

Research and Construction of Personalized Sleep Model Based on Questionnaire Data

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Abstract

The purpose of this study is to investigate the sleep habits, cervical health status, and the demand and preference for pillow products of different populations through data analysis. A total of 780 valid responses were gathered via an online questionnaire to explore the sleep habits, cervical health conditions, and pillow product preferences of modern individuals. The study found that sleeping late and staying up late are common, and the use of electronic devices and caffeine consumption have a negative impact on sleep. Most respondents have cervical discomfort and have varying satisfaction with pillows, which shows their demand for personalized pillows. The machine learning model for predicting the demand of latex pillow was constructed and optimized to provide personalized pillow recommendation, aiming to improve sleep quality and provide market data for sleep product developers.

Keywords

Sleep Model, Personalization, Questionnaire Survey, Data Analysis

1. Introduction

Good sleep is an important part of a healthy life. More and more people begin to pay attention to the quality of sleep and seek ways to improve the sleep environment [1] [2]. The demand for personalized sleep solutions has also increased. China Sleep Research Report 2024 pointed out that consumers have a positive attitude towards intelligent sleep products [3] [4], and more than 30% of respondents are willing to use intelligent sleep products [5] [6] to improve sleep.

Based on the method of data analysis, the sleep habits, cervical health status, and the demand and preference for pillow products of different populations were investigated and analyzed [7] [8]. In this paper, the basic information of participants, such as gender, age, occupation, as well as their sleep patterns, habits of using electronic devices, cervical health status and other data were collected to

build a comprehensive sleep health data model [9]. The paper also discusses the respondents' satisfaction with the existing pillow products, preferences and needs for specific functions [10]. This research can contribute to improving people's sleep health [11] [12].

Gongyuansong, vice president of Huawei sports health and Huawei terminal BG smart wear and sports health product line [13], delivered a keynote speech on "innovative practice of sleep solutions based on smart wear", introducing Huawei sports health sleep management solutions. They used intelligent wearable devices to collect users' sleep data, and investigated volunteers' subjective data such as lifestyle, sleep environment, insomnia, sleep apnea through professional sleep questionnaire, and carried out research on sleep health status in the home environment. The 2021 Chinese sleep quality report and pillow health white paper released by Mengjie [14], through the research of huami technology, AI media data and other data, explores the sleep quality problems of consumers. The report pointed out that 77% of the people did not know how to choose a pillow, and 89% said they were not satisfied with the pillow they were sleeping on. The report suggests that consumers should confirm the appropriate pillow height and hardness according to the test sleep experience and maintain the good habit of changing pillows every two years. Mr. Tangguohai, chairman of Qisheng Technology Co., Ltd. [15] proposed to develop a personalized Sleep Solution for everyone through Shuford's data system. Their goal is to make sleep as customized as furniture, and through intelligent systems without human intervention.

2. Research Methods

2.1. Questionnaire Survey and Data Analysis

The questionnaire consisted of a comprehensive set of 25 questions, meticulously designed to cover various aspects related to sleep habits, cervical health status, and pillow product preferences. Additionally, confidence questions were strategically incorporated into the survey to enhance its validity and reliability, ensuring that the collected data accurately reflected the opinions and experiences of the respondents.

This study used a questionnaire survey to collect data. The questionnaire design covered many dimensions, such as sleep habits, cervical health status, pillow use satisfaction, and so on. A total of 780 valid data were collected through the online platform, of which 45.21% were men and 54.79% were women. In the data analysis part, the data were cleaned first, including processing missing values, abnormal values, and feature coding. Then, the statistical analysis method was used to analyze the sleep habits, daily living habits, sleep posture and discomfort, pillow use and satisfaction, cervical health and disease, consumption habits, and product preferences in detail. The results of data analysis revealed the prevalence of staying up late and staying up late, the negative impact of electronic equipment use and caffeine consumption on sleep, and the obvious demand of respondents for personalized pillows. Through the collation and analysis of these data, a sleep health

data model is constructed.

2.2. Construction and Optimization of Machine Learning Model

Based on the collected data, this paper constructs a machine learning model to predict the demand of latex pillow. First, the data is further processed, including feature selection, data standardization, and so on. Different algorithms such as support vector machine (SVM), random forest, naive Bayes, logistic regression and gradient lifting tree are selected for model training and testing. The performance of the model was evaluated by comparing the accuracy, recall, F1 score, training and prediction time of each model. The research optimizes these models to ensure that the model can provide rapid and accurate personalized pillow recommendation in practical application.

3. Data Analysis

3.1. Analysis of Sleep Habits

Table 1 shows the survey data of sleep habits. Among the respondents, 47.71% fell asleep before 24:00, 41.88% fell asleep after 24:00, 52.71% often stayed up late, 41.04% occasionally stayed up late, and only 6.25% never stayed up late.

Table 1. Survey data of sleep habits.

ID	Survey content	Percentage
1	Before 22:00	10.42%
	Before 24:00	47.71%
	After 24:00	41.88%
2	Often	52.71%
	Occasionally	41.04%
	Never	6.25%

The distribution of sleep time reveals that the sleep habits of respondents may be related to social trends and personal lifestyles. 47.71% of the respondents fell asleep before 12 p.m., including people who pay attention to health and have a regular schedule, as well as people who need to get up early due to work or family responsibilities. While 41.88% of the respondents chose to go to bed after 12 midnight. Sleeping late has become a part of many people's lives, which is related to overtime work, night entertainment activities or personal biological clock.

Data show that 52.71% of the respondents often stay up late, more than half of them. The impact of work stress or entertainment lifestyle on sleep patterns is widespread in modern society. 41.04% of the respondents stayed up late occasionally, sacrificing part of their sleep time because of occasional social activities or work needs. However, only 6.25% of the respondents did not stay up late. This

low proportion may include those who pay great attention to health, have strict work and rest rules or need to ensure adequate sleep due to health problems.

With the acceleration of social rhythm and the enrichment of nightlife culture, sleeping late and staying up late have become a part of many people's lives. This trend is related to urbanization, the popularity of smart phones and the Internet, and the increase of work pressure.

3.2. Analysis of Daily Living Habits

Based on the data analysis in **Table 2**, 76.88% of the respondents use electronic devices for more than 4 hours a day, of which 47.92% use electronic devices for more than 6 hours. This trend is related to the popularity and dependence of electronic devices, especially smart phones and computers. Using electronic devices for a long time, especially before going to bed, will affect the quality of sleep. Blue light exposure of electronic equipment can inhibit the secretion of melatonin, which is a hormone regulating sleep and wake cycle. Long-time use of electronic equipment may lead to difficulty in falling asleep, decreased sleep quality, and increased daytime fatigue.

Table 2. Survey data of daily life.

ID	Survey content	Percentage	
1	Service time of electronic equipment	>6 Hour	47.92%
		4 - 6 hour	28.96%
		2 - 4 hour	17.71%
2	Stimulating beverage preference	Like	31.46%
		Dislike	33.54%

According to the data of beverage preference, 31.46% of the respondents like to drink cola, coffee and other stimulating beverages, 33.54% do not like them, and 35% occasionally drink them. The data shows that respondents' preference for stimulant drinks is relatively balanced. Coffee, coke and other drinks contain caffeine, which is a stimulant of the central nervous system, can improve alertness and attention, but it may also interfere with sleep. Those who like these drinks may experience sleep disorders, especially if they consume them at night or before bed. People who drink such drinks occasionally may not have the same sleep problems, but they may still be affected by caffeine to some extent.

Based on the above analysis, it can be concluded that the popularity of electronic equipment and the widespread consumption of coffee may be two important factors affecting the sleep quality of the contemporary population. In order to improve sleep quality, it is recommended to reduce the time of using electronic devices at night, especially before going to bed, and reduce caffeine intake, especially in the afternoon and evening.

3.3. Sleep Posture and Discomfort

Based on the data analysis of sleep postures in **Table 3**, 40.63% of the respondents adopted multiple sleep postures, which may indicate that these people are not fixed in one posture during sleep and may change their posture according to comfort or physical needs. 35.63% of the respondents slept on their side, which is recognized as a healthier sleep posture because it can reduce the pressure on the spine and neck. The proportion of respondents who sleep on their back and on their stomach is low, 19.79% and 3.96% respectively, which may be related to the lack of support for the neck and back in these two positions, resulting in discomfort or sleep interruption.

Table 3. Survey data of sleep state.

ID	Survey content	Percentage	
1	Sleep posture	Side sleep	30.63%
		Supine sleep	19.79%
2	Neck or back discomfort	Occasionally	58.54%
		Often	27.29%
3	Cervical spine sensation when waking up	Comfort	20.63%
		Slightly stiff	33.13%
		Discomfort	14.58%

The data of neck or back discomfort showed that 85.83% of the people who occasionally or frequently suffered from discomfort may have experienced sleep problems related to improper sleep posture or support. This emphasizes the importance of sleep posture and the selection of sleeping supplies such as mattresses and pillows for the maintenance of cervical spine and back health. Only 14.17% of the respondents never felt unwell, which may be related to their conscious choice of sleep posture and use of appropriate sleep products.

The data of cervical vertebra sensation at wake-up further supported the influence of sleep posture and sleep products on sleep quality. Only 20.63% of respondents felt comfortable when they woke up, which may mean that the sleep experience of most respondents needs to be improved. 33.13% of the people felt slightly stiff, which may be caused by improper sleep posture or inappropriate sleep products. 14.58% felt unwell, which may indicate more frequent sleep interruptions or deeper sleep problems. 31.67% of the people had no special feeling, which may include those who did not feel unwell, although their sleep posture and supplies were not optimal.

Sleep posture and the choice of sleep products have a direct impact on sleep quality and cervical health. In order to reduce neck or back discomfort, respondents are advised to evaluate and adjust their sleep posture and consider using pillows and

mattresses that can provide appropriate support. In addition, for those who often feel neck or back discomfort, further medical assessment may be required to rule out potential health problems.

3.4. Pillow Use and Satisfaction

Based on the analysis of the survey data of pillow use in **Table 4**, the survey results of pillow satisfaction reveal the respondents' overall feelings about the pillows currently used. Among the respondents, 36.25% expressed satisfaction, indicating that a certain proportion of pillows in the market can meet the basic needs and comfort of users. 47.92% felt it was average, which may mean that although their pillows had no obvious problems, they also lacked particularly satisfactory features, such as support, comfort or personalized design. The dissatisfaction rate was 9.17%, indicating that a small number of respondents' pillows may not meet their specific needs, possibly because the material, height or design of pillows do not meet their personal preferences. In addition, 6.67% of the respondents said they were not concerned, which may include those who paid little attention to pillow selection or were not aware of the impact of pillows on sleep quality.

Table 4. Survey data of pillow usage.

ID	Survey content	Percentage	
1	Pillow satisfaction	Satisfaction	36.25%
		Commonly	47.92%
		Dissatisfied	9.17%
		Not concerned	6.67%
2	Pillow preference	Latex pillow	39.58%
		Down pillow	26.04%
		Buckwheat pillows	17.71%

In terms of pillow preference, 39.58% of respondents preferred latex pillows, which may be because latex pillows are generally considered to have good support and durability and are also suitable for people allergic to dust mites. 26.04% of the respondents chose down pillows, which may be because down pillows are favored for their softness and warmth retention. 17.71% of the respondents preferred buckwheat and other naturally filled pillows, which may be popular due to their natural materials and adjustable filling amount. 16.67% chose other types of pillows, which may include special types of pillows such as memory cotton pillows, water pillows, etc. These pillows may attract specific user groups because of their special design or material.

According to the analysis, the demand for pillows in the market is diversified, and different user groups choose different types of pillows according to their own

needs and preferences. The distribution of satisfaction shows that although a considerable number of people are satisfied with the pillows currently used, there is still much room for improvement. Pillow manufacturers can design more ergonomic and personalized pillows to improve user satisfaction by investigating and studying the specific needs of users. In addition, providing more choices of pillow types and materials, as well as increasing education on the comfort and health impact of pillows, can help consumers make more informed choices, thereby improving the overall sleep quality and satisfaction.

3.5. Cervical Spine Health and Disease Analysis

Based on the data analysis in **Table 5**, 14.58% of the respondents confirmed that they had cervical diseases. This ratio is relatively low and may point to several potential problems. First, the symptoms of cervical spondylosis may not be obvious in the early stage, leading many people to fail to recognize or diagnose the disease in time. Secondly, this may also reflect the respondents' insufficient understanding of cervical health problems, or lack of sufficient understanding of the symptoms of cervical diseases.

Table 5. Cervical spine health survey data.

ID	Survey content	Percentage	
1	Cervical spondylosis	Yes	14.58%
		Nothing	52.50%
		Not clear	32.92%
2	Cervical vertebra sensation after sleep	Feel comfortable	20.63%
		Slightly stiff	33.13%
		Feel unwell	14.58%
		No special feeling	31.67%

Cognitive differences in cervical spondylosis. 52.5% of the respondents clearly said that they did not have cervical spondylosis, which may indicate that these people have a better understanding of their own health status, or their lifestyle and habits help to maintain cervical health. 32.92% of the respondents were not clear about their cervical health status. This high proportion may indicate that there is a certain degree of cognitive ambiguity or neglect, which may be related to the lack of regular health examination or insufficient understanding of the importance of cervical health.

In terms of daily feeling of cervical vertebra, 20.63% of respondents felt comfortable when they woke up, which indicated that they had better sleep habits and suitable sleep environment, including suitable pillows and mattresses. 33.13% of the people felt slightly stiff, which may be caused by improper sleep posture,

inappropriate pillow or unsatisfactory sleep environment. 14.58% felt unwell, which may point to more frequent sleep interruptions or more serious cervical problems. While 31.67% of the people had no special feeling, which may include those who had adapted to less ideal sleep conditions, or those whose cervical spine problems had not affected their daily feelings.

The data analysis shows that the low cognitive rate and high “unclear” proportion of cervical spondylosis indicate that it is necessary to strengthen public education on the importance of cervical spine health and improve the awareness of regular health examination.

3.6. Analysis of Consumption Habits and Product Preferences

Based on the data analysis in **Table 6**, the respondents’ interest in customized pillows can be seen. 69.38% of the respondents showed interest in customized pillows, indicating that there is a demand for personalized and customized products in the market. This demand may stem from consumers’ pursuit of improving sleep quality and their concern about cervical health. 30.63% of the respondents said they were not interested, which may be related to their understanding of customized products, price sensitivity or personal preferences.

Table 6. Consumption survey data.

ID	Survey content	Percentage	
1	Monthly consumption level	<3000 yuan	67.92%
		3000 - 5000 yuan	20%
		>5000 yuan	12.08%
2	Interest in customized pillows	Interested	69.38%
		Not interested	30.63%
3	Price acceptance of latex pillow	<100 yuan	39.38%
		100 - 300 yuan	42.29%
		300 - 500 yuan	13.75%
4	Pillow function preference	>500 yuan	4.58%
		Relieve fatigue	77.92%
		Helps sleep	75%
		Adjust sleeping position	56.67%
		Focus on price factors	42.50%

In terms of price acceptance of latex pillows, 42.29% of respondents were willing to accept the price range of 100 - 300 yuan, while 39.38% of respondents accepted the price within 100 yuan. It shows that most respondents are sensitive to the price of latex pillows and expect to buy products with reliable quality in the

low and medium price range. 13.75% and 4.58% of the respondents accepted the price of 300 - 500 yuan and more than 500 yuan respectively, which may reflect the demand for high-end or special function latex pillows.

Pillow functional characteristics preference. 77.92% of the respondents hope that the latex pillow can relieve fatigue, which may be related to the fast pace of life and high work pressure of modern people. They seek to relieve daily fatigue by improving sleep. 75% of the respondents hoped that latex pillows would help improve the quality of sleep, which further emphasized the importance consumers attached to healthy sleep. 56.67% of the respondents hoped that the pillow could adjust their sleeping position, which was related to the dual attention to cervical health and sleep quality. While 42.5% of people pay attention to the price factor, which shows that consumers also pay attention to the cost performance of products while considering functionality.

Combined with the above data, it can be concluded that when consumers buy Pillows, they not only pay attention to the functionality of the product, but also consider the price factor. The demand for customized pillows in the market shows that consumers are increasingly inclined to choose products that can meet their specific needs.

4. Build the Model

Based on the questionnaire data, the eigenvalue is extracted, and the data is processed by missing value processing, abnormal value processing, feature coding and so on. After data processing, each feature is assigned a tag value, including eigenvalue and target variables (latex pillow demand or not). The decision table on latex pillow demand or not is constructed, as shown in **Table 7**.

Table 7. Part of the decision table of latex pillow demand.

Age	Sleeping time	Use time of electronic equipment	Stay up late	Cervical discomfort experience	Wake up cervical spine feeling	Lateral sleep	Latex pillow demand
0	1	0	1	1	1	0	y
1	0	1	0	0	1	1	y
2	1	0	1	1	0	1	y
2	2	2	0	0	0	0	n
2	1	0	1	1	1	1	y

Table 7 is a classified data set used to predict the demand for latex sleepers. **Table 7** contains several features that may be related to the demand for latex sleepers and a target variable. Through appropriate pretreatment and model training of these data, a machine learning model which can predict whether an individual needs latex pillow is constructed. The latex pillow demand model in the personalized

sleep solution model is trained and predicted based on algorithm models such as SVM.

The performance of different algorithm models is evaluated based on the accuracy, recall and F1 score. From the preliminary results, the gradient lifting tree model performed best in accuracy, reaching 92%, while the random forest model performed better in recall rate and F1 score, 92% and 91%, respectively. At the same time, the training and prediction time of the model are also considered to ensure the practicability of the model, as shown in **Table 8**.

Table 8. Comparison of model learning effect.

ID	Algorithm model	Accuracy	Recall	F1Score
1	SVM	85%	80%	82%
2	Random forest	90%	92%	91%
3	Naive Bayes	80%	75%	77%
4	logistic regression	88%	85%	86%
5	Gradient lifting tree	92%	93%	92%

Model optimization and selection. Based on the results of model performance evaluation, the gradient ascending tree model and random forest model with good performance are optimized, the model parameters are adjusted to improve the generalization ability of the model, and the model with the best performance and the training prediction efficiency meeting the requirements is selected as the recommended model for personalized sleep solutions.

The trained model is applied to the personalized Sleep Solution to provide users with customized pillow recommendations. According to users' sleep habits, cervical health status and specific needs for pillows, the model can predict users' demand for latex pillows, so as to provide users with appropriate product suggestions. At the same time, the model also provides market information for sleep product developers to help them design products more in line with consumer needs.

The model constructed based on the questionnaire data, which involves eigenvalue extraction and thorough data processing such as missing value handling, abnormal value processing, and feature coding, holds significant importance. It enables a data-driven approach to understanding complex patterns and relationships surrounding sleep habits, cervical health, and pillow preferences. By ensuring data quality through preprocessing steps and assigning tag values to features, including the eigenvalue and target variable (latex pillow demand), the model gains predictive capability. This allows for personalized and customized product development and marketing strategies, ultimately leading to informed decision-making and enhanced business operations related to latex pillows. Thus, the model serves as a valuable tool for gaining insights, improving customer satisfaction,

and driving strategic decisions.

5. Conclusions

Based on 780 valid questionnaires, this study analyzed the sleep habits, cervical health status, and the needs and preferences for pillow products of different populations. The study found that it was common to sleep late and stay up late. Most respondents had cervical discomfort and had varying degrees of satisfaction with pillows, indicating an obvious demand for personalized pillows. By constructing and optimizing the machine learning model, we can accurately predict the demand for latex pillows and provide a scientific basis for personalized pillow recommendation.

Future research will be further explored in the following directions: first, expand the sample size and diversity to improve the universality and accuracy of research results; second, explore more factors affecting sleep quality, such as eating habits, exercise frequency, etc.; The third is to study the specific impact of different materials and designs of pillows on sleep quality; Fourth, develop more accurate personalized sleep solutions, including intelligent sleep monitoring and intervention systems. It can provide consumers with more scientific and personalized sleep improvement suggestions, and also provide more innovative inspiration for sleep product developers.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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