Depression and Sleep Duration Associated With Health-related Quality of Life in Individuals With Type 2 Diabetes: a Cross-sectional Study in China

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Research

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Abstract

Background: Limited study has evaluated the association among depression, depression and health-related quality of life in individuals with type 2 diabetes in China. We aimed to evaluate the effects of depression and sleep duration on health-related quality of life (HRQoL) in community-based individuals with type 2 diabetes in China.

Methods: A total of 1,891 individuals with type 2 diabetes from Pujiang Town, Minhang District, Shanghai, China were included in the study. Self-reported sleep duration per night was obtained by questionnaire. Participant Health Questionnaire-9 (PHQ-9) was used to detect depression. European Quality of Life-5 Dimensions-5 Levels index (EQ-5D-5L) and visual analogue scale (VAS) were used to evaluate the individuals' HRQoL.

Results: The prevalence of depression (PHQ-9 scores ≥ 5) was 8.9%. The proportion of depression in individuals with sleep duration < 7 h was higher compared with those with sleep duration of 7-8h and ≥ 8 h, respectively (14% vs. 5.3%, 14% vs. 4.3%, all $p < 0.001$). Depression was negatively associated with both EQ-5D-5L index score and EQ-VAS ($\beta = -0.1273$, 95% CI: -0.1389, -0.1158 for EQ-5D-5L index score; $\beta = -8.8762$, 95% CI: -10.3150, -7.4374 for EQ-VAS). Compared to individuals with sleep duration of 7-8h, sleep duration < 7 h was associated with lower EQ-5D-5L index score and EQ-VAS ($\beta = -0.0242$, 95% CI: -0.0116, -0.0367 for EQ-5D-5L index score; $\beta = -2.9386$, 95% CI: -1.5210, -4.3562 for EQ-VAS). However, sleep duration ≥ 8 h did not show significant difference in HRQoL before and after full adjustments.

Conclusion: To improve quality of life in individuals with type 2 diabetes in China, those with depression and shorter sleep duration may be identified as at-risk populations. Longer sleep duration over 8h might not further improve the quality of life for individuals with type 2 diabetes.

Background

The prevalence of diabetes in China reached 12.8% with the highest number of patients worldwide according to the report in JAMA [1]. The dramatic increment of type 2 diabetes causes considerable chronic complications and a decrease in health-related quality of life (HRQoL) [2], an important predictor of mortality and morbidity [3]. Nonetheless, health care providers focus on medical outcomes rather than HRQoL in clinical practice. To improve HRQoL of individuals with diabetes, evaluation of the risk factors of the HRQoL would bring valuable social and economic benefits.

Depression is a common mood disorder and could trigger unhealthy lifestyles, poor treatment adherence, and chronic complications outcomes [4–6]. Also depression could affect the quality of life in individuals with type 2 diabetes [7]. Considering that the cross-national differences in depression prevalence were present [8], the association between depression and quality of life might demonstrate cross-regional discrepancies. Although the association was evaluated in several countries, there was limited evidence reported in China, especially in the community-based individuals with type 2 diabetes.

Individuals with depression syndrome are prone to having sleep problems [9] that associated with poor life quality in the general population [10, 11]. Thus, it is understandable that poor sleep might associate with quality of life in individuals with type 2 diabetes. So far, only one study reported that poor sleep was inversely associated with quality of life in individuals with type 2 diabetes who lived in Xiamen, a second-tier city of China [12]. However, whether the longer sleep duration leading to a higher HRQoL has not been clearly identified in individuals with type 2 diabetes.

In this study, we aimed to evaluate the relationship among depression, sleep duration, and health quality of life in community-based individuals with type 2 diabetes in China.

Methods

Participants, data, and sample collection

This study was a community-based cross-sectional study. From December 2016 to April 2017, we recruited 1,994 individuals with type 2 diabetes from the Diabetic Health Record Systems at Pujiang Town, Minhang District, Shanghai, China. The details of the diabetes health management program of Minhang District have been described previously¹¹. This study was approved by the institutional review board of Renji Hospital, Shanghai Jiao Tong University School of Medicine with all individuals giving informed consent.

A total of 1,891 individuals were included in the final analysis, except when exclusion criteria were present: (1) unable to complete the sleeping questionnaire (N = 52); (2) unable to complete Patient Health Questionnaire-9 (PHQ-9) quick depression assessment (N = 9); (3) unable to complete five-level Version of European Quality of Life-5 Dimensions (EQ-5D-5L) questionnaire (N = 12); (4) type 1 diabetes or those who were uncertainty about the type of diabetes (N = 20); (5) psychotropic medication use (N = 10).

Questionnaire data and anthropometric and biochemical measurements

Standardized phenotypic data were collected using a common protocol by the trained staffs. A half-day examination included face-to-face interviews, anthropometric measurements, and blood and spot urine samples obtained from each participant. Information about lifestyle and medical histories were obtained using a standardized questionnaire during interviews by trained investigators. Educational attainment level was classified as elementary school education (primary school or below), middle school education (junior secondary and high secondary school), and high school education (high school or above). Smoking and alcohol consumption habits were defined as 'never', 'former' (not smoking or consuming alcohol for more than six months), and 'current' (smoking or consuming alcohol regularly in the past six months)¹². Information about use of hypoglycemic, antihypertensive and lipid-lowering medications in the previous one month was collected.

Blood samples were collected before and after a meal of 100 g of steamed bread made of standard flour from individuals fasting for at least 8 hours. Fasting plasma glucose (FPG), postprandial plasma glucose (PPG), fasting serum triglycerides (TGs), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) were measured using an automated analyzer (Beckman Coulter AU5811, Beckman Coulter Inc. Tokyo, Japan). Glycated hemoglobin A1c (HbA1c) was measured using HPLC (Bio-Rad, Hercules, CA). First-morning spot urine samples were collected. The urinary albumin-to-creatinine ratios (UACR) in milligrams per gram was calculated by dividing the urinary albumin concentration (Beckman Coulter Inc.) by the urinary creatinine concentration in millimoles per liter, which was measured using an automatic analyzer (Beckman Coulter AU5811, Beckman Coulter Inc. Tokyo, Japan).

Depression and sleeping duration assessment

Depression symptom was evaluated with the PHQ-9 [13]. Individuals were asked to rate the frequency of each depressive symptom of nine items that they had in the past two weeks (not at all = 0; several days = 1; more than half the days = 2; nearly every day = 3). Adding each item score resulted in the total PHQ-9 score, ranging from 0 to 27. At least mild depressive symptoms (PHQ-9 scores ≥ 5) [14] were defined as depression in our study.

According to self-reported sleep duration per night in the last week in the questionnaire, individuals were categorized into three groups: sleeping < 7h, 7-8h, and ≥ 8 h.

HRQoL assessment

To evaluate the HRQoL of the participates, we used EQ-5D-5L questionnaire concluding the EQ-5D-5L descriptive system and the EQ visual analogue scale (EQ-VAS). EQ-5D-5L descriptive system includes five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has five response categories corresponding to no problems, slight problems, moderate problems, severe problems, and extreme problems. We used the Chinese value set to calculate the EQ-5D index scores [15]. Using a graded, vertical line ranging from 0 to 100 (worst to best imaginable health state), individuals were asked to mark a point best reflecting their health state. The self-rated EQ VAS from each participant was collected.

Statistical analyses

Statistical analyses were carried out with SAS version 9.3 (SAS Institute, Inc., Cary, North Carolina). Continuous variables were presented as the mean $\pm$ standard deviation (SD) or median (interquartile range). TG, duration of diabetes, and UACR were logarithmically transformed before the analyses due to their skewed distributions. Categorized variables were presented as numbers (proportions).

Student's *t*-test for continuous variables, χ^2 analysis, and Fisher's exact test for categorical variables were used to compare clinical characteristics between Subjects with and without depression. One-way analysis of variance (ANOVA) with Student Newman–Keuls (SNK) analysis for continuous variables, χ^2 analysis, and Fisher's exact test for categorical variables were used to compare clinical characteristics across

sleeping groups. Univariate logistic regression was used for multiple comparisons of three sleeping groups.

Factors associated with HRQoL

Spearman correlation and multiple stepwise regression analysis (forward-backward variable selection with p values < 0.05) were used to identify clinical factors associated with EQ-5D-5L index score and EQ-VAS, respectively, including sleep duration, PHQ-9 score, age, sex, education levels, smoking status, drinking status, use of hypoglycemic drugs, antihypertensive drugs, and lipid-lowering drugs, duration of diabetes, BMI, systolic blood pressure (SBP), diastolic blood pressure (DBP), FPG, PPG, HbA1c, TGs, TC, LDL-C, HDL-C, and UACR.

Association between depression, sleep duration and HRQoL

Multiple regression analysis was used to evaluate the association among depression, sleep duration, and HRQoL. Regression models included unadjusted model 1, model 1 + age, sex, education status, smoking and drinking status, duration of diabetes, BMI, SBP, DBP, use of hypoglycemic drugs, use of antihypertensive drugs, use of lipid-lowering drugs (model 2), model 2 + FPG, PPG, TGs, TC, HDL-C, and LDL-C (model 3). Results are presented as linear regression coefficients and 95% CIs (confidence intervals). Statistical significance was considered to be $p < 0.05$.

Results

Study population

A total of 1,891 individuals with type 2 diabetes were involved in the final analysis, with a mean age of 64 ± 7 years, a median diabetes duration of 9 years (5–12 years), a mean HbA1C of 55 ± 17 mmol/mol, a mean EQ-5D-5L index score of 0.92 ± 0.12 , a mean EQ-VAS of 73.2 ± 13.8 . The proportion of at least mild depression defined as PHQ-9 score ≥ 5 was 8.9% (169/1891). The proportion of sleeping < 7 h, 7-8h, and ≥ 8 h was 45% (851/1891), 34% (644/1891), and 21% (396/1891), respectively.

Table 1 shows the demographics of individuals with and without depression. Individuals with depression had significantly lower EQ-5D-5L index score and EQ-VAS than those without [0.79 ± 0.25 vs. 0.95 ± 0.09 for EQ-5D-5L index score, 62.60 ± 17.16 vs. 74.2 ± 13.0 for EQ-VAS, both $p < 0.001$]. The proportions of high school education, use of lipid-lowering drugs, and sleep duration < 7 h were higher in the depression group (all $p < 0.001$). The proportion of depression in sleep duration < 7 h was higher compared with those in sleep duration of 7-8h and ≥ 8 h, respectively (14% vs. 5.3%, 14%, and 4.3%, all $p < 0.001$) (Fig. 1).

Table 1
Demographics of individuals with and without depression

Variables	Depression status		<i>p</i> value
	No	Yes	
N	1722	169	—
HRQoL			
EQ-5D-5L index score	0.95 ± 0.09	0.79 ± 0.25	< 0.001
EQ-VAS	74.2 ± 13.0	62.6 ± 17.2	< 0.001
Age (years)	65 ± 8	65 ± 9	0.81
Leisure-time physical activity (MET-hr/week)	46.20 (23.10-80.85)	46.20 (23.10-80.85)	0.24
Duration of diabetes (years)	9 (5–12)	8.7 (5–14)	0.15
Body mass index (kg/m ²)	26.5 ± 3.4	26.5 ± 3.5	0.98
Waist circumference (cm)	90 ± 9	90 ± 10	0.77
Systolic blood pressure (mmHg)	148 ± 20	147 ± 20	0.31
Diastolic blood pressure (mmHg)	79 ± 19	78 ± 11	0.55
Fasting plasma glucose level (mmol/L)	8.81 ± 2.58	8.73 ± 3.01	0.74
Prandial plasma glucose level (mmol/L)	15.50 ± 4.37	15.14 ± 4.44	0.32
Haemoglobin A1c (mmol/mmol)	55 ± 17	54 ± 16	0.65
Triglycerides (mmol/L)	1.48 (1.06–2.12)	1.41 (1.07–1.96)	0.47
Total cholesterol (mmol/L)	5.25 ± 1.17	5.30 ± 1.16	0.62
Low-density lipoprotein cholesterol (mmol/L)	2.80 ± 0.76	2.87 ± 0.77	0.29
High-density lipoprotein cholesterol (mmol/L)	1.52 ± 0.36	1.56 ± 0.41	0.20
Urine albumin-to-creatinine ratio (mg/g)	30.77 (14.82–80.82)	32.62 (16.63–80.79)	0.44
Men, n (%)	754 (44)	62 (37)	0.075

At least mild depressive symptoms (PHQ-9 scores ≥ 5) was defined as depression. Values are mean ± SD or median (interquartile range) or number (proportion). *P* values were obtained using Student's *t*-test for continuous variables, χ^2 analysis, and Fisher's exact test for categorical variables. Abbreviation: EQ-5D-5L, European Quality of Life-5 Dimensions-5 Levels index; EQ-VAS, EQ visual analogue scale; PHQ-9: participant Health Questionnaire-9; HRQoL, Health-related quality of life.

Variables	Depression status		<i>p</i> value
	No	Yes	
High school education, n (%)	22 (1.3)	3 (1.8)	0.002
Current smoker, n (%)	346 (20%)	28 (17%)	0.12
Current drinker, n (%)	209 (12%)	12 (7%)	0.075
Use of hypoglycemic drugs, n (%)	1623 (94)	158 (94)	0.69
Use of antihypertensive drugs, n (%)	961 (56)	97 (57.4)	0.69
Use of lipid-lowering drugs, n (%)	180 (11)	29 (17)	0.008
Sleep duration < 7h, n (%)	773 (43)	118 (70)	< 0.001
<p>At least mild depressive symptoms (PHQ-9 scores ≥ 5) was defined as depression. Values are mean $\pm$ SD or median (interquartile range) or number (proportion). <i>P</i> values were obtained using Student's <i>t</i>-test for continuous variables, χ^2 analysis, and Fisher's exact test for categorical variables.</p> <p>Abbreviation: EQ-5D-5L, European Quality of Life-5 Dimensions-5 Levels index; EQ-VAS, EQ visual analogue scale; PHQ-9: participant Health Questionnaire-9; HRQoL, Health-related quality of life.</p>			

Table 2 shows the demographics of individuals with type 2 diabetes across the three sleeping groups. The EQ-5D-5L index score and EQ-VAS showed significant differences across sleep duration groups of < 7h, 7-8h, and ≥ 8 h (0.92 ± 0.14 vs. 0.95 ± 0.09 vs. 0.95 ± 0.09 for EQ-5D-5L, 71.5 ± 14.0 vs. 74.9 ± 12.9 vs. 74.0 ± 14.3 for EQ-VAS; $p < 0.001$). Individuals with sleeping < 7h had significantly lower EQ-5D-5L index score and EQ-VAS than those with sleeping 7-8h and ≥ 8 h. Additionally, the means of age, SBP, PPG, and UACR, and the proportions of high school education and current smoker reached statistically differences across the sleeping groups ($p < 0.05$).

Table 2
Demographics of individuals across three sleeping groups

Variables	Sleeping groups			<i>p</i> value
	<7h	7-8h	≥8h	
N	851	644	396	—
HRQoL				
EQ-5D-5L index score	0.92 ± 0.14	0.95 ± 0.09 ^a	0.94 ± 0.11 ^b	< 0.001
EQ-VAS	71.5 ± 14.0	74.9 ± 12.9 ^a	74.0 ± 14.3 ^b	< 0.001
Age (years)	64 ± 8	64 ± 8	66 ± 8 ^{b, c}	< 0.001
Leisure-time physical activity (MET-hr/week)	46.20 (23.10–80.85)	46.20 (23.10–92.40)	46.20 (23.10–69.30) ^c	0.10
Duration of diabetes (years)	9 (5–12)	9 (5–12)	9 (5–13)	0.54
Body mass index (kg/m ²)	26.5 ± 3.5	26.6 ± 3.1	26.5 ± 3.5	0.93
Waist circumference (cm)	89 ± 10	90 ± 9	91 ± 9	0.36
Systolic blood pressure (mmHg)	147 ± 20	149 ± 21 ^a	150 ± 21 ^b	0.013
Diastolic blood pressure (mmHg)	79 ± 22	79 ± 11	79 ± 23	0.82
Fasting plasma glucose level (mmol/L)	8.71 ± 2.64	8.77 ± 2.41	9.04 ± 2.87 ^b	0.12
Prandial plasma glucose level (mmol/L)	15.25 ± 4.32	15.39 ± 4.13	16.06 ± 4.84 ^{b, c}	0.009
Haemoglobin A1c (mmol/mol)	55 ± 17	54 ± 16	56 ± 18	0.25
Triglycerides (mmol/L)	1.47 (1.05–2.17)	1.44 (1.01–2.05)	1.51 (1.14–2.09)	0.45
Total cholesterol (mmol/L)	5.25 ± 1.14	5.21 ± 1.17	5.34 ± 1.23	0.21
Low-density lipoprotein cholesterol (mmol/L)	2.80 ± 0.73	2.79 ± 0.77	2.85 ± 0.82	0.41

Values are mean ± SD or median (interquartile range) or number (proportion). *P* values were obtained using the one-way analysis of variance (ANOVA) with Student Newman–Keuls (SNK) analysis for continuous variables, χ^2 analysis and Fisher's exact test for categorical variables across the three groups. Univariate logistic regression models were used to calculate the *p* values of multiple comparisons of categorical variables. a: *p* < 0.05 for comparison between sleeping of 7-8h and that < 7h; b: *p* < 0.05 for comparison between sleeping ≥ 8h and that < 7h; c: *p* < 0.05 for sleeping ≥ 8h compared with that of 7-8h.

Variables	Sleeping groups			<i>p</i> value
	<7h	7-8h	≥8h	
High-density lipoprotein cholesterol (mmol/L)	1.52 ± 0.36	1.52 ± 0.39	1.52 ± 0.34	0.99
Urine albumin-to-creatinine ratio (mg/g)	31.29 (15.52-78.00)	27.96 (13.67–75.13)	34.52 (16.48–100.00) ^c	0.018
Men, n (%)	347 (41)	295 (46) ^a	174 (44)	0.14
High school education, n (%)	15 (1.8)	8 (1.3) ^a	2 (0.5) ^c	< 0.001
Current smoker, n (%)	145 (17%)	148 (23%)	81 (20%)	0.032
Current drinker, n (%)	96 (11%)	83 (13%)	42 (11%)	0.81
Use of hypoglycemic drugs, n (%)	804 (95)	605 (94)	372 (94)	0.89
Use of antihypertensive drugs, n (%)	483 (57)	355 (55)	220 (56)	0.81
Use of lipid-lowering drugs, n (%)	102 (12)	64 (10)	43 (11)	0.45
Values are mean ± SD or median (interquartile range) or number (proportion). <i>P</i> values were obtained using the one-way analysis of variance (ANOVA) with Student Newman–Keuls (SNK) analysis for continuous variables, χ^2 analysis and Fisher's exact test for categorical variables across the three groups. Univariate logistic regression models were used to calculate the <i>p</i> values of multiple comparisons of categorical variables. a: <i>p</i> < 0.05 for comparison between sleeping of 7-8h and that < 7h; b: <i>p</i> < 0.05 for comparison between sleeping ≥ 8h and that < 7h; c: <i>p</i> < 0.05 for sleeping ≥ 8h compared with that of 7-8h.				

Factors associated with HRQoL in individuals with type 2 diabetes

We used Spearman correlation and multiple stepwise regression analysis to identify risk factors associated with EQ-5D-5L index score and EQ-VAS (Table 3). In spearman correlation analysis for EQ-5D-5L index score, sleeping status, depression status, age, sex, smoking, and drinking status, use of antihypertensive drugs and lipid-lowering drugs, log-transformed duration of diabetes, BMI, DBP, PPG, and log-transformed UACR showed significant associations. For EQ-VAS, sleeping status, depression status, age, use of antihypertensive and lipid-lowering drugs, log-transformed duration of diabetes, TC, and LDL-C showed significant associations. In stepwise multiple linear regression models, depression status and use of antihypertensive drugs were inversely associated with both EQ-5D-5L index score and EQ-VAS.

Table 3

Spearman correlation and multiple stepwise regression analysis of risk factors associated with HRQoL

Variables	EQ-5D-5L index score				EQ-VAS			
	ρ	p value	β (95% CI)	p value	ρ	p value	β (95% CI)	p value
Sleeping status	0.1057	< 0.001			0.0941	< 0.001		
Depression status	-0.2746	< 0.001	-0.1314 (-0.1428, -0.1200)	< 0.001	-0.2089	< 0.001	-8.8174 (-10.2481, -7.3866)	< 0.001
Age (years)	-0.1587	< 0.001	-0.0019 (-0.0025, -0.0013)	< 0.001	-0.0669	0.004		
Sex (men = 1, women = 0)	-0.1103	< 0.001			0.01663	0.47		
Education levels (high school = 2, middle school = 1, elementary school = 0)	0.0158	0.49			-0.0063	0.78		
Smoking status (current smoker = 2, former smoker = 1, never = 0)	0.1146	< 0.001			0.0133	0.56		
Drinking status (current drinker = 2, former drinker = 1, never = 0)	0.0796	< 0.001	0.0094 (0.0022, 0.0166)	0.011	0.0105	0.65		
Use of hypoglycemic drugs (yes = 1, no = 0)	0.0029	0.90			-0.0281	0.22		
Use of antihypertensive drugs (yes = 1, no = 0)	-0.1051	< 0.001	-0.0195 (-0.0294, -0.0096)	< 0.001	-0.1190	< 0.001	-2.9562 (-4.1780, -1.7344)	< 0.001
Use of lipid-lowering drugs (yes = 1, no = 0)	-0.0638	0.006			-0.1464	< 0.001	-5.1623 (-7.0555, -3.2690)	< 0.001

Forward-backward variable selection with p values in multiple stepwise regression model is < 0.05 . ρ , correlation coefficient; β , Regression coefficient; CI, Confidence interval.

Variables	EQ-5D-5L index score				EQ-VAS			
	ρ	p value	β (95% CI)	p value	ρ	p value	β (95% CI)	p value
Log duration of diabetes (years)	-0.1087	< 0.001			-0.0998	< 0.001	-1.2543 (-1.9317, -0.5767)	< 0.001
Body mass index (kg/m ²)	-0.0829	< 0.001	-0.0020 (-0.0035, -0.0005)	0.032	-0.0270	0.24		
Systolic blood pressure (mmHg)	0.0287	0.21			0.0315	0.17	0.0404 (0.0110, 0.0698)	0.017
Diastolic blood pressure (mmHg)	0.098	< 0.001	0.0002 (0.0000, 0.0005)	0.042	0.0363	0.12		
Fasting plasma glucose level (mmol/L)	0.0365	0.11			0.0307	0.18		
Prandial plasma glucose level (mmol/L)	0.0631	0.006			0.0076	0.74		
Hemoglobin A1c (%)	0.0276	0.24			0.0050	0.83		
Log triglycerides (mmol/L)	-0.0006	0.98			-0.0006	0.64		
Total cholesterol (mmol/L)	0.0035	0.88			0.0510	0.027		
Low-density lipoprotein cholesterol (mmol/L)	-0.0152	0.51			0.0668	0.004		
High-density lipoprotein cholesterol (mmol/L)	-0.0182	0.43			0.0237	0.30		
Log urine albumin-to-creatinine ratio (mg/g)	-0.0737	0.0016			-0.0042	0.86		
Forward-backward variable selection with p values in multiple stepwise regression model is < 0.05. r , correlation coefficient; β , Regression coefficient; CI, Confidence interval.								

Associations among depressions, sleep duration, and HRQoL in individuals with type 2 diabetes

Multiple linear regression models were used to evaluate the relationship between depression and HRQoL (Table 4). In unadjusted model, depression was associated with both EQ-5D-5L index score and EQ-VAS ($\beta = -0.1331$, 95% CI: -0.1448, -0.1215 for EQ-5D-5L index score; $\beta = -9.1317$, 95% CI: -10.5824, -7.6809 for EQ-VAS; both $p < 0.0001$). After further adjustment for possible factors in model 2 and model 3, including age, sex, education status, smoking and drinking status, duration of diabetes, BMI, SBP, DBP, use of hypoglycemic drugs, use of antihypertensive drugs, use of lipid-lowering drugs, FPG, PPG, TGs, TC, HDL-C, and LDL-C, the significant associations retained ($\beta = -0.1273$, 95% CI: -0.1389, -0.1158 for EQ-5D-5L index score; $\beta = -8.8762$, 95% CI: -10.3150, -7.4374 for EQ-VAS, both $p < 0.0001$).

Table 4

Multiple regression analysis to evaluate the association among depression, sleep duration, and HRQoL

Model 1			Model 2		Model 3		
β (95% CI)			p	B (95% CI)	p	β (95% CI)	p
Association between depression and HRQoL							
EQ-5D-5L	-0.1331 (-0.1448, -0.1215)	< 0.001	-0.1295 (-0.1410, -0.1180)	< 0.001	-0.1273 (-0.1389, -0.1158)	< 0.001	
EQ-VAS	-9.1317 (-10.5824, -7.6809)	< 0.001	-0.7306 (-10.2693, -7.4035)	< 0.001	-8.8762 (-10.3150, -7.4374)	< 0.001	
Association between sleep duration and EQ-5D-5L index score							
Total	0.0129 (0.0059, 0.0199)	< 0.001	0.0133 (0.0064, 0.0202)	< 0.001	0.0136 (0.0065, 0.0207)	0.021	
< 7h	-0.0270 (-0.0147, -0.0394)	< 0.001	-0.0240 (-0.0119, -0.0362)	< 0.001	-0.0242 (-0.0116, -0.0367)	< 0.001	
7-8h	1.00 (ref)	—	1.00 (ref)	—	1.00 (ref)	—	
≥ 8h	-0.0058 (-0.0182, 0.0066)	0.36	-0.0033 (-0.0156, -0.0156)	0.60	-0.0025 (-0.0151, 0.0101)	0.69	
Association between sleep duration and EQ-VAS							
Total	1.5170 (0.7163, 2.3176)	< 0.001	1.4202 (0.6287, 2.2117)	< 0.001	1.3401 (0.5254, 2.1548)	< 0.001	
< 7h	-3.3729 (-1.9861, -4.7598)	< 0.001	-3.0296 (-1.6578, -4.4014)	< 0.001	-2.9386 (-1.5210, -4.3562)	< 0.001	
7-8h	1.00 (ref)	—	1.00 (ref)	—	1.00 (ref)	—	
≥ 8h	-0.9312 (-2.6241, 0.7618)	0.28	-0.6961 (-2.3615, 0.969)	0.41	-0.6351 (-2.3478, 1.0776)	0.47	
Depression and sleep duration associated with HRQoL were accessed using multiple linear regression models.							
Model 1: unadjusted model;							
Model 2: model 1 + age, sex, education status, smoking and drinking status, duration of diabetes, body mass index, systolic and diastolic blood pressure, use of hypoglycemic drugs, use of antihypertensive drugs, and use of lipid-lowering drugs							
Model 3: model 3 + fasting plasma glucose, prandial plasma glucose, triglycerides, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol.							

Similar analyses were also conducted to evaluate the relationship between sleep duration and HRQoL (Table 4). Sleep duration was associated with EQ-5D-5L index score and EQ-VAS before and after

adjustment for possible confounders (in unadjusted models: $\beta = 0.0129$, 95% CI: 0.0059, 0.0199 for EQ-5D-5L index score; $\beta = 1.5170$, 95% CI: 0.7163, 2.3176 for EQ-VAS; both $p < 0.0001$; after adjustment in model 2 and model3: $\beta = 0.0136$, 95% CI: 0.0065, 0.0207, $p = 0.021$ for EQ-5D-5L index score; $\beta = 1.3401$, 95% CI: 0.5254, 2.1548, $p < 0.0001$ for EQ-VAS).

Compared with sleep duration of 7-8h, sleep duration < 7 h was associated with a lower EQ-5D-5L index score and EQ-VAS before and after adjusted for possible confounders (in unadjusted models: $\beta = -0.0270$, 95% CI: -0.0147, -0.0394 for EQ-5D-5L index score, $\beta = -3.3729$, 95% CI: -1.9861, -4.7598 for EQ-VAS; both $p < 0.001$; fully-adjusted models: $\beta = -0.0242$, 95% CI: -0.0116, -0.0367, for EQ-5D-5L index score; $\beta = -2.9386$, 95% CI: -1.5210, -4.3562 for EQ-VAS, both $p < 0.001$). However, sleep duration ≥ 8 h did not show significant differences in EQ-5D-5L index score and EQ-VAS compared with sleep duration of 7-8h (in unadjusted models: $\beta = -0.0058$, 95% CI: -0.0182, 0.0066, $p = 0.36$ for EQ-5D-5L index score, $\beta = -0.9312$, 95% CI: -2.6241, 0.7618, $p = 0.28$ for EQ-VAS; fully-adjusted models: $\beta = -0.0025$, 95% CI: -0.0151, 0.0101, $p = 0.69$ for EQ-5D-5L index score; $\beta = -0.6351$, 95% CI: -2.3478, 1.0776, $p = 0.47$ for EQ-VAS).

Discussion

In the present study, we identified depression and use of antihypertensive drugs were independently associated with HRQoL. We also found that compared with sleep duration of 7-8h, sleeping < 7 h was associated with a significantly lower HRQoL, while sleep duration ≥ 8 h did not show a significant difference. It might suggest that a longer sleep duration might not improve the quality of life in individuals with type 2 diabetes.

HRQoL has gained more attention as an essential health outcome indicator in chronic diseases[16]. A list of determinants of HRQoL includes country, social-economic class, and scoring methods, et al. Therefore, the country-specific scoring algorithms were developed to calculate EQ-5D-5L index score, a standardized generic instrument for estimation of HRQoL. To date, a few studies explored the possible factors associated with HRQoL in participants with type 2 diabetes in China. Reportedly, age and chronic complications of participants with type 2 diabetes had inverse correlations with the EQ-5D scores, while clinical factors, including glycemic control, lipids, hypertension, showed minimal associations[17] [18]. Furthermore, we found in the present study that use of antihypertensive drugs is an independent factor of EQ-5D-5L index score and EQ-VAS. HRQoL is an important predictor of mortality and morbidity, further studies are warranted to improve life quality and prolong life span of individuals with type 2 diabetes in China.

Depression is a common mood disorder and affects individuals with diabetes. A published meta-analysis reported a double odd of depression among individuals with diabetes[19]. Till now, the prevalence of depression in individuals with type 2 diabetes has been reported with great variations among different studies in China. For example, Zhang, et. al. reported [20] a depression prevalence of 5.7 % among the hospitalized participants with type 2 diabetes in which depression was defined as Beck Depression Inventory scores ≥ 14 . Another research from Hong Kong using the Geriatric Depression Scale showed

that 26% of individuals with diabetes aged 60 years or older had elevated levels of depressive symptoms [21]. Our study reported that 8.9% of a community-based population of participants with type 2 diabetes had at least mild depression with the cutoff of PHQ-9 scores ≥ 5 . These discrepancies probably accounted for study design, demographic characteristics, time frame, and measurement tools [20–23]. A further nationwide epidemiological survey is required for validation of the prevalence of depression among individuals with type 2 diabetes in China.

Extensive research has identified the risk factors of depression in individuals with type 2 diabetes. In the present study, individuals with depression had higher educational levels and more usage of lipid-lowering drugs. Similarly, Yu S, et al. found that sleep duration was significantly associated with depressive symptoms in individuals with diabetes, in particular those with higher education levels. The positive association between lipid-lowering drug use and depression was consistent with other human studies as well as animal studies [24, 25]. A mendelian randomization study found an increased risk of depression during statin and proportion convertase subtilisin/kexin type 9 inhibitor therapy [25]. One possible mechanism lied on the deregulations in serotonin neurotransmission results from the perturbed cholesterol metabolism [26]. The other documented variables significantly were associated with depression syndrome in individuals with diabetes did not show significant associations in the present study, such as glycemic control and gender [20, 27]. The low prevalence of depression and the mild depression symptoms might affect the statistical power.

More likely to be neglected by health care providers, sleep disturbance was often accompanied by depression, such as longer sleep latency, increased awakenings, and earlier waking compared with non-depressed individuals [28]. Thus, sleep duration might be a factor associated with HRQoL in type 2 diabetes. In our study, sleep duration was significantly associated with HRQoL in individuals with type 2 diabetes. Further, sleep duration of 7-8h was associated with a higher quality of life compared with sleep duration < 7h. However, a longer duration equal to or more than 8h does not mean a better quality of life, consistent with that in the general population [29]. Also, involvement of depression, sleep duration, and other clinical factors in multiple stepwise regression analysis found the association between sleep duration and quality of life was attenuated. That means depression might act as a confounder in the association between sleep and quality of life.

This study had several limitations. First, the study was cross-sectional, limiting the causality. Longitudinal research could draw a more confirmative conclusion. Second, the “gold standard” for diagnosis of depression in clinical practice is a clinical interview for the Structured Clinical Interview for DSM-IV Axis I Disorders. However, it is difficult to use in epidemiological studies with thousands of participants. Thus, PHQ-9 was one of the most often used international measurement tools with high sensitivity and specificity.

In summary, the results of the current study demonstrate that depression was inversely associated with health-related quality of life in community-based individuals with type 2 diabetes in China. Individuals with shorter sleep duration (< 7h) are prone to having depression and those with sleep duration of 7-8h

have a better health-life quality. Our results suggest that it is important to identify individuals with type 2 diabetes with depression and shorter sleeping hours in the clinical treatments.

Abbreviations

One-way analysis of variance	ANOVA
Diastolic blood pressure	DBP
Five-level Version of European Quality of Life-5 Dimensions	EQ-5D-5L
EQ visual analogue scale	EQ-VAS
Fasting plasma glucose	FPG
Gylcated hemoglobin A1c	HbA1c
High-density lipoprotein cholesterol	HDL-C
Health-related quality of life	HRQoL
Low-density lipoprotein cholesterol	LDL-C
Patient Health Questionnaire-9	PHQ-9
postprandial plasma glucose	PPG
systolic blood pressure	SBP
Student Newman–Keuls	SNK
Total cholesterol	TC
Triglycerides	TGs
Urinary albumin-to-creatinine ratios	UACR

Declarations

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Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest disclosures

The author declare that there is no duality of interest associated with this manuscript.

Ethics approval

This study was approved by the institutional review board of Renji Hospital, Shanghai Jiao Tong University School of Medicine

Consent to participate

Each individual gave the informed consent.

Competing Interests

The authors declared that no competing interests exist.

Consent for publication

All of the authors agree to its publication when the article is submitted to the journal.

Authors' contributions

Yu Liu, Beirui Wu, and Hua Xu contributed to data interpretation and manuscript writing. Xu Wan and Huichao Wu and Jing Gao contributed to the analysis and interpretation of data. Wei Huang and Wei Luan contributed to the acquisition and interpretation of data. Wei Liu and Jie Shen were involved in all aspects of the study, including study design and data collection, analysis, and interpretation. All authors made critical intellectual contributions to drafting and/or revising the manuscript and all approved the final version. Jing Ma are the guarantors of this work and, as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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Figures

Figure 1

Prevalence of depression across sleep duration groups. P value was calculated using χ^2 tests. Bar 1: number of patients with and without depression (n = 118 and 733, respectively), bar 2: number of patients with and without depression (n = 34 and 610, respectively), bar 3: number of patients with and without depression (n = 17 and 379, respectively).