

Parallel Mediation Model Linking Type D Personality with Adverse Health Outcomes in People with Type 2 Diabetes

Eun-Hyun Lee (✉ ehlee@ajou.ac.kr)

Ajou University <https://orcid.org/0000-0001-7188-3857>

Young Whee Lee

Inha University

Duckhee Chae

Chonnam National University

Eun Hee Kang

Ajou University

Hyun-Jung Kang

Ajou University

Research

Keywords: Diabetes, Distress, Social isolation, Glycemic control, Health-related quality of life, Type D personality

Posted Date: September 29th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-910459/v1>

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Abstract

Background: This study aims to investigate a parallel mediation model to directly link Type D personality with adverse glycated hemoglobin (HbA1c) health outcomes and health-related quality of life (HRQOL), and indirectly through diabetes distress and social isolation in people with type 2 diabetes.

Methods: Secondary data analysis of a cross-sectional survey was used. Data on 524 people with type 2 diabetes from June 2020 to February 2021 were recruited from outpatient clinics. The analyzed components of the data set were Type D personality, diabetes distress, social isolation, HbA1c, and health-related quality of life (HRQOL). The hypothesized parallel mediation model was tested using the PROCESS macro for SPSS. A 10,000-bootstrap bias-corrected procedure was used to estimate 95% confidence intervals for indirect effects.

Results: Type D personality was present in 31.3% of the participants. The direct effect of Type D personality on HbA1c was insignificant, but was significant on HRQOL. The indirect effects of Type D personality on HbA1c and HRQOL through diabetes distress and social isolation were both significant. The indirect effect on HRQOL through diabetes distress was greater than that through social isolation.

Conclusion: People with a Type D personality more often experienced negative emotions in response to the burden of living with and managing diabetes and might have fewer interpersonal contacts, which in turn impair glycemic control and HRQOL. This study identified the mechanisms underlying the relationship between Type D personality and glycemic control and HRQOL in people with type 2 diabetes. Both diabetes distress and social isolation mediated these relationships. Health professionals must monitor people with type 2 diabetes to determine the presence of Type D personality. It is particularly recommended for those with Type D personality to be provided with interventions to reduce diabetes distress and to enhance social isolation in order to improve their glycemic control and HRQOL.

Background

Type D (or “distressed”) personality is characterized by the combination of two stable personality traits: negative affectivity and social inhibition [1]. Negative affectivity denotes the tendency to experience negative emotions, and social inhibition denotes the tendency to inhibit self-expression during social interactions [2]. Although Type D personality originally emerged as a risk factor for adverse health outcomes in people with coronary health disease, it has since been recognized as also being a risk factor for people with other medical conditions [3]. However, there is insufficient evidence for this regarding people with type 2 diabetes [4].

According to the American Diabetes Association and European Association for the Study of Diabetes, the goals for treatment of type 2 diabetes are to control blood glucose in order to prevention or delay complications and to maintain the quality of life [5]. Glycated hemoglobin (HbA1c) is a standard objective marker of blood glucose control, reflecting average blood glucose levels over 2–3 months [6]. Despite the lack of a universally accepted definition, “quality of life” is too broad since it includes welfare,

the economic situation, and health status, and instead “health-related quality of life” (HRQOL) is a more concise outcome indicator for use in clinical situations [7]. From these perspectives, HbA1c and HRQOL can be representative outcome parameters for type 2 diabetes. Therefore, a negative association can be assumed between Type D personality and diabetes outcomes such as HbA1c and HRQOL.

Studies have been conducted on Type D personality in people with type 2 diabetes even in the early stage [8]. The few studies that examined the relationship between Type D personality and HbA1c in people with type 2 diabetes produced inconsistent findings. Some studies found that people with Type D personality were more likely to have higher HbA1c levels [4, 9, 10], while another study found no direct association and suggested exploring its indirect effect through mediators [11].

People with Type D personality with chronic disease, particularly with cardiovascular disease, have been reported to have greater impairment of HRQOL [12–14]. However, this relationship has rarely been investigated among people with diabetes. Conti et al. [9] were the first and only authors to empirically demonstrate this relationship in people with type 2 diabetes.

The mechanisms underlying the association between Type D personality and adverse clinical outcomes are unclear [15]. It is therefore necessary to determine which factors mediate the adverse effects of Type D personality on the outcomes [14]. Psychosocial factors have been conjectured as plausible mediators of this mechanism [16].

Diabetes distress regards negative emotions in response to the burden of living with and managing diabetes [17, 18]. A previous study of people with type 2 diabetes indicated that people with Type D personality had greater diabetes distress [19]. Greater diabetes distress was known to induce worse blood glycemic control [20, 21] and poor HRQOL in people with type 2 diabetes [22–24]. Together these observation studies suggest that the relationships between Type D personality and HbA1c and HRQOL would be mediated by diabetes distress.

Another plausible pathway for Type D personality predicting adverse diabetes outcomes is social isolation, characterized as a paucity of contact with others and a lack of social involvement [25]. Associations have been reported between Type D personality and social isolation in people with cardiovascular disease and those from a general population [26, 27]. Social isolation is known to be associated with HbA1c in people with diabetes [28], and negatively related to HRQOL among older adults [29, 30]. Accordingly, it may be postulated that Type D personality is associated with social isolation, which in turn relates to adverse HbA1c and HRQOL diabetes outcomes in people with type 2 diabetes.

A parallel mediation model is where two or more mediators linked by the same independent and outcome variables are not based on causality and are strongly correlated [31]. Since no evidence exists between the diabetes distress and social isolation mediators, these are expected to be parallel mediators in the association between Type D personality and the diabetes health outcomes of HbA1c and HRQOL.

Methods

Aim

This study aimed to investigate a parallel mediation model directly linking Type D personality with adverse health outcomes (HbA1c and HRQOL), and indirectly through both diabetes distress and social isolation in people with type 2 diabetes. The following two hypotheses were tested:

Hypothesis 1

Type D personality is directly related to HbA1c and indirectly related through both diabetes distress and social isolation in people with type 2 diabetes.

Hypothesis 2

Type D personality is directly related to HRQOL and indirectly related through both diabetes distress and social isolation in people with type 2 diabetes.

Study design and participants

This study performed a secondary analysis of data derived from a cross-sectional survey of people with type 2 diabetes [32]. Data were obtained on 524 people with type 2 diabetes from June 2020 to February 2021 who were recruited from outpatient clinics after the approval of the associated institutional review boards. The inclusion criteria for participants were being at least 19 years old, articulate in the Korean language, and undergoing a treatment regimen (oral hypoglycemic agents, insulin, or both) for type 2 diabetes. The mean age of participants was 60.35 years (SD = 11.19 years). About one-third were female (35.9%), and three-quarters (75.6%) were taking oral hypoglycemic agents. The mean duration of diagnosed diabetes was 11.77 years (SD = 8.72 years).

Measurement

Type D personality

Type D personality was identified using the 14-item Type D Scale (DS14), which consists of two 7-item subscales measuring negative affectivity (NA) and social inhibition (SI) [1]. Each item is scored on a 5-point rating scale ranging from 0 to 4, with subscale scores ranging from 0 to 28. The cutoff point for Type D personality categorization is a score of ≥ 10 on both the NA and SI subscales. In the original study, the Cronbach's alpha values were .88 and .86 for NA and SI, respectively, and test-retest reliability coefficients were .72 and .82. The DS14 has been validated in various populations, including people with type 2 diabetes [19] and in Koreans [33]. In the present study, Cronbach's alpha values for the NA and SI subscales were .86 and .78, respectively.

Diabetes distress

Diabetes distress was measured using a five-item short-form version of the Problem Areas in Diabetes (PAID-5) [34] scale derived from the original 20-item PAID [35]. Each item is scored on a 5-point Likert

scale from “not a problem” to “a serious problem.” The possible total scores on the PAID-5 range from 0 to 20, with higher scores implying greater diabetes-related distress. The Korean version of the PAID-5 had satisfactory factorial structural validity, convergent validity, known-groups validity, internal consistency (Cronbach’s alpha = .87), and test–retest reliability (intraclass correlation coefficient: ICC = .89) among 440 people with type 2 diabetes [36]. In the present study, Cronbach’s alpha of the Korean version was .91.

Social isolation

Social isolation was measured using the five-item Social Isolation Index [25], which determines whether a respondent (1) is not married/not cohabiting with a partner; (2) does not participate in any organization, religious group, or committee; and has contact less frequently than monthly (including face-to-face, telephone, or written/e-mail) with (3) friends, (4) relatives, and (5) other family members they do not live with. The scores ranged from 0 to 5, with higher scores indicating greater social isolation.

Glycated hemoglobin

HbA1c, an integrated marker of glycemic control, was collected from the medical records of participants.

Health-related quality of life

The Diabetes-specific Quality of Life (D-QOL) was used to measure HRQOL and comprised 16 items, responses to which were provided on a 5-point Likert-type scale [37]. All items were reversed and averaged so that a higher score indicated a better HRQOL. The D-QOL demonstrated satisfactory content validity, factorial construct validity (using exploratory and confirmatory factor analyses), concurrent validity, known-groups validity, and internal consistency (Cronbach’s alpha = .92) among 402 people with diabetes. In the present study, Cronbach’s alpha of the D-QOL was .91.

Statistical analysis

Data were analyzed using SPSS (version 25.0 for Windows) and its PROCESS macro (version 3.5.3). Study variables were computed using descriptive statistics. Pearson’s correlation analysis, t-tests, and ANOVA were performed to identify any covariates between general participant characteristics and the mediator/outcome variables (diabetes distress, social isolation, HbA1c, and HRQOL). General characteristics associated with both mediators and outcome variables were considered covariates [31]. Statistical assumption tests were performed before the mediation analysis. Collinearity and multicollinearity among predicting variables were determined using point-biserial or Pearson’s correlation analysis, and the variance inflation factor (VIF). The Durbin-Watson statistic was computed to determine whether the residuals in the model were independent. Linearity and homoscedasticity assumptions were determined using a plot of standardized residuals against standardized predicted values [31, 38].

The hypothesized parallel mediation model was analyzed using the PROCESS macro [37]. A 10,000-bootstrap bias-corrected procedure was used to estimate the 95% confidence intervals (CIs) of the indirect

effects. Data values were quoted to three decimal places. A significant indirect effect was indicated when the 95% CI of an indirect (mediation) effect did not span zero.

Results

Preliminary analyses

Of the 524 participants, 31.3% ($n = 164$) were categorized as Type D personality. The mean values for diabetes distress, social isolation, HbA1c, and HRQOL were 8.38 (SD = 5.29), 1.07 (SD = 1.03), 7.30 (SD = 1.27), and 2.96 (SD = 0.75), respectively.

There were no covariates among the general characteristics that were associated with both mediators and the HbA1c outcome variable. However, gender was significantly associated with diabetes distress and HRQOL, and education level was associated with social isolation and HRQOL (Additional file 1: Table S1). Gender and education level were therefore included as covariates in the subsequent parallel mediation model linking Type D personality and HRQOL.

Type D personality demonstrated a positive correlation with diabetes distress ($r_{pb} = .29, p_{cript} > .001$) and social isolation ($r_{pb} = .18, p_{cript} > .001$). Diabetes distress had a weak correlation with social isolation ($r = .10, p_{cript} > .015$). The VIF values for all predicting variables were < 10 for the HbA1c (1.04–1.12) and HRQOL (1.04–1.12) diabetes health outcomes, indicating no problem of high redundancy among predicting variables. Durbin-Watson values were near 2 (1.92 and 1.90 for HbA1c and HRQOL, respectively) for the independent residuals of the dependent variables (no autocorrelation). The standardized residual plot against standardized predicted values for HbA1c and HRQOL indicated satisfactory linearity (the Loess curve centers along the entire X axis were close to zero) and homoscedasticity (data were consistently and equally spread on the Y axis throughout the plot).

Hypothesis 1

Figure 1 (and Additional file 1: Table S2) indicate that Type D personality significantly predicted both diabetes distress ($a_1 = 3.314, p < .001$) and social isolation ($a_2 = 0.397, p < .001$). HbA1c exhibited significant regression with diabetes distress ($b_1 = 0.026, p = .021$) and social isolation ($b_2 = 0.136, p = .013$) when holding other variables constant. However, the direct effect ($c' = 0.062, p = .622$) of Type D personality on HbA1c was insignificant after controlling for diabetes distress and social isolation.

Table 1 indicates that the indirect effect ($a_1 \times b_1 = 3.314 \times 0.026 = 0.083$) of Type D personality on HbA1c via diabetes distress after controlling for social isolation was significant, because the 95% bootstrap CI (0.014–0.163) did not include zero. This suggests that participants with Type D personality scored 0.083 points higher than those without Type D personality on HbA1c due to the indirect effect through diabetes distress, when holding social isolation constant. The indirect effect ($a_2 \times b_2 = 0.397 \times 0.136 = 0.054$) of Type D personality on HbA1c through social isolation was also significant after controlling for diabetes distress (95% bootstrap CI = 0.007 to 0.121). Comparing the magnitudes of the two indirect effects

revealed an insignificant difference (95% bootstrap CI = - 0.061 to 0.121); however, the total effect was insignificant ($c = 0.199, p = .096$).

Table 1
Indirect effects on HbA1c with 95% bootstrap confidence interval

	Product of coefficient		95% bootstrap CI	
	Point estimate	Bootstrap SE	Lower limit	Upper limit
Indirect effects on HbA1c				
$a_1 \times b_1$	0.083	0.038	0.014	0.163
$a_2 \times b_2$	0.054	0.029	0.007	0.121
Comparison between indirect effects on HbA1c ($a_1 \times b_1$ minus $a_2 \times b_2$)	0.029	0.046	-0.061	0.121
CI: confidence interval; SE: standard error. $a_1 \times b_1$: indirect effect of Type D personality on HbA1c through diabetes distress; $a_2 \times b_2$: indirect effect of Type D personality on HbA1c through social isolation.				

Hypothesis 2

Figure 2 (and Additional file 1: Table S3) 3 indicate that all regression coefficients were significant, including the direct effect ($c' = - 0.326, p < .001$) of Type D personality on HRQOL after controlling for mediators and covariates. Table 2 indicates that the indirect effect ($a_1 \times b_1 = - 0.254$) of Type D personality on HRQOL through diabetes distress was significant after controlling for social isolation and covariates (95% bootstrap CI = - 0.335 to - 0.178). The indirect effect ($a_2 \times b_2 = - 0.029$) through social isolation was also significant after controlling for diabetes distress and covariates (95% bootstrap CI = - 0.056 to - 0.008). The indirect effect through diabetes distress was greater than through social isolation (95% bootstrap CI = - 0.316 to - 0.145). The total effect was significant ($c = - 0.609, p < .001$).

Table 2

Indirect effects on HRQOL with 95% bootstrap confidence interval while controlling for covariates

	Product of coefficient		95% bootstrap CI	
	Point estimate	Bootstrap SE	Lower limit	Upper limit
Indirect effects on HRQOL				
$a_1 \times b_1$	-0.245	0.040	-0.335	-0.178
$a_2 \times b_2$	-0.029	0.012	-0.056	-0.008
Comparison between indirect effects on HRQOL ($a_1 \times b_1$ minus $a_2 \times b_2$)	-0.226	0.042	-0.312	-0.145

CI: confidence interval; SE: standard error. $a_1 \times b_1$: indirect effect of Type D personality on HRQOL through diabetes distress; $a_2 \times b_2$: indirect effect of Type D personality on HRQOL through social isolation.

Discussion

In this study, 31.3% of the participants with type 2 diabetes had a Type D personality. This rate was consistent with the ranges reported previously among Dutch (22.8–55.8%) [11, 39] and Chinese (27.9–41.4%) [10, 40] adults with type 2 diabetes.

In this study, the mean HbA1c level of people with Type D personality was the same as that of people without Type D personality. Nefs et al. [11] similarly reported no difference after subdividing people without Type D personality into three groups based on scores higher or lower than the cutoff of 10 for the NA and SI sum scores (NA⁺SI⁻, NA⁻SI⁺, and NA⁻SI⁻). In contrast, another study that analyzed the continuous scores of the NA and SI sums found a significant relationship between Type D personality (NA) and HbA1c [9]. Li et al. [41] suggested that the association between Type D personality and HbA1c might differ with the analysis method, including whether Type D was operationalized as a categorical or continuous variable.

Type D personality has mostly been included as a categorical variable (e.g., Type D vs. not Type D) using a cutoff point of 10, while the personality was included as a continuous variable using scores from 0 to 28 for both the NA and SI constructs. Regarding the categorical approach, the cutoff point of 10 was criticized based on the value of the median split [42]. However, the cutoff point of 10 was demonstrated as accurate in classifying Type D vs. not Type D using item response theory analysis among people with cardiovascular diseases [43]. Those against the categorical approach insisted that Type D personality was more accurately represented by the continuous constructs of NA and SI [42] or was analyzed more effectively using a continuous interaction method including quadratic NA and SI effects [44]. This

controversy means that further exploration is needed into how to deal with the Type D personality variable.

In this study, those with Type D personality had poor HRQOL. This finding was consistent with that of the sole study conducted on people with type 2 diabetes [9]. That previous study measured HRQOL using a generic instrument (the World Health Organization QOL-BREF: WHOQOL-BREF) that measured physical health, psychological variables (e.g., self-esteem), social relationships (e.g., social support), and environment (e.g., physical safety) [45]. The generic type is applicable when measuring HRQOL across healthy and disease populations [7]. In clinical situations, using a disease-specific type of HRQOL instrument designed to focus on specific problems induced by an illness and its treatment, such as diabetes, is more effective [37]. We recommend conducting more studies on the relationship between Type D personality and HRQOL, with a particular focus on using a diabetes-specific HRQOL instrument.

The present study was the first that we know of to test the association between Type D personality and diabetes outcomes (HbA1c and HRQOL) through multiple mediators among people with type 2 diabetes. In this study, the two hypotheses for the indirect effects through both diabetes distress and social isolation were supported. This mediation-based research provided new information on how people with Type D personality easily experience negative emotions in response to the burden of living with and managing diabetes, and might have fewer interpersonal contacts with others (e.g., with family, friends, or health professionals) and be more socially withdrawn, which will negatively impact blood glycemic control and HRQOL. This new information may contribute to furthering comprehensive theory development regarding Type D personality and its effects on people with type 2 diabetes.

Implications for practice

In this study, the findings for the indirect effects suggest directions for furthering practice for people with type 2 diabetes. First, we recommend that health professionals monitor clients with type 2 diabetes to determine the presence of Type D personality, which is a risk factor for adverse blood glycemic control and HRQOL. The health professionals must then plan and provide interventions toward reducing diabetes distress and social isolation, particularly for those with Type D personality. For example, we suggest that applying diabetes-specific psychological interventions had supporting evidence from a meta-analysis of randomized controlled trial studies toward reducing diabetes distress [46]. Others have indicated that using active listening and talking about the emotional experiences of patient also exert similar effects on reducing diabetes distress when compared with a psychological intervention [47]. Chen and Schulz [48] asserted that social interventions based around information and communications technology (ICT) such as using the internet or web-based apps would promote social contact and alleviate social isolation by providing connections with the outside world, improving social support, increasing engagement with activities of interest, and boosting self-confidence. ICT interventions using digital devices may be particularly useful during the current coronavirus disease-19 pandemic, which requires non-face-to-face contact, social distancing, and restricted gatherings [49].

Strengths and limitation

The first strength of this study was the use of a bootstrapping method for the statistical mediation analysis. The traditional method for a mediation test by Baron and Kenney [50] has previously been the most common. However, this method has been criticized for its lack of statistical power and its failure in testing indirect effects, and no longer seems to be recommended [31, 51]. The normal theory approach, called the Sobel test, has been used as a type of mediation analysis, but is criticized due to its inability to cope with indirect effects that have an asymmetric distribution [51]. To overcome the normality assumption, it is recommended to use the bootstrapping method, which provides more power in detecting indirect effects and reduces the risk of type I errors [52]. Structural equation modeling (SEM) is also frequently used for mediation analysis, and has the advantage of accounting for random measurement errors; however, results from a sufficient sample are substantially identical when applying the SEM and PROCESS-bootstrapping methods [53]. The second strength of the present study was the consideration of potential covariates among general participant characteristics, which might have threatened with the findings of the mediation model.

The main limitation of this study was its cross-sectional design, which induced difficult temporal interpretations of the mediation effects between Type D personality and adverse diabetes outcomes. Further research is recommended to use a longitudinal design.

Conclusions

Type D personality was found to directly affect HRQOL but not HbA1c among people with type 2 diabetes. Type D personality indirectly affected HbA1c and HRQOL through the diabetes distress and social isolation mediators, respectively. The indirect effect of Type D personality on HRQOL through diabetes distress was greater than through social isolation. For people with Type D personality, we recommend providing interventions to reduce diabetes distress and enhance social isolation, which in turn will improve their HbA1c and HRQOL.

List Of Abbreviations

Type D personality
distressed personality
HbA1c
Glycated hemoglobin
HRQOL
health-related quality of life
DS14
Type D scale
NA
negative affectivity
SI
social inhibition

PAID
Problem Areas in Diabetes
ICC
intraclass correlation coefficient
D-QOL
Diabetes-specific Quality of Life
VIF
variance inflation factor
CIs
confidence intervals
ICT
information and communication
SEM
structural equation modeling

Declarations

Funding This research was supported by a grant from the National Research Foundation of Korea (NRF) funded by the government of the Republic of Korea (MSIT) (NRF-2018R1A2B6001719). The funder did not participate in conducting or publishing the study.

Conflict of interest The authors have no conflict of interest to declare.

Ethical approval Ethical approval was obtained from the institutional review boards of the included university hospitals in South Korea (AJIRB-SBR-SUR-18-535; IUH-IRB 2020-05-036; CNUH-2020-176).

Informed consent Written informed consent was obtained from all participants included in this study.

Author contributions E.-H.L.: study conception and design; funding acquisition; data analysis and interpretation; draft preparation, review, and editing of the manuscript; approval of the submitted version of the manuscript. Y.H.L., D.C., E.H.K., and H.-J.K.: investigation; data interpretation; review and editing of the manuscript; approval of the submitted version of the manuscript.

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Figures

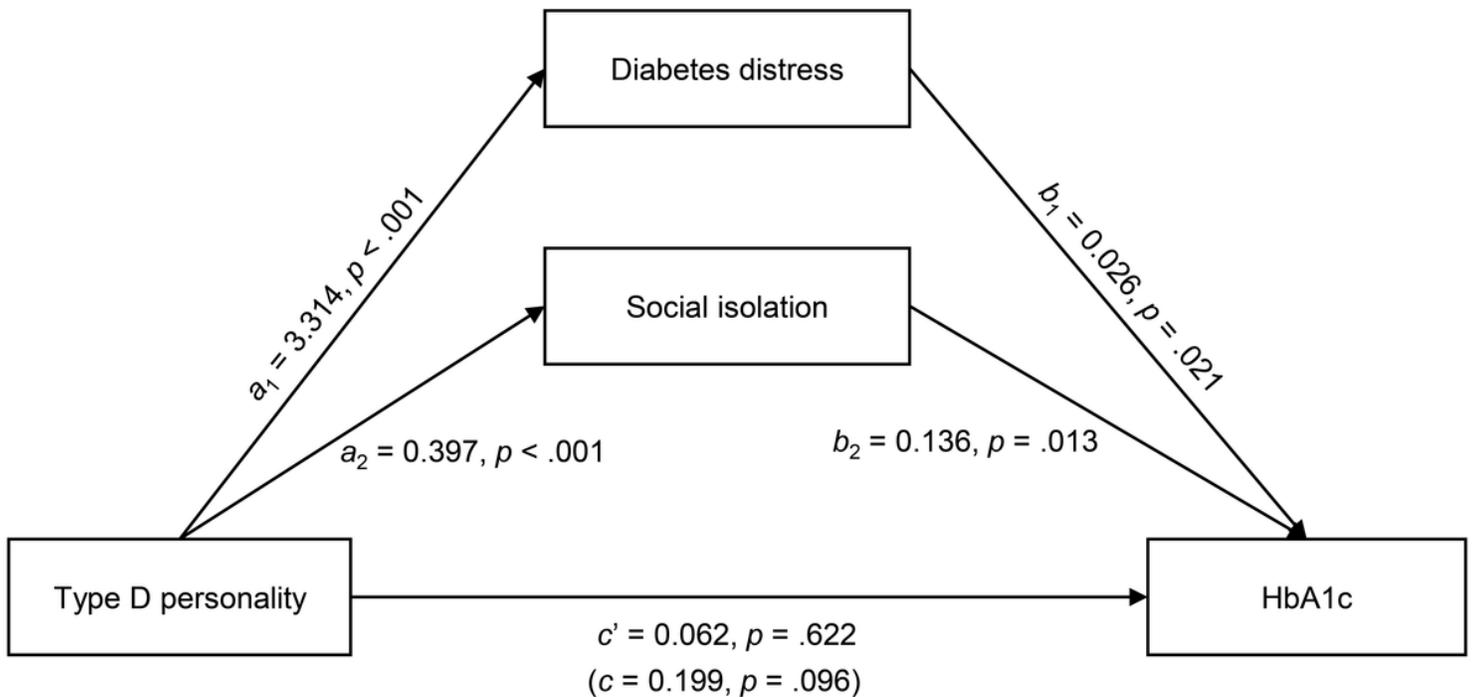


Figure 1

Parallel mediation model linking Type D personality with HbA1c. People with Type D personality were coded as 1 and others were coded as 0. a_1 : regression coefficient for Type D personality predicting diabetes distress; a_2 : regression coefficient for Type D personality predicting social isolation; b_1 : regression coefficient for diabetes distress predicting HbA1c while holding Type D personality and social isolation constant; b_2 : regression coefficient for social isolation predicting HbA1c while holding Type D personality and diabetes distress constant; c' : regression coefficient for Type D personality predicting HbA1c while holding diabetes distress and social isolation constant (direct effect); c : total effect.

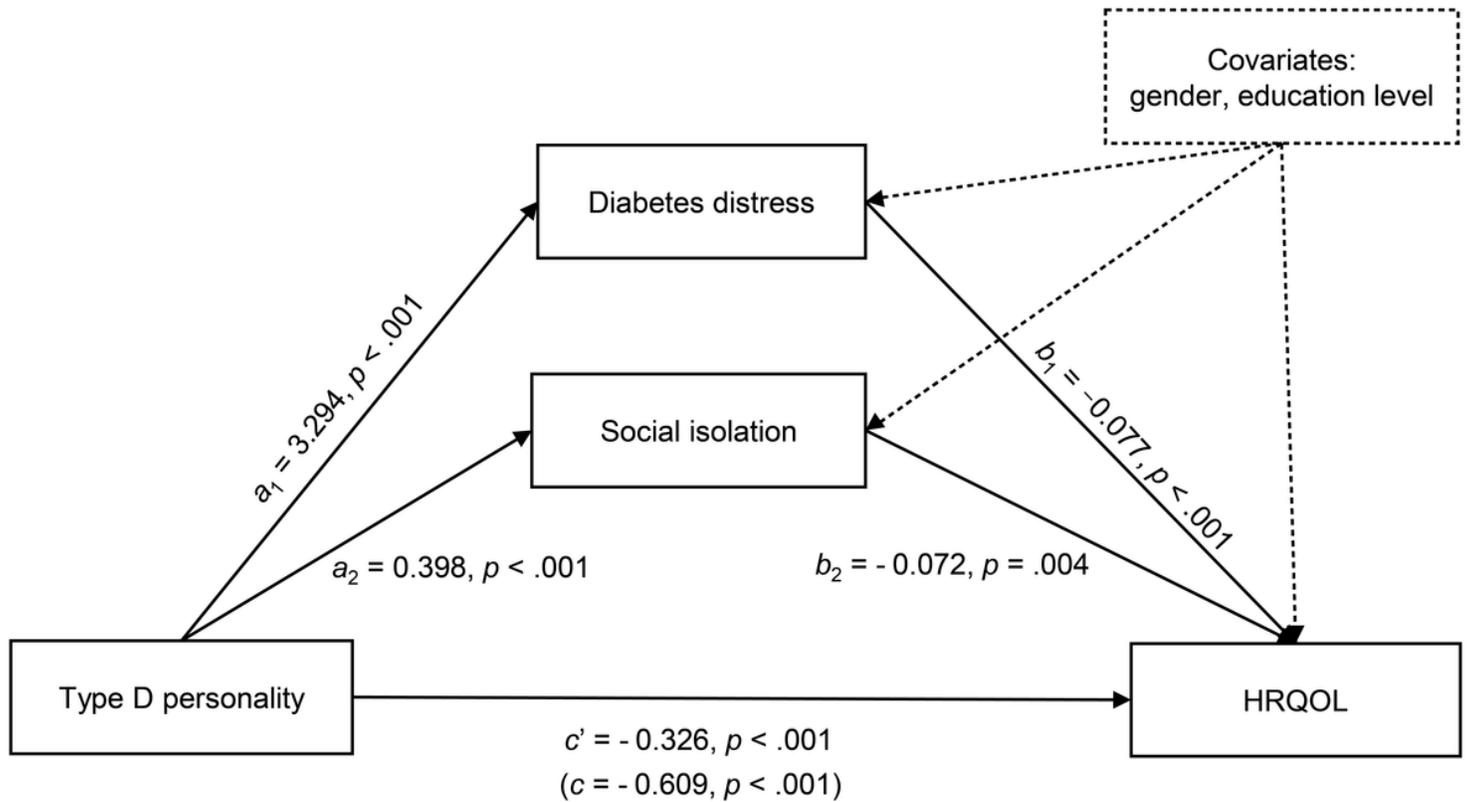


Figure 2

Parallel mediation model linking Type D personality with HRQOL while controlling for covariates. People with Type D personality were coded as 1 and others were coded as 0. a_1 : regression coefficient for Type D personality predicting diabetes distress; a_2 : regression coefficient for Type D personality predicting social isolation; b_1 : regression coefficient for diabetes distress predicting HRQOL while holding Type D personality, social isolation, gender, and education level constant; b_2 : regression coefficient for social isolation predicting HRQOL while holding Type D personality, diabetes distress, gender, and education level constant; c' : regression coefficient for Type D personality predicting HRQOL while holding diabetes distress, social isolation, gender and education level constant; c : total effect while controlling for gender and education level.

Supplementary Files

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