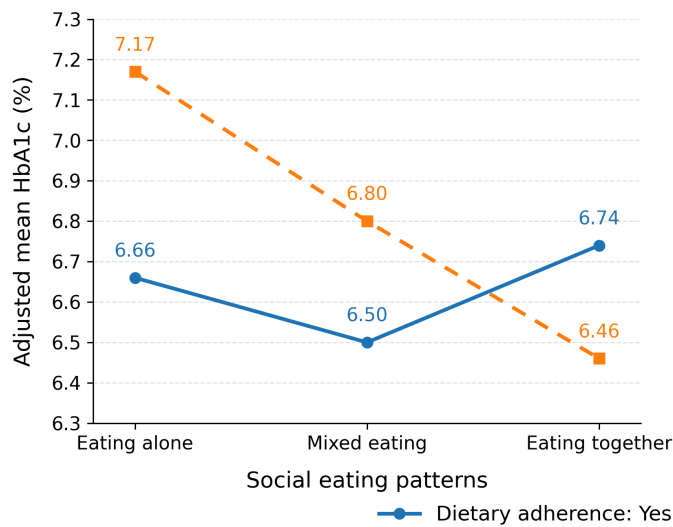


Figure 2C. Women (n=525)

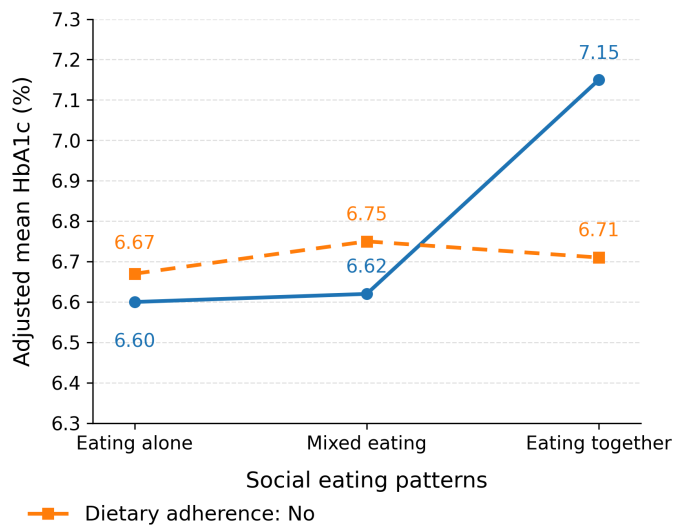


Figure 2
Interaction plot of social eating patterns × self-reported dietary adherence on HbA1c

Supplementary Files

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