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Association of the combination of sleep duration and sleep quality with quality of life in type 2 diabetes patients

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Abstract

Purpose Sleep problems are very common in people with diabetes. The aim of this study was to assess the association of the combination of self-reported sleep duration and sleep quality on quality of life (QOL) in Chinese patients with type 2 diabetes mellitus (T2DM).

Methods We analyzed the community-based cross-sectional data of 798 patients with T2DM in Xiamen, China, in 2016. Sleep duration was measured as self-reported average sleep time during the previous month. Sleep quality was evaluated as self-rated reports. QOL was assessed by the Diabetes-specific Quality of Life (DSQL), with scores < 40 and ≥ 80 set as cut-off values for differentiating good, fair, and poor QOL. Ordinal logistic regression was performed to model the associations of QOL with sleep duration, sleep quality, and their combined effects by adjusting for certain covariates.

Results The separate associations of sleep duration and sleep quality in relation to QOL in T2DM patients were significant ($P < 0.05$). After controlling for sleep quality, there was no significant correlation between sleep duration and QOL. The combined analysis suggested that the association of sleep duration with QOL in T2DM patients was sleep quality-dependent. Longer sleep duration was associated with higher odds ratios (ORs) of better QOL for patients who reported fair sleep quality and good sleep quality, but no such trend was observed for patients who reported poor sleep quality ($P > 0.05$). Excessive sleep duration (≥ 9 h per day) was detrimental to QOL in T2DM only when they reported poor sleep quality.

Conclusions Specific disparities exist in the association of sleep quality with sleep duration and QOL in T2DM patients. Failures to take into account the effect of sleep quality when evaluating the impact of sleep on QOL significantly bias the results. It is important to integrate duration and quality of sleep as a composite sleep index when assessing sleep of patients with T2DM.

Keywords Sleep duration · Sleep quality · Association of the combination · Quality of life · Type 2 diabetes

Introduction

With the rise in the older population and unhealthy lifestyles, diabetes has become one of the primary risk factor for death worldwide, especially in China [1]. The International Diabetes Federation (IDF) estimated that the number of people with diabetes in China reached 114.4 million in 2017, with type 2 diabetes mellitus (T2DM) being predominant [2]. Compared with the general population, people with T2DM report poorer quality of life (QOL) due to functional decline and disability [3–5]. QOL is one of the most important indexes in individuals with T2DM, as it reflects the physical and social function as well as the emotional health. Therefore, improvements in QOL represent a major goal of health interventions. Even more compelling evidence of this association was provided by a prospectively followed cohort

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study that revealed a strong relation between worse QOL and mortality in patients with T2DM [6].

Previous studies have indicated that QOL in adults with T2DM can be significantly influenced by certain medical interventions and by lifestyle and educational interventions, such as insulin use, glycemic control, smoking cessation, weight control, and psychologically health [7–12]. Insufficient sleep and poor sleep quality are very common in people with T2DM [13–15]. Even after controlling for age, race, education, body mass index (BMI), and diabetes-related distress, poor sleep is significantly correlated with worse QOL in T2DM [16].

Sleep, as a part of a healthy lifestyle, plays an important role in sustaining good health. Sufficient sleep of good quality plays an important and effective role in preventing mental disorders, chronic health conditions, and cardiovascular disease and even death [17]. Although ethnic differences in the risk of poor sleep are frequently reported [18], sleep duration and sleep quality have not been well studied in the Chinese T2DM population. Furthermore, there is increasing evidence that the effectiveness of strategies for the prevention and control of T2DM varies with ethnicity [19, 20]. However, many studies have failed to consider the potential interaction between the duration and quality of sleep. People with enough sleep usually experience good sleep quality [21]. When analyzing the correlation between diabetes and sleep, it is insufficient to consider sleep duration alone and the individual and combined effects of sleep duration and sleep quality on QOL in T2DM patients remain to be established.

Therefore, using the data from a representative cross-sectional survey conducted in Xiamen, China, we assessed the separated associations of self-reported sleep duration and quality with QOL in T2DM patients. Furthermore, the association of the combination of sleep duration and sleep quality on diabetes-specific QOL was explored.

Materials and methods

Study population

We carried out a cross-sectional survey among five subdistricts in Xiamen, China, in 2016. In total, 800 T2DM patients aged 18+ years who were local residents were enrolled in the study using a multi-stage stratified sampling procedure. Using a self-designed questionnaire, patient information (sociodemographic characteristics, living habits, and quality of life) was obtained through face-to-face interviews. Complete data were obtained for 798 patients.

Quality of life assessment

The main primary outcome in the present study was the diabetes-specific QOL measured according to the Diabetes-specific Quality of Life (DSQL), which is a validated scale designed for Chinese patients with T2DM [22]. The Cronbach's alpha of DSQL is 0.95, and the split-half reliability of DSQL is 0.91. The scale consists of 24 questions with four dimensions which reflect the QOL status of patients in terms of physiology, psychology, sociology, and therapy. The sum of DSQL scores ranges from 24 to 120 points, higher scores represent poorer QOL. The DSQL scores were classified as follows: 'poor QOL (≥ 80),' 'fair QOL (40–79),' and 'good QOL (<40).'

Key variables

The factors of interest were sleep duration and sleep quality. Information on sleep duration was obtained from the responses to questions about usual sleep duration per day (including night and daytime sleep). The results for sleep duration were rounded up to the nearest whole hour classified as follows: '≤ 6 h per day', '7–8 h per day'(reference group), and '≥ 9 h per day.' We further considered sleep quality as a potential modifier of the association between sleep duration and QOL. Information on sleep quality was measured by asking 'What is the quality of your sleeping recently?' with the choice of five different answers: 'poor,' 'rather poor,' 'fair,' 'rather good,' and 'good.' We furthered categorized sleep quality as 'poor sleep quality (poor or rather poor; reference group),' 'fair sleep quality (fair),' and 'good sleep quality (rather good or good).' The covariates in the study included demographic characteristics, early-life health behaviors, type of medication, comorbidities, complications, and hemoglobin A1c (HbA1c) levels. Demographic characteristics included sex, age educational level, and BMI. Early-life health behaviors included smoking and drinking (alcohol) habits. As diabetes duration plays a major role in the QOL of diabetes patients [23, 24], we also evaluated the effects of both sleep duration and sleep quality in relation to different diabetes duration classified as follows: '<5 years' (reference group), '5–10 years', and '>10 years.'

Statistical analysis

First, we summarized the characteristics of the T2DM patients according to QOL status using Chi-squared tests. Ordinal logistic regressions were then performed without considering the interactions and QOL status was then modeled according to diabetes duration only, sleep duration only, sleep quality only, diabetes duration and sleep duration,

diabetes duration and sleep quality adjusting for the covariates mentioned previously (models 1–6, respectively). Finally, in model 7, we further considered the interaction of the two sleep parameters (duration and quality). ORs were calculated using the function for linear combinations of coefficients, where the sleep duration '7–8 h per day' and poor sleep quality were viewed as reference categories. All the analyses were performed using SAS V.9.4 (SAS Institute Inc., Cary, North Carolina, USA).

The seven regression models were expressed as follows:

Model 1: logit (QOL) ~ Diabetes duration + covariates;
Model 2: logit (QOL) ~ Sleep duration + covariates;
Model 3: logit (QOL) ~ Sleep quality + covariates;
Model 4: logit (QOL) ~ Diabetes duration + sleep duration + covariates;
Model 5: logit (QOL) ~ Diabetes duration + sleep quality + covariates;
Model 6: logit (QOL) ~ Diabetes duration + sleep duration + sleep quality + covariates;
Model 7: logit (QOL) ~ Diabetes duration + sleep duration + sleep quality + sleep duration × sleep quality + covariates;

Results

Basic characteristics of T2DM patients

The basic characteristics of the 798 diabetes patients included in this study are shown according to the QOL in Table 1. As diabetes duration advanced, the diabetes-specific QOL increased ($P = 0.001$). The patients who were female with longer sleep duration, better sleep quality, and suffered from fewer comorbidities and complications presented significantly higher rates of better QOL. Furthermore, those who reported no medication use or 'pills only' showed better QOL.

Separated association of sleep duration and quality with QOL in T2DM patients

The ORs of QOL across different levels of diabetes duration, sleep duration, and sleep quality are shown in Table 2. As expected, ORs of better QOL decreased as diabetes duration increased in all the models in which diabetes duration was considered as a predictor (models 1, 4, 5, and 6). Furthermore, ORs of better QOL increased as sleep quality improved in all the models in which sleep quality was considered as a predictor (models 3, 5, and 6). This trend was consistent in model 2 and model 4 when the sleep duration improved. However, after controlling for sleep quality, there was no significant correlation between sleep duration and QOL in model 6.

Association of the combination of sleep duration and quality with QOL in T2DM patients

The interaction of sleep duration and sleep quality was included in model 7 (Table 3). Patients who reported '7–8 h per day' sleep duration and poor sleep quality were set as the reference group. In general, better sleep quality was associated with higher ORs of better QOL among diabetes patients with the same sleep duration. In addition, longer sleep duration was associated with higher ORs of better QOL among patients who reported fair and good sleep quality, but no such trend was observed for patients who reported poor sleep quality ($P > 0.05$). Among all the groups, poor sleep quality with '≥ 9 h per day' sleep duration had the least ORs of better QOL, although this association is failed to reach the level of statistical significance (ORs 0.16, 95% CI 0.01–1.71).

Discussion

In this cross-sectional survey, the total rate of good QOL was only 12.03% among a population of local household-registered adults with T2DM in Xiamen, China. The low QOL score among patients with T2DM identified in the current study is consistent with previous findings in China and other countries [7, 22].

In an effort to improve the QOL of T2DM patients in Chinese adults, the association of the separation and combination of sleep duration and sleep quality with the QOL were assessed, when controlling for diabetes duration, sex, age, educational level, BMI, smoking and drinking (alcohol) habits, type of medication, comorbidities, complications, and HbA1c level as potential confounders. Longer sleep duration and good sleep quality were separately found to be associated with good QOL. Moreover, assessment of the combined effects of sleep duration and sleep quality on QOL in the current study suggested the existence of sleep quality-specific disparities in the association between sleep duration and QOL in T2DM patients. These findings suggest that sleep duration as well as sleep quality exert a combined influence on diabetes-specific QOL.

In the current study, we found that nearly half (49.12%) of the diabetes patients reported the extremes of sleep duration (≤ 6 or ≥ 9) and more than a half (60.3%) of the patients had sleep quality problems. Previous studies have shown that 45–67% of T2DM patients suffer from poor sleep [25–27]. Furthermore, a national survey conducted in China in 2013 showed that 49.3% of T2DM patients reported poor sleep quality [28]. Poor sleep is associated with problems of mobility, pain/discomfort, and anxiety/depression [29–31].

Table 1 Basic characteristics of 798 diabetes patients according to the quality of life

Characteristic	Diabetes-specific quality of life			χ^2	*P* value
	Poor	Fair	Good		
Total, *N* (%)	35 (4.39)	667 (83.58)	96 (12.03)		
Sex, *N* (%)				3.83	0.050*
Female	11 (3.11)	294 (83.05)	49 (13.84)		
Male	24 (5.41)	373 (84.01)	47 (10.59)		
Age group (years), *N* (%)				0.71	0.399
< 60	12 (5.31)	189 (83.63)	25 (11.06)		
≥ 60	23 (4.02)	478 (83.57)	71 (12.41)		
Educational level, *N* (%)				0.65	0.420
None/primary	13 (4.63)	236 (83.99)	32 (11.39)		
Secondary	17 (4.43)	322 (83.85)	45 (11.72)		
Tertiary	5 (3.76)	109 (81.95)	19 (14.29)		
BMI (kg/m^2), *N* (%)				0.06	0.814
Underweight (< 18.5)	1 (4.55)	20 (90.91)	1 (4.55)		
Normal (18.5–23.0)	12 (4.17)	240 (83.33)	36 (12.50)		
Overweight (> 23.0–27.0)	13 (3.69)	296 (84.09)	43 (12.22)		
Obese (> 27)	9 (6.62)	111 (81.62)	13 (11.76)		
Smoking habit, *N* (%)				0.93	0.335
Smoker	5 (3.52)	117 (82.39)	20 (14.08)		
Non-smoker	30 (4.57)	550 (83.84)	76 (11.59)		
Alcohol drinking, *N* (%)				0.96	0.328
Drinker	3 (2.31)	110 (84.62)	17 (13.08)		
Non-drinker	32 (4.79)	557 (83.38)	79 (11.83)		
Duration of diabetes (years), *N* (%)				11.70	< 0.001***
< 5	9 (3.49)	205 (79.46)	44 (17.05)		
5–10	6 (2.48)	210 (86.78)	26 (10.74)		
> 10	20 (6.71)	252 (84.56)	26 (8.72)		
Sleep duration (hours), *N* (%)				15.39	< 0.001***
≤ 6	22 (7.36)	252 (84.28)	25 (8.36)		
7–8	12 (2.96)	340 (83.74)	54 (13.30)		
≥ 9	1 (1.08)	75 (80.65)	17 (18.28)		
Sleep quality, *N* (%)				32.18	< 0.001***
Poor	22 (10.53)	176 (84.21)	11 (5.26)		
Fair	8 (2.92)	232 (84.67)	34 (12.41)		
Good	5 (1.59)	259 (82.22)	51 (16.19)		
Type of medication, *N* (%)				22.50	< 0.001***
None	1 (3.33)	18 (60.00)	11 (36.67)		
Pills only	15 (2.94)	431 (84.34)	65 (12.72)		
Insulin only	4 (12.12)	25 (75.76)	4 (12.12)		
Pills and insulin	15 (6.70)	193 (86.16)	16 (7.14)		
Comorbidities, *N* (%)				19.29	< 0.001***
None	8 (2.56)	251 (80.19)	54 (17.25)		
1–2 diseases	18 (4.92)	312 (85.25)	36 (9.84)		
≥ 3 diseases	9 (7.56)	104 (87.39)	6 (5.04)		
Complications, *N* (%)				38.61	< 0.001***
None	11 (1.94)	469 (82.86)	86 (15.19)		
≥ 1	24 (10.34)	198 (84.34)	10 (4.31)		
HbA1c level, *N* (%)				0.36	0.551
< 7%	20 (4.53)	388 (84.29)	59 (11.18)		
≥ 7%	15 (4.28)	279 (83.08)	37 (12.63)		

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Table 2 Odds ratios (95% confidence intervals (CI)) obtained from multivariable adjusted ordinal logistic models (models 1–6)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Diabetes duration						
< 5 years	1.00			1.00	1.00	1.00
5–10 years	0.83 (0.51, 1.35)			0.83 (0.51, 1.35)	0.88 (0.54, 1.43)	0.86 (0.53, 1.41)
> 10 years	0.58 (0.35, 0.96)			0.59 (0.36, 0.98)	0.60 (0.36, 0.99)	0.60 (0.36, 0.99)
Sleep duration						
≤ 6 h		0.55 (0.36, 0.85)		0.56 (0.36, 0.87)		0.80 (0.50, 1.28)
7–8 h		1.00		1.00		1.00
≥ 9 h		1.47 (0.81, 2.64)		1.49 (0.83, 2.70)		1.40 (0.77, 2.56)
Sleep quality						
Poor			1.00		1.00	1.00
Fair			2.89 (1.64, 5.10)		2.85 (1.61, 5.03)	2.56 (1.41, 4.64)
Good			3.76 (2.14, 6.62)		3.74 (2.13, 6.59)	3.19 (1.73, 5.88)

Covariates: sex, age, educational level, BMI, smoking habits, alcohol drinking habits, type of medication, comorbidities, complications, and HbA_{1c} level

Dependent variable: DQOL (poor, fair, and good)

Table 3 Odds ratios (95% CI) obtained from multivariable adjusted ordinal logistic models regressing QOL against sleep duration and sleep quality (model 7) and accounting for their interaction

Sleep quality	Sleep duration		
	≤ 6 h	7–8 h	≥ 9 h
Poor	0.73 (0.28, 1.90)	1.00	0.16 (0.01, 1.71)
Fair	1.99 (0.72, 5.56)	1.98 (0.77, 5.14)	4.67 (1.32, 16.48)
Good	1.84 (0.61, 5.58)	3.03 (1.20, 7.67)	3.85 (1.31, 11.28)

Covariates: diabetes duration, sex, age, educational level, BMI, smoking habits, alcohol drinking habits, type of medication, comorbidities, complications, and HbA_{1c} level

Dependent variable: DQOL (poor, fair, and good)

The consistently high proportions of patients reporting poor sleep in these studies highlight the seriousness of sleep problems experienced among the population in China and that this issue remains to be solved effectively. There is evidence to show poor sleep quality are potential risk factors for insulin resistance, glucose intolerance, and metabolic syndrome [32]. Thus, it is important for primary care physicians to have a high degree of suspicion of an underlying sleep disorder in patients with diabetes.

With regard to QOL in T2DM, we observed that longer sleep duration and good sleep quality were significantly associated with an improvement in QOL. Previous studies have indicated an inverse U-shaped relationship between sleep duration and QOL in T2DM patients, which implies that QOL can be detrimentally affected by short sleep duration, as well as long sleep duration [33–36]. In our study, comparatively speaking, we did not found an inverse U-shaped association between sleep duration and QOL. Patients with sleep duration ≥ 9 h per day also showed a higher OR of improved QOL. It can be speculated that the conflicting results obtained in the current study may be due to the failure of those studies to consider the potential confounding effects of sleep quality. Nevertheless, the conclusive nature of our evidence may be limited by the small sample size of patients with long sleep duration.

The evaluation of sleep requires full consideration of sleep quantity and sleep quality. Epidemiological and experimental studies have shown that reductions in the both the quantity and quality of sleep impair metabolic control and increase the severity of T2DM [35, 37]; this association is also supported by the current study. Without adjusting for sleep quality as a confounding factor, longer sleep duration was found to be associated with higher QOL. After controlling for sleep quality, sleep duration was not significantly associated with DSQL, a finding that is consistent with those of two other studies in China [38, 39].

To preclude the interactively confounding effects, we further explored the associations of the combination of sleep duration and sleep quality in relation to QOL in T2DM patients. The results suggested that the association of sleep duration with QOL in T2DM patients varied with sleep quality. For patients with poor sleep quality, no category of sleep duration was found to be related to QOL. However, each category of sleep duration showed significant associations with QOL among the patients reporting fair and good sleep quality. Longer sleep duration had higher ORs of better QOL for patients who reported fair and good sleep quality, while an inverse U-shaped trend was observed for patients who reported poor sleep quality, although this effect was not statistically significant. Compared with other studies, our results showed that excessive

sleep duration was detrimental to QOL in T2DM patients only when they reported poor sleep quality. The combined effect of sleep duration and sleep quality suggests the importance of ensuring good sleep quality as well as adequate sleep duration. The conflicting evidence for the correlation of sleep duration and QOL in T2DM patients may be due to the failure of some studies to take the effect of sleep quality into consideration [33, 34, 40].

Patients with longer duration of diabetes have a higher rate of poor glycemic control because the function of insulin secretion has been uncontrolled over a longer period time [41]. In the current study, we also identified a relationship between diabetes duration and sleep. Considering the more frequent sleep problems and poor QOL in patients with longer diabetes duration, we have made particular efforts to control for the confounding effect of diabetes duration in the present study.

As far as we know, this is the first representative population-based study to assess the combined effects of sleep duration and sleep quality on QOL in T2DM patients in China. Nevertheless, some limitations should also be acknowledged. First, the cross-sectional survey study design limits our ability to draw causal inferences. Second, the data for sleep quality were obtained self-reported by the patients rather than the validated instrument Pittsburgh Sleep Quality Index (PSQI) in other studies. This was determined by more than one-third of participants reported none/primary educated and more than 70% of participants are elderly in our study. After a pilot study, we found that these patients were hard to understand or complete PSQI in a face-to-face interview setting. So, in view of the testability of PSQI, we determined to use simple questions considering trade-off between validity and academic authority. Moreover, many studies have confirmed the acceptable of self-reported sleep quality [30, 42–45]. Nevertheless, future studies using the PSQI are still warranted. Third, we were unable to include some well-known significant risk factors of diabetes management, such as obstructive sleep apnoea (OSA) and depression, in our study.

In conclusion, in this sample of Chinese adults with T2DM, sleep quality as well as sleep duration were found to be positively correlated with a higher QOL. More importantly, there are sleep quality-specific disparities in the association between sleep duration and QOL in T2DM patients. Failure to take into account the effect of sleep quality when evaluating the impact of sleep on QOL may be detrimental to the QOL of T2DM patients. Therefore, measures need to be taken to target specific aspects of sleep to improve the QOL of T2DM patients in China. In addtion, it is important to integrate duration and quality of sleep as a composite sleep index when assessing sleep of patients with T2DM.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Xu, Y., Wang, L., He, J., Bi, Y., Li, M., Wang, T., et al. (2013). Prevalence and control of diabetes in Chinese adults. *JAMA, 310*(9), 948–959. https://doi.org/10.1001/jama.2013.168118.
2. IDF diabetes atlas-8th edition (2017). http://www.diabetesatlas.org. Accessed 1 Jan 2018.
3. Rubin, R. R., & Peyrot, M. (1999). Quality of life and diabetes. *Diabetes Metabolism Research and Reviews, 15*(3), 205–218.
4. Volpato, S., Maraldi, C., & Fellin, R. (2010). Type 2 diabetes and risk for functional decline and disability in older persons. *Current Diabetes Reviews, 6*(3), 134–143.
5. Ribu, L., Hanestad, B. R., Moum, T., Birkeland, K., & Rustoen, T. (2007). A comparison of the health-related quality of life in patients with diabetic foot ulcers, with a diabetes group and a nondiabetes group from the general population. *Quality of Life Research, 16*(2), 179–189. https://doi.org/10.1007/s11136-006-0031-y.
6. Landman, G. W., van Hateren, K. J., Kleefstra, N., Groenier, K. H., Gans, R. O., & Bilo, H. J. (2010). Health-related quality of life and mortality in a general and elderly population of patients with type 2 diabetes (ZODIAC-18). *Diabetes Care, 33*(11), 2378–2382. https://doi.org/10.2337/dc10-0979.
7. Wexler, D. J., Grant, R. W., Wittenberg, E., Bosch, J. L., Cagliero, E., Delahanty, L., et al. (2006). Correlates of health-related quality of life in type 2 diabetes. *Diabetologia, 49*(7), 1489–1497. https://doi.org/10.1007/s00125-006-0249-9.
8. Imayama, I., Plotnikoff, R. C., Courneya, K. S., & Johnson, J. A. (2011). Determinants of quality of life in type 2 diabetes population: The inclusion of personality. *Quality of Life Research, 20*(4), 551–558. https://doi.org/10.1007/s11136-010-9772-8.
9. Takahashi, K., Yamakawa, T., Sakamoto, R., Harada, M., Fujii, R., Shinoda, M., et al. (2017). Quality of life in japanese patients with type 2 diabetes mellitus. *Diabetes, 66*, A450–A450.
10. Duarte, L., Silva-Nunes, J., Lopes, A. F., & Malheiro, F. (2009). Determinants of glycaemic control, compliance to treatment and quality of life in type 2 diabetes. *Diabetes, 58*, A642–A642.
11. Lund, N., Colclough, H. A., & Hammer, M. (2008). Impact of body mass index on health-related quality-of-life for persons with type 2 diabetes in the USA. *Diabetes, 57*, A342–A342.

12. Kleefstra, N., Landman, G. W. D., Houweling, S. T., Ubink-Veltmaat, L. J., Logtenberg, S. J. J., Meyboom-de Jong, B., et al. (2008). Prediction of mortality in type 2 diabetes from health-related quality of life (ZODIAC-4). *Diabetes Care, 31*(5), 932–933. https://doi.org/10.2337/dc07-2072.
13. Johnson, S. T., Thiel, D., Al Sayah, F., Mundt, C., Qiu, W., Buman, M. P., et al. (2017). Objectively measured sleep and health-related quality of life in older adults with type 2 diabetes: A cross-sectional study from the Alberta's Caring for Diabetes Study. *Sleep Health, 3*(2), 102–106. https://doi.org/10.1016/j.sleh.2016.12.002.
14. McNeil, J., Doucet, E., & Chaput, J. P. (2013). Inadequate sleep as a contributor to obesity and type 2 diabetes. *Canadian Journal of Diabetes, 37*(2), 103–108. https://doi.org/10.1016/j.jcjd.2013.02.060.
15. Plantinga, L., Rao, M. N., & Schillinger, D. (2012). Prevalence of self-reported sleep problems among people with diabetes in the United States, 2005–2008. *Preventing Chronic Disease*, https://doi.org/10.5888/pcd9.110244.
16. Johnson, S. T., Qiu, W., Mundt, C., Sayah, A. F., & Johnson, J. A. (2015). Sleep and health-related quality of life in adults with type 2 diabetes. *Diabetologia, 58*, S456–S457.
17. Chien, K. L., Chen, P. C., Hsu, H. C., Su, T. C., Sung, F. C., Chen, M. F., et al. (2010). Habitual sleep duration and insomnia and the risk of cardiovascular events and all-cause death: Report from a community-based cohort. *Sleep, 33*(2), 177–184.
18. Shadyab, A. H., Kritz-Silverstein, D., Laughlin, G. A., Wooten, W. J., Barrett-Connor, E., & Araneta, M. R. G. (2015). Ethnic-specific associations of sleep duration and daytime napping with prevalent type 2 diabetes in postmenopausal women. *Sleep Medicine, 16*(2), 243–249. https://doi.org/10.1016/j.sleep.2014.11.010.
19. Florez, H., Pan, Q., Barrett-Connor, E., Kriska, A. M., Delahanty, L. M., Saudek, C. D., et al. (2010). Race/ethnic baseline differences and overall lifestyle intervention benefits in quality of life among participants in the diabetes prevention program. *Diabetes, 59*, A86–A86.
20. Zhang, L., Ferguson, T. F., Simonsen, N., Chen, L. W., & Tseng, T. S. (2014). Racial/ethnic disparities in health-related quality of life among participants with self-reported diabetes from NHANES 2001–2010. *Diabetes Educator, 40*(4), 496–506. https://doi.org/10.1177/0145721714530573.
21. Bliwise, D. L., Holm-Larsen, T., & Goble, S. (2014). Increases in duration of first uninterrupted sleep period are associated with improvements in PSQI-measured sleep quality. *Sleep Medicine, 15*(10), 1276–1278. https://doi.org/10.1016/j.sleep.2014.05.013.
22. Chen, A., Zhang, Z., Liao, Z., Wan, L., Deng, W., & Yuan, H. (2006). Self-management and quality of life in patients with diabetes mellitus. *Chinese Journal of Behavioral Medicine Science, 15*(5), 434–436.
23. Song, T. T., Luo, Y. Y., Wang, X. H., Li, J., Han, Q., Zhu, H., et al. (2017). Clinical characteristics of Chinese patients with duration of type 2 diabetes> 40 years. *Journal of Diabetes, 9*(1), 45–52. https://doi.org/10.1111/1753-0407.12375.
24. Twigg, S. M., Escalada, J., Grisoni, M. L., Stella, P., Merino-Trigo, A., Gonzalez, F. J. L., et al. (2015). Age, BMI, and diabetes duration: Effect on glycemic control and hypoglycemia with insulin glargine 300 U/mL in type 2 diabetes (T2DM). *Diabetes, 64*, A260–A260.
25. Luyster, F. S., & Dunbar-Jacob, J. (2011). Sleep quality and quality of life in adults with type 2 diabetes. *The Diabetes Educator, 37*(3), 347–355. https://doi.org/10.1177/0145721711400663.
26. Knutson, K. L., Ryden, A. M., Mander, B. A., & Van Cauter, E. (2006). Role of sleep duration and quality in the risk and severity of type 2 diabetes mellitus. *Archives of Internal Medicine, 166*(16), 1768–1774. https://doi.org/10.1001/archinte.166.16.1768.
27. Van Cauter, E. (2009). Short sleep, poor sleep: Novel risk factors for type 2 diabetes. *Faseb Journal, 23*, 417 .
28. Song, Y. X., Ye, X., Ye, L. Q., Li, B. J., Wang, L. J., & Hua, Y. Y. (2013). Disturbed subjective sleep in chinese females with type 2 diabetes on insulin therapy. *PLoS ONE, 8*(1), e54951.
29. Pan, C. W., Cong, X. L., Zhou, H. J., Li, J., Sun, H. P., Xu, Y., et al. (2017). Self-reported sleep quality, duration, and health-related quality of life in older Chinese: Evidence from a rural town in Suzhou, China. *Journal of Clinical Sleep Medicine, 13*(8), 967–974.
30. Siwasaranond, N., Nimitphong, H., Saetung, S., Chirakalwasan, N., Ongphiphadhanakul, B., & Reutrakul, S. (2016). Shorter sleep duration is associated with poorer glycemic control in type 2 diabetes patients with untreated sleep-disordered breathing. *Sleep and Breathing, 20*(2), 569–574. https://doi.org/10.1007/s11325-015-1243-6.
31. Altaf, Q., Lascar, N., Jenner, H., Bellary, S., & Tahrani, A. (2017). Shorter sleep duration and poor sleep quality are associated with increased adiposity in patients with young onset Type 2 diabetes: A cross-sectional study. *Diabetic Medicine, 34*, 31–31.
32. Iyer, S. R. (2012). Sleep and type 2 diabetes mellitus-clinical implications. *JAPI, 60*, 42–47.
33. Ohayon, M. M., Reynolds, C. F., & Dauvilliers, Y. (2013). Excessive sleep duration and quality of life. *Annals of Neurology, 73*(6), 785–794. https://doi.org/10.1002/ana.23818.
34. Faubel, R., Lopez-Garcia, E., Guallar-Castillon, P., Balboa-Castillo, T., Gutierrez-Fisac, J. L., Banegas, J. R., et al. (2009). Sleep duration and health-related quality of life among older adults: A population-based cohort in Spain. *Sleep, 32*(8), 1059–1068.
35. Shan, Z. L., Ma, H. F., Xie, M. L., Yan, P. P., Guo, Y. J., Bao, W., et al. (2015). Sleep duration and risk of type 2 diabetes: A meta-analysis of prospective studies. *Diabetes Care, 38*(3), 529–537. https://doi.org/10.2337/dc14-2073.
36. Alnaji, A., Law, G. R., & Scott, E. M. (2016). The role of sleep duration in diabetes and glucose control. *Proceedings of the Nutrition Society, 75*(4), 512–520. https://doi.org/10.1017/S002966511600063x.
37. Cedernaes, J., Schioth, H. B., & Benedict, C. (2015). Determinants of shortened, disrupted, and mistimed sleep and associated metabolic health consequences in healthy humans. *Diabetes, 64*(4), 1073–1080.
38. Chiu, H. F. K., Xiang, Y. T., Dai, J., Chan, S. S. M., Yu, X., Ungvari, G. S., et al. (2013). Sleep duration and quality of life in young rural Chinese residents. *Behavioral Sleep Medicine, 11*(5), 360–368. https://doi.org/10.1080/15402002.2013.764524.
39. Lou, P., Qin, Y., Zhang, P., Chen, P., Zhang, L., Chang, G., et al. (2015). Association of sleep quality and quality of life in type 2 diabetes mellitus: A cross-sectional study in China. *Diabetes Research and Clinical Practice, 107*(1), 69–76. https://doi.org/10.1016/j.diabres.2014.09.060.
40. Pandey, A., Demede, M., Robinson, L., Weatherhead, K., Mofor, J., Zizi, F., et al. (2011). Race/ethnicity, sleep duration and quality of life: Analysis of the behavioral risk factor surveillance system. *Sleep, 34*, A263–A263.
41. Ji, L. N., Su, Q., Feng, B., Shan, Z. Y., Hu, R. M., Xing, X. P., et al. (2017). Structured self-monitoring of blood glucose regimens improve glycemic control in poorly controlled Chinese patients on insulin therapy: Results from COMPASS. *Journal of Diabetes, 9*(5), 495–501. https://doi.org/10.1111/1753-0407.12434.
42. Sampaio, R. A. C., Sampaio, P. Y. S., Yamada, M., Tsuboyama, T., & Arai, H. (2014). Self-reported quality of sleep is associated with bodily pain, vitality and cognitive impairment in Japanese older adults. *Geriatrics & Gerontology International, 14*(3), 628–635.
43. Malinowska, K. B., Okura, M., Ogita, M., Yamamoto, M., Nakai, T., Numata, T., et al. (2016). Effect of self-reported quality of

sleep on mobility in older adults. *Geriatrics & Gerontology International, 16*(2), 266–271. https://doi.org/10.1111/ggi.12468.

44. Gildner, T. E., Liebert, M. A., Kowal, P., Chatterji, S., & Snodgrass, J. J. (2014). Associations between sleep duration, sleep quality, and cognitive test performance among older adults from six middle income countries: Results from the Study on global ageing and adult health (SAGE). *Journal of Clinical Sleep Medicine, 10*(6), 613–621.
45. Mesas, A. E., Lopez-Garcia, E., Leon-Munoz, L. M., Graciani, A., Guallar-Castillon, P., & Rodriguez-Artalejo, F. (2011). The association between habitual sleep duration and sleep quality in older adults according to health status. *Age and Ageing, 40*(3), 318–323.