Sleep quality and its impact on glycaemic control in patients with type 2 diabetes mellitus

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ABSTRACT

Purpose: To investigate the sleep quality of patients with type 2 diabetes (T2D) and its impact on glycaemic control.

Methods: Using a convenience sampling method, 220 patients with T2D were recruited. The Pittsburgh Sleep Quality Index (PSQI) was used to evaluate the sleep quality with threshold at PSQI/C21/8. The glycosylated haemoglobin A1c (HbA1c) test was used to measure the glycaemic control with threshold at HbA1c/C21/7%.

Results: The PSQI score was 8.30 ± 4.12. The sleep disorder incidence rate was 47.1%. Patients with HbA1c/C21/7% had significantly lower PSQI global and factor scores (p < 0.01) versus the control group. Sleep latency, sleep disturbance, and daytime dysfunction were the risk factors for poor glycaemic control.

Conclusion: Patients with T2D have high sleep disorder rate negatively impacting glycaemic control. Health care providers should pay close attention to the sleep quality of T2D patients, and provide them with appropriate educational material.

1. Introduction

Diabetes mellitus is a common metabolic disease. By year 2035, it is estimated that 592 million people across the world will live with diabetes [1]. Type 2 diabetes currently accounts for 95% of all diagnosed diabetes [2]. In China, the incidence of diabetes is high at 9.75% [3], exerting vast burden on the individuals, families, and society [4]. Multiple studies have recognized sleep disorder a novel risk factor for diabetes [5,6]. The sleep disorder plays a pivotal role in the occurrence and development of diabetes via neuro–endocrine metabolic pathway [7]. People suffering from a sleep disorder – sleep quality or sleep quantity are impaired – experience reduction in the insulin sensitivity and consequently, elevated blood glucose, aggravating the progress of diabetes. On the other hand, sleep disorder can facilitate the hypothalamic–pituitary–adrenocortical system to release extra glucocorticoid. As a result, the glucose production increases, while the consumption decreases, affecting the glycaemic control [8,9]. Therefore, good sleep quality is crucial for maintaining an effective glycaemic control and improving the
quality of life of patients with diabetes. Nevertheless, the majority of the current sleep studies in diabetic patients focus on obstructive sleep respiratory disease. Some studies deployed complex evaluation methods which are difficult to use pervasively in practice. Furthermore, there have been only a few domestic studies addressing the role of sleep disorder in diabetic patients, and their generalization has been restricted due to the singleness of subjects, who were either senior citizens or females. The aim of our study was to reveal further evidence verifying the relationship between sleep and glycaemic control. The sleep quality and its impact on glycaemic control in patients with type 2 diabetes were analysed, thereby laying foundation for corresponding interventions in practice.

2. Subjects and methods

2.1. Subjects

A total of 220 patients was administered in the Department of Endocrinology in the 1st and 2nd Affiliated Hospital of Xi’an Jiaotong University during September, 2013 and January, 2014. Participants were selected using convenience sampling method, and the sample size was determined using the observational study formulae [10]. The inclusion criteria were:  

- a) meet the diagnostic criteria for type 2 diabetes (symptoms of diabetes + fasting plasma glucose (FPG) ≥ 7.0 mmol/L) [11],
- b) symptoms of diabetes and 2 h postprandial plasma glucose (2hPG) ≥ 11.1 mmol/L,
- c) symptoms of diabetes and random plasma glucose ≥ 11.1 mmol/L,
- d) over 18 years old with diabetes duration > 1 year. Patients were excluded if they had type 1 diabetes, gestational diabetes, or other specific types of diabetes, as were the patients with acute diabetic complications, severe heart diseases, lung diseases, and cerebral diseases. Those with mental illness or family history of mental illness, and those with intelligence or cognitive impairment were also excluded from this study.

2.2. Study tools

2.2.1. General information questionnaire

Using literature search, clinical and research experts, a questionnaire was developed, modified, and improved. Participants’ demographic information such as gender, age, education, marital status, and lifestyle (smoking, drinking and exercise) were evaluated. Additionally, data on chronic diabetic complications and family history were collected to assess their disease status. Physiological and biochemical indicators such as HbA1c and body mass index (BMI) were obtained using this questionnaire.

2.2.2. Pittsburgh sleep quality index (PSQI)

PSQI is a self-rating scale developed by Buysse et al., in 1989 [12]. The scale was translated into Chinese by Xian-Chen Liu to evaluate the sleep quality. A total of 19 self-rating items were categorized into seven factors, all subjective, sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleeping medications, and daytime dysfunction. Each factor was scored from 0 to 3. The sum of the scores for the seven factors yields PSQI global score, which ranges from 0 to 21. Higher the PSQI global score, poorer the sleep quality. PSQI has been used widely in multiple populations, and has shown a good internal consistency, test-retest reliability, construct validity, and empirical validity. In a study carried out by Xian-Chen Liu [13], the Cronbach’s coefficient of PSQI was 0.84, the split half reliability was 0.87, and a 2-week test-retest reliability was 0.81. The cut-off PSQI score was >8, the sensitivity was 98.3%, and the specificity was 90.2%. Therefore, PSQI ≥8 was used as an indication of the presence of sleep disorder in this study.

2.3. Data collection

The study protocol was approved by the Ethics Committee of the Xi’an Jiaotong University and was conducted in accordance with the Declaration of Helsinki. All participants provided a written informed consent.

2.3.1. Questionnaires

A total of 220 questionnaires were handed out. Systematically trained investigators carried out unified interviews. The face-to-face interviews and the questionnaires were completed independently by the participants per se. The participants unable to complete the questionnaire by themselves were asked item by item orally by the investigators. The investigators recorded the answers truthfully. If any questions arose during the interview, the investigators provided an explanation or clarification to a participant. Once completed the questionnaires were recovered. Any missing parts were supplemented by the patients to ensure the consistent data quality.

2.3.2. Physiological and biochemical indicators

Participants’ height, weight, and blood pressure were measured on the first day of being admitted. The HbA1c level (using high pressure liquid chromatography) and liver function were evaluated under fasting state for at least 10 h. Parameters reflecting liver function such as total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL-C), and low density lipoprotein cholesterol (LDL-C) were measured using the ADVIA® 2400 automatic biochemical analyser (Siemens, Berlin, Germany). The fingertip blood samples were collected to assess FPG and 2hPG (OneTouch UltraVue, Johnson, America). According to the American Diabetes Association guidelines for 2010 [14], HbA1c < 7% is considered to be a good glycaemic control.

2.4. Statistical analysis

Data were managed using Epi Info 7 software and double entry method was used to ensure the quality. Statistical analysis was conducted using SPSS version 13.0 software (SPSS Inc., Chicago, IL, USA). Frequency, percentage, and mean ± standard deviation were used for statistical description. The independent-samples t test, nonparametric Mann–Whitney U-test, and χ² test were performed for statistical inference. Finally, a logistic regression model was established, using PSQI factor scores as independent variables and HbA1c as dependent variables. Values of p < 0.05 were considered statistically significant.
3. Results

3.1. General information

Overall, 14 participants were excluded from the analysis due to lack of data, resulting in the final number of analysed questionnaires to be 206. The age range was from 25 to 80 years (57.23 ± 11.24 years). Of 206 participants, 136 (66.0%) were males. The average duration of diabetes was 9.77 ± 6.72 years. The number of patients under insulin treatment was 123 (60.0%). There were 63/206 (30.6%) smokers and 31/206 (15.0%) drinkers. There were 90/206 (43.7%) patients with a family history of diabetes.

3.2. Comparison of the general information between good sleepers and poor sleepers

According to the PSQI global score, patients were categorized into poor sleepers (PSQI > 8) and good sleepers (PSQI < 8). Poor sleepers accounted for 47.1%, and their diabetes duration, age, FPG, 2hPG, and HbA1c were significantly higher than in good sleepers (p < 0.05). Additionally, the percentage of patients using insulin in the poor sleepers group was significantly higher than in the good sleepers group (χ² = 5.29, p < 0.05). As is shown in Table 1, there were no statistical differences between the two groups in terms of other indicators.

3.3. Relationship between glycaemic control and PSQI score

Patients were categorized into either a good glycaemic control group (HbA1c < 7%) or a poor glycaemic control group (HbA1c ≥ 7%) based on their HbA1c. The average PSQI global score was 8.30 ± 4.12, and only 50 (24.3%) patients maintained good glycaemic control. Those with good glycaemic control had an average PSQI global score of 4.96 ± 2.46 which was significantly lower than that of the patients with poor glycaemic control (Z = 7.08, p < 0.01) (Table 2). There were statistical differences between these two groups in terms of six PSQI factors, except for the “use of sleeping medications”.

3.4. The impact of sleep quality on glycaemic control in patients with type 2 diabetes

Logistic regression analyses were conducted to examine the association between glycaemic control and the PSQI score. After adjusting for gender, age, diabetes duration, use of insulin, diabetic feet, and diabetic neuropathy, the final model was established (Table 3). Sleep latency, sleep disturbance, and daytime dysfunction were risk factors for poor glycaemic control (HbA1c ≥ 7%). The ORs (95% CI) for each factor were 2.14 (1.26–3.69), 5.09 (1.48–17.52), and 3.50 (2.02–6.07), respectively.

4. Discussions

4.1. Sleep quality of patients with type 2 diabetes

Sleep can be influenced by various factors. Sleep disorder is commonly seen nowadays with reported <10% of the general population suffering from at least one form of sleep disorders [15]. When it comes to people with type 2 diabetes, the incidence of sleep disorder is even more of a concern. So far, there have been a variety of methods available for sleep evaluation, among which PSQI is the most widely used due to
its convenience and accuracy in practice. In this study, the sleep quality of patients with type 2 diabetes was evaluated using PSQI ≥8 as the cutting point. The results showed that the incidence rate of sleep disorder in patients with type 2 diabetes was 47.1%, which is much higher than that in the general population [16,17]. Nevertheless, this value is lower than the reported values in other studies, which were 71.0%, 69.0%, and 73.9% [18–20]. A potential explanation is that our PSQI cut-off value was higher than that in other reports, potentially lowering the chance to recognize sleep disorder. Meanwhile, the wide age range of our participants may have affected the results, since age is a known factor that can affect sleep. While most of the mentioned studies focused only the senior citizens. All of this taken together could have been responsible for the comparatively low incidence rate of sleep disorder among our participants.

4.2. The impact of sleep quality on glycaemic control in patients with type 2 diabetes

A life style such as smoking, drinking, blood glucose monitoring, and exercise, as well as, metabolic indicators (blood pressure and lipids) did not seem to have a statistically significant influence on the glycaemic control. This finding is consistent with the previously published results [21]. Generally, nearly half of the patients with the painful diabetic neuropathy suffer from sleep disorder [22]. However, most of our participants who had diabetic neuropathy experienced only minor symptoms (coldness or numbness of the limbs) which had a minimal effect on sleep. Plus, the duration of diabetic neuropathy was short. Thus, no statistical significant difference was found in the PSQI global score between those with and without diabetic neuropathy. There was, however, a statistically significant difference in the PSQI global score between those who maintained a good glycaemic control and participants with poor glycaemic control with the latter group having a far higher PSQI global score. The only PSQI factor not showing a statistically significant difference between these two groups was the “use of sleeping medications”. Those participants with sleep disorders had a significantly higher FPG, 2hPG, and HbA1c (all p < 0.05). This finding further suggests that sleep disorder in diabetic patients can lead to an elevated blood glucose, a poor glycaemic control [21,23]. Unlike most of the mammals, humans can sleep in a single 7 – 9 h stretch, during which the reactivity of insulin β cell and insulin sensitivity may be affected. Sleep has been shown to regulate glucose tolerance and its dynamic balance. Consequently, various types of sleep disorder can affect glucose tolerance. The circadian regulation of sleep plays a significant role in the production of insulin, insulin sensitivity, and glucose consumption [24]. There is evidence showing that a lack of 3 h sleep could lead to 1.1% elevation of HbA1c during one single night. With 0.5 increase in PSQI global score, the HbA1c can increase by 1.9%. [25]

The PSQI factor “sleep efficiency” is one of the components that can influence glycaemic control [26]. A previously published study suggests negative correlation between HbA1c and sleep efficiency [27]. Nevertheless, no significant association was found between sleep efficiency and glycaemic control in this study. The difference might come from variations in the sample size and the corresponding sleep quality measurement tools. As indicated by the logistic regression analysis, sleep latency, sleep disturbance, and daytime dysfunction are the risk factors for poor glycaemic control. Their OR (95% CI) are 2.14 (1.26–3.69), 5.09 (1.48–17.52), and 3.50 (2.02–6.07), respectively. These values indicate that with one increase in the score of sleep latency, sleep disturbance and daytime dysfunction, the risk for poor glycaemic control would increase 2.14, 5.09, and 3.50 times, respectively. In conclusion, the sleep in patients with type 2 diabetes plays a decisive role in the glycaemic control.

The fundamental treatment for diabetes lies in a good glycaemic control, the core measure for delaying the development of diabetes. Some researchers proposed that improving sleep quality, treating sleep disorder, and optimizing sleep duration could be used as a regimen to indirectly promote the glycaemic control [5,25]. HbA1c has long

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<th>Table 2 – PSQI scores of the good glycaemic control and poor glycaemic control patients</th>
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**p < 0.01.

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<th>Table 3 – Logistic regression analysis of the PSQI score and glycaemic control</th>
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*p < 0.05; **p < 0.01.
been seen as the golden standard for assessing glycaemic control. In this study, the HbA1c levels were measured in 206 patients with type 2 diabetes. Alarmingly, only 24.3% of the participants had a good glycaemic control, which supports other studies where merely 39.1% and 15.5% of the patients maintained good glycaemic control [26,28]. All of these results suggest that at present a large number of diabetic patients do not have a good glycaemic control representing a huge challenge for the effective management of diabetes for the future.

No significant difference was found in terms of the “use of sleeping medications” between the good glycaemic control and poor glycaemic control. This finding is similar to the result reported by Zhi-Qiang Li et al. [29] The reason for this phenomenon is that most of the participants chose not to use the hypnotics because of the drug side effects. Our participants chose more traditional methods to manage their sleep. These alternative approaches (exercise, drinking hot milk and foot bath) lack the side-effects associated with sleep medications and most likely contributed to lower usage of sleep medications. [30]

4.3. Limitations of the study

Unlike foreign studies, our study used the convenience sampling method to only recruit participants from the hospitals, potentially causing the difference in sleep disorder from foreign studies. In the future research, a more rigorous sampling method can be introduced to improve the generalization of the results. Furthermore, a subjective method was used to evaluate the sleep quality possibly lowering the objectivity of this study. A more objective method, for example polysomnography, could be combined with a subjective method providing a more satisfying study. Additionally, although the results in this study indicated that the sleep quality can affect glycaemic control in patients with type 2 diabetes, no further interventions were given to those who suffered from sleep disorder.

Compared with the general population, diabetic people experience a higher prevalence of sleep disorder further exerting detrimental influence on glycaemic control. Our findings provide basis for verifying the inter-relationship between sleep and glycaemic control. In the future clinical practice, health care providers should pay attention to the early recognition of sleep disorder in diabetic patients so that corresponding measures could be taken to improve patient’s sleep quality in a timely fashion, thereby facilitating management of diabetes.

Conflict of interest

The authors declare no conflict of interest associated with this manuscript.

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