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Variability in sleep disturbance, physical activity and quality of life according to level of depressive symptoms in women with Type 2 diabetes

S. C. Danhauer[1], **G. A. Brenes**[2], **B. J. Levine**[1], **L. Young**[3], **H. A. Tindle**[4], **E. L. Addington**[5], **R. B. Wallace**[6], **M. J. Naughton**[7], **L. Garcia**[8], **M. Safford**[9], **M. M. Kim**[10], **E. S. LeBlanc**[11], **B. M. Snively**[12], **L. G. Snetselaar**[6], **S. Shumaker**[1]

[1]Department of Social Sciences and Health Policy, Wake Forest School of Medicine

[2]Department of Internal Medicine, Section on Gerontology and Geriatric Medicine, Wake Forest School of Medicine, Winston Salem, NC

[3]Department of Medicine, Division of Endocrinology and Metabolism, Section on Gerontology and Geriatric Medicine, UNC School of Medicine, Chapel Hill, NC

[4]Division of General Internal Medicine and Public Health, Department of Medicine, Vanderbilt University Medical Center, Nashville, TN

[5]Department of Medical Social Sciences, Northwestern University Feinberg School of Medicine, Chicago, IL

[6]Department of Epidemiology, University of Iowa College of Public Health, Iowa City, IA

[7]Division of Cancer Prevention and Control, Department of Internal Medicine, The Ohio State University, Columbus, OH

[8]Department of Public Health Sciences, University of California Davis School of Medicine, Davis, CA

[9]Department of Medicine, Weill Cornell Medical College, New York, NY

[10]Center for Biobehavioral Health Disparities Research, Department of Community and Family Medicine, Duke University, Durham, NC

[11]Kaiser Permanente Center for Health Research NW, Portland, OR, USA

[12]Department of Biostatistical Sciences, Division of Public Health Sciences, Wake Forest School of Medicine, Winston Salem, NC

Abstract

Aims—To examine (1) the prevalence of depressive symptoms in women with Type 2 diabetes, (2) the associations between depressive symptoms and the following dependent variables: sleep disturbance; physical activity; physical health-related; and global quality of life, and (3) the

Correspondence to: Suzanne C. Danhauer. danhauer@wakehealth.edu.

Competing interests

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potential moderating effects of antidepressants and optimism on the relationship between depressive symptoms and dependent variables.

Methods—Participants in the Women's Health Initiative who had Type 2 diabetes and data on depressive symptoms (*N*=8895) were included in the analyses. In multivariable linear regression models controlling for sociodemographic, medical and psychosocial covariates, we examined the main effect of depressive symptoms, as well as the interactions between depressive symptoms and antidepressant use, and between depressive symptoms and optimism, on sleep disturbance, physical activity, physical health-related quality of life and global quality of life.

Results: In all, 16% of women with Type 2 diabetes reported elevated depressive symptoms. In multivariable analyses, women with depressive symptoms had greater sleep disturbance ($P<0.0001$) and lower global quality of life ($P<.0001$). We found evidence of significant statistical interaction in the models for quality-of-life outcomes: the increased risk of poor physical health-related quality of life associated with antidepressant use was stronger in women without vs with depressive symptoms, and the association between greater optimism and higher global quality of life was stronger in women with vs without depressive symptoms.

Conclusions—To improve health behaviours and quality of life in women with Type 2 diabetes, sociodemographic and medical characteristics may identify at-risk populations, while psychosocial factors including depression and optimism may be important targets for non-pharmacological intervention.

Introduction

Depressive symptoms in adults with diabetes can have a negative impact on glycaemic control, health behaviours (e.g. physical activity, medication adherence), symptom severity, sleep, functional status, quality of life, cardiovascular health and mortality [1–7]. Adults with diabetes are more likely to report significant depressive symptoms than those without diabetes [8,9]; however, estimated rates of clinically significant depressive symptoms among adults with diabetes have ranged widely (10.6–50.6%) [1,2,8,9].

Depressive symptoms disproportionately affect women compared with men with diabetes, consistent with trends in the general population [8]. Depression has been reported to be twice as likely in women than in men with diabetes, but estimated prevalence varies widely (14.3–48.4% among women with diabetes) [8,9]. Research in larger samples of women with diabetes is needed to better estimate rates of depression and identify whether it uniquely contributes to health-related outcomes and quality of life.

The effects of depression among people with diabetes may depend, in part, on treatment for depression. Adults with diabetes, particularly older adults, tend to receive pharmacological treatment for depression [9], but the results are mixed. Although antidepressant use can improve glycaemic control in adults with comorbid depression and diabetes [10,11], it also is associated with poorer physical health-related quality of life [12]; therefore, the effects of antidepressant use among adults with diabetes require further study [10].

Additional research is also needed to examine the effects of positive psychological characteristics, such as optimism, in people with diabetes [13]. Dispositional optimism (the

tendency to expect positive future events) is associated with lower rates of depression among older adults and may mitigate its negative effects on health [14–16]. Optimism is associated with better health and behaviours critical to optimizing care of diabetes, including diet and physical activity [15,17–19]; thus, higher levels of optimism may be particularly important for maintaining quality of life in people with diabetes and comorbid depression, which is characterized by poor self-care.

The aims of the present study were: (1) to estimate the prevalence of depressive symptoms in a sample of middle-aged and older women (N=9300) with diabetes; (2) to examine the association between level of depressive symptoms and sleep disturbance, physical activity, physical health-related quality of life and global quality of life, before and after adjusting for demographic, medical and psychosocial variables; and (3) to examine whether antidepressant use or optimism modifies the relationship between depressive symptoms and outcomes of interest.

Methods

Study population

The Women's Health Initiative (WHI) is a longitudinal study of 161 809 post-menopausal women originally recruited at 40 clinical centres across the USA between 1993 and 1998. Women were enrolled either in the WHI observational study (n=93 676) or to randomized clinical trials (n=68 133) [20]. Women were 50–79 years of age at recruitment and had to be postmenopausal at baseline. For these analyses, we included data from the WHI baseline visit (clinical trials and observational study), when depressive symptoms were first assessed, and narrowed the sample to include only women with a history of Type 2 diabetes determined via self-reported diagnosis of diabetes mellitus (reported ever having diabetes beginning at age ≥20 years without any hospitalizations for diabetic coma) or current use of diabetic medications. This definition was also used in a previous WHI publication [21]; self-reports of Type 2 diabetes have been found to be reliable [22].

Measures

Main exposure variable: presence/absence of depressive symptoms.— Depressive symptoms over the past week were measured with six items from the Centres for Epidemiological Studies Depression scale and two items from the Diagnostic Interview Schedule [23]. Responses were scored according to the Burnam algorithm, which computes a depression score from 0 to 1, with scores >0.06 indicating greater probability of depressive symptoms [23]. We dichotomized scores at this threshold and defined a group with strong evidence of depressive symptoms [score >0.06] and those without [score ≤0.06]. In the present paper we use the terms 'presence/absence of depressive symptoms' and 'depressed status' interchangeably; both indicate a dichotomous classification pertaining to greater or lesser probability of depressive symptoms according to the Burnam algorithm.

Outcome (dependent) variables—We considered the following outcomes in relation to presence/absence of depressive symptoms in our statistical models.

(1) Sleep disturbance. The five-item WHI Insomnia Rating Scale (WHIIRS) was used as the measure of sleep disturbance. This assesses difficulty falling asleep, waking up several times at night, waking up earlier than planned, having trouble getting back to sleep after waking up early, and overall sleep quality. Reliability and validity of the scale has been established [24]. Scores range from 0 to 20, with higher scores indicating greater sleep disturbance.

(2) Physical activity. Physical activity level was quantified as total energy expended from recreational physical activity (MET-h/week). Self-reported mild, moderate and strenuous physical activities, in addition to walking, were included in this summary measure.

(3) Physical health-related quality of life. The physical component summary score from the RAND-36 was used as a measure of physical health-related quality of life [25]. This measure assesses four physical subscales: (1) general health perceptions; (2) physical functioning (i.e. ability to perform vigorous/moderate intensity activities that one might do in a typical day); (3) bodily pain; and (4) role limitations (i.e. problems with work and other daily activities attributable to physical health). For each subscale, scores were obtained by summing responses to the individual questions linked to that particular subscale. Scores are transformed to a scale from 0 to 100, with higher scores indicating higher levels of functioning. These scales have demonstrated reliability and adequate construct validity [25]. The subscales are weighted in the computation of the physical component summary score [25].

(4) Global quality of life. This was measured using a single item: ‘Overall, how would you rate your quality of life?’ [26]. Response categories were on a scale from 0 (worst) to 10 (best).

Covariates—To characterize the sample and to examine covariates that have been associated with depression and the outcomes of interest, we included the following measures.

(1) Demographic and personal characteristics. Participants self-reported age, race/ethnicity (non-Hispanic white, Hispanic, black, other), educational attainment (≤ high school, some college/vocational, 4-year college degree, postgraduate), income (< $50,000, $50,000–99,999, ≥$100,000), and marital status (married/with partner, not married/no partner) at baseline.

(2) Antidepressant medication use at baseline (yes/no). Use of antidepressants was indicated as reported use of any of the following medication classes: tetracyclics; monoamine oxidase inhibitors; modified cyclics; selective serotonin reuptake inhibitors; tricyclic agents; and miscellaneous antidepressants.

(3) Number of comorbid conditions. History of any of the following prevalent and burdensome conditions were self-reported on the baseline survey: asthma, emphysema, cardiovascular disease, osteoarthritis, hypertension, cancer/malignancy, and hip fracture reported at age ≥55 years. We summed the number

of comorbid conditions reported for each woman, and then created an ordinal variable of 0, 1 or ≥2 comorbid conditions.

(4) Optimism. This was assessed at baseline using the six-item Life Orientation Test-Revised (e.g. 'I'm always hopeful about my future' and 'In unclear times, I usually expect the best'), with Cronbach's α=0.78, test–retest reliability of 0.68, and adequate predictive and discriminant validity [14]. A summary score was calculated from the six components, coded from 1=strongly disagree to 5=strongly agree. Scores range from 6 to 30, where a higher score indicated greater optimism [14].

(5) Social support. Nine questions from the Medical Outcomes Study Social Support Questionnaire were used to measure the social support available to WHI participants [27]. Responses were on a five-point scale ranging from 'none of the time' to 'all of the time'. Responses to all nine items were summed together, forming a total social support score (range 9–45), with higher scores indicating higher levels of social support [27].

Statistical analysis

To characterize the sample and provide descriptive statistics, we calculated the mean and standard deviation as well as the range for continuous variables, and the count and percentage for categorical variables, stratified by depressed status. We conducted *t*-tests (for the continuous covariates) and chi-squared tests (for the categorical, included ordered categorical, covariates) to test differences in covariate levels by depressed status. We additionally examined Spearman correlation coefficients among all variables included in our analyses.

We first conducted bivariate analyses to examine the association between our primary exposure variable of interest (depressed status) and each of our four dependent variables of interest (sleep disturbance, physical activity, physical health-related and global quality of life) by depressed status. We compared means and medians of the dependent variables by level of depressed status. Next we modelled these four dependent variables in separate multiple linear regression models. In addition to the main variable of interest (depressed status),we included the covariates age, race/ethnicity, education, household income, marital status, antidepressant use, number of comorbid conditions (0, 1, ≥2), optimism, and social support in our models, and also included interaction terms between presence/absence of depressive symptoms and both optimism (optimism*depressed status) and antidepressant use (antidepressant use*depressed status). In models where interaction terms were not significant, we removed the interaction terms and report results from the main-effects-only model, to allow a more straightforward interpretation of model parameter estimates. All bivariate and multivariate analyses are complete-case analyses. We used a two-tailed α level of 0.05 throughout. All analyses were conducted with SAS v.9.4. (Cary, NC, USA).

Results

Of 161 809 women with WHI (observational study + clinical trials) baseline data, 9300 reported a history of Type 2 diabetes. Of these, 8895 reported data on the depressive symptoms measure. These 8895 constituted our analytical sample. In this sample of middle-aged and older women with a history of Type 2 diabetes, the prevalence of depressive symptoms (Burnam algorithm score >0.06) was 16.2% (n=1443; Table 1). Table 1 also presents additional baseline characteristics of the sample stratified by depression status. While age spanned the range of 50–79 years in both groups, women in the depressed group were, on average, younger (mean age 62.9 years) than the non-depressed women (mean age 64.7 years). Both groups comprised predominantly non-Hispanic white people, although the proportion was lower in the depressed group (61.5%) vs the non-depressed group (67.9%). Significantly more of the depressed group (53.1%) was not married/had no partner than the non-depressed group (44.0%). Almost 21% of the depressed group had at least a 4-year college degree, while the corresponding percentage for the non-depressed group was 29%. The depressed women were more likely to report a household income of < $50,000 (76.7%) than non-depressed women (70.1%). Depressed women were more likely (66.5%) to report two or more comorbid conditions than the non-depressed women (57.0%). Among the depressed women, 20.7% reported using some type of antidepressant at baseline, with selective serotonin reuptake inhibitors being the most common type; among the non-depressed women, 8.5% reported use of antidepressants, with tricyclics being the most common type in this group. Both social support and optimism scores were lower among the depressed group.

We examined correlations between all study variables (Table 2). We next examined unadjusted (crude) bivariate associations between presence/absence of depressive symptoms and the outcome variables (sleep disturbance, physical activity, physical health-related and global quality of life). In these unadjusted bivariate analyses using the t-test, each of the outcome variables was statistically significantly better (all P values <0.0001) in the non-depressed group (Table 3). Wilcoxon tests conducted on the median values similarly produced a set of P values all <0.0001.

Finally, we examined whether the significant associations between presence/absence of depressive symptoms and each outcome (sleep disturbance, physical activity, physical health-related and global quality of life) remained after adjustment for covariates. We also examined the data for presence of significant interactions between presence/absence of depressive symptoms and both optimism and antidepressant use.

We found a significant association for presence/absence of depressive symptoms with respect to sleep disturbance [b=2.84, 95% CI 2.55–3.13; P=0.001 (Table 4)], with depressed women having higher predicted levels of sleep disturbance. Neither the antidepressant use*depressed status interaction nor the optimism*depressed status interaction was statistically significant.

No significant association was found between presence/absence of depressive symptoms and physical activity (Table 4) after covariate adjustment. No interactions (antidepressant

use*depressed status, optimism*depressed status) were significant in this model. Of all of the models examined, the model for physical activity had the lowest R^2 value (0.03).

For physical health-related quality of life, we found a significant interaction between antidepressant use and depressed status [b=2.11, 95% CI 0.41–3.81; P=0.02 (Table 4)]. Among the non-depressed, being on antidepressants was associated with a significantly lower (almost 5 points lower) physical health-related quality of life compared with those not on antidepressants. Among the depressed, the negative effect on physical health-related quality of life associated with being on antidepressants was smaller (close to 3 points).

For global quality of life, there was a significant interaction between optimism and presence/absence of depressive symptoms (Table 4). Depressed status was associated with lower predicted global quality of life, and higher optimism with better predicted global quality of life. The positive association between optimism and global quality of life was stronger (i.e. the slope relating optimism to predicted global quality of life was steeper) among depressed than non-depressed women (Fig. 1).

Discussion

In this analytical sample of 8895 middle-aged and older women with Type 2 diabetes, 16.2% reported a significant level of depressive symptoms. This prevalence is lower than that reported in many previous studies, including a meta-analysis that found the prevalence of depression among women with diabetes to be 23.8% [8]; however, it is similar to recent findings from a nationally representative US sample. In an analysis of the 2005–2012 US National Health and Nutrition Examination Survey (NHANES) data, prevalence of clinically relevant depression was 14.3% among women with diabetes [9]. Differences in methodology may have contributed to these discrepancies. For example, the NHANES analysis included adults aged ≥30 years and used the Patient Health Questionnaire to assess depressive symptoms, whereas the present analysis of the WHI focused on middle-aged and older women (age 50–79 years) and used the Burnam algorithm to measure elevated depressive symptoms.

Presence/absence of depressive symptoms showed significant bivariate associations with all outcome variables, that is, sleep disturbance, physical activity, physical health-related quality of life and global quality of life; however, in multivariable analyses, depressed status was not statistically significantly associated with physical activity or physical health-related quality of life. Other factors, such as age, race, socio-economic status, medical comorbidity, antidepressant use, social support and optimism, remained uniquely associated with these outcomes. This suggests that psychosocial factors other than depression (i.e. optimism and social support) may be important targets for increasing physical activity and physical health-related quality of life, and that sociodemographic and medical characteristics may be used to identify women with the greatest need for interventions to improve these two outcomes.

While the main effect of depressive symptoms was not significant for physical health-related quality of life, we found a significant interaction between presence/absence of depressive symptoms and antidepressant use. In both non-depressed and depressed women with Type 2

diabetes, the association between antidepressant use and physical health-related quality of life was negative, although it was more strongly negative among the non-depressed. This is consistent with prior longitudinal research in adults with comorbid depression and diabetes [12]. Thus, evidence is growing that antidepressant use is associated with poorer physical health-related quality of life among adults with diabetes, despite recent reviews that identified improved glycaemic control in trials of antidepressants among adults with comorbid depression and diabetes [10,11]. In the present study, antidepressant use also was associated with lower levels of physical activity but was unrelated to sleep disturbance or global quality of life. The relationship between antidepressant use and diabetes-related outcomes warrants additional investigation.

The present results indicate that depression in women with diabetes is more strongly related to poorer sleep and global quality of life. While these cross-sectional analyses do not establish causality, our findings support previous research suggesting that addressing depression in women with diabetes may improve other health-related outcomes. Longitudinal, population-based research suggests that US adults with comorbid diabetes and depression who receive psychotherapy have greater quality of life than those receiving no treatment for depression [12], but intervention trials in adults with diabetes have not focused on sleep outcomes. A recent meta-analysis demonstrated that cognitive behavioural therapy, in particular, improves depression, quality of life, and fasting glucose among adults with comorbid depression and diabetes [28]; however, compared with pharmacological treatment for depression in adults with diabetes, use of psychological services is low (~15%) [9]. More accessible and effective non-pharmacological interventions for comorbid depression in people with diabetes therefore remain needed.

Optimism was significantly associated with better scores on all four outcomes of interest. Moreover, the association between greater optimism and higher global quality of life was stronger in women with vs without depressive symptoms, consistent with the hypothesis that optimism may buffer against the negative impact of depressive symptoms on well-being. The totality of evidence, which our findings support, suggests that optimism may be an important target for improving multiple outcomes in women with Type 2 diabetes, particularly for those with comorbid depression. Previous research with other populations indicates that interventions can increase optimism [29]. A small pilot study (N=15) of a positive psychological intervention for adults with Type 2 diabetes reported increased optimism, but additional research in larger samples is needed [30]. In addition to the outcomes supported by our findings (i.e. sleep disturbance, physical activity, physical health-related and global quality of life), intervention trials should examine objective health outcomes (e.g. insulin levels) and the behavioural (e.g. improved diet and medication adherence) and physiological (e.g. decreased inflammation), mechanisms by which positive psychological constructs such as optimism may improve the health of individuals with diabetes [13].

The present study is the largest sample to date to examine the prevalence of depressive symptoms among women with Type 2 diabetes and the relationships among depressed status, antidepressant use, optimism, and important diabetes-related outcomes. In this sample, depressive symptoms were common and associated with poorer sleep, lower

physical activity, and poorer physical health-related and global quality of life. Given the inherent limitations of cross-sectional analyses, longitudinal research is needed to further explore these findings. Nonetheless, our results, in combination with findings from previous studies, indicate that the health and well-being of women with Type 2 diabetes may benefit from non-pharmacological approaches to decreasing depressive symptoms and increasing optimism.

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Appendix 1:: List of WHI Investigators

Program Office:(National Heart, Lung, and Blood Institute, Bethesda, Maryland) Jacques Rossouw, Shari Ludlam, Joan McGowan, Leslie Ford, Nancy Geller.

Clinical Coordinating Centre:(Fred Hutchinson Cancer Research Center, Seattle, WA) Garnet L. Anderson, Ross Prentice, Charles Kooperberg, Lisa Johnson, Andrea LaCroix, Lesley Tinker, Marian Neuhouser, Susan Heckbert, Alex Reiner, Chongzhi Di, Xiaoling Song, Wayne Rosamond, Shirley Beresford, Chu Chen, Barbara Cochrane.

Regional Centres:(Albert Einstein College of Medicine, Bronx, NY) Sylvia Wassertheil-Smoller (Brigham and Women's Hospital, Harvard Medical School, Boston, MA) JoAnn E. Manson, Shari Bassuk, Howard Sesso, Lu Wang; (Brown University, Providence, RI) Charles B. Eaton, Simin Liu (MedStar Health Research Institute, Washington, DC) Barbara V. Howard; (The Ohio State University, Columbus, OH) Rebecca Jackson, Randall Harris, Electra Paskett, W. Jerry Mysiw, Michael Blumenfeld; (Stanford Prevention Research Center, Stanford, CA) Marcia Stefanick, Mark Hlatky, Marco Perez, Themistocles (Tim) Assimes and Jean Tang; (University of Arizona, Tucson/Phoenix, AZ) Cynthia A. Thomson, Tamsen Bassford, Cheryl Ritenbaugh, Zhao Chen, Marcia Ko; (University at Buffalo, Buffalo, NY) Jean Wactawski-Wende, Michael LaMonte, Amy Millen, Heather Ochs-Balcom, Christopher Andrews; (University of Florida, Gainesville/Jacksonville, FL) Marian Limacher, Michael Perri, Andrew Kaunitz, R. Stan Williams, Yvonne Brinson; (University of Iowa, Iowa City/Davenport, IA) Robert Wallace, James Torner, Susan Johnson, Linda Snetselaar, Jennifer Robinson; (University of Pittsburgh, Pittsburgh, PA) Lewis Kuller, Jane Cauley, N. Carole Milas; (University of Tennessee Health Science Center, Memphis, TN)

Karen C. Johnson, Suzanne Satterfield, Rongling Li, Stephanie Connelly, Fran Tylavsky; (Wake Forest University School of Medicine, Winston-Salem, NC) Sally Shumaker, Stephen Rapp, Claudine Legault, Mark Espeland, Laura Coker, Michelle Naughton.

Former Principal Investigators and Project Officers:(Albert Einstein College of Medicine, Bronx, NY) Sylvia Wassertheil-Smoller (Baylor College of Medicine, Houston, TX) Haleh Sangi-Haghpeykar, Aleksandar Rajkovic, Jennifer Hays, John Foreyt; (Brown University, Providence, RI) Charles B. Eaton, Annlouise R. Assaf; (Emory University, Atlanta, GA) Lawrence S. Phillips, Nelson Watts, Sally McNagny, Dallas Hall; (Fred Hutchinson Cancer Research Center, Seattle, WA) Shirley A.A. Beresford, Maureen Henderson; (George Washington University, Washington, DC) Lisa Martin, Judith Hsia, Valery Miller; (Harbor-UCLA Research and Education Institute, Torrance, CA) Rowan Chlebowski (Kaiser Permanente Center for Health Research, Portland, OR) Erin LeBlanc, Yvonne Michael, Evelyn Whitlock, Cheryl Ritenbaugh, Barbara Valanis; (Kaiser Permanente Division of Research, Oakland, CA) Bette Caan, Robert Hiatt; (National Cancer Institute, Bethesda, MD) Carolyn Clifford[1]; (Medical College of Wisconsin, Milwaukee, WI) Jane Morley Kotchen (National Heart, Lung, and Blood Institute, Bethesda, Maryland) Linda Pottern; (Northwestern University, Chicago/Evanston, IL) Linda Van Horn, Philip Greenland; (Rush University Medical Center, Chicago, IL) Lynda Powell, William Elliott, Henry Black; (State University of New York at Stony Brook, Stony Brook, NY) Dorothy Lane, Iris Granek; (University at Buffalo, Buffalo, NY) Maurizio Trevisan; (University of Alabama at Birmingham, Birmingham, AL) Cora E. Lewis, Albert Oberman; (University of Arizona, Tucson/Phoenix, AZ) Tamsen Bassford, Cheryl Ritenbaugh, Tom Moon; (University of California at Davis, Sacramento, CA) John Robbins; (University of California at Irvine, CA) F. Allan Hubbell,Frank Meyskens, Jr.; (University of California at Los Angeles, CA) Lauren Nathan, Howard Judd[1]; (University of California at San Diego, LaJolla/Chula Vista, CA) Robert D. Langer; (University of Cincinnati, Cincinnati, OH) Michael Thomas, Margery Gass, James Liu; (University of Hawaii, Honolulu, HI) J. David Curb; (University of Massachusetts/Fallon Clinic, Worcester, MA) Judith Ockene; (University of Medicine and Dentistry of New Jersey, Newark, NJ) Norman Lasser; (University of Miami, Miami, FL) Mary Jo O'Sullivan, Marianna Baum; (University of Minnesota, Minneapolis, MN) Karen L. Margolis, Richard Grimm; (University of Nevada, Reno, NV) Robert Brunner, Sandra Daugherty[1]; (University of North Carolina, Chapel Hill, NC) Gerardo Heiss, Barbara Hulka, David Sheps; (University of Tennessee Health Science Center, Memphis, TN) Karen Johnson, William Applegate; (University of Texas Health Science Center, San Antonio, TX) Robert Brzyski, Robert Schenken; (University of Wisconsin, Madison, WI) Gloria E. Sarto, Catherine Allen[1]; (Wake Forest University School of Medicine, Winston-Salem, NC) Mara Vitolins, Denise Bonds, Electra Paskett, Greg Burke; (Wayne State University School of Medicine/Karmanos Cancer Institute, Detroit, MI) Michael S. Simon, Susan Hendrix.

[1]deceased.

Women's Health Initiative Memory Study:(Wake Forest University School of Medicine, Winston-Salem, NC) Mark Espeland, Sally Shumaker, Stephen Rapp, Claudine Legault, Laura Coker, Michelle Naughton.

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What's new?

- Depression in women with diabetes is common and has a negative impact on health. Research in large samples is needed to better estimate its prevalence, outcomes and clinical implications.
- Among the 8895 participants with Type 2 diabetes in the Women's Health Initiative, 16% reported elevated depressive symptoms, which were associated with greater sleep disturbance and lower quality of life.
- Increased risk of poor physical health-related quality of life associated with antidepressant use was stronger in women without depressive symptoms.
- The positive association between optimism and global quality of life was stronger in women with depressive symptoms.
- Depression and optimism may be important targets for non-pharmacological intervention.

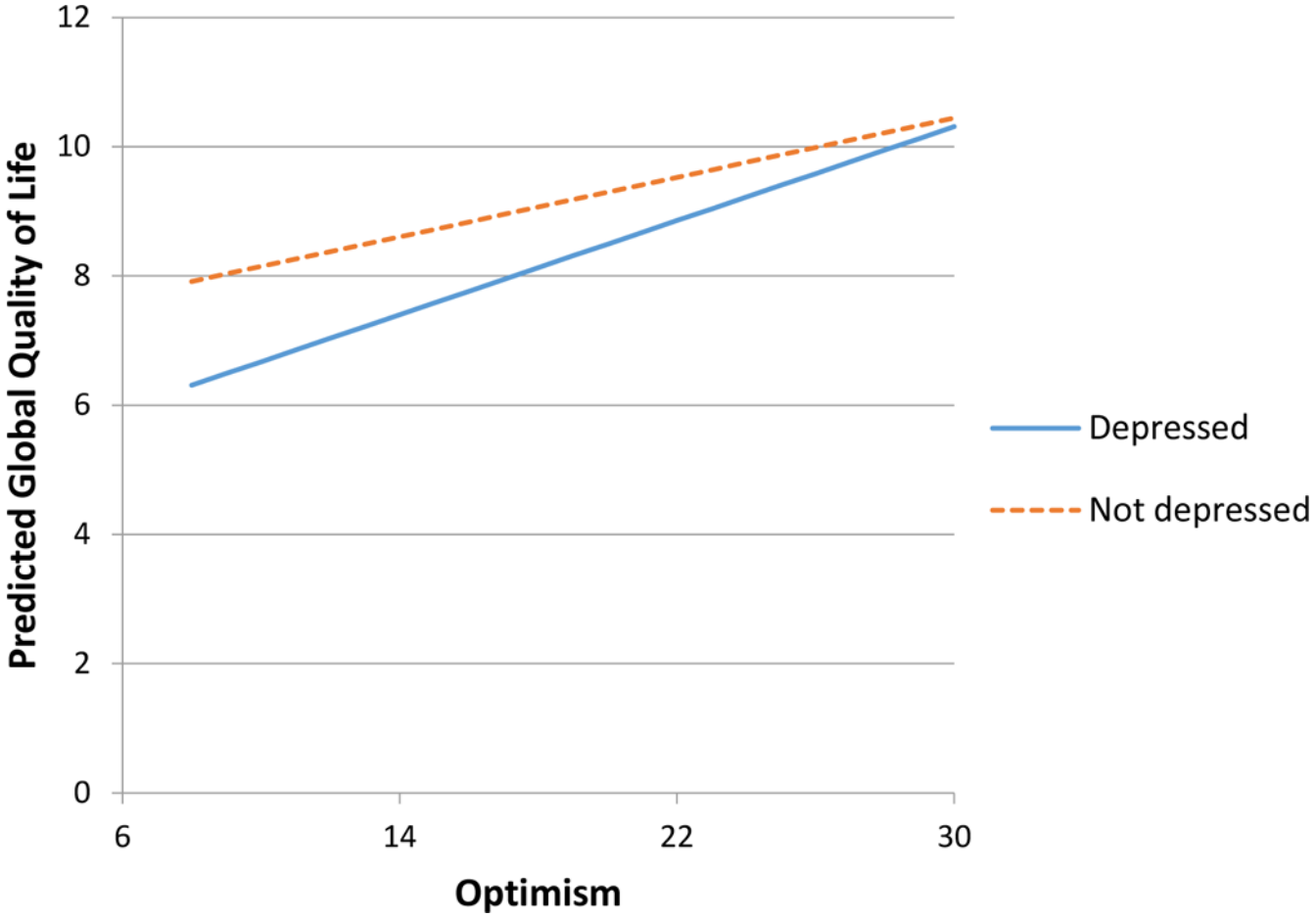

Figure 1.

Interaction (based on predicted values of outcome, Global Quality of Life) between depressed status and optimism Note: Slope=0.11 for non-depressed, 0.18 for depressed. P-value for interaction <0.0001.

Table 1

Baseline characteristics of the study sample (*N*=8895)

	Depressed (*n*=1443)		Non-depressed (*n* =7452)		*P**
	n	**%**	***n***	**%**	
Race/ethnicity					<0.0001
Non-Hispanic white	887	61.5	5058	67.9	
Hispanic	153	10.6	371	5.0	
Black	317	22.0	1525	20.5	
Other	82	5.7	477	6.4	
Unknown	4	0.3	21	0.3	
Education					<0.0001
≤High school	540	37.4	2240	30.1	
Some college/ vocational	590	40.9	3038	40.8	
4-year college degree	98	6.8	575	7.7	
Postgraduate	197	13.7	1549	20.8	
Unknown	18	1.2	50	0.7	
Income					<0.0001
< $50,000	1107	76.7	5221	70.1	
$50,000–$99,999	190	13.2	1486	19.9	
≥ $100,000	25	1.7	268	3.6	
Unknown	121	8.4	477	6.4	
Marital status					<0.0001
Married/ partnered	661	45.8	4136	55.5	
Not married/ partnered	766	53.1	3275	43.9	
Unknown	16	1.1	41	0.5	
Number of comorbid conditions					<0.0001
0	132	9.1	930	12.5	
1	350	24.3	2262	30.4	
≥2	959	66.5	4246	57.0	
Unknown	2	0.1	14	0.2	
Antidepressant medication use					<0.0001
None	1144	79.3	6815	91.5	
Tetracyclics	0	0.0	0	0.0	
MAO inhibitors	0	0.0	1	0.0	
Modified cyclics	32	2.2	48	0.6	
SSRIs	170	11.8	223	3.0	
Tricyclic agents	87	6.0	341	4.6	
Miscellaneous	10	0.7	24	0.3	
	Mean (SD)	Range	*n*	Mean (SD)	Range	*n*	
Age at baseline	62.9 (7.1)	50–79	1443	64.7 (6.8)	50–79	7452	<0.0001
Social support	29.6 (9.0)	9–45	1391	35.2 (8.1)	9–45	7240	<0.0001

	Depressed (*n*=1443)			Non-depressed (*n* =7452)			*P**
	n	%		*n*	%		
Optimism	20.0 (3.9)	6–30	1379	22.9 (3.3)	9–30	7236	<0.0001

MAO, monoamine oxidase; SSRI, selective serotonin reuptake inhibitor.

* *P* values are for comparisons across depressive symptom groups based on independent samples *t*-test for continuous variables and chi-squared test for categorical variables.

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Table 2

Spearman correlation coefficients among study variables

	Spearman correlation coefficients Prob>|r|under H0: Rho=0								
	Depressed status	**Physical HRQoL**	**Sleep disturbance**	**Global QoL**	**Physical activity**	**White race/ ethnicity**	**Other race/ ethnicity**	**Black race/ ethnicity**	**Hispanic race/ ethnicity**
Depressed status	1.00000	−0.09763 <0.0001	0.27403 <0.0001	−0.28115 <0.0001	−0.06665 <0.0001	−0.05039 <0.0001	−0.01093 0.3032	0.01370 0.1971	0.08819 <0.0001
Physical HRQoL	−0.09763 <0.0001	1.00000	−0.24839 <0.0001	0.18828 <0.0001	0.24346 <0.0001	0.02425 0.0243	0.05090 <0.0001	−0.06238 <0.0001	0.00640 0.5524
Sleep disturbance	0.27403 <0.0001	−0.24839 <0.0001	1.00000	−0.21080 <0.0001	−0.08517 <0.0001	0.06863 <0.0001	−0.04122 <0.0001	−0.06799 <0.0001	0.02176 0.0392
Global QoL	−0.28115 <0.0001	0.18828 <0.0001	−0.21080 <0.0001	1.00000	0.12714 <0.0001	−0.03224 0.0020	−0.00200 0.8477	0.03684 0.0004	0.00275 0.7924
Physical activity	−0.06665 <0.0001	0.24346 <0.0001	−0.08517 <0.0001	0.12714 <0.0001	1.00000	0.04363 <0.0001	0.01838 0.0826	−0.05643 <0.0001	−0.00844 0.4256
White race/ethnicity	−0.05039 <0.0001	0.02425 0.0243	0.06863 <0.0001	−0.03224 0.0020	0.04363 <0.0001	1.00000	n/a	n/a	n/a
Other race/ethnicity	−0.01093 0.3032	0.05090 <0.0001	−0.04122 <0.0001	−0.00200 0.8477	0.01838 0.0826	n/a	1.00000	n/a	n/a
Black race/ethnicity	0.01370 0.1971	−0.06238 <0.0001	−0.06799 <0.0001	0.03684 0.0004	−0.05643 <0.0001	n/a	n/a	1.00000	n/a
Hispanic race/ethnicity	0.08819 <0.0001	0.00640 0.5524	0.02176 0.0392	0.00275 0.7924	−0.00844 0.4256	n/a	n/a	n/a	1.00000
Education	−0.08828 <0.0001	0.12173 <0.0001	−0.09101 <0.0001	0.04101 <0.0001	0.11497 <0.0001	0.10965 <0.0001	−0.02492 0.0169	−0.03266 0.0017	−0.13445 <0.0001
Income	−0.14035 <0.0001	0.21117 <0.0001	−0.11074 <0.0001	0.16095 <0.0001	0.11063 <0.0001	0.16263 <0.0001	0.03648 0.0007	−0.13442 <0.0001	−0.12909 <0.0001
Married	−0.07008 <0.0001	0.04619 <0.0001	−0.02683 0.0112	0.11361 <0.0001	0.02242 0.0346	0.14671 <.0001	0.03852 0.0002	−0.18629 <0.0001	−0.01058 0.3103
Number of comorbidities	0.07066 <0.0001	−0.35567 <0.0001	0.15275 <0.0001	−0.09490 <0.0001	−0.08119 <0.0001	0.03331 0.0014	−0.07247 <0.0001	0.05584 <0.0001	−0.08700 <0.0001
Antidepressant use	0.14625 <0.0001	−0.15567 <0.0001	0.06873 <0.0001	−0.09436 <0.0001	−0.06006 <0.0001	0.08255 <0.0001	−0.05261 <0.0001	−0.05595 <0.0001	−0.01407 0.1755
Age	−0.09316 <0.0001	−0.09687 <0.0001	0.00530 0.6148	0.10115 <0.0001	0.05309 <0.0001	0.17172 <0.0001	−0.01452 0.1620	−0.12281 <0.0001	−0.11306 <0.0001
Optimism	−0.27890 <0.0001	0.15230 <0.0001	−0.19694 <0.0001	0.37717 <0.0001	0.09729 <0.0001	0.06574 <0.0001	−0.06444 <0.0001	0.01521 0.1515	−0.09002 <0.0001

	Spearman correlation coefficients Prob>|r|under H0: Rho=0								
	Depressed status	**Physical HRQoL**	**Sleep disturbance**	**Global QoL**	**Physical activity**	**White race/ ethnicity**	**Other race/ ethnicity**	**Black race/ ethnicity**	**Hispanic race/ ethnicity**
Social support	−0.22865 <0.0001	0.11651 <0.0001	−0.16443 <0.0001	0.41493 <0.0001	0.08018 <0.0001	0.05684 <0.0001	−0.00822 0.4374	−0.02560 0.0156	−0.05979 <0.0001

	Spearman correlation coefficients Prob>|r|under H0: Rho=0							
	Education	Income	Married	Number of comorbidities	Antidepres-sant use	Age	Optimism	Social support
Depressed status	−0.08828 <0.0001	−0.14035 <0.0001	−0.07008 <0.0001	0.07066 <0.0001	0.14625 <0.0001	−0.09316 <0.0001	−0.27890 <0.0001	−0.22865 <0.0001
Physical HRQoL	0.12173 <0.0001	0.21117 <0.0001	0.04619 <0.0001	−0.35567 <0.0001	−0.15567 <0.0001	−0.09687 <0.0001	0.15230 <0.0001	0.11651 <0.0001
Sleep disturbance	−0.09101 <0.0001	−0.11074 <.0001	−0.02683 0.0112	0.15275 <0.0001	0.06873 <0.0001	0.00530 0.6148	−0.19694 <0.0001	−0.16443 <0.0001
Global QoL	0.04101 <0.0001	0.16095 <0.0001	0.11361 <0.0001	−0.09490 <0.0001	−0.09436 <0.0001	0.10115 <0.0001	0.37717 <0.0001	0.41493 <0.0001
Physical activity	0.11497 <0.0001	0.11063 <.0001	0.02242 0.0346	−0.08119 <0.0001	−0.06006 <0.0001	0.05309 <0.0001	0.09729 <0.0001	0.08018 <0.0001
White race/ethnicity	0.10965 <0.0001	0.16263 <0.0001	0.14671 <0.0001	0.03331 0.0014	0.08255 <0.0001	0.17172 <0.0001	0.06574 <0.0001	0.05684 <0.0001
Other race/ethnicity	−0.02492 0.0169	0.03648 0.0007	0.03852 0.0002	−0.07247 <0.0001	−0.05261 <0.0001	−0.01452 0.1620	−0.06444 <0.0001	−0.00822 0.4374
Black race/ethnicity	−0.03266 0.0017	-0.13442 <0.0001	−0.18629 <0.0001	0.05584 <0.0001	−0.05595 <0.0001	−0.12281 <0.0001	0.01521 0.1515	−0.02560 0.0156
Hispanic race/ethnicity	−0.13445 <0.0001	−0.12909 <0.0001	−0.01058 0.3103	−0.08700 <0.0001	−0.01407 0.1755	−0.11306 <0.0001	−0.09002 <0.0001	−0.05979 <0.0001
Education	1.00000	0.40636 <0.0001	0.00150 0.8859	−0.03678 0.0004	0.00202 0.8459	−0.03510 0.0007	0.22911 <.0001	0.04023 0.0001
Income	0.40636 <0.0001	1.00000 8657	0.42135 <0.0001	−0.09301 <0.0001	−0.04395 <0.0001	−0.16946 <0.0001	0.20105 <0.0001	0.23234 <0.0001
Married	0.00150 0.8859	0.42135 <0.0001	1.00000	-0.05154 <0.0001	-0.02012 0.0532	−0.12569 <0.0001	0.03388 0.0014	0.26036 <0.0001
Number comorbidities	−0.03678 0.0004	−0.09301 <0.0001	−0.05154 <0.0001	1.00000	0.10079 <0.0001	0.11390 <0.0001	−0.06613 <0.0001	−0.06407 <0.0001
Antidepressant use	0.00202 0.8459	−0.04395 <0.0001	−0.02012 0.0532	0.10079 <0.0001	1.00000	−0.04352 <0.0001	−0.08412 <0.0001	−0.06870 <0.0001

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	Spearman correlation coefficients Prob>|r|under H0: Rho=0								
	Depressed status	**Physical HRQoL**	**Sleep disturbance**	**Global QoL**	**Physical activity**	**White race/ ethnicity**	**Other race/ ethnicity**	**Black race/ ethnicity**	**Hispanic race/ ethnicity**
Age	−0.03510 0.0007	−0.16946 <0.0001	−0.12569 <0.0001	0.11390 <0.0001	−0.04352 <0.0001	1.00000	0.01842 0.0820	−0.01811 0.0866	
Optimism	0.22911 <0.0001	0.20105 <0.0001	0.03388 0.0014	−0.06613 <0.0001	−0.08412 <0.0001	0.01842 0.0820	1.00000	0.31119 <0.0001	
Social support	0.04023 0.0001	0.23234 <0.0001	0.26036 <0.0001	-0.06407 <0.0001	-0.06870 <0.0001	-0.01811 0.0866	0.31119 <0.0001	1.00000	

HRQoL, health-related quality of life; QoL, quality of life.

Table 3

Descriptive statistics (central tendency and range) of health behaviours and quality-of-life scores by depression status.

	Depressed				Non-depressed				
	Mean (SD)	**Median (IQR)**	**Range**	***n***	**Mean (SD)**	**Median (IQR)**	**Range**	***n***	***P* value***
Sleep disturbance	10.5 (4.9)	10 (7–14)	0–20	1411	6.8 (4.4)	6 (3–10)	0–20	7294	<0.0001
Physical activity	7.7 (10.6)	3.8 (0–10.5)	0–105	1406	9.5 (12.1)	5.3 (0.8–13.5)	0–121.3	7193	<0.0001
Physical HRQoL	39.4 (12.0)	39.6 (29.7–48.9)	12.8–68.4	1325	42.4 (11.1)	44.7 (34.7–51.3)	7.6–65.6	7073	<0.0001
Global QoL	6.6 (2.1)	7 (5–8)	0–10	1434	8.1 (1.5)	8 (7–9)	0–10	7427	<0.0001

HRQoL, health-related quality of life; IQR, interquartile range; QoL, quality of life.

** P* values are for comparisons of the means across depressive symptom groups based on independent samples *t*-test. Wilcoxon rank-sum tests performed on medians resulted in same *P* values.

Table 4

Associations between demographic, medical and psychosocial variables and diabetes-related outcomes

	Sleep disturbance	Physical activity	Physical HRQoL	Global QoL
Variable	**Estimate (95% CI)**	**Estimate (95% CI)**	**Estimate (95% CI)**	**Estimate (95% CI)**
Age	–0.01 (–0.03,0.003)	0.10 (0.06,0.14) *	–0.07 (–0.11,–0.04) *	0.03 (0.02,0.03) *
Race/Ethnicity				
Black	–0.89 (–1.15,–0.63) *	–0.82 (–1.53,–0.12) ***	–1.09 (–1.73,–0.46) **	0.29 (0.20,0.37) *
Other	–0.85 (–1.26, –0.43) *	0.44 (–0.67,1.54)	1.16 (0.17, 2.16) ***	0.16 (0.03,0.29) ***
Hispanic	–0.36 (–0.81,0.09)	1.32 (0.11,2.53) ***	–0.23 (–1.32,0.87)	0.38 (0.24,0.52) *
Education	–0.10 (–0.15,–0.04) **	0.37 (0.22,0.53) *	0.14 (0.004,0.28) ***	–0.03 (–0.05,–0.01) **
Income	–0.16 (–0.24,–0.08) *	0.62 (0.40,0.83) *	1.02 (0.83,1.21) *	0.09 (0.07,0.12) *
Married (Y/N)	0.21 (–0.02,0.44)	–0.57 (–1.17,0.05)	–1.17 (–1.71,–0.63) *	0.05 (–0.02,0.12)
Number comorbidities	0.75 (0.61,0.89) *	–1.11 (–1.50,–0.73) *	–4.82 (–5.16,–4.48) *	–0.09 (–0.14,–0.05) *
Social support	–0.03 (–0.05,–0.02) *	0.06 (0.02,0.09) **	0.05 (0.02,0.08) **	0.06 (0.05,0.06) *
Antidepressant use (Y/N)	0.05 (–0.28,0.37)	–1.17 (–2.03,–0.30) **	–4.88 (–5.79,–3.97) *	–0.08 (–0.18,0.02)
Optimism	–0.14 (–0.17,–0.10) *	0.12 (0.03,0.20) **	0.23 (0.16,0.31) *	0.11 (0.10,0.13) *
Depressed (Y/N)	2.84 (2.55,3.13) *	–0.15 (–0.93,0.63)	–0.65 (–1.41,0.11)	–2.14 (–2.61,–1.68) *
Antidepressant use * depression status interaction	–	–	2.11 (0.41,3.81) ***	–
Optimism * depression status interaction	–	–	–	0.07 (0.05,0.09) *
R^2	0.13	0.03	0.17	0.33

HRQoL, health-related quality of life; QoL, quality of life.

Table provides parameter estimates and CIs obtained from multivariable linear regression models conducted separately for each of the four outcomes of interest. In models where interaction terms were not significant, we removed the interaction terms (cells shown as empty) and report results from the main-effects-only model.

* $P<0.0001$

** $P<0.01$

*** $P<0.05$.