A Study on the Association between Lifestyle, Psychological State, and Diabetes Mellitus among Chinese Elderly

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Abstract: This study is based on the questionnaire data from the 2018 China Health and Retirement Longitudinal Study (CHARLS) to analyze the association between lifestyle, psychological status, and the prevalence of Diabetes Mellitus (DM) among Chinese adults aged 60 and above. A total of 9,695 participants were included in the study. Variance analysis, binary logistic regression, negative binomial regression and random forest were employed to examine the impact of sociodemographic factors (gender, highest level of education, marital status), lifestyle factors (smoking, alcohol consumption, physical activity, sleep), and depression on diabetes, as well as the mediating role of depression. The results indicate that both lifestyle factors and depression have varying degrees of influence on diabetes. Additionally, the highest level of education and marital status are associated with diabetes through their effects on depression.

1. Introduction

Population aging is one of the important factors contributing to the rising incidence of Diabetes Mellitus (DM). As of 2022, the number of elderly individuals aged 60 and above in China exceeds 280 million, accounting for 19.8% of the total population, with over 20% of them suffering from DM. [1] DM not only significantly impacts the quality of life for the elderly but also imposes a heavy burden on the healthcare system and social welfare system. Improving the efficiency of DM prevention and control has become a global imperative. Research has demonstrated that a healthy lifestyle plays a crucial role in preventing and managing DM. Factors such as diet, smoking and alcohol consumption, physical activity, and sleep have a significant impact on blood sugar control. [2-6] Additionally, there is a notable correlation between psychological well-being and DM. [7] This study focuses on individuals aged 60 and above, aiming to explore the association between lifestyle, psychological state, and DM in this age group. The findings are expected to serve as a reference for DM prevention and treatment in the elderly, contribute to extending the global lifespan, and enhance the overall quality of life for people worldwide.

2. Research Subjects and Methods

2.1. Study Participants

The questionnaire data from the 2018 China Health and Retirement Longitudinal Study (CHARLS) Item were utilized in this study. Inclusion criteria were as follows: age ≥ 60 years, sociodemographic factors (gender, highest level of education, marital status), lifestyle factors (smoking, alcohol consumption, physical activity, sleep), scores on the Center for Epidemiologic Studies Depression Scale-10 (CES-D-10), and absence of missing data on key variables such as DM (diabetes mellitus) test results. After screening, a total of 9695 participants were included in the sample, with a male-to-female ratio of 49.58:50.42, indicating a balanced distribution.

2.2. Indicator Definition and Assignment

2.2.1. Definition of explanatory variables. Sociodemographic data are defined as explanatory variables, including gender, highest level of education, and marital status. Specific assignments are shown in Table 1.

2.2.2. Definition of DM. Based on the question "Has a doctor ever told you that you have diabetes or high blood sugar (including impaired glucose tolerance and elevated fasting blood sugar)?" responses of "yes" were assigned a value of 1, and responses of "No" were assigned a value of 2. Specific situations are shown in Table 1.

2.2.3. Definition of lifestyle. CHARLS surveyed participants' drinking, smoking, exercise, and sleep habits. Relevant questions and specific assignment situations are shown in Table 1.

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2.2.4. Definition of depression. CHARLS used a simplified version of the stress scale, consisting of 10 items, with scores ranging from 0 (rarely or hardly ever) to 3 (most of the time). Items 5 and 8 require reverse scoring. According to existing research, a score ≥10 is considered indicative of depressive symptoms and is recorded as 1, while a score <10 is considered indicative of the absence of depressive symptoms and is recorded as 2. [8] Specific details are shown in Table 1. The Cronbach's α coefficient of this scale is 0.792, the KMO test coefficient is 0.877, and the Bartlett spherical test chi-square value is 10647.569, with a significance level of 0.000, indicating that the scale has good reliability and validity.

Table 1: Indicator Definitions and Assignments

Name	Item	assignment	Frequency	Percent(%)
Gender	Male	1	4807	49.58
	Female	2	4888	50.42
Highest level of education	No Formal Education (Illiterate)	1	3009	31.04
	Did not Finish Primary School	2	2237	23.07
	Sishu/Home School	3	41	0.42
	Elementary School	4	2047	21.11
	Middle School	5	1487	15.34
	High School	6	539	5.56
	Vocational School	7	217	2.24
	Two-/Three-Year College/Associate Degree	8	69	0.71
	Four-Year College/Bachelor's Degree	9	49	0.51
Marital Status	Married with Spouse Present	1	7268	74.97
	Married But Not Living with Spouse Temporarily for Reasons Such as Work	2	342	3.53
	Separated	3	25	0.26
	Divorced	4	91	0.94
	Widowed	5	1898	19.58
	Never Married	6	71	0.73
Time spent playing high-intensity sports	<2 Hours	1	7645	78.86
	>=2 Hours	2	2050	21.14
Length of night sleep (n=640)	＜6 Hours	1	253	39.53
	6-7 Hours	2	210	32.81
	＞7 Hours	3	177	27.66
Nap length (n=640)	No	1	224	35.00
	＜30min	2	86	13.44
	30-60min	3	162	25.31
	＞60min	4	168	26.25
Smoking	Quit	1	9507	98.06
	Still smoke	2	188	1.94
Alcohol consumption (n=9693)	None of These	0	6631	68.41
	Drink But Less than Once a Month	1	644	6.64
	Drink More than Once a Month	2	2418	24.95
(n=586)	Yes	1	580	98.98
	No	2	6	1.02
DM	Yes	1	640	6.60
	No	2	9055	93.40
Total			9695	100.0

2.3. Research Tools

Variance analysis, linear regression analysis, and negative binomial regression were performed using SPSS 26.0 to examine the effects of lifestyle and psychological factors on the occurrence of DM (Diabetes Mellitus). Bootstrap method was employed to investigate the mediating effect of stress on lifestyle and the occurrence of DM. The tools and methods mentioned above are used for statistical analysis in the study. They are employed to analyze the relationships and effects between variables, specifically focusing on the impact of lifestyle factors and psychological factors on the occurrence of Diabetes Mellitus (DM), as well as the potential mediating role of stress in this relationship.

3. Analysis Results

3.1. Differences in Lifestyle and Psychological Status between Elderly DM Patients and Non-DM Patients

Table 2: Analysis of Variance Results

	DM(Mean±SD)		F	p
	1 Yes(n=640)	2 No(n=9055)		
Gender	1.57±0.49	1.50±0.50	13.164	0.000**
Highest level of education	3.05±2.01	2.98±1.87	0.697	0.404
Marital Status	1.83±1.60	1.89±1.63	0.750	0.387
Length of Night Sleep	5.95±2.16	6.16±2.14	5.538	0.019*
Nap Length	0.82±0.80	0.79±0.79	1.187	0.276
Time Spent Playing High-intensity Sports	1.17±0.38	1.21±0.41	6.439	0.011*
Smoking	1.03±0.17	1.02±0.14	3.821	0.051
Alcohol Consumption	1.43±0.77	1.57±0.87	16.964	0.000**
Depression	23.73±9.74	22.36±9.44	11.405	0.001**

* p<0.05 ** p<0.01

According to Table 2, it can be observed that there were no significant differences between DM patients and non-DM patients in four variables: highest level of education, marital status, duration of afternoon nap, and smoking. However, significant differences were found in five variables: gender, duration of nighttime sleep, time spent on high-intensity exercise, alcohol consumption, and stress.

3.2. Binary Logic Analysis of Factors Influencing Diabetes Mellitus (DM) in Elderly Individuals

Using gender, highest level of education, marital status, duration of nighttime sleep, duration of afternoon nap, time spent on high-intensity exercise, smoking, alcohol consumption, and stress as independent variables, and Diabetes Mellitus (DM) as the dependent variable, binary logistic regression analysis was conducted. After excluding 870 samples with missing data, there were 8825 remaining samples, resulting in an effective sample rate of 91.0%. The p-value was 0.000, indicating the model's effectiveness. The results are as follows:

Table 3: Summary of Binary Logistic Regression Analysis Results

Item	Regression coefficient	SE	z	Wald $\chi 2$	p	OR	OR 95% CI
Gender	0.203	0.102	1.991	3.965	0.046	1.225	1.003 ~ 1.495
Highest level of education	0.047	0.025	1.856	3.445	0.063	1.048	0.997 ~ 1.101
Marital Status	-0.036	0.029	-1.241	1.539	0.215	0.964	0.911 ~ 1.021
Length of Night Sleep	-0.027	0.021	-1.303	1.699	0.192	0.973	0.934 ~ 1.014
Nap Length	0.114	0.055	2.072	4.293	0.038	1.121	1.006 ~ 1.248
Time Spent Playing High-intensity Sports	-0.194	0.114	-1.696	2.877	0.090	0.824	0.658 ~ 1.031
Smoking	0.579	0.271	2.135	4.558	0.033	1.783	1.049 ~ 3.033
Alcohol Consumption	-0.149	0.059	-2.512	6.312	0.012	0.861	0.767 ~ 0.968
Depression	0.010	0.005	2.288	5.233	0.022	1.010	1.001 ~ 1.019
Intercept	-2.485	0.693	-3.584	12.844	0.000	0.083	0.021 ~ 0.324

Y: DM

McFadden R2: 0.015

Cox & Snell R2: null

Nagelkerke R2: null

Based on Table 3, it can be inferred that gender, duration of afternoon nap, smoking, and stress have significant positive effects on Diabetes Mellitus (DM). Conversely, alcohol consumption has a significant negative effect on DM. However, the variables highest education level, marital status, duration of nighttime sleep, and time spent on high-intensity exercise do not have a significant impact on DM.

Thus, the model formula can be constructed as follows:

$$P(DM) = \frac{1}{1+e-(\beta_0+\beta_1 \text{Gender}+\beta_2 \text{AfternoonNapDuration} +\beta_3 \text{Smoking}+\beta_4 \text{Stress}+\beta_5 \text{AcoholConsumption})}$$

Where:

P(DM) represents the probability of having Diabetes

Mellitus.

Bo represents the intercept.

β_1, β_2, β_3, β_4, β_5 represent the coefficients for Gender, Afternoon Nap Duration, Smoking, Stress, and Alcohol Consumption, respectively.

$$\ln\left(\frac{p}{1-p}\right) = -2.485 + 0.203 * \text{Gender} + 0.047 * \text{Highest Level of Education} - 0.036 * \text{Marital Status} - 0.027 * \text{Length of Night Sleep} + 0.114 * \text{Nap Length} - 0.194 * \text{Time Spent Playing High} - \text{intensity Sports} + 0.579 * \text{Smoking} - 0.149 * \text{Alcohol Consumption} + 0.010 * \text{Depression}.$$

Using gender, highest level of education, marital status, nighttime sleep duration, afternoon nap duration, time spent on high-intensity exercise, smoking, alcohol consumption, and stress as independent variables, and DM as the dependent variable, negative binomial regression analysis was conducted. The results are as follows:

Table 4: Summary of Negative Binomial Regression Analysis Results (n=8827)

Item	regression coefficient	SE	z	p	OR	OR 95% CI
Intercept	-3.338	0.609	-5.479	0.000	0.036	0.011 ~ 0.117
Gender	0.237	0.100	2.357	0.018	1.267	1.041 ~ 1.542
Highest level of education	0.029	0.024	1.204	0.229	1.030	0.982 ~ 1.080
Marital Status	-0.040	0.028	-1.416	0.157	0.961	0.910 ~ 1.015
Length of Night Sleep	-0.040	0.021	-1.948	0.051	0.960	0.922 ~ 1.000
Nap Length	0.102	0.055	1.863	0.062	1.107	0.995 ~ 1.232
Time Spent Playing High-intensity Sports	-0.200	0.112	-1.778	0.075	0.819	0.657 ~ 1.021
Smoking	0.532	0.269	1.977	0.048	1.703	1.005 ~ 2.886
Alcohol Consumption	-0.166	0.059	-2.817	0.005	0.847	0.755 ~ 0.951
Depression	0.351	0.430	0.816	0.414	1.420	0.612 ~ 3.299

Y: DM

McFadden R2: 0.008

Based on Table 4, the following model is considered:

$$\log(Y) = -3.338 + 0.237 \times \text{Gender} + 0.029 \times \text{Highest level of Education} - 0.040 \times \text{Marital Status} - 0.040 \times \text{Length of Night Sleep} + 0.102 \times \text{Nap Length} - 0.200 \times \text{Time Spent Playing High-intensity Sports} + 0.532 \times \text{Smoking} - 0.166 \times \text{Alcohol Consumption} + 0.351 \times \text{Depression}.$$

This means that gender and smoking have a significant positive impact on DM, while alcohol consumption has a significant negative impact on DM. Highest level of education, marital status, nighttime sleep duration, afternoon nap duration, time spent on high-intensity exercise, and stress do not have an impact on DM.

3.3. Random Forest Analysis of Factors Influencing Diabetes Mellitus (DM) in Elderly Individuals

Using gender, highest level of education, marital status, nighttime sleep duration, afternoon nap duration, time spent on high-intensity exercise, smoking, alcohol consumption, and stress as independent variables, and DM as the dependent variable, random forest analysis was conducted. There were 868 missing samples, leaving 9695 remaining samples, resulting in a sample validity rate of 91.05%. The final model achieved an accuracy of 92.24% on the test set, with a precision (composite) of 87.92%, recall (composite) of 92.24%, and F1-score (composite) of 0.90, indicating acceptable model performance. The results are shown in the following figure:

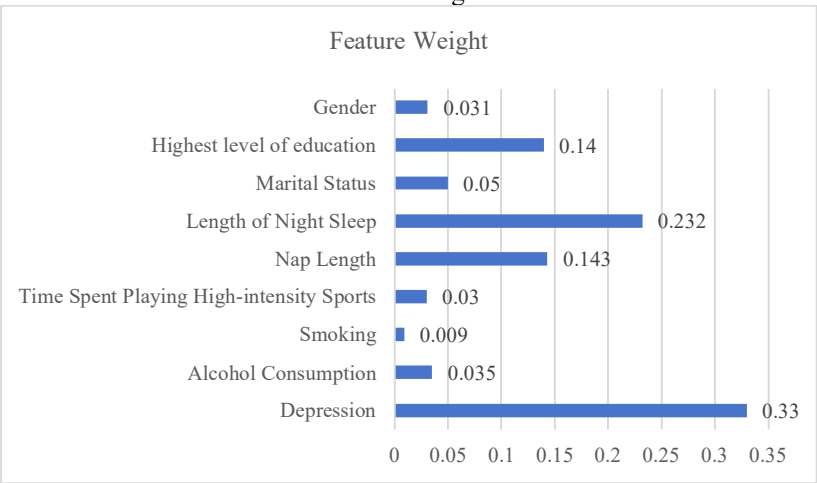

Figure 1. Feature Weight Obtained with RF

It can be observed that stress has a significant impact on the probability of developing DM, playing a crucial role in the model construction. Moreover, both nighttime and afternoon sleep exhibit strong correlations with DM, contributing significantly to the model construction. The combined weight of these three features accounts for 70.54% of the total. The influence of other factors is relatively minor.

3.4. Analysis of the Mediating Effect of Psychological Status on Lifestyle and the Incidence of DM

From the analysis results above, it can be observed that stress has a significant impact on DM. Gender, nighttime sleep duration, afternoon nap duration, time spent on high-intensity exercise, alcohol consumption, and smoking also influence DM, although the results obtained from various methods are not entirely consistent. Stress, as an important indicator of psychological factors, consistently demonstrates significant effects across different results. In this context, considering the mediating effect of stress seems warranted, which is also consistent with previous research findings. Therefore, in the subsequent analysis, the mediating effect of stress on the relationship between lifestyle and DM will be examined using the bootstrap method. The results are as follows:

Table 5: Results of Mediation Analysis (n=8827)

	DM					Depression					DM				
	B	SE	t	p	β	B	SE	t	p	β	B	SE	t	p	β
Constants	0.042	0.028	1.502	0.133	-	29.710**	1.020	29.125	0.000	-	0.017	0.030	0.583	0.560	-
Gender	0.016*	0.006	2.506	0.012	0.031	0.249	0.224	1.110	0.267	0.013	0.015*	0.006	2.473	0.013	0.031
Highest level of education	0.002	0.002	1.197	0.231	0.014	-1.003**	0.055	-18.223	0.000	-0.198	0.003	0.002	1.723	0.085	0.020
Marital Status	-0.003	0.002	-1.514	0.130	-0.016	0.479**	0.062	7.791	0.000	0.080	-0.003	0.002	-1.747	0.081	-0.019
Length of Night Sleep	-0.003*	0.001	-2.058	0.040	-0.022	-0.780**	0.046	-16.849	0.000	-0.173	-0.002	0.001	-1.519	0.129	-0.017
Nap Length	0.007*	0.003	2.004	0.045	0.022	0.037	0.124	0.301	0.763	0.003	0.007*	0.003	1.995	0.046	0.022
Time Spent Playing High-intensity Sports	-0.010**	0.003	-2.917	0.004	-0.034	-0.822**	0.121	-6.772	0.000	-0.076	-0.009**	0.003	-2.704	0.007	-0.032
Smoking	-0.012	0.006	-1.858	0.063	-0.020	-0.060	0.234	-0.258	0.796	-0.003	-0.012	0.006	-1.851	0.064	-0.020
Alcohol Consumption	0.040*	0.020	2.040	0.041	0.022	0.634	0.709	0.894	0.372	0.009	0.040*	0.020	2.014	0.044	0.022
Depression											0.001**	0.000	2.876	0.004	0.032
R 2	0.004					0.103					0.005				
Adjust R 2	0.004					0.102					0.004				
F value	F (8,8818)=4.962,p=0.000					F (8,8818)=126.443,p=0.000					F (9,8817)=5.333,p=0.000				

* p<0.05 ** p<0.01

From Table 5, it can be observed that the mediation analysis involves three models, as follows:

Model 1: DM=0.042+0.016×Gender+0.002×Highest Level of Education−0.003×Marital Status−0.003×Length of Night Sleep+0.007×Nap Length−0.010×Alcohol Consumption−0.012×Time Spent Playing High-intensity Sports+0.040×Smoking

Model 2: Depression=29.710+0.249×Gender−1.003×Highest Level of Education+0.479×Marital Status−0.780×Length of Night Sleep+0.037×Nap Length−0.822×Alcohol Consumption−0.060×Time Spent Playing High-intensity Sports+0.634×Smoking

Model 3: DM=0.017+0.015×Gender+0.003×Highest Level of Education−0.003×Marital Status−0.002×Length of Night Sleep+0.007×Nap Length−0.009×Alcohol Consumption−0.012×Time Spent Playing High-intensity Sports+0.040×Smoking+0.001×Depression

Table 6: Summary of Mediation Analysis Results

Item	c	a	b	a*b	a*b (Boot SE)	a*b (z)	a*b (p)	a*b (95% BootCI)	c’	Conclusion
Gender=>Depression =>DM	0.016*	0.249	0.001**	0.000	0.000	0.467	0.640	-0.000 ~ 0.002	0.015*	not significant
Highest Level of Education=>Depression =>DM	0.002	-1.003**	0.001**	-0.001	0.002	-0.437	0.662	-0.011 ~ -0.002	0.003	Full Mediation

Table 6: Summary of Mediation Analysis Results

Item	c	a	b	a*b	a*b (Boot SE)	a*b (z)	a*b (p)	a*b (95% BootCI)	c’	Conclusion
Marital Status=>Depression =>DM	-0.003	0.479**	0.001**	0.000	0.001	0.477	0.634	0.001 ~ 0.005	-0.003	Full Mediation
Length of Night Sleep=>Depression =>DM	-0.003*	-0.780**	0.001**	-0.001	0.002	-0.359	0.719	-0.010 ~ -0.002	-0.002	Full Mediation
Nap Length=>Depression =>DM	0.007*	0.037	0.001**	0.000	0.000	0.087	0.931	-0.001 ~ 0.001	0.007*	not significant
Alcohol Consumption=>Depression =>DM	-0.010**	-0.822**	0.001**	-0.001	0.001	-0.933	0.351	-0.004 ~ -0.001	-0.009**	Partial Mediation
Time Spent Playing High-Intensity Sports=>Depression =>DM	-0.012	-0.060	0.001**	-0.000	0.000	-0.231	0.817	-0.001 ~ 0.001	-0.012	not significant
Smoking=>Depression =>DM	0.040*	0.634	0.001**	0.001	0.000	1.462	0.144	-0.000 ~ 0.001	0.040*	not significant

* p<0.05 ** p<0.01

Bootstrap type：Percentile Bootstrap Method

As shown in Table 6, after adding the mediator variable stress, the mediating pathways between highest level of education, marital status, nighttime sleep duration, and DM become fully mediated. They do not have a direct impact on the incidence of DM but can influence the probability of developing DM by affecting stress. Alcohol consumption affects DM and also influences stress, thereby affecting the incidence rate of DM. However, other pathways do not show significant effects.

4. Summary and Discussion

Analysis reveals that gender, psychological stress, nighttime sleep duration, afternoon nap duration, high-intensity exercise, alcohol consumption, and smoking influence the probability of elderly individuals contracting diabetes mellitus (DM). While variance and linear regression highlight gender as a significant factor, negative binomial regression identifies gender and smoking as positively affecting DM, and alcohol consumption as negatively affecting it. Random forest analysis emphasizes the impact of stress and sleep on DM incidence. Introducing a mediation effect model shows stress as a significant mediator, with education level, marital status, and sleep duration influencing psychological state and subsequently DM incidence. Alcohol consumption directly impacts disease incidence and psychological state, thus affecting DM incidence. Regarding the negative impact of alcohol consumption, previous researchers have also found that moderate alcohol intake (20g/day) has a positive effect on the prevention of T2DM. [9] However, some studies suggest that any alcohol consumption can have negative effects on blood sugar control. [10] The mechanisms of exercise in the prevention and treatment of diabetes mellitus (DM) are also complex, and personalized exercise plans tailored to individual circumstances may have more pronounced effects. [11]

Research indicates that sleep significantly impacts blood sugar control, with both nighttime sleep and napping effectively reducing stress levels. Considering the results of random forest analysis, quality sleep emerges as a cost-effective means of managing blood sugar levels. In China, napping is prevalent among the elderly, with a nap rate exceeding 65%. [12] This study also links napping with the prevalence of diabetes mellitus (DM). As research on napping and health progresses, its role in DM prevention and treatment garners increasing attention. Previous studies on sleep patterns and DM incidence yield inconsistent conclusions. For instance, excessive napping (>90 minutes) is positively correlated with type 2 DM incidence in elderly individuals with metabolic syndrome. [13] Moreover, individuals with prolonged nighttime sleep (≥10 hours) and extended napping (>60 minutes) face a 72% higher risk of DM compared to those with moderate nighttime sleep (7-8 hours) and no napping. [14] Conversely, shorter nap duration (≤60 minutes) correlate with a reduced risk of DM. [15] This research underscores that napping over one hour serves as a protective factor for DM prevention and treatment among the elderly, highlighting the significance of appropriate nap duration in managing DM. Psychological well-being significantly correlates with DM risk, with studies indicating that 10% to 20% of DM patients experience depression. [16] This study reveals that education level, marital status, nighttime sleep duration, and DM exhibit a fully mediating pathway, influencing DM prevalence indirectly via stress. Similarly, alcohol consumption impacts DM and stress levels, thereby affecting DM incidence. While altering elderly education levels is impractical, promoting health literacy can enhance DM prevention and treatment outcomes. Attention to the emotional well-being of the elderly is crucial. Despite data limitations, this study highlights the impact of marital status on elderly stress. Post-retirement, seniors

undergo significant lifestyle changes, increasing susceptibility to psychological issues. Enriching retirees' daily activities, attending to family dynamics, and addressing emotional needs can foster a sense of societal support, bolstering mental and physical health among the elderly.

In summary, maintaining a healthy lifestyle and psychological well-being positively impact DM prevention and treatment. Actions such as quitting smoking and drinking, moderate exercise (approximately 1 hour), and appropriate sleep duration (around 8 hours) contribute to overall health. Additionally, the mental health of the elderly is crucial. The disparities in model outcomes may stem from several factors. Firstly, CHARLS lacks comprehensive DM-specific variables. Secondly, the absence of blood sample collection in the 2018 CHARLS survey may underestimate DM prevalence. Lastly, mediating effects among variables may obscure correlations. Thus, this study has limitations. CHARLS' non-specialized DM survey limits the scope of factors considered, leading to constrained conclusions. Moreover, the cross-sectional nature of the 2018 CHARLS data restricts temporal analysis. Future research can explore the mutual influence between lifestyle, psychological state, and DM in greater depth.

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