

Relationship of Type D Personality to Adverse Health Outcomes in People with Type 2 Diabetes: Parallel Mediating Effects of Diabetes Distress and Social Isolation

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Abstract

Background: This study aims to investigate the relationship of Type D personality to glycosylated hemoglobin (HbA1c) and health-related quality of life (HRQOL) directly, and also indirectly via 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 outpatient clinics were obtained from June 2020 to February 2021. The hypotheses of this study were tested using the PROCESS macro with 10,000 bootstrapping iterations to estimate 95% confidence intervals (CIs) for indirect (mediating) effects.

Results: Type D personality was present in 31.3% of the participants, and exerted a significant direct effect on HRQOL but not on HbA1c. Type D personality exerted a significant indirect effects on HbA1c via diabetes distress and social isolation (95% CI = 0.014 to 0.163 and 0.007 to 0.121, respectively), and on HRQOL via diabetes distress and social isolation (95% CI = -0.335 to -0.178 and -0.056 to -0.008, respectively). The indirect effects of Type D personality on HRQOL via diabetes distress had a greater magnitude than that via social isolation.

Conclusion: It is necessary for health professionals to monitor people with type 2 diabetes to determine whether Type D personality is present. Those with Type D personality should be provided with interventions to reduce diabetes distress and alleviate social isolation in order to improve their glycemic control and HRQOL.

Introduction

Type D (or “distressed”) personality is characterized by the combination of two constant personality traits: negative affectivity (NA) and social inhibition (SI) [1]. NA is the tendency to experience negative emotions, and SI is 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 diseases, it has since also been recognized as a risk factor for people with other medical conditions [3]. However, there is insufficient evidence for its relationship among people with type 2 diabetes [4].

According to the American Diabetes Association and European Association for the Study of Diabetes, the goals of type 2 diabetes treatment are to control blood glucose so as to prevent or delay complications, and to maintain the quality of life [5]. Glycosylated hemoglobin (HbA1c) is a standard objective marker of blood glucose control, and reflects average blood glucose levels over 2–3 months [6]. The term of “quality of life” is a concept that is too broad since it includes welfare, economic situations, and health statuses; however, health-related quality of life (HRQOL) is considered as a more-concise indicator to determine outcomes in clinical situations [7]. From these perspectives, HbA1c and HRQOL can represent outcome parameters for type 2 diabetes. Negative associations can therefore 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 at early stages [8]. However, the few studies that examined the relationship between Type D personality and HbA1c in people with type 2 diabetes produced inconsistent findings, with some indicating that people with Type D personality had a greater risk of high HbA1c levels [4, 9, 10], while another indicating no direct association and hence suggesting the need to explore its indirect effects via mediators [11].

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

The mechanisms that underlie the associations between Type D personality and adverse clinical outcomes are currently unclear [15]. It is therefore necessary to determine which factors mediate the adverse effects of Type D personality on health outcomes [14]. Psychosocial factors have been conjectured to be plausible mediators of these mechanisms [16].

Diabetes distress refers to negative emotions experienced in response to the burden of living with and managing diabetes [17, 18]. A previous study of people with type 2 diabetes found that those with Type D personalities had greater feelings of distress from diabetes [19]. Greater diabetes distress has been suggested to worsen blood glycemic control [20, 21] and reduce HRQOL in people with type 2 diabetes [22–24]. Together these findings suggest that the relationships between Type D personality and HbA1c and HRQOL are mediated by diabetes distress.

Another plausible pathway for how Type D personality predicts adverse diabetes outcomes is via social isolation, which is characterized as a lack of contact with others and social involvement [25]. An association has been reported between Type D personality and social isolation among both people with cardiovascular disease and those from a general population [26, 27]. Social isolation is known to have an association with HbA1c in people with diabetes [28], and to be negatively related to HRQOL among elderly people [29, 30]. Accordingly, Type D personality can be postulated to have an association with social isolation, which in turn relates to adverse HbA1c and HRQOL outcomes in people with type 2 diabetes.

If two or more mediators linked by the same independent and outcomes variables are weakly correlated with each other or not based on causality, they are parallel mediators [31]. Since no causal evidence exists between the diabetes distress and social isolation mediators, they are expected to be parallel mediators in the association between Type D personality and the diabetes outcomes of HbA1c and HRQOL.

In this study, we aimed to investigate the relationship of Type D personality to adverse outcomes (HbA1c and HRQOL) directly, and also indirectly via parallel mediators (diabetes distress and social isolation) in people with type 2 diabetes. The following two hypotheses were tested:

Hypothesis 1: Type D personality is related to HbA1c directly and also indirectly related via diabetes distress and social isolation in people with type 2 diabetes.

Hypothesis 2: Type D personality is related to HRQOL directly and also indirectly related via diabetes distress and social isolation in people with type 2 diabetes.

Methods

2.1 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 on 524 people with type 2 diabetes were obtained from June 2020 to February 2021 from outpatient clinics after receiving approval from the relevant institutional review boards. The inclusion criteria were being at least 19 years old, articulate in the Korean language, and undergoing a treatment regimen for type 2 diabetes (oral hypoglycemic agents, insulin, or both). The mean age of participants was 60.35 years (SD = 11.19 years). About one-third of them were female (35.9%), and three-quarters (75.6%) were taking oral hypoglycemic agents. The mean duration of diabetes diagnoses was 11.77 years (SD = 8.72 years).

2.2 Measurements

2.2.1 Type D personality

Type D personality was identified using the 14-item Type D Scale (DS14), which consists of two 7-item subscales measuring NA and SI [1]. Each item is scored on a 5-point rating scale ranging from 0 to 4, with the scores of each subscale ranging from 0 to 28. Cronbach's alpha values in the original study were 0.88 and 0.86 for NA and SI, respectively, and test-retest reliability coefficients were 0.72 and 0.82, respectively. The DS14 has been validated in various populations, including people with type 2 diabetes [19] and Koreans [33]. Cronbach's alpha values in the present study for NA and SI were 0.86 and 0.78, respectively. Type D personality was categorized using a criterion of ≥ 10 points on both the NA and SI subscales.

2.2.2 Diabetes distress

Diabetes distress was measured using a 5-item short-form version of the Problem Areas in Diabetes (PAID-5) [34] scale derived from the original 20-item version of PAID [35]. Each item is scored on a 5-point Likert scale from "not a problem" to "a serious problem." The PAID-5 has possible scores ranging from 0 to 20, with higher scores indicating greater diabetes-related distress. The Korean version of the PAID-5 had satisfactory factorial structural, convergent, and known-groups validities, internal consistency

(Cronbach's alpha = 0.87), and test–retest reliability (intraclass correlation coefficient = 0.89) among 440 people with type 2 diabetes [36]. Cronbach's alpha of the Korean version was 0.91 in the present study.

2.2.3 Social isolation

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

2.2.4 Glycated hemoglobin

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

2.2.5 Health-related quality of life

The Diabetes-Specific Quality of Life (D-QOL) was used to measure HRQOL and consisted of 16 items that were responded to on a 5-point Likert scale [37]. All items were reversed and averaged to ensure that higher scores indicated better HRQOL. The D-QOL demonstrated satisfactory content, factorial construct (using exploratory and confirmatory factor analyses), concurrent, and known-groups validities, and internal consistency (Cronbach's alpha = 0.92) among 402 people with type 2 diabetes. Cronbach's alpha of the D-QOL was 0.91 in the present study.

2.3 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 ANOVAs were performed to identify any covariates between the general characteristics of participants and the mediator/outcome variables (diabetes distress, social isolation, HbA1c, and HRQOL). The covariates were the general characteristics associated with both mediators and outcome variables [31]. Statistical assumptions of the multiple regression were determined before the mediation analysis. Multicollinearity among predictive variables was determined using the variance inflation factor (VIF). The Durbin-Watson statistic was computed to determine if the residuals from the multiple regression analysis were independent. Assumptions of linearity and homoscedasticity were determined using a plot of

standardized residuals versus standardized predicted values [31, 38]. The hypotheses of this study were analyzed using the PROCESS macro of SPSS [31]. A 10,000-bootstrap bias-corrected procedure was used to estimate the 95% confidence intervals (CIs) of indirect effects. An indirect effect was considered significant when its 95% CI did not include zero. Indirect-effect values were quoted to three decimal places.

Results

3.1 Preliminary analyses

The 524 participants included 164 (31.3%) categorized as Type D personality. The mean scores 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. Diabetes distress had a weak correlation with social isolation ($r = 0.10, p < .015$).

In the assumption tests, the VIF values for all predictive variables were < 10 for the HbA1c (1.04–1.12) and HRQOL (1.04–1.12) outcome variables, indicating a low redundancy among them. The values of the Durbin-Watson statistic were near 2 (1.92 and 1.90 for HbA1c and HRQOL, respectively) for the independent residuals of the dependent variables, indicating the absence of autocorrelation. The plot of standardized residuals versus standardized predicted values for HbA1c and HRQOL indicated satisfactory linearity (the LOESS curves centered along the entire X axis were close to zero) and homoscedasticity (all data on the plot were consistently and equally spread on the Y axis).

No covariates among the general characteristics were found to be associated with both mediators and HbA1c. However, gender was significantly associated with diabetes distress ($t = 3.93, p < .001$) and HRQOL ($t = 2.63, p = .010$), and education level was significantly associated with social isolation ($t = 3.05, p = .002$) and HRQOL ($t = 2.96, p = .003$) (Additional file 1). Gender and education level were therefore included as covariates in the subsequent parallel mediation model linking Type D personality and HRQOL.

3.2 Hypothesis 1

Figure 1 (and Additional file 2) indicates 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 other variables were kept constant. However, the direct effect of Type D personality on HbA1c ($c' = 0.062$) was insignificant when controlling for diabetes distress and social isolation ($p = .622$).

Table 1 indicates that there was a significant indirect effect of Type D personality on HbA1c via diabetes distress when controlling for social isolation ($a_1 \times b_1 = 3.314 \times 0.026 = 0.083$), because the 95% CI did not

include zero (0.014 to 0.163). This suggests that, on average, participants with Type D personality scored 0.083 points higher regarding HbA1c than those without due to the indirect effect via diabetes distress, when social isolation was kept constant. The indirect effect of Type D personality on HbA1c via social isolation was also significant when controlling for diabetes distress ($a_2 \times b_2 = 0.397 \times 0.136 = 0.054$, 95% CI = 0.007 to 0.121). Comparing the magnitudes of the two indirect effects revealed an insignificant difference (95% CI = -0.061 to 0.121), and the total effect was also not significant ($c = 0.199$, $p = .096$).

3.3 Hypothesis 2

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

Discussion

4.1 Findings for the study hypotheses

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

The mean HbA1c level of people with Type D personality did not differ from that of people without this personality, indicating that there was no direct association between Type D personality with HbA1c. Nefs et al. [11] similarly reported no difference after subdividing people without Type D personality into three groups based on their scores relative to the cutoff of ≥ 10 for the NA and SI sum scores: NA^+SI^- , NA^-SI^+ , and NA^-SI^- . In contrast, another study analyzing the continuous scores of the sums of NA and SI found a significant relationship between Type D personality and HbA1c [9].

Li et al. [41] reported a controversial finding of the association between Type D personality and HbA1c appearing to differ depending on whether Type D personality was considered a categorical or continuous variable. Type D personality is often measured as a categorical variable (e.g., Type D vs not Type D) with a criterion of ≥ 10 points. The cutoff score used in this categorical approach was criticized due to it being the median [42]. However, the cutoff score was empirically demonstrated to accurately classify Type D vs not Type D using item response theory analysis among people with cardiovascular diseases [43]. Those who have disagreed with the categorical approach insisted that Type D personality

was more accurately represented by the continuous constructs of NA and SI [42], and was analyzed more effectively using a continuous interaction method including quadratic NA and SI effects [44]. It seems to be important to reach a consensus on how to operationalize Type D personality.

The present study found a significant direct relationship of Type D personality to HRQOL. This finding is consistent with that of a previous study conducted on people with type 2 diabetes [9]. That study measured HRQOL using a generic instrument (the World Health Organization QOL-BREF) that measures physical health, psychological variables (e.g., self-esteem), social relationships (e.g., social support), and environment (e.g., physical safety) [45]. A generic instrument is applicable when measuring HRQOL on a healthy population or across healthy and diseased populations [7], whereas a disease-specific HRQOL instrument designed to focus on specific problems induced by an illness such as diabetes and its treatment is more effective in clinical situations [37]. It is therefore recommended that more studies are required into the relationship between Type D personality and HRQOL, with a particular focus on using a diabetes-specific HRQOL instrument.

The present study is the first to test hypotheses on the indirect effects of Type D personality on diabetes outcomes (HbA1c and HRQOL) via diabetes distress and social isolation, and these hypotheses were supported. This mediation-based research provided new information on how people with Type D personality readily experience negative emotions in response to the burden of living with diabetes, and how they might have fewer interpersonal contacts with others (e.g., family, friends, or health professionals) and be more socially withdrawn, which will negatively impact blood glycaemic control and HRQOL. This new information may further the development of a comprehensive theory regarding Type D personality and its effects on people with type 2 diabetes.

4.2 Implications for practice

The findings of this study for the indirect effects suggest directions for furthering the clinical interventions applied to people with type 2 diabetes. It is recommended that health professionals monitor clients with type 2 diabetes to determine whether Type D personality is present, since this is a risk factor for adverse blood glycaemic control and HRQOL. These health professionals must then plan and provide interventions aimed at reducing diabetes distress and social isolation, particularly among those with Type D personality. For example, providing diabetes-specific psychological interventions is recommended, since a meta-analysis of randomized control trials found that they reduce diabetes distress [46]. Others have indicated that using active listening and talking about the emotional experiences of patients also induce similar effects toward 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 2019 pandemic,

since this has increased experiences of no face-to-face contact, social distancing, and restricted gatherings [49].

4.3 Strengths and limitation

The first strength of this study was the use of a bootstrapping method in the statistical mediation analysis. The traditional mediation test method introduced by Baron and Kenny [50] has previously been the most common. However, that method has been criticized for its low statistical power and its lack of testing for indirect effects, and no longer seems to be recommended [32, 51]. The normal theory approach, called the Sobel test, has been used for mediation analysis, but is criticized due to its inability to cope with asymmetrically distributed indirect effects [51]. The bootstrapping method is recommended to overcome the requirement for a normality assumption, 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 analyses, and has the advantage of accounting for random measurement errors; however, the results obtained when analyzing a sufficient sample can be substantially identical when applying the SEM and PROCESS methods [53]. The second strength of the present study was its consideration of potential covariates from among the general characteristics of the participants, which would have threatened the validity of the findings obtained when analyzing the mediation model.

One limitation of the present study was its cross-sectional design, which induced difficult temporal interpretations of the mediation effects between Type D personality and adverse diabetes outcomes. A longitudinal design is recommended for further research.

Conclusions

This study has revealed possible mechanisms underlying the relationships between Type D personality and adverse health outcomes (HbA1c and HRQOL) in people with type 2 diabetes. Type D personality was found to directly affect HRQOL but not HbA1c. Type D personality indirectly affected HbA1c and HRQOL via the diabetes distress and social isolation mediators, respectively. The indirect effect of Type D personality on HRQOL via diabetes distress had a greater magnitude than that via social isolation. We recommend providing interventions to people with Type D personality that reduce diabetes distress and alleviate social isolation, which in turn will improve their blood glucose control and HRQOL.

List Of Abbreviations

CI: Confidence interval; D-QOL: Diabetes-Specific Quality of Life; DS14: Type D scale; HbA1c: Glycated hemoglobin; HRQOL: Health-related quality of life; ICT: Information and communications technology; NA: Negative affectivity; OHA: Oral hypoglycemic agents; PAID-5: 5-item short-form version of the Problem Areas in Diabetes; SD: Standard deviation; SE: standard error; SEM: Structural equation modeling; SI: Social inhibition; Type D personality: distressed personality; VIF: Variance inflation factor;

Declarations

Authors' contribution

E.-H.L.: study conception and design; funding acquisition; data analysis and interpretation; draft preparation, review, and manuscript editing; approval of the submitted version of the manuscript. Y.W.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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Availability of data and materials

The dataset used and/or analyzed during the current study are not publicly available due to ethical concerns.

Ethical approval and consent to participate

Ethical approval was obtained from the institutional review boards of the included university hospitals in the Republic of Korea (approval numbers AJIRB-SBR-SUR-18-535, IUH-IRB 2020-05-036, and CNUH-2020-176). All participants gave their written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

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.

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.

Figures

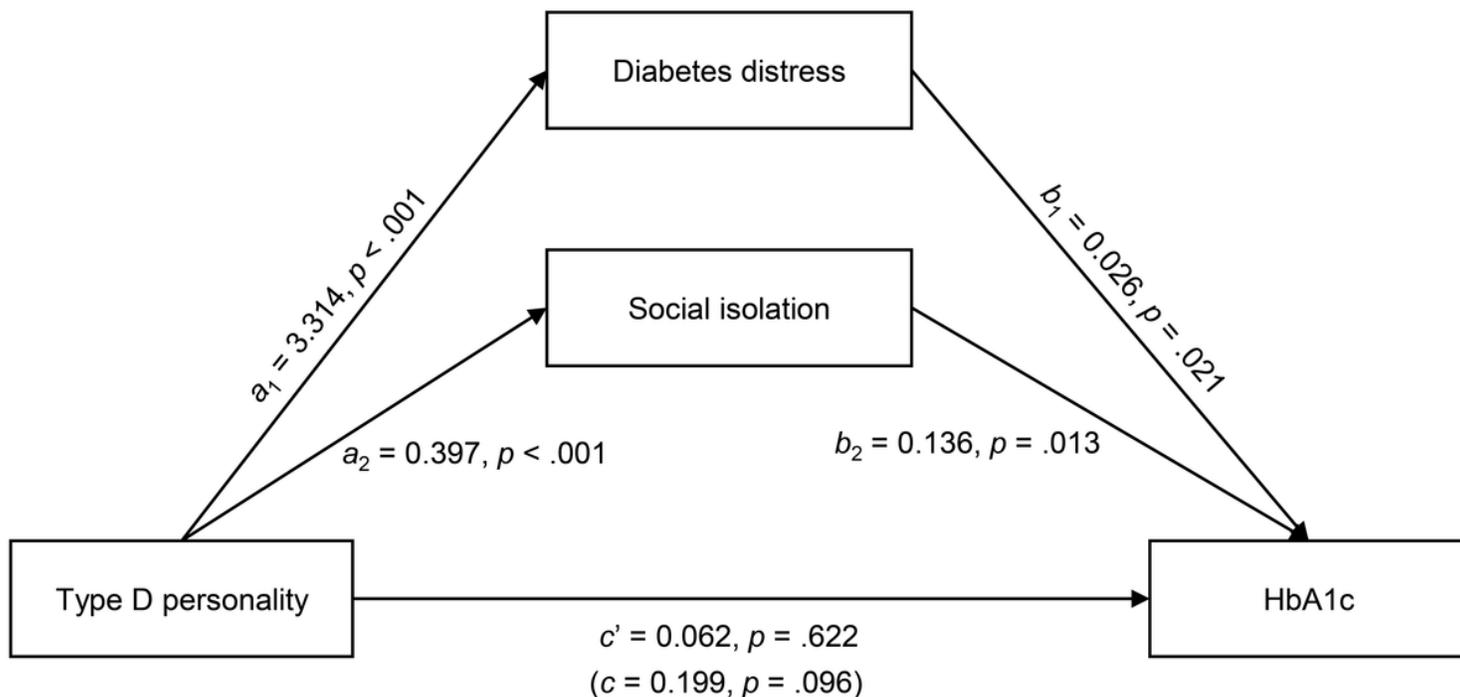


Figure 1

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.

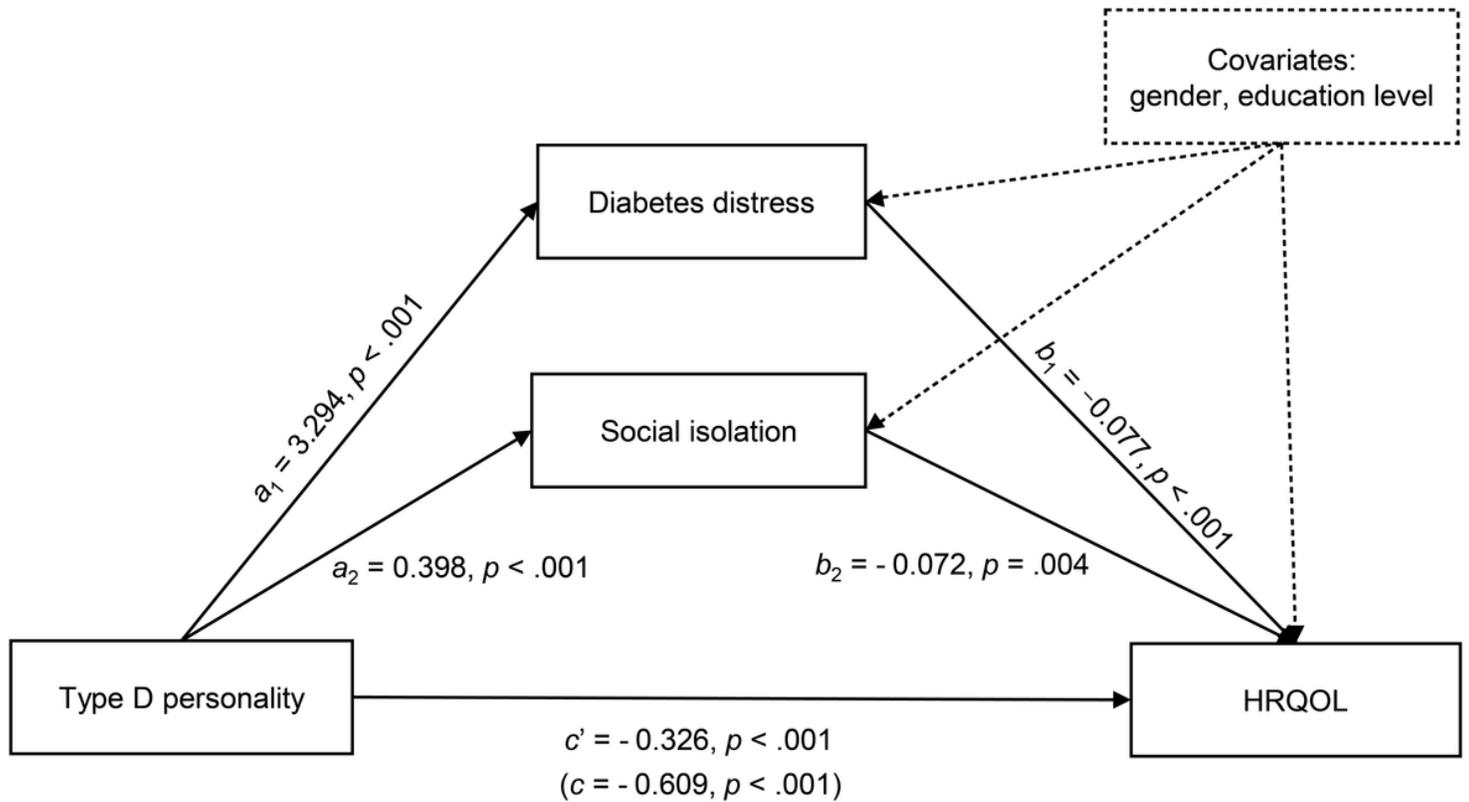


Figure 2

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.

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