

INVESTIGATION AND ANALYSIS ON SLEEPING POSITIONS OF TAIWANESE

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ABSTRACT

High quality sleep is essential to human body. A suitable pillow can provide appropriate support and get a high quality sleep. The study aims to investigate the natural positions during sleep and provide guidelines for pillow design. Thirty subjects with age ranges from 17 to 36 years participated in the study for sleep position observation. An infrared video was used to record the positions of head and neck during sleep. The software the Noldus Observer V. 4.1 was used to observe and analyze the sleep positions. The results showed that the proportions of the four sleep positions, supine, left lateral, right lateral, and prone were 60%, 22%, 17%, and 1%, respectively. This indicated that the lateral positions occupied about 40% of total sleep duration and required to pay attention to. The observation results illustrated when the participants slept in the supine position, their necks were bent forward, whereas when they slept in the lateral positions, the participants often placed their arm under the head. This indicated that the current pillows were too high for the supine position and too low for lateral positions. Furthermore, the location of head was far from the center of the pillow. This indicated that the pillow width was too narrow to the participants. The design guidelines were then established according to the results. The pillow height for lateral positions should be higher than for supine position. More, the pillow width should be enlarged.

Keywords : sleep duration, rotation frequency, design guidelines

I . INTRODUCTION

Humans spend one-third of their lives for sleeping. The total sleep time is equivalent to 25 years for a people with an average life span of 75 years old. Sleep is essential to human beings for functioning properly. In general, people need sleep to maintain their normal physiological functions and vital processes (Schutz, et al., 2009). The major functions of sleep are to conserve energy, to give the brain the opportunity to reorganize and store the information gathered during the day more efficiently, and to help the body to recuperate physically.

To achieve these functions, the appropriate sleep duration should be taken. It is believed that 7-8 hours of sleep a day is the appropriate duration for a healthy person. Many topics associated with the sleep duration have been studied. For example, the association between mortality and sleep durations (Allen, 2002; Heslop, et al., 2002; Kripke, et al., 2002), the relationship between obesity and sleep duration (Anic, et al., 2010; Itani, et al., 2011; Kong, et al., 2011; Magee, et al., 2010; Marshall, et al., 2010; Sahlin, et al., 2009), the relationship between physical condition and sleep duration (Mesas, et al., 2011), the association between blood

pressure and sleep duration (Wang, et al., 2011), the relationships between health, quality of life, and sleep duration (Magee, et al., 2011), and the risk factors associated with sleep duration (Chaput, et al., 2009; Li, et al., 2010; Tuomilehto, et al., 2008). Other studies on the related topics have also been reported, for example, the association between the quality of sleep and human health and living standards (Kyle, et al., 2010), the relationship between short sleep duration and performance on IQ measurements (Gruber, et al., 2010), the relationship between sleep and fluid intelligence performance (Johnston, et al., 2010), the relationship between sleep and working memory performance (Gradisar, et al., 2008), the sleep habits and factors associated with short sleep duration (Tagaya, et al., 2004), the quality of sleep and factors associated with poor sleep (Pallos, et al., 2007), the impact of sleep debt on metabolic and endocrine function (Spiegel, et al., 1999), the effects of sleep restriction on insulin sensitivity (Buxton, et al., 2010), and the relationship between sleep deprivation and perceptions of being healthy, attractive, and tired (Axelsson, et al., 2010).

Sleep positions can also be a factor affecting the physical health of individuals. For example, a study (Leung, et al., 2003) demonstrated that patients with congestive heart failure avoid the left lateral decubitus position spontaneously during sleep to prevent discomfort from the enlarged apical heartbeat or further hemodynamic or autonomic compromise. Another study (Gordon, et al., 2011) pointed out that the lateral positions produced significantly lower diastolic and systolic blood pressure, rate pressure product, and mean arterial pressure than the supine position.

It is commonly known that the appropriate sleep position is essential to the human body. Using a suitable pillow to have good support on the head and neck to maintain the natural curvature of the spine during sleep will lead to enjoying the appropriate amount of sleep and reducing neck and shoulder pain (Lavin, et al., 1997). There are many pillows in the market that are designed based on the shape of head and neck. They are supposed to increase the contact area between the pillow and the head and neck in order for the pressure exerted

on the head and neck to be distributed evenly. This design is workable for the fixed supine position.

However, due to body dimension measurements, the length (horizontal distance) between head (hindbrain) and (upper) back in sagittal plane (equal to pillow height in supine position) and the length (horizontal distance) between head (ear) to shoulder in crown plane (equal to pillow height in lateral position) were significantly different. In addition, people change positions continuously during sleep. Generally, four positions are identified: supine, left lateral, right lateral, and prone. The supine and lateral positions were the most commonly used positions. A study (Sahlin, et al., 2009) reported that the proportions of sleep durations in the supine position and lateral position were 41% and 50%, respectively for Swedish women. In order to provide design guidelines for pillow design, this study aims to investigate the proportions of the four sleep positions and the unnatural postures during sleep for Taiwanese.

II . METHODS

2.1 Subjects

Thirty Subjects (15 male and 15 female) were recruited for the sleep position study. Their ages ranged from 17 to 36 years with a mean age of 25.3 years (SD = 7.0 years). The participants claimed they were in good health without sleeping disorders and did not have any significant work on the following day so that they are able to sleep without any mental stresses. In this way, the entire sleep positions can be recorded for further observation and analysis. The participants were asked to sleep using their ordinary beddings, sleeping habit, and room conditions to obtain natural sleep positions. All of the participants were voluntary subjects and paid the equivalent of 35USD for their participation.

2.2 Equipment and procedures

An infrared video camera with a night-vision function was used to record the posture of head and neck during sleep regardless to the brightness of the bedrooms. Sleeping positions were recorded in their own bedrooms with their own beddings. The all situations of settings were according to the participant's custom for preventing them to interfere with the participant's sleep. When



the participants were ready to go to bed, they first set up the camera to focus on their heads, necks, and shoulders from a side location. Then they pressed the photo switch and went to bed. On the following day, when they woke up, then turned off the camera to complete the recording process. The recorded video files were then observed and analyzed by using the software Noldus the Observer V. 4.1.

2.3 Posture identification and criteria

Sleep positions are classified into four types of positions for further analysis, namely supine position, left lateral position, right lateral position, and prone position. The supine position was defined as the body lying down with the face up, and the prone position was defined as that with the face down. The left lateral position was defined as the upper body rotated leftward with an angle greater than 45 degree from supine position, and the right lateral position was defined as that rotated rightward. As sleeping positions change continuously, the sleep positions were identified only when they could be clearly identified as one of the four positions mentioned above. For example, if a participant began to sleep in the supine position, the supine position would begin at this moment and would end when the next identifiable position was observed which also marked the beginning of the second position. Two criteria, duration and frequency, were used to calculate the four positions.

III. RESULTS AND DISCUSSION

3.1 Sleep duration

Table 1 shows the average sleep duration of the 30 participants was 434 min (434 min = 7.23 hr; SD = 76 min). The longest duration was 713 min and the shortest one was 340 min. The total sleep duration was similar to the sleep pattern of the Taiwanese, 7.19 hours (Nielsen, 2004). This was also close to the average sleep duration of 7.25 hours in 13 countries, including Australia,

Mainland China, Hong Kong, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Thailand, and Vietnam (Nielsen, 2004).

Table 1 shows the statistics of the sleep duration of the four sleeping positions. The average sleep duration of supine position, left lateral position, right lateral position, and prone position were 19.80, 14.84, 10.86, and 6.58 min, respectively. The longest sleep duration was supine position, the following were left lateral position and right lateral position, and the least was prone position. The sleep duration of supine position was longer than that of left lateral position ($t= 3.301$, $p= 0.001$). The difference of sleep durations between left lateral position and right lateral position was not significant ($t= 1.506$, $p= 0.133$). The sleep duration of right lateral position was longer than that of prone position ($t= 2.336$, $p= 0.02$). Among all of the sleep durations of the four positions, the longest sleep duration was in the supine position. It was maintained for 176 min (2.93 hour). The shortest one was in the left lateral position, which was maintained for only 2 sec.

Table 1 illustrated that the average rotation frequency was 26.67 times (SD= 7.83 times) for a person sleeping for a night. The minimum rotation frequency was only 15 times and the maximum one was 48 times which was three times of the minimum frequency.

3.2 Frequency of sleeping positions

Table 2 demonstrates the statistics of the frequency of the four sleeping positions of the 30 subjects. The frequency of the supine positions, left lateral position, right lateral position, and prone position were 395, 195, 188, and 22 times, and occupied 49.4, 24.4, 23.5, and 2.7 percent, respectively. The frequency of the supine position was the greatest whereas that of the prone position was the least. The summation frequency of the left lateral position and right lateral position was 383 times,

Table 1. The statistics of sleep duration and rotation frequency (min)

Positions	N	Min	Max	Mean	SD
Supine position	395	0.07	176.68	19.80	22.34
Left lateral position	195	0.03	90.68	14.84	15.53
Right lateral position	188	0.17	51.95	11.62	10.86
Prone position	22	0.05	27.83	6.51	6.58
Total sleep duration	30	340.32	713.33	434.72	81.84
Total Rotation frequency (time)	30	15.00	48.00	26.67	7.83

Table 2. The rotation frequency of the four sleep positions

Positions	Frequency	Percent	Cumu. Percent
Supine position	395	49.375	49.375
Left lateral position	195	24.375	73.750
Right lateral position	188	23.500	97.250
Prone position	22	2.750	100.000
Total	800	100.000	

Table 3. The proportions in the four sleep positions

Positions	Frequency% (F)	Mean duration (D)	F × D	Percent
Supine position	49.375	19.80	977.63	59.94
Left lateral position	24.375	14.84	361.73	22.19
Right lateral position	23.500	11.62	273.07	16.75
Prone position	2.750	6.51	17.90	1.10
Total			1630.33	100

which was approximately equivalent to the frequency of the supine position (383/ 395= 97.0%). This indicated that both supine position and lateral position were significantly important during sleeping process.

Table 3 showed the average frequency and average sleep durations of the four positions. The Table illustrated the percentages of frequency of the supine position, left lateral position, right lateral position, and prone position were 49.4%, 24.4%, 23.5%, and 2.7%, respectively. It was found that both the average frequency and average sleep duration of the supine position were the greatest and that of the prone position were the least among the four positions. In order to obtain reasonable proportions of the four positions, the current study calculated the product of the duration and percentages of frequency of the four positions. As a result, the proportions of the supine position, left lateral position, right lateral position, and prone position were 60%, 22%, 17%, and 1%, respectively.

This result is different from that of a previous study (Sahlin, et al., 2009), which concluded that Swedish women spent 41% of their sleep time in the supine position, 50% in the lateral position, and 9% in the prone position. Comparing the two studies, the Taiwanese spend more time in the supine position, whereas the Swedish spend more time in the lateral position. This difference may be attributed to the differences in the curves of their hindbrain, in which the Taiwanese had a flatter hindbrain and the Swedish a more curved hindbrain, and the differences in the ages of the subjects [Taiwanese (age ranges 17-36 years old) and Swedish

(age ranges 20-70 years old)].

3.3 Comparison of the genders

Table 4 illustrates the sleep durations of the four sleep positions and the total sleep duration of the two genders. From the Table, the sleep durations for female were greater than that for male in values. T-tests showed that the sleep duration for female was greater than that for male in supine position ($t= 2.991, p< 0.01$) and in right lateral position ($t= 2.167, p= 0.031$). However the durations in left lateral position, prone position and total were not significantly different. The supine position was the most frequently used and longest-duration sleeping position and the right lateral position was better position of the two lateral positions. We concluded that the female have longer sleep duration than male in Taiwan.

Table 5 shows the rotation frequency of the four sleep positions of the two genders. The results of t-test showed that the rotation frequency in supine position for male was greater than that for female ($t= 3.125, p= 0.004$). The rotation frequencies of the other three positions, prone, left lateral and right lateral position were not significantly different. The rotation frequency in total for male was greater than that for female. This demonstrated that the males were more active than females even during sleep.

From the results, we inferred that the female could have better sleep quality than male in Taiwan due to the sleep duration and rotation frequency. Theoretically, the sleep quality was positively correlated to the sleep duration and negatively correlated to the rotation frequency. In



addition, this study investigated the sleep positions of fifteen male and female respectively. The more subjects could be recruited for study reliability in the future.

The sleeping positions of the 30 participants were observed. From the observation, five situations were found as follows and showed in Figure 1 and 2:

3.4 Observation of sleeping positions

Table 4. The statistics of sleep duration of the two genders

Positions	Male		Female		t-vale	Sig.
	Mean	SD	Mean	SD		
Supine position	16.80	19.81	23.72	24.78	-2.991	0.003
Left lateral position	13.23	12.52	16.73	18.33	-1.532	0.127
Right lateral position	10.19	10.87	13.64	10.58	-2.167	0.031
Prone position	6.32	6.19	7.16	8.55	-0.243	0.810
Total	425.38	101.56	444.0	58.10	-0.618	0.542

Table 5. The statistics of rotation frequency of the two genders

Positions	Male		Female		t-vale	Sig.
	Frequency	%	Frequency	%		
Supine position	224	49.1	171	49.7	3.125	0.004
Left lateral position	105	23.0	90	26.2	1.243	0.228
Right lateral position	110	24.1	78	22.7	1.988	0.057
Prone position	17	3.7	5	1.5	0.474	0.655
Total	456	100.0	344	100.0	2.936	0.007



Figure1. The participants padded their arm under the head to make the neck straight.



Figure 2. The neck of the participants bent and deviated.

1. When the participants slept in the lateral positions, their shoulders and arms were often seriously pressed. The cause of this situation may be the lack of the height of the current pillow.
2. The participants often used their arms or quilts to pad under their head to get into a more comfortable posture. Some examples in Figure 1 illustrated this situation. This may be due to the insufficient height of the pillow for the participants.
3. The neck was bent forward and the throat was pressed when the participants slept in the supine position. This could be because the height of pillow was too high for the participants when they were in the supine position (Figure 2).
4. The location of the head was far from the center of the pillow when the subject was in lateral positions. The width of the pillow seemed to be shorter for the subjects.
5. The participant's head often deviated from the center of the pillow with an unnatural posture. Hence, we can conclude

that the more the head deviated from the center of the pillow, the more the unnatural posture will be (Figure 2).

Using the general pillows in the current market, we found that the pillow height was too high for the supine position so that the necks of the participants were bent forward and throats pressed. On the other hand, the pillow height was too low for the lateral positions thus people often used their arms under the head for height compensation. In addition, the location of the head of the participants was far from the center of the pillow during the sleeping process, indicating that the width of the pillow was too narrow.

IV. CONCLUSION

Positions during the entire sleeping process of each subject were recorded, observed, and analyzed. The position analytical results can be summarized as follows. The total sleep duration was 7.23 hours and the rotation frequency was 26.67 times each night. The average



sleep duration of each time of supine position, left lateral position, right lateral position, and prone position were 19.80, 14.84, 11.62, and 6.51 min, respectively, whereas the percentages of rotation frequency of the four positions each night were 49.4%, 24.4%, 23.5%, and 2.7%, respectively. The proportions of the four positions were 60%, 22%, 11%, and 1%, respectively. The supine position is the most commonly used position and occupies 60% of the total sleep duration while the lateral positions can also be considered as commonly used position about 40% of the total sleep duration.

Several conclusions can be made based on the observations of sleep positions. The current general pillow designs in the markets are too high for the supine position so that the neck of the participants was bent and throat pressed. On the other hand, the pillow height was too low for the lateral positions, leading people to use their arms under the head to compensate for the pillow height. In addition, the location of the participant's head was far from the center of the pillow during the sleeping process. This signified that the width of the pillow was too narrow.

We recommend that the pillow height for the supine position and lateral positions should be different. Comparing the dimensions of pillows in the current markets, the pillow height should be lower for the supine position and be higher for the lateral positions. Moreover, pillow width should be wider in future designs. Furthermore, the body dimensions on the head, neck, and shoulder should be measured to provide reference for pillow design, and the concept designs should be proposed to suggest appropriate pillow for natural sleep position in future studies.

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台灣人睡眠姿勢之調查與分析

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摘 要

睡眠品質對人體是重要的。適當的枕頭可以提供合宜的支撐而能得到高品質的睡眠。本研究旨在調查睡眠的自然姿勢以提供枕頭設計的指南。三十位年齡在 17 到 36 歲的受測者參與本研究的睡眠觀察。紅外線攝影機用作頭部與背部的記錄，Noldus 觀察軟體用作睡眠姿勢的觀察與分析。結果顯示，正躺、左側躺、右側躺、及俯躺這四種姿勢的比例分別為 60%、22%、17%、及 1%。這意謂側躺佔有約 40% 的比例而應該要加以注意。觀察的結果顯示，當受測者在正躺姿勢時，他們的脖子是前屈的，而側躺時，他們常用他們的手臂或墊子墊在頭下。這表示他們的枕頭在正躺時太高而在側躺時又太低。此外，他們的頭部也都常偏離枕頭的中心位置，這表示枕頭的寬度過窄。根據觀察及分析的結果本研究建立了枕頭設計的指南。枕頭設計時，枕頭的高度在正躺時應該要低些，而側躺時則要高些，枕頭的寬度也要加寬。

關鍵詞：睡眠時間、翻轉頻率、設計指南

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