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Personality traits and diabetes incidence among postmenopausal women

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Abstract

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Objective: We examined whether personality traits, including optimism, ambivalence over emotional expressiveness, negative emotional expressiveness, and hostility, were associated with risk of developing type 2 diabetes (hereafter diabetes) among postmenopausal women.

Methods: A total of 139,924 postmenopausal women without diabetes at baseline (between 1993 and 1998) aged 50 to 79 years from the Women's Health Initiative were prospectively followed for a mean of 14 (range 0.1–23) years. Multivariable Cox proportional hazards regression models were used to assess associations between personality traits and diabetes incidence adjusting for common demographic factors, health behaviors, and depressive symptoms. Personality traits were gathered at baseline using questionnaires. Diabetes during follow-up was assessed via self-report of physician-diagnosed treated diabetes.

Results: There were 19,240 cases of diabetes during follow-up. Compared with women in the lowest quartile of optimism (least optimistic), women in the highest quartile (most optimistic) had 12% (hazard ratio [HR], 0.88; 95% confidence interval [CI]: 0.84–0.92) lower risk of incident diabetes. Compared with women in the lowest quartile for negative emotional expressiveness or hostility, women in the highest quartile had 9% (HR, 1.09; 95% CI: 1.05–1.14) and 17% (HR, 1.17; 95% CI: 1.12–1.23) higher risk of diabetes, respectively. The association of hostility with risk of diabetes was stronger among nonobese than obese women.

Conclusions: Low optimism and high NEE and hostility were associated with increased risk of incident diabetes among postmenopausal women independent of major health behaviors and depressive symptoms. In addition to efforts to promote healthy behaviors, women's personality traits should be considered to guide clinical or programmatic intervention strategies in diabetes prevention.

Keywords

Ambivalence over emotional expressiveness; Diabetes; Hostility; Negative emotional expressiveness; Optimism; Personality traits

More than 30 million Americans, or 9.4% of the US population, have diabetes.¹ The prevalence of diabetes increases with age, with a 25.2% prevalence among those aged 65 years or older.¹ Type 2 diabetes is the most common type, accounting for 90% to 95% of all diagnosed cases in adults.² Overweight or obesity, family history of diabetes, race/ethnicity, and physical inactivity are major risk factors for diabetes.³ Accumulating evidence demonstrates that depression is also associated with increased risk of diabetes.^{4,5} However, in addition to depression, little is known about whether other psychological factors, including personality traits, are associated with diabetes risk.

The notion that personality might influence health has attracted public health attention. Studies have reported that type A personality (characterized by ambitiousness, hostility, competitiveness, and impatience) and type D personality (characterized by negative affectivity and social inhibition) are associated with adverse health outcomes.^{6,7} Links between other personality traits (such as optimism or hostility) and health are becoming evident.^{8,9} It has been suggested that the connections are likely mediated through both behavioral and physiological pathways,^{10,11} although the mechanisms remain unclear.

Previous studies of personality have focused on total mortality or cardiovascular disease outcomes, although some studies have examined personality characteristics that may increase diabetes risk.^{12–15} High levels of hostility have been associated with high fasting glucose levels,¹⁶ insulin resistance,^{17,18} and prevalent diabetes.¹⁹ In a study among a subcohort of the Women’s Health Initiative, cynicism was associated with incident diabetes during a 1-year follow-up period.¹² Two studies reported that trait anger and angry temperament were associated with increased risk of diabetes.^{13,14} It appears that no prior study has examined whether expression of negative emotions, or ambivalence over expression of negative emotions, are associated with risk of diabetes. Furthermore, few studies have investigated the association of potentially protective personality characteristics, such as optimism, with diabetes risk.¹⁵

From an applied perspective, an improved understanding of the contributions of personality to diabetes risk may help to educate people on personal risks, or to inform health care professionals about risks or protective factors faced by patients. The aim of the current study was to examine whether personality traits, including optimism, ambivalence over emotional expressiveness (AEE), negative emotional expressiveness (NEE), and hostility, were associated with risk of developing type 2 diabetes (hereafter diabetes) among postmenopausal women. Furthermore, we examined whether associations of personality traits with diabetes risk were mediated by behavioral pathways, such as diet, physical activity, smoking or high alcohol consumption, and whether these associations were modified by major diabetes risk factors, including obesity or race/ethnicity.

METHODS

Women’s Health Initiative

The WHI is a large prospective cohort study, designed to address the major causes of morbidity and mortality among postmenopausal women.²⁰ Details of the study are described elsewhere.²¹ Briefly, 161,808 women ages 50 to 79 were recruited from 40 clinical centers throughout the United States between 1993 and 1998. The WHI includes both clinical trial (CT) and observational study (OS) components. The study was approved by institutional review boards at all 40 clinical centers and at the coordinating center. All participants provided written informed consent. Reconsents were required to continue follow-up through the post-trial WHI extension periods (2005–2010 and 2011–2020). All participants in the WHI were followed-up every 6 months in the CT through 2005, and annually in the CT after 2005 and in the OS.

The following participants were excluded from the WHI cohort of 161,808 for this analysis: 12,655 women who had a history of cancer (except nonmelanoma skin cancer) at baseline; 636 who joined but provided no follow-up information; and 8,593 women with prevalent self-reported diabetes at baseline. After exclusions, 139,924 women remained for further analysis.

Measurements

Exposures—The following four personality traits were included as exposures. Detailed questions from which these exposure variables were derived are listed in Supplemental Table 1 (<http://links.lww.com/MENO/A375>), and basic statistics of each trait are summarized in Supplemental Table 2 (<http://links.lww.com/MENO/A375>).

Optimism—The revised version of the Life Orientation Test²² was used to assess optimism. It contains six items that measure constructs such as perceived control, positive expectations, and hopefulness. The responses were summed for possible ranges from 6 to 30. Higher scores indicate greater optimism.

Ambivalence over emotional expressiveness

AEE was measured with a three-item validated²³ subscale of the Ambivalent Over Emotional Expression Questionnaire.²⁴ Each item was coded from 1 = strongly disagree to 5 = strongly agree. The summary score was the average response value of the three questions ranging from 1 to 5, with a higher score indicating greater ambivalence in expressing negative emotions.

Negative emotional expressiveness—NEE was measured with four items of the Emotional Expressiveness Questionnaire.²⁴ Items are scored from 1 = strongly disagree to 5 = strongly agree. The summary score ranges from 1 to 5, with a higher score indicating greater expression of negative emotions.

Hostility—Hostility is a trait that is typically considered a negative cynical attitude toward others.¹¹ It was assessed by the cynical subscale of the Cook and Medley Questionnaire,²⁵ which contains 13 true/false questions as used in other WHI publications.^{9,12} The summary score is the sum of 13 true/false items resulting in a possible range from 0 to 13, with a higher score indicating greater hostility.

Follow-up and ascertainment of cases—All participants were followed from enrolment to date of diabetes diagnosed, date of death, loss to follow-up, or end of CT or OS follow-up (February 28, 2017), whichever occurred first. Incident diabetes during follow-up was the primary outcome. This was defined via self-report of a new diagnosis of diabetes treated with insulin or oral drugs during follow-up. Self-reported diabetes in the WHI has been found to be reliable and valid based on medication inventories, fasting glucose levels, and medical record review.^{26,27} For example, the two validation studies have shown that approximately 74% to 82% of self-reported incident diabetes were confirmed by fasting glucose or medical records. Approximately 3% to 5.5% had undiagnosed diabetes.

Covariates—Potential confounders measured at baseline included age, race/ethnicity (American Indian or Alaska Native, Asian or Pacific Islander, Black or African-American, Hispanic/Latina, non-Hispanic White, or other), education level (high school or less, some college/technical training, college or some postcollege, and master or higher), physical activity (<5, 5-<10, 10-<20, 20-<30, 30+ metabolic equivalent task values per week), smoking (never, former, current), alcohol intake (nondrinker, past drinker, current and <7

drinks/wk, current and 7 drinks/wk), family history of diabetes, body mass index (BMI), healthy eating index (HEI)-2005 score (quartile), depressive symptoms (none, mild, and moderate), family income, history of hormone therapy use (none, estrogen alone, estrogen and progestin, mixed), history of cardiovascular disease, waist-to-hip ratio, and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs). Total HEI-2005 score was a measure of diet quality that assesses conformance to the 2005 dietary guidelines for Americans.²⁸ Depressive symptom severity was measured with a short (six-item) form of the Center for Epidemiologic Studies Depression (CES-D) Scale plus two questions from the National Institute of Mental Health's Diagnostic Interview Schedule,²⁹ ranging from 0 to 1; higher scores indicate greater severity. Depressive symptoms were categorized as none, mild, or moderate based on previously defined cut-points of 0.009 and 0.06.²⁹

Statistical analysis

Pearson correlations were calculated between the four personality trait variables. Cox proportional hazards regression models were used to evaluate associations between personality traits and diabetes incidence, with results reported as hazard ratios and 95% confidence intervals (CIs). Personality trait scores were categorized into quartiles. Tests for linear trend were performed by evaluating personality trait variables as continuous predictors in the models.

Multivariable models were adjusted for potential confounders using a progressively adjusted regression approach. The first model included age, ethnicity, education, family income, history of cardiovascular disease, family history of diabetes, and study cohort (CT or OS and different treatment assignments for CTs) (model 1). The second model was additionally adjusted for major modifiable lifestyle factors including BMI, waist-to-hip ratio, prior hormone use, diet quality, physical activity, smoking, and alcohol consumption (model 2). The final model was adjusted for depressive symptoms (model 3). Missing data were included in the regression models as separate categories.

Interactions between personality traits and obesity status and race/ethnicity were tested by entering multiplicative interaction terms into the model. Statistical analyses were performed using SAS Version 9.4 (SAS Institute, Cary, NC). *P* values were two sided and statistically significant at values <0.05.

RESULTS

Table 1 presents means and proportions of baseline demographic and behavioral characteristics by optimism as an example of one of the personality traits. Compared with the lowest quartile of optimism (least optimistic), women in the highest quartile (most optimistic) were more likely to be younger, White (not of Hispanic origin), more educated, have higher family income, have lower history of cardiovascular diseases, have higher prior hormone use, have lower BMI, have higher levels of physical activity, have higher HEI-2005 score, smoke less, consume moderate levels of alcohol, and were less likely to have depressive symptoms. Other personality traits are not shown in the table but the patterns were similar, although in inverse direction to optimism.

All correlations between personality traits were significant, with the highest correlation between optimism and hostility ($r = -0.25$) and lowest between NEE and AEE ($r = -0.04$).

There were 19,240 cases of incident diabetes during an average of 14 years of follow-up. Table 2 shows associations between the four personality measures and risk of diabetes. There was a significant trend toward lower diabetes risk (P value for trend <0.0001) across increasing level of optimism and higher risk across increasing level of NEE (P value for trend <0.0001) and hostility (P value for trend <0.0001), after adjusting for age, race/ethnicity, education, income, history of cardiovascular disease, family history of diabetes, and study cohort (model 1). Hazard ratios for all three personality traits were attenuated slightly but remained significant after further adjustment for BMI, waist-to-hip ratio, smoking, alcohol intake, physical activity, diet quality, and prior hormone use and depressive symptoms. Compared with women in the lowest quartile of optimism (least optimistic), women in the highest quartile (most optimistic) had 12% lower risk of diabetes (hazard ratio, 0.88; 95% CI: 0.84–0.92). Compared with women in the lowest quartile of NEE or hostility (lowest level of NEE or least hostile), women in the highest quartiles had 9% (95% CI: 1.05–1.14) and 17% (95% CI: 1.12–1.23) higher risk of diabetes, respectively. There was no significant association between AEE and risk of diabetes. We also conducted an analysis by entering all four personality variables at once into the final-adjusted model. Three personality traits (optimism, NEE, and hostility) were slightly attenuated but all remained significant (data not shown).

There was a significant interaction between hostility and obesity status ($P=0.02$). Table 3 shows results stratified by obesity status. The association between hostility and risk of diabetes was stronger among nonobese than obese women. There were no significant interactions between optimism or NEE and obesity. Furthermore, there were no significant interactions between race/ethnicity or hormone use and any of the personality traits.

DISCUSSION

In this large, prospective study among more than 130,000 postmenopausal women, we observed that optimism was significantly associated with lower risk of diabetes and that NEE and hostility were significantly associated with increased risk of diabetes. Associations remained significant after adjustment for demographic characteristics, modifiable health behaviors, and depressive symptoms. Furthermore, our findings show that the association of hostility with diabetes was stronger among nonobese compared with obese women.

Our findings are consistent with previous studies reporting that positive psychological well-being was associated with lower risk of incident coronary heart disease and longevity.^{9,30,31} Several studies have also reported that positive psychological traits, including optimism, were associated with better glucose control and lower mortality rates in patients with type 2 diabetes.^{32,33} However, to our knowledge, there has been only one prior prospective study assessing optimism and risk of diabetes.³⁴ This study was based on middle-aged British men and women and reported that life satisfaction and emotional vitality, but not optimism, were associated with reduced risk of incident diabetes. The lack of association between optimism

and diabetes in that study may have been due to the single item measure that was used in their study or different study population characteristics, including age and sex.

We also observed that hostility and NEE were associated with increased risk of diabetes. A similar association of cynicism (using the same measurement of hostility as our study) and diabetes risk was reported in a small subset (n=3,658) of the WHI during a 1-year follow-up period.¹² Prior studies have reported that a high level of hostility was associated with high fasting glucose levels¹⁶ and insulin resistance.^{17,18} In addition, although our study is the first to demonstrate an association between NEE and risk of diabetes, two other studies have reported that angry temperament was associated with onset of diabetes.^{13,14}

It has been suggested that emotional stress may play a role in the etiology of diabetes.³⁵ Although most of these studies focused on depression as an expression of emotional stress, other forms of emotional stress, including hostility, NEE, or angry temperament may contribute to the development of diabetes.³⁵ We also observed that the relationship between hostility and diabetes varied by BMI and was stronger among nonobese than obese women. Reasons explaining these findings are unclear. Although obesity is a major risk factor for diabetes, there are many healthy weight individuals with endocrinology disruptions and diabetes.³⁶ Therefore, there are both obesity-related and non-obesity-related pathways in the development of diabetes. Because the association between hostility and risk of diabetes was adjusted for BMI, the observed association might largely reflect non-obesity-related pathways. It is possible that factors related to emotions are overshadowed by obesity-related mechanisms in obese women.

Although the mechanisms linking personality characteristics and diabetes incidence are unclear, several potential mechanisms have been suggested. One possibility is that personality may have indirect roles in the development of diabetes via behavioral pathways such as poor diet, physical inactivity, smoking, or high alcohol consumption. Previous studies suggested that positive psychological well-being is associated with healthy behaviors such as being physically active or engaging in a healthier diet, or in reduced smoking,³⁷ as also was shown in our data. However, we observed that optimism, hostility, and NEE were associated with the risk of diabetes independently of major health behaviors. Similarly, other studies have found that health behaviors do not entirely explain associations between well-being and incident heart disease as strongly as expected.^{9,15} Another possibility is that psychosocial factors may influence the development of diabetes directly through mechanisms such as glucose dysregulation and inflammation.¹⁰ Our data suggest that additional biological mechanisms related to cortisol regulation, or reduced inflammation may be more likely to reside on the pathway between personality characteristics and diabetes. There is some evidence showing that a rise in the concentration of proinflammatory cytokines and glucocorticoids, particularly cortisol, is present in conditions of chronic stress and often in depression,^{38,39} which may lead to accumulation of visceral fat or lipolysis or release of free fatty acids and then insulin resistance.^{40,41}

A personality trait implies a style of responding or thinking. Thus, knowing how an individual typically or likely thinks or behaves allows the attentive clinician to fashion the communication or treatment accordingly. Although it may be hard to change people's

personality traits, especially for older people, we can use information about personality to guide clinical or programmatic intervention strategies. For example, a person with low levels of optimism may be encouraged to set modest initial goals to encourage success. It may also be possible to intervene earlier in life to teach children to reduce their risks by encouraging optimism, positive attitudes, or appropriate emotional expressiveness. We should also realize that personality is shaped, in part, by environment, such that persons with lower optimism or higher hostility might reflect realistic responses to life circumstances, and appreciating these circumstances may assist us in developing appropriate prevention strategies.

Strengths of our study include the prospective study design with detailed information on potential confounders, large sample size, long-term follow-up, and assessment of a variety of personality characteristics. Our study also has several limitations. First, diabetes diagnosis was based on self-report. This may have resulted in some degree of misclassification of the outcome, which may have biased our estimates toward the null. However, validation studies in the WHI have shown a high degree of concordance between self-report with a criterion standard based on medical record review and with medication inventories.^{26,27} Second, our exposures and all covariates were based on information collected at baseline, and we did not examine any changes of personality variables during follow-up, which may have caused some exposure misclassification and further biased our results toward the null. Third, we did not perform formal mediation analysis to test the indirect effects of personality on risk of diabetes, because personality and health behavior were measured concurrently and a mediation analysis would be limited. Fourth, we were unable to adjust for frequency of medical visits, which may be related to both personality traits⁴² and to probability of detecting diabetes. However, we conducted a post-hoc analysis using mammogram receipt in the last 5 years (yes/no) and the number of mammograms that were received in the last 5 years as surrogate measures for contact with health providers (results not shown). Based on a subcohort analysis, we observed that optimism was associated with more contact with providers while NEE and hostility were associated with less contact. If fewer contact with providers is associated with more undiagnosed diabetes, our results were likely biased toward the null. In addition, our results are limited to postmenopausal women in the United States who were healthy at baseline and may not be generalizable to other populations.

CONCLUSIONS

Based on this large prospective cohort study, we found that personality traits, including optimism, NEE, and hostility, were associated with risk of diabetes among postmenopausal women. Associations were independent of major health behaviors and depressive symptoms, suggesting that women's personality traits may also be considered in prevention of diabetes in addition to promotion of healthy behaviors. Additional studies are needed to investigate possible mechanisms linking psychosocial factors and diabetes incidence. People may benefit from knowing how their own personality traits might heighten risk for diabetes, and potentially take protective actions to reduce risk. It may also be of benefit in future research to investigate whether diabetes prevention intervention may be tailored according to different personality traits.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1.

Baseline characteristics of participants by optimism^a

	Optimism ^b											
	Q1 (6-21) (least optimistic)			Q2 (22-23)			Q3 (24-25)			Q4 (26-30) (most optimistic)		
	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %
Age (mean, y)	35,875	63.0 (7.4)	33,726	63.3 (7.2)	31,263	63.1 (7.1)	35,615	62.6 (7.1)				
Ethnicity												
American Indian or Alaskan Native	173	0.5	125	0.4	100	0.3	118	0.3				0.3
Asian or Pacific Islander	1,386	3.9	943	2.8	635	2.0	514	1.4				1.4
Black or African-American	3,092	8.6	2,496	7.4	2,368	7.6	2,906	8.2				8.2
Hispanic/Latino	2,107	5.9	1,128	3.3	868	2.8	903	2.5				2.5
White (not of Hispanic origin)	28,471	79.4	28,620	84.9	26,910	86.1	30,786	86.4				86.4
Other	646	1.8	414	1.2	382	1.2	388	1.1				1.1
Education												
High school diploma or less	11,086	30.9	7,680	22.8	5,734	18.3	4,850	13.6				13.6
Some college/technical training	13,486	37.6	13,084	38.8	11,946	38.2	12,586	35.3				35.3
College graduate or some postcollege	6,471	18.0	7,390	21.9	7,613	24.4	9,608	27.0				27.0
Master degree or higher	4,547	12.7	5,359	15.9	5,751	18.4	8,322	23.4				23.4
Family income												
<\$20,000	851	24.7	7,727	21.5	4,719	14.0	3,723	11.9				11.9
\$20,000-\$34,999	719	20.9	9,031	25.2	7,837	23.2	6,891	22.0				22.0
\$35,000-\$49,999	541	15.7	6,402	17.8	6,820	20.2	6,375	20.4				20.4
\$50,000-\$74,999	454	13.2	5,630	15.7	6,456	19.1	6,263	20.0				20.0
\$75,000-\$99,999	179	5.2	2,285	6.4	2,806	8.3	3,010	9.6				9.6
\$100,000-\$149,999	128	3.7	1,435	4.0	1,888	5.6	2,106	6.7				6.7
\$150,000 or more	72	2.1	690	1.9	979	2.9	989	3.2				3.2
History of cardiovascular diseases												
No	2,635	76.5	27,369	76.3	26,379	78.2	24,602	78.7				78.7
Yes	533	15.5	6,193	17.3	5,331	15.8	4,722	15.1				15.1
Prior hormone use												

	Optimism ^b							
	Q1 (6-21) (least optimistic)		Q2 (22-23)		Q3 (24-25)		Q4 (26-30) (most optimistic)	
	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %
Never use	1,757	51.0	16,213	45.2	14,250	42.3	12,978	41.5
Estrogen alone	978	28.4	10,853	30.3	10,246	30.4	9,377	30.0
Estrogen and progestin	570	16.5	6,997	19.5	7,276	21.6	7,015	22.4
Mixed	140	4.1	1,812	5.1	1,954	5.8	1,893	6.1
Body mass index, kg/m ²	35,585	28.2 (6.1)	33,416	27.7 (6.1)	31,003	27.6 (5.6)	35,296	27.3 (5.6)
Waist to hip ratio (WHR)	35,702	0.81 (0.08)	33,567	0.81 (0.08)	31,341	0.81 (0.08)	35,450	0.80 (0.08)
Physical activity (MET-h/wk)	34,075	10.9 (13.1)	32,051	12.3 (13.3)	29,625	12.1 (13.8)	34,092	14.4 (14.7)
Healthy eating index (HEI)-2005 score	35,815	65.6 (11.1)	33,666	67.3 (10.6)	31,204	67.8 (10.5)	35,535	68.3 (10.5)
Smoking status								
Never smoked	17,873	49.8	17,019	50.5	15,745	50.4	18,438	51.8
Past smoker	14,365	40.0	14,122	41.9	13,262	42.4	14,792	41.5
Current smoker	3,180	8.9	2,208	6.5	1,920	6.1	2,041	5.7
Alcohol intake								
Nondrinker	4,261	11.9	3,387	10.0	3,145	10.1	3,350	9.4
Past drinker	7,209	20.1	5,631	16.7	4,910	15.7	5,538	15.5
<1 Drink/mo	4,768	13.3	4,249	12.6	3,755	12.0	4,161	11.7
<1 Drink/wk	7,545	21.0	7,233	21.4	6,526	20.9	7,004	19.7
1-<7 Drinks/wk	8,286	23.1	9,088	26.9	8,716	27.9	10,258	28.8
7+ Drinks/wk	3,535	9.9	3,936	11.7	4,027	12.9	5,101	14.3
Family history of type 2 diabetes								
No	21,924	61.1	21,802	64.6	20,584	65.8	24,131	67.8
Yes	11,604	32.3	10,341	30.7	9,359	29.9	10,151	28.5
Depressive symptoms								
None	20,855	58.1	25,244	74.9	24,878	79.6	29,966	84.1
Mild	6,186	17.2	4,811	14.3	3,853	12.3	3,732	10.5
Moderate	7,665	21.4	2,975	8.8	1,939	6.2	1,352	3.8

MET, metabolic equivalent.

^aThe total number does not always sum to 139,924 due to missing data. All difference tests across optimism were significant.

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Optimism was assessed by the revised version of the Life Orientation Test. It contains six items that measure constructs such as perceived control, positive expectations, and hopefulness. The responses were summed for possible ranges from 6 to 30. Higher scores indicate greater optimism. Q1, Q2, Q3, and Q4 refer to the first, second, third, and fourth quartile of optimism. The numbers in parentheses are the ranges for each quartile.

TABLE 2.

Associations between personality traits and diabetes risk

	Cases	Multivariable-adjusted model ^d HR (95% CI)	Multivariable-adjusted model ^b HR (95% CI)	Multivariable-adjusted model ^c HR (95% CI)
Optimism^d				
Q1 (6–21)	5,432	Reference	Reference	Reference
Q2 (22–23)	4,555	0.88 (0.85–0.90)	0.91 (0.88–0.95)	0.93 (0.89–0.97)
Q3 (24–25)	4,214	0.86 (0.83–0.90)	0.91 (0.87–0.95)	0.93 (0.89–0.97)
Q4 (26–30)	4,533	0.82 (0.78–0.85)	0.86 (0.83–0.90)	0.88 (0.84–0.92)
<i>P</i> for trend ^e		<0.0001	<0.0001	<0.0001
Ambivalence over emotional expressiveness (AEE)^d				
Q1 (1.00–2.33)	4,738	Reference	Reference	Reference
Q2 (2.67–3.00)	6,293	0.97 (0.94–1.01)	0.99 (0.95–1.03)	0.98 (0.95–1.02)
Q3 (3.33–3.33)	3,350	0.98 (0.93–1.02)	1.00 (0.95–1.05)	0.99 (0.95–1.04)
Q4 (3.67–5.00)	4,682	1.02 (0.97–1.06)	1.02 (0.98–1.07)	1.00 (0.96–1.05)
<i>P</i> for trend ^e		0.31	0.24	0.76
Negative emotional expressiveness (NEE)^d				
Q1 (1.00–2.25)	4,027	Reference	Reference	Reference
Q2 (2.50–2.75)	5,209	1.07 (1.02–1.11)	1.05 (1.01–1.10)	1.05 (1.01–1.10)
Q3 (3.00–3.00)	3,298	1.10 (1.05–1.15)	1.06 (1.01–1.12)	1.06 (1.02–1.12)
Q4 (3.25–5.00)	6,513	1.16 (1.11–1.21)	1.10 (1.05–1.14)	1.09 (1.05–1.14)
<i>P</i> for trend ^e		<0.0001	<0.0001	<0.0001
Hostility^d				
Q1 (0–1)	4,278	Reference	Reference	Reference
Q2 (2–3)	4,845	1.07 (1.02–1.11)	1.03 (0.99–1.07)	1.03 (0.98–1.07)
Q3 (4–5)	4,226	1.11 (1.06–1.16)	1.04 (0.995–1.09)	1.04 (0.99–1.08)
Q4 (6–13)	5,156	1.31 (1.25–1.36)	1.19 (1.14–1.24)	1.17 (1.12–1.23)
<i>P</i> for trend ^e		<0.0001	<0.0001	<0.0001

CI, confidence interval; CT, clinical trial; HR, hazard ratio; OS, observational study.

^a Adjusted for age at enrollment (in continuous), race/ethnicity (American Indian or Alaska Native, Asian or Pacific Islander, Black or African-American, Hispanic/Latina, non-Hispanic White, and other), education (high school or less, some college/technical training, college or some post-college, and master or higher), family income (<\$20,000, \$20,000-\$34,999, \$35,000-\$49,999, \$50,000-\$74,999, \$75,000-\$99,999, \$100,000-\$149,999, \$150,000, or more), history of cardiovascular disease (no, yes), family history of diabetes (no, yes), and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs).

^b Further adjusted for BMI, waist-to-hip ratio, smoking (never, former, current), alcohol intake (nondrinker, past drinker, current and <7drinks/wk, current and 7drinks/wk), physical activity (<5, 5-<10, 10-<20, 20-<30, 30+ metabolic equivalent [METs]/wk), prior hormone use (never use, estrogen alone use, estrogen plus progestin use, mixed), and quality of diet (quartile).

^c Further adjusted for depressive symptoms (none, mild, and moderate).

^d Q1, Q2, Q3, and Q4 for each exposure refer to first, second, third, and fourth quartile. The numbers in parentheses are the ranges for each quartile. The summary score for optimism ranges from 6 to 30. Higher scores indicate greater optimism. The fourth quartile refers to the most optimistic. The summary score for AEE (ambivalence over emotional expressiveness) was the average response value of the three questions ranging from 1 to 5, with a higher score indicating greater ambivalence in expressing negative emotions. The summary score for NEE (ambivalence over emotional expressiveness) ranges from 1 to 5, with a higher score indicating greater expression of negative emotions. The summary score for hostility is the sum of 13 true/false items resulting in a possible range from 0 to 13, with a higher score indicating greater hostility.

^e *P* for trend was estimated when the variable was analyzed as a continuous variable in the model.

TABLE 3.

Associations between personality traits and diabetes risk stratified by body mass index status^a

	BMI <30, kg/m ²	BMI 30, kg/m ²	
	HR (95% CI)	HR (95% CI)	P for interaction
Optimism ^b			0.17
Q1 (6–21)	Reference	Reference	
Q2 (22–23)	0.93 (0.88–0.99)	0.92 (0.87–0.98)	
Q3 (24–25)	0.91 (0.85–0.96)	0.95 (0.90–1.02)	
Q4 (26–30)	0.89 (0.84–0.95)	0.86 (0.81–0.92)	
P for trend ^c	0.002	<0.0001	
Ambivalence over emotional expressiveness (AEE) ^b			0.81
Q1 (1.00–2.33)	Reference	Reference	
Q2 (2.67–3.00)	0.97 (0.92–1.03)	1.00 (0.94–1.06)	
Q3 (3.33–3.33)	1.00 (0.93–1.06)	0.98 (0.92–1.05)	
Q4 (3.67–5.00)	1.01 (0.95–1.07)	0.99 (0.93–1.06)	
P for trend ^c	0.55	0.73	
Negative emotional expressiveness (NEE) ^b			0.74
Q1 (1.00–2.25)	Reference	Reference	
Q2 (2.50–2.75)	1.06 (1.00–1.12)	1.04 (0.98–1.11)	
Q3 (3.00–3.00)	1.06 (0.99–1.13)	1.07 (1.00–1.15)	
Q4 (3.25–5.00)	1.11 (1.05–1.18)	1.07 (1.003–1.13)	
P for trend ^c	0.0004	0.04	
Hostility ^b			0.02
Q1 (0–1)	Reference	Reference	
Q2 (2–3)	1.07 (1.01–1.13)	0.97 (0.91–1.04)	
Q3 (4–5)	1.07 (1.01–1.13)	0.98 (0.92–1.05)	
Q4 (6–13)	1.17 (1.10–1.24)	1.14 (1.07–1.22)	
P for trend ^c	<0.0001	<0.0001	

BMI, body mass index; CI, confidence interval; CT, clinical trial; HR, hazard ratio; OS, observational study.

^a Adjusted for age at enrollment (in continuous), race/ethnicity (American Indian or Alaska Native, Asian or Pacific Islander, Black or African-American, Hispanic/Latino, non-Hispanic White, and other), education (high school or less, some college/technical training, college or some postcollege, and master or higher), family income (<\$20,000, \$20,000-\$34,999, \$35,000-\$49,999, \$50,000-\$74,999, \$75,000-\$99,999, \$100,000-\$149,999, \$150,000 or more), history of cardiovascular disease (no, yes), family history of diabetes (no, yes), and different study cohorts (participation in OS or CTs, and different treatment assignments for all three CTs), BMI (in continuous), smoking (never, former, current), alcohol intake (nondrinker, past drinker, current and <7drinks/wk, current and 7drinks/wk), physical activity (<5, 5-<10, 10-<20, 20-<30, 30+ metabolic equivalent [METs]/wk), and quality of diet (quartile), and depressive symptoms (none, mild, and moderate).

^b Q1, Q2, Q3, and Q4 for each exposure refer to first, second, third, and fourth quartile. The numbers in parentheses are the ranges for each quartile. The summary score for optimism ranges from 6 to 30. Higher scores indicate greater optimism. The fourth quartile refers to the most optimistic. The summary score for AEE (ambivalence over emotional expressiveness) was the average response value of the three questions ranging from 1 to 5, with a higher score indicating greater ambivalence in expressing negative emotions. The summary score for NEE (ambivalence over emotional expressiveness) ranges from 1 to 5, with a higher score indicating greater expression of negative emotions. The summary score for hostility is the sum of 13 true/false items resulting in a possible range from 0 to 13, with a higher score indicating greater hostility.

^c *P* for trend was estimated when the variable was analyzed as a continuous variable in the model.