# Deteriorated sleep quality and associate factors in patients with type 2 diabetes mellitus complicated with diabetic peripheral neuropathy

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**Objectives** To understand the sleep quality and its influencing factors in patients with type 2 diabetes mellitus(T2DM) who suffered diabetic peripheral neuropathy (DPN), and provide evidence for clinicians to carry out comprehensive intervention measures to improve the sleep quality of patients. **Methods** Patients who were admitted to the Endocrinology Department of Affiliated Hospital of Zunyi Medical University were recruited from May to December 2022, and the investigation were conducted by face-to-face interview. The questionnaires included PSQI questionnaire and influencing factors, such as lifestyle and health status. **Results** Among the 193 patients, 40.4% of the patients never took physical examination, 56.5% of the patients had duration of illness greater than 5 years, 61.7% of the patients had had an operation, 10.4% of the patients had bad dietary status, and 55.4% of the patients had physical pain. In addition, PSQI general score was 8.34±3.98, the occurrence rate of poor sleep quality (PSQI ≥ 8) was 54.4%, and the results showed that sleep quality of the physical pain group was worse than the no pain group. Moreover, the results of multivariate analysis revealed that the factors affecting sleep quality were lower frequency of exercise, bad dietary status, lower frequency of physical examination, longer duration of illness, and smoking, and the OR and 95%CI were (1.40, 1.04~1.89), (3.42, 1.86~6.29), (1.49, 1.01~2.20), (1.78, 1.09~2.92), (2.38, 1.17~4.88), respectively. **Conclusion** Patients with DPN have higher risk of poor sleep quality. Moreover, there were many risk factors associated with poor sleep quality, clinicians and health policymakers should timely detect and effectively intervene in these factors to improve the sleep quality, which is important to enhance the quality of life of T2DM patients complicated with DPN.

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2    diabetes mellitus complicated with diabetic peripheral neuropathy
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24   **Abstract**
25       **Objectives** To understand the sleep quality and its influencing factors in patients with type 2
26   diabetes mellitus(T2DM) who suffered diabetic peripheral neuropathy (DPN), and provide
27   evidence for clinicians to carry out comprehensive intervention measures to improve the sleep
28   quality of patients. **Methods** Patients who were admitted to the Endocrinology Department of
29   Affiliated Hospital of Zunyi Medical University were recruited from May to December 2022,
30   and the investigation were conducted by face-to-face interview. The questionnaires included
31   PSQI questionnaire and influencing factors, such as lifestyle and health status. **Results** Among
32   the 193 patients, 40.4% of the patients never took physical examination, 56.5% of the patients
33   had duration of illness greater than 5 years, 61.7% of the patients had had an operation, 10.4% of
34   the patients had bad dietary status, and 55.4% of the patients had physical pain. In addition, PSQI

35    general score was 8.34±3.98, the occurrence rate of poor sleep quality (PSQI ≥ 8) was 54.4%,

36    and the results showed that sleep quality of the physical pain group was worse than the no pain

37    group. Moreover, the results of multivariate analysis revealed that the factors affecting sleep

38    quality were lower frequency of exercise, bad dietary status, lower frequency of physical

39    examination, longer duration of illness, and smoking, and the OR and 95%CI were (1.40,

40    1.04~1.89), (3.42, 1.86~6.29), (1.49, 1.01~2.20), (1.78, 1.09~2.92), (2.38, 1.17~4.88),

41    respectively. **Conclusion** Patients with DPN have higher risk of poor sleep quality. Moreover,

42    there were many risk factors associated with poor sleep quality, clinicians and health

43    policymakers should timely detect and effectively intervene in these factors to improve the sleep

44    quality, which is important to enhance the quality of life of T2DM patients complicated with

45    DPN.

46    **Key words：Type 2 diabetes mellitus, Diabetic peripheral neuropathy, Sleep quality,**

47    **Influence factors**

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## Introduction

Type 2 diabetes mellitus (T2DM) is a metabolic disorder based on insulin resistance and pancreatic β-cell dysfunction, which is a clinically typical chronic disease (Society 2021). China has one of the highest prevalence of diabetes mellitus in the world, and according to the World Health Organization (WHO) in 2016 (Yang et al. 2016), there are about 110 million people with diabetes mellitus in China, and this figure is expected to reach 150.7 million by 2040. A number of lifestyle behaviors, including bad dietary status, lack of physical activity, and sleep problems have contributed to the surge in T2DM patients (Cabrera-Mino et al. 2021).

Sleep is vital for maintaining health and social adaptability in humans. Healthy sleep behaviors are considered one of the key lifestyle components in the treatment of T2DM (Committee 2021). Sleeping problems are common in T2DM and cause disturbances in sleep quality and duration. Research has shown that insomnia, sleep apnea syndrome and other types of sleeping problems are strongly associated with the onset and progression of T2DM (Zhang et al. 2019). These sleep problems may lead to chronic inflammatory responses, neuroendocrine disruption and weight gain, which can increase the risk of developing diabetes (Fallahi et al. 2019; Zuraikat et al. 2020).

Among the many complications of diabetes, diabetic peripheral neuropathy (DPN) is one of the most common and early manifesting complications, which is a symptom of peripheral nerve dysfunction in diabetic patients when other causes are excluded (Gylfadottir et al. 2020; Iqbal et al. 2018). Previous studies have demonstrated a significantly higher incidence of complications in T2DM compared to non-T2DM individuals. (Amutha et al. 2017; Pan et al. 2018). A national retrospective study of diabetic inpatients from 1991-2000 showed that the prevalence of DPN was 60.3%, of which T2DM accounted for 61.8% (Society & Association 2002). Pain, abnormal sensation and numbness in the hands and feet associated with DPN not only affect patients' emotion and social function seriously, but also lead to a decline in sleep quality (Kioskli et al. 2019). What's more, decreased sleep quality can exacerbate glucose metabolism disorders, lead to decreased insulin sensitivity and aggravate insulin resistance, which have a serious impact on the plasma glycemic control and quality of life of T2DM (Dong et al. 2020).

To our knowledge, most studies have focused on the relationship between sleep duration and plasma glycemic control in T2DM, as well as the influencing factors of sleep quality in T2DM patients. However, few studies have been conducted on the sleep status and influencing factors of T2DM suffering from complications. In addition, related studies have shown that 47.1% of

82 patients with T2DM have poor sleep quality, and this percentage may be higher among those

83 with DPN (Zhu et al. 2018; Karmilayanti et al. 2021). This study analyzed the sleep quality and

84 its influencing factors in patients with T2DM who suffered DPN and provided evidence for

85 clinical workers to carry out comprehensive intervention measures to improve the sleep quality

86 of patients.

87

## Materials and Methods

89 **Study design**

90 A cross-sectional survey was conducted between May to December 2022 in the Endocrinology

91 Department of Affiliated Hospital of Zunyi Medical University.

92 The following inclusion criteria were used: (1) patients who met the World Health

93 Organization's diagnostic criteria for T2DM; (2) patients who had been diagnosed with DPN by

94 region-current perception threshold (R-CPT); (3) patients with good cognitive function and can

95 communicate normally. The following exclusion criteria were used: (1) patients with type 1

96 diabetes mellitus or other types of diabetes; (2) patients with acute complications of diabetes

97 (diabetic ketoacidosis, hyperglycemic hyperosmolar state), acute cardiac insufficiency, severe

98 liver and kidney abnormalities and malignant tumors; (3) patients with mental illness and severe

99 hearing impairment who cannot cooperate to complete the questionnaire.

100 **Questionnaire**

101 The questionnaire consisted of three parts, including basic demographic data, the influence

102 factors questionnaire, and the Pittsburgh Sleep Quality Index (PSQI) questionnaire.

103 The first part included the basic demographic data of age, sex, occupation, body mass index

104 (BMI) and marital status. And BMI were calculated based on the height and weight recorded in

105 the patients' admission medical records.

106 The second part was the influence factors questionnaire. By reviewing the relevant literature,

107 we hold a point on that the questionnaire should contain influence factors as follows, such as

108 smoking habits, drinking habits, history of hypertension, history of operation, physical pain,

109 duration of illness, dietary status, frequency of exercise, frequency of physical examination,

110 psychological burden, life pressure. Additionally, preliminary investigation results indicated an

111 acceptable level of reliability and validity for the second part of the questionnaire, with a

112 Cronbach's alpha coefficient of 0.736 and a KMO coefficient of 0.754. In this study, smoking

113 represented patients who were currently smoking or had smoked for more than a month in the

114　past but had currently quit. The same definition applied to drinking habits. Operation was

115　defined as the operation of Grade three or above in the Operation Grading Management

116　Measures for Medical Institutions issued by the National Health Commission of the People's

117　Republic of China within 10 years (China 2022). History of hypertension was self-reported by

118　patients, but hypertension was not categorized and graded. The physical pain came from the

119　patients' self-report based on their own pain conditions. Dietary status was reported by the

120　patients based on their appetite in the last month, and good dietary status means having a healthy

121　appetite and consuming an adequate amount of food. General dietary status means having a

122　moderate appetite and consuming a moderate amount of food. Bad dietary status means having a

123　poor appetite and consuming a significantly reduced amount of food. Exercise was defined as 30

124　minutes or more of moderate-intensity exercise, including brisk walking, jogging, stair climbing,

125　etc. For the assessment of exercise frequency, we divided it into "≥5 times/week" "3-4

126　times/week" "1-2 times/week" and "hardly". These classifications were based on the frequency

127　of exercise reported by the patients. The frequency of physical examination referred to the

128　number of times that patients went to medical and health institutions for health examination.

129　Psychological burden meant psychological stress and burden due to having diabetes and related

130　complications. And life pressure was defined as high levels of stress originating from work and

131　life in general.

132　　　The third part was the PSQI questionnaire which is the most common measure of sleep quality.

133　The questionnaire was developed by Buysse (Buysse et al. 1989) in 1989 to evaluate the quality

134　of sleep in the last one month. The Chinese version of the PSQI questionnaire has reported good

135　internal consistency and test-retest reliability (Ho et al. 2021). And this questionnaire has been

136　widely used to assess sleep quality currently (Liu et al. 2020; Zhang et al. 2023). It contains

137　seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep

138　efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. These scores

139　are summed to yield a total PSQI score with a range of 0–21 and higher scores indicate poorer

140　sleep quality. In our study, a PSQI score of < 8 and ≥ 8 were defined as good sleep quality and

141　poor sleep quality, respectively, based on previous research (Barakat et al. 2019).

142　**Study sample**

143　　　The sample size required for the study was estimated by the sample size calculation formula of

144　the cross-sectional study. $n=Z^2\times(P\times(1-P))/d^2$. A previous study showed that the prevalence of

145　poor sleep quality among painless DPN patients was 64.5% (Choi et al. 2021). So, we set

146    *p*=0.645, the precision (two-sided) was 0.16, and the confidence level was 0.95, a sample size of

147    148 participants could be calculated by PASS 15.0 (NCSS, LLC, Kaysville, Utah, USA).

148    Considering the 20% non-response rate, the minimum required sample size was 185 participants.

149        A total of 200 eligible T2DM patients were invited into the study. Among them, seven patients

150    refused to participate in the survey. Finally, 193 individuals with T2DM complicated by DPN

151    who met the criteria were enrolled in the study. The response rate was 96.5%. The study

152    involving human patients was reviewed and approved by the Medical Research Ethics

153    Committee of Affiliated Hospital of Zunyi Medical University (KLLY-2021-192). The patients

154    provided their written informed consent to participate in this study. The survey was conducted

155    using a uniform questionnaire and questioning methods, and the investigation was conducted

156    with face-to-face inquiry and the results were recorded faithfully.

157    **Statistical analysis**

158        Statistical analyses were performed using SPSS 18.0 (IBM Corp., Armonk, NY, USA). Mean

159    and standard deviation ($\overline{x} \pm s$) were used to describe normally distributed measurement data,

160    while the differences between groups were assessed using two-independent samples t-test. For

161    abnormally distributed measurement data, the average rank was used for description, and the

162    Mann－Whitney U test was used to test the differences between two groups. Count data was

163    presented as rates or percentages. Logistic regression analysis was employed to assess the impact

164    of variables on sleep quality. The significance level was set at α=0.05. The logistic regression

165    model was visualized in the form of a nomogram using the rms package (Frank E Harrell Jr,

166    2021, https://CRAN.R-project.org/package=rms) in R (R Core Team, Vienna, Austria) software.

167    **Result**

168    **General profile of patients**

169        The average age of the 193 patients was (56.12±11.59) years, with the oldest was 89 years old

170    and the youngest was 19 years old. Among them, 60.1% (116/193) were male, 39.9% (77/193)

171    were female, 39.9% (77/193) smoked, 36.8% (71/193) drank, 43.5% (84/193) hardly exercised,

172    40.4% (78/193) never took physical examination, 56.5% (109/193) had a duration of illness

173    greater than 5 years, 61.7% (119/193) had had an operation, 10.4% (20/193) had bad dietary

174    status, 55.4% (107/193) had physical pain, and 16.6% (32/193) had greater psychological burden.

175    According to the guideline for the prevention and treatment of type 2 diabetes mellitus in China

176    (2020 edition) (Society 2021), the rates of meeting the standard were as follows: hemoglobin

177    A1C (HbA1c) was 18.1% (35/193), fasting plasma glucose (FPG) was 21.8% (42/193), 2-h

178    postprandial glucose (2h PG) was 35.2% (68/193), and body mass index (BMI) was 45.6%

179    (88/193) (See Table 1).

180    **The analysis of sleep quality among different types of patients**

181    High prevalence of poor sleep quality was reported, and the rate of poor sleep quality was 54.4%

182    (105/193). The average of PSQI general score was 8.34 ± 3.98. And concerning physical pain,

183    the t-test results indicated differences in the PSQI general score ($P < 0.05$), while the Mann–

184    Whitney U test results revealed differences in various PSQI components, including subjective

185    sleep quality, sleep duration, habitual sleep efficiency, and sleep disturbances ($P < 0.05$). Sleep

186    quality among the group of pain was worse than that in no pain group. There were no statistically

187    significant differences found in other variables (See Table 2).

188    **The analysis of influence factors related to sleep quality**

189    In this study, the patients were divided into poor sleep quality group (PSQI ≥ 8) and good

190    sleep quality group (PSQI < 8). And according to the PSQI scores, there were 105 for the poor

191    sleep quality group and 88 for the good sleep quality group. The results of univariate logistic

192    regression analysis of influence factors for sleep quality showed that there were statistically

193    significant differences in marital status, smoking, frequency of exercise, frequency of physical

194    examination, duration of illness, operation, dietary status, psychological burden and physical

195    pain ($P < 0.05$). However, there were no significant differences in age, BMI, FPG, 2h PG,

196    HbA1c, drinking, life pressure, meal regularity and hypertension between the two groups ($P >$

197    0.05) (See Table 3).

198    In order to further explore the influencing factors of sleep quality in T2DM complicated with

199    DPN, in the univariate logistic regression analysis, certain factors showed statistically significant

200    differences. These factors were considered as independent variables, while sleep quality (PSQI <

201    8 = 0, PSQI ≥ 8 = 1) served as the dependent variable. The results of multivariate logistic

202    regression revealed that several variables were associated with an increased likelihood of poor

203    sleep quality. These variables included lower frequency of exercise (OR: 1.40 (1.04~1.89)), bad

204    dietary status (OR: 3.42 (1.86~6.29)), lower frequency of physical examination (OR: 1.49

205    (1.01~2.20)), longer duration of illness (OR: 1.78 (1.09~2.92)) and smoking (OR: 2.38

206    (1.17~4.88)) (See Table 4).

207    **Nomogram prediction model of factors influencing sleep quality**

208    Frequency of exercise, dietary status, frequency of physical examination, duration of illness,

209    and smoking were used as predictors to construct a nomogram prediction model of poor sleep

210    quality (See Figure 1).

211    **Discussion**

212        China has one of the highest prevalence of diabetes in the world. With the development of

213    social economy and changes of people's lifestyle and dietary habits, the incidence and prevalence

214    of diabetes are constantly increasing (Liu et al. 2017). DPN is a major cause of physical

215    disability in diabetic patients which can occur at all stages of diabetes development. Diabetic

216    patients often experience poor sleep quality, while those with DPN may have even worse sleep

217    quality (Lien et al. 2020). In this study, the sleep quality and influencing factors were analyzed

218    and nomogram prediction model in patients with T2DM who suffered DPN was constructed.

219        The results in this survey showed that 54.4% of patients had poor sleep quality, which was

220    higher than previous studies. Related studies have shown that the prevalence of poor sleep

221    quality among adults in China ranges from 8.3% to 27.7% (Dong et al. 2018; Wu et al. 2020),

222    and a cross-sectional study by Tsai et al (whose cut-off scores was PSQI $\geq$ 8) reported a

223    prevalence of poor sleep quality in T2DM patients was 34.8% (Tsai et al. 2012), and depending

224    on PSQI $\geq$ 8, Cappuccio et al also found that 47.1% of T2DM patients were poor sleepers

225    (Cappuccio et al. 2009).The difference in the prevalence of poor sleep quality might be due to

226    the differences in participants and dietary cultures. Besides, the participants of this study were

227    patients with T2DM who suffered DPN. And the occurrence of complications of diabetes is not

228    conducive to ensuring sleep quality (Lien et al. 2020), which may be the reason for the higher

229    prevalence of poor sleep quality in this study.

230        In addition, there were statistically significant differences in sleep quality between the group

231    of physical pain and the no pain group, such as the general score of PQSI, subjective sleep

232    quality, sleep duration, habitual sleep efficiency and sleep disturbances. A previous study

233    reported that common psychiatric disorders, such as depression and anxiety, are highly

234    associated with sleeping problems in patients with chronic physical pain (Keilani et al. 2018).

235    Meanwhile, the patients of this study were T2DM patients complicated with DPN, which

236  included some patients with painful diabetic peripheral neuropathy (PDPN). And the main

237  clinical manifestations of PDPN are distal pain of bilateral symmetrical limbs, especially at night,

238  which can affect patients' sleep, emotion, social function and other quality of life seriously

239  (Alleman et al. 2015).

240  Marital status is considered to be an influencing factor of sleep quality, and the reason might

241  be that married patients need to invest more time and energy to maintain a harmonious marriage

242  relationship. However, since there were only 4 unmarried patients among the participants in our

243  study, the interpretation of the results may be affected due to the small sample size, and further

244  evidence is needed. Additionally, operation and big psychological burden was harmful to

245  maintaining good sleep quality, which was consistent with the results of Lu et al's study (Lu et al.

246  2019). This might be such patients are often prone to psychological and social problems, which

247  is not conducive to patients to maintain good sleep quality. And a related study has shown that

248  people with high BMI are more likely to have poor sleep quality (Huang et al. 2022) while some

249  studies have suggested that sleep quality is not influenced by BMI. Our study showed that BMI

250  was not an influencing factor for sleep quality, and the reason might be the uneven distribution

251  of BMI among the patients, with the majority of them having a high BMI and only 45.6% of

252  patients meeting the standard. Chen et al found that FPG, 2h PG and HbA1c are influencing

253  factors of sleep quality in diabetic patients (Chen et al. 2020), while in our study, neither of them

254  was influencing factor in sleep quality, and the reason might be that the participants included in

255  the research were all from hospitals, and their diabetes status were less stable.

256  The results of multivariate logistic regression analysis displayed that the influence factors of

257  sleep quality consisted of lower frequency of exercise, poor dietary status, lower frequency of

258  physical examination, longer duration of illness and smoking. And a nomogram prediction model

259  based on the above independent risk factors was established to quantify and visualize the results.

260  The model has shown that patients who hardly exercise have a high probability of poor sleep

261 quality. Previous studies have shown that appropriate physical exercise can promote the
262 secretion of endorphins in the human brain, which is conducive to the calmness of individual
263 emotions (Dolezal et al. 2017; Kelley & Kelley 2017). Results of a randomized controlled trial
264 showed that moderate-intensity exercise training has a positive effect on sleep quality (Tseng et
265 al. 2020). For diabetic patients, proper exercise can not only improve the ability of body tissue to
266 combine with insulin, also obtain social support and reduce the psychological burden brought by
267 the disease. Our study also found that the lack of regular physical examination was a risk factor
268 for sleep quality. And the reason might be that people who have regular physical examination
269 can better understand their own health status and promote better lifestyle habits. And regular
270 physical examination for diabetics will enable them to intervene earlier for their existing diseases,
271 which could reduce the diabetic status. Additionally, bad dietary status is a risk factor for sleep
272 quality. A previous study has shown that good dietary status and diet planning can help patients
273 to improve self-management, reduce diabetic status, and improve sleep status (Bao et al. 2018).
274 A cross-sectional study in Japan showed that good dietary status and appetite would help
275 maintain sleep quality in middle-aged and older adults (Yamamoto et al. 2020). But a relevant
276 study has shown that different dietary patterns have different effects on sleep quality (Mondin et
277 al. 2019). Further studies on the relationship between dietary patterns and sleep quality of
278 chronic patients should be discussed in the future. Furthermore, the research also indicated that
279 smoking and the duration of the illness could affect patients' sleep quality. The risk of poor sleep
280 quality in patients who smoke was 2.38 times higher when compared with non-smokers, and the
281 reason might be that nicotine in tobacco stimulates the release of a variety of neurotransmitters.
282 Besides, the longer the duration of diabetes, the poorer sleep quality. Kasteleyn et al (Kasteleyn
283 et al. 2015) found that diabetic patients with a longer disease duration were more likely to
284 develop complications, and the function of pancreatic β cells gradually declined, which was
285 detrimental to the patient's glycemic status and sleep quality.

286    There were several shortcomings in this study. Firstly, the data on sleep quality and some

287    influencing factors in this study were reported by patients, which might lead to recall bias.

288    However, the data in this study were obtained through face-to-face inquiries with the patients

289    themselves, who all had good cognitive function and could communicate normally, to some

290    degree, the recall bias could be reduced. Additionally, the patients of this study were all from the

291    same hospital, so the sample representation was insufficient. But the hospital is a tertiary hospital

292    with an adequate volume of patients. What's more, the physical pain and dietary status in this

293    study were self-reported by patients according to their own physical conditions, which were

294    subjective to a certain extent. In a way, the results of this study could reveal the main factors

295    affecting the sleep quality of patients with T2DM complicated with DPN, and provide a basis for

296    the formulation of measures to improve the sleep quality of patients.

297    **Conclusion**

298    The investigation reported that patients with T2DM complicated with DPN have poor sleep

299    quality. The factors that affect the sleep quality were lower frequency of exercise, bad dietary

300    status, lower frequency of physical examination, longer duration of illness, and smoking. And

301    the nomogram prediction model constructed in the study could be used to evaluate the risk of

302    poor sleep quality in patients. What's more, clinical workers and health policymakers should

303    timely detect and effectively intervene in these factors to improve the sleep quality, which is

304    important to improve the quality of life of T2DM patients complicated with DPN.

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319    **Competing Interests**

320    The authors declare no conflict of interest.

321    **Author Contributions**

322    Lin Fu, Liping Zhong and Yanna Zhou conceived and designed the experiments, performed the

323    experiments, analyzed the data, prepared tables, authored or reviewed drafts of the paper, and

324    approved the final draft.

325    Lin Fu, Youyi Wang, Lingrui Wang, Yanna Zhou, and Xin Liao performed the experiments,

326    collected data, prepared tables, and approved the final draft.

327    Yanna Zhou and Xiuquan Shi conceived and designed the experiments, authored or reviewed

328    drafts of the paper, and approved the final draft.

329    **Human Ethics**

330    The following information was supplied relating to ethical approvals (i.e., approving body and

331    any reference numbers)

332    This study was reviewed by the Medical Research Ethics Committee of Affiliated Hospital of

333    Zunyi Medical University (KLLY-2021-192).

334    **Data Availability**

335    The following information was supplied regarding data availability:

336    The raw measurements are available in the Supplementary Files.

337

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**Table 1**(on next page)

General profile of the participants (n=193)

| Category | | n (%) | Category | | n (%) |
|---|---|---|---|---|---|
| Gender | male | 116 (60.1) | Operation | yes | 119 (61.7) |
| | female | 77 (39.9) | | no | 74 (38.3) |
| Smoking | yes | 77 (39.9) | Hypertension | yes | 86 (44.6) |
| | no | 116 (60.1) | | no | 107 (55.4) |
| Drinking | yes | 71 (36.8) | Physical pain | yes | 107 (55.4) |
| | no | 122 (63.2) | | no | 86 (44.6) |
| FPG (mmol/l) | < 7.0 | 42 (21.8) | 2h PG (mmol/l) | < 10.0 | 68 (35.2) |
| | ≥ 7.0 | 151 (78.2) | | ≥ 10.0 | 125 (64.8) |
| HbA1c (%) | < 7.0 | 35 (18.1) | BMI (kg/m$^2$) | < 24.0 | 88 (45.6) |
| | ≥ 7.0 | 158 (81.9) | | ≥ 24.0 | 105 (54.4) |
| Marital Status | married | 170 (88.1) | Dietary status | good | 90 (46.6) |
| | unmarried | 4 (2.1) | | general | 83 (43.0) |
| | others | 19 (9.8) | | bad | 20 (10.4) |
| Frequency of physical examination | biannual | 13 (6.7) | Frequency of exercise | ≥ 5 times/week | 45 (23.3) |
| | yearly | 80 (41.5) | | 3-4 times/week | 31 (16.1) |
| | biennial | 22 (11.4) | | 1-2 times/week | 33 (17.1) |
| | never | 78 (40.4) | | hardly | 84 (43.5) |
| Duration of illness | < 1 year | 38 (19.7) | Meal regularity | very regular | 50 (25.9) |
| | 1-5 years | 46 (23.8) | | regular | 81 (42.0) |
| | > 5 years | 109 (56.5) | | irregular | 47 (24.4) |
| Psychological burden | no | 45 (23.3) | | very irregular | 15 (7.7) |
| | slightly | 73 (37.8) | Life pressure | never | 36 (18.7) |
| | moderate | 35 (18.2) | | rarely | 61 (31.6) |
| | high | 32 (16.6) | | sometimes | 48 (24.9) |
| | severe | 8 (4.1) | | often | 38 (19.7) |
| | | | | always | 10 (5.1) |

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**Table 2**(on next page)

The differences of PSQI component scores between pain conditions

Notes: *All data were reported as`$R$ and analyzed by the Mann–Whitney U test.

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| Indices | No | Yes | $Z/t$ | $P$ value |
|---|---|---|---|---|
| PSQI general score | 7.26±3.54 | 9.21±4.10 | 3.535 | 0.001 |
| Subjective sleep Quality * | 80.69 | 110.11 | 3.792 | < 0.001 |
| Sleep latency * | 91.35 | 101.54 | 1.313 | 0.189 |
| Sleep duration * | 88.24 | 104.04 | 2.040 | 0.041 |
| Habitual sleep Efficiency * | 86.98 | 105.06 | 2.310 | 0.021 |
| Sleep disturbances * | 85.38 | 106.34 | 3.093 | 0.002 |
| Use of sleep medications * | 95.26 | 98.40 | 1.122 | 0.262 |
| Daytime dysfunction * | 89.63 | 102.92 | 1.710 | 0.087 |

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**Table 3**(on next page)

The univariate logistic regression analysis of different influencing factors

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| Category | OR (95%CI) | P value |
|---|---|---|
| BMI | 1.00 (0.92~1.09) | 0.967 |
| FPG | 1.02 (0.95~1.09) | 0.574 |
| 2h PG | 0.97 (0.92~1.02) | 0.271 |
| HbA1c | 1.02 (0.92~1.13) | 0.727 |
| Age (1: ≤45, 2: 46-55, 3: 56-65, 4: >65) | 1.26(0.94~1.68) | 0.121 |
| Smoking (1: no, 2: yes) | 1.87 (1.03~3.38) | 0.037 |
| Drinking (1: no, 2: yes) | 1.23 (0.68~2.23) | 0.477 |
| Operation (1: no, 2: yes) | 2.08 (1.15~3.75) | 0.015 |
| Hypertension (1: no, 2: yes) | 1.69 (0.95~3.02) | 0.072 |
| Physical pain (1: no, 2: yes) | 2.30 (1.29~4.12) | 0.005 |
| Dietary status (1: good, 2: general, 3: bad) | 4.02 (2.37~6.81) | < 0.001 |
| Duration of illness (1: <1 year, 2: 1-5 years, 3: > 5 years） | 1.74 (1.20~2.52) | 0.003 |
| Meal regularity (1: very regular, 2: regular, 3: irregular, 4: very irregular) | 1.15 (0.83~1.58) | 0.390 |
| Frequency of physical examination (1: biannual, 2: yearly, 3: biennial, 4: never) | 1.43 (1.08~1.90) | 0.011 |
| Frequency of exercise (1: ≥ 5 times/week, 2: 3-4 times/week, 3: 1-2 times/week, 4: hardly) | 1.51 (1.19~1.93) | 0.001 |
| Life pressure (1: never, 2: rarely, 3: sometimes, 4: often, 5: always) | 1.15 (0.89~1.47) | 0.268 |
| Psychological burden (1: no, 2: slightly, 3: moderate, 4: high, 5: severe) | 1.29 (1.01~1.68) | 0.049 |
| Marital (1: married, 2: unmarried, 3: others) | | |
| Marital（2） | 0.30 (0.31~2.97) | 0.306 |
| Marital（3） | 3.41 (1.08~10.70) | 0.035 |

**Table 4**(on next page)

The multivariate logistic regression analysis of different influencing factors

| Variables | *B* | *S.E* | *Wald* | *P* value | OR (95%CI) |
|---|---|---|---|---|---|
| Smoking | 0.870 | 0.365 | 5.688 | 0.017 | 2.38 (1.17~4.88) |
| Duration of illness | 0.579 | 0.251 | 5.313 | 0.021 | 1.78 (1.09~2.92) |
| Dietary status | 1.231 | 0.310 | 15.720 | < 0.001 | 3.42 (1.86~6.29) |
| Frequency of physical examination | 0.399 | 0.199 | 4.013 | 0.045 | 1.49 (1.01~2.20) |
| Frequency of exercise | 0.338 | 0.153 | 4.865 | 0.027 | 1.40 (1.04~1.89) |

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# Figure 1

A Nomogram model for predicting sleep quality.