(二) 所發表之論文

本次會議所發表之三篇論文題目如下。

1. Cai, D.C., Chen, H.L., Lee, J., Sleep quality investigation of Taiwanese,
2. Shao, T., Cai, D.C., The effects of walking in place before sleep on sleep quality,
3. Chen, J.F., Cai, D.C., Effect of ergometer exercise on sleep quality.

(三) 主持會議證書。

主持本次會議的證書如附件所示。

Sleep Quality Investigation of Taiwanese

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Abstract. Many studies have demonstrated that the sleep quality is strongly positively correlated with quality of life. This study investigated the sleep quality of 300 subjects (male= 150, female= 150) in Taiwan. The subject's age ranged from 20 to 70 year with a mean age of 38 year (SD= 14.1 years).
The Pittsburgh sleep quality index questionnaire was used to assess sleep quality. The survey was conducted at north, central, and south Taiwan.
The results demonstrated that the subjects went to bed at 23:24 pm. and got up at 7:43 am. The subjects slept 7 hour and 5 min a night and took 18.8 min to fall asleep. The female went to bed earlier than male, got up later then male, and took more time to fall asleep than male. The overall PSQI of the subjects was 5.99 indicating the sleep quality of the surveyed Taiwanese citizens was worse than average. The sleep quality of the young group was better than that of the middle age and old groups. The sleep quality of the male was better than that of the female. The differences of sleep quality between residential districts and between body weights were not found.

Keywords: PSQI, sleep investigation, sleep duration, public health.

1. INTRODUCTION

Sleep is an activity of human beings. It has several functions, for example to restore physical fitness efficiently, to enhance memory and comprehension, and to reduce working and living stress, leading to a better quality of life.

Studies have demonstrated that sleep quality is strongly positively correlated with quality of life (Baglioni et al., 2010; Gregory and Sadeh, 2012; Salo et al., 2012; Kyle, 2010). Also, many factors can affect sleep quality. The most frequently reported factor is the sleep duration (Magee et al., 2011; Chaput et al., 2009; Tuomilehto et al., 2008).

Furthermore, Studies (Vandekerckhove and Cluydts, 2010; Suh et al., 2012) have also illustrated that insufficient sleep duration leads to aggressive behavior, poor strain resistance, and poor sleep quality.

The sleep duration can be the most important factor and affected by many factors, for example different gender, different age, different population, tobacco use, alcohol consumption, physical activity, body weight, hypertension, and diabetes can be the independent variables (Sabanayagam and Shankar, 2012). Other variables such as occupation, marital status, and education level (Lima et al., 2012) also can affect sleep quality.

Circadian rhythm also can be a factor affecting the sleep quality. Studies (Leger and Bayon, 2010; Saksvik et al., 2011; Grandner et al., 2010) reported that over 20% of office workers are required to work at night such as people work in power plants, medical treatment and care, transportation, and the police force, are therefore likely to suffer poor sleep quality.

To understand the sleep quality of citizens in Taiwan and provide a reference for academic and practical application, this study investigates sleep quality of Taiwanese using the Pittsburgh sleep quality index (PSQI) questionnaire.

2. METHODS

2.1Subject

Three hundred citizens in Taiwan were recruited for this sleep quality investigation, of which 150 (50.0%) were female and 150 (50.0%) were male. The age of the subjects ranged from 20 to 77, with a mean age of 38 years (SD= 14.1 years). The subjects dwelt in northern (33.3%), central (33.3%), and southern (33.3%) Taiwan.

Table 1. The statistics of basic information of the subjects

Items	N	Min	Max	Mean	SD
Total					
Stature	300	135	185	165.2	8.8
Weight	300	38	120	64.8	13.2
Age	300	20	77	38.0	14.1
Male					
Stature	150	153	185	171.7	5.8
Weight	150	47	120	72.9	12.0
Age	150	20	77	36.0	13.3
Female					
Stature	150	135	175	158.65	6.04
Weight	150	38	85	56.70	8.43
Age	150	20	73	39.97	14.62

2.2 Pittsburgh sleep quality index

The Pittsburgh sleep quality index (PSQI, 2015) questionnaire was used to survey the sleep quality of Taiwanese citizens.

A total of 10 questions of the PSQI questionnaire were surveyed. The 10 questions were showed as following.

The response of question 1-4 and the PSQI score were calculated and discussed in the following section. The data was also analyzed by Stratified variables such as gender, age, residential area, and body weight.

2.3 Procedure

The Pittsburgh sleep quality index questionnaire was used to survey the sleep quality of Taiwanese citizens at north, central, and south Taiwan. One hundred questionnaires of subjects (50 male and 50 female) were collected at the three districts.

3. RESULTS AND DISCUSSION

(1) Q1. During the past month, what time have you usually gone to bed at night?

Q1 asked the subjects what time they usually went to bed at night during the past month. Table 2 showed that the mean bed time was 23:24 pm, indicating the Taiwanese went to bed close to midnight.

The mean bed times of male and female were 23:35 and 23:13, indicating the female went to bed earlier than the male.

The bed times for people at northern, central, and southern Taiwan were 24:13, 22:52, and 23:66 respectively. The people in northern Taiwan went to bed later than in central and southern Taiwan.

However, no difference was found between different body weights and different ages.

(2) Q2. During the past month, how long (in minutes) has it usually been taken you to fall asleep each night?

Q2 asked the subjects how long it usually took them to fall asleep each night during the past month. Table 3 showed that the mean time was 18.8 min, indicating the subjects were usually able to fall asleep within the health requirement of 30 min.

The female took 19.30 min to fall asleep and the male took 18.27 min to fall asleep. The female took longer time to fall asleep than the male.

People with lighten body weight took less time to fall asleep than that with weighted.

People who live in northern Taiwan took less time to fall asleep than live in central and southern Taiwan.

The old people took more time to fall asleep than the middle and young people.

(3) Q3. During the past month, what time have you usually gotten up in the morning?

Q3 asked the subjects what time they usually got up in the morning during the past month. Table 4 showed that the mean time was 7:43am, which again fit health guidelines.

The mean time for male to got up was 7:37 and for female to got up was 7:49. The male got up earlier than the female.

People with middle body weight got up earlier than people with weighted body weight.

People who live in southern Taiwan got up earlier than live in central Taiwan.

The older people got up earlier than the middle age and the middle age got up earlier than the young people.

(4) Q4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

Q4 asked the subjects how many hours of actual sleep they got each night during the past month. Table 5 showed the mean time was 7 h 05 min, which was shorter than the average recorded for Asian people (Nielsen, 2004).

The male got 7 h 3 min for sleep and the female got 7 h 8 min for sleep a night. The sleep time for female was

longer than the male.

The older people got less time for sleep than the middle age and young people.

However, the difference of sleep time was not found among people who live in northern, central, and southern Taiwan. Also no difference was found in people with different body weight.

Table 2. The statistics of the Q1: What time did you usually go to bed at night?

Stratified variables	N	Min	Max	Mean	SD	ANOVA, t-test
Total	300	3.0	29.0	23.40	2.84	
Male	150	6.0	29.0	23.58	2.51	M > F
Female	150	3.0	29.0	23.22	3.13	
Light	100	3.0	29.0	23.60	2.85	A
Middle	100	9.0	29.0	23.47	2.04	A
Weight	100	6.0	28.5	23.12	3.45	A
North	100	22.0	29.0	24.22	1.46	B
Central	100	3.0	29.0	22.87	3.87	A
South	100	6.5	26.5	23.11	2.49	A
Old	105	9.0	26.0	23.06	1.78	A
Middle	99	6.5	28.5	23.51	2.54	A
Young	96	3.0	29.0	23.65	3.88	A

Table 3. The statistics of the Q2: How long (in minutes) did it usually take you to fall asleep each night?

Stratified variables	N	Min	Max	Mean	SD	ANOVA, t-test
Total	300	1.0	120.0	18.76	16.53	
Male	150	1.0	120.0	18.27	15.15	F > M
Female	148	0.0	120.0	19.30	17.95	
Light	99	0.0	60.0	15.41	10.41	A
Middle	99	1.0	120.0	21.21	17.72	B
Weight	100	0.0	120.0	19.71	19.71	A B
North	100	0.0	66.0	15.31	11.64	A
Central	99	0.0	120.0	21.11	20.35	B
South	99	1.0	120.0	19.96	16.21	B
Old	104	0.0	120.0	22.84	20.19	B
Middle	98	1.0	60.0	16.94	12.40	A
Young	96	1.0	120.0	16.27	15.24	A

Table 4. The statistics of the Q3: What time did you usually get up in the morning?

Stratified variables	N	Min	Max	Mean	SD	ANOVA, t-test
Total	300	4.0	20.5	7.71	2.05	
Male	150	4.5	17.0	7.61	1.94	F > M
Female	150	4.0	20.5	7.81	2.16	
Light	100	4.2	16.0	7.80	1.82	AB
Middle	100	4.5	12.5	7.35	1.58	A
Weight	100	4.0	20.5	7.98	2.58	B
North	100	4.0	12.5	7.75	1.65	AB
Central	100	4.2	20.5	8.03	2.66	B
South	100	4.5	15.5	7.34	1.62	A
Old	105	4.0	11.0	6.80	1.31	A
Middle	99	5.0	16.0	7.85	1.82	B
Young	96	5.0	20.5	8.56	2.50	C

Table 5. The statistics of the Q4: How many hours of actual sleep did you get at night?

Stratified variables	N	Min	Max	Mean	SD	ANOVA, t-test
Total	300	4.0	11.0	7.09	1.26	
Male	150	4.0	11.0	7.05	1.25	F > M
Female	150	4.0	11.0	7.13	1.27	
Light	100	4.5	11.0	7.09	1.11	A
Middle	100	4.0	10.5	7.17	1.33	A
Weight	100	4.0	11.0	7.01	1.33	A
North	100	4.0	10.0	6.91	1.14	A
Central	100	4.5	11.0	7.19	1.22	A
South	100	4.0	11.0	7.17	1.40	A
Old	105	4.0	11.0	6.83	1.40	A
Middle	99	5.0	10.5	7.25	1.08	B
Young	96	4.0	11.0	7.20	1.22	B

Table 6. The statistics of the PSQI score

Stratified variables	N	Min	Max	Mean	SD	ANOVA, t-test
Total	300	.0	18.0	5.99	3.16	
Male	150	1.0	14.0	5.69	2.64	F > M
Female	150	0.0	18.0	6.29	3.59	
Light	100	0.0	14.0	5.61	2.87	A
Middle	100	2.0	18.0	6.16	3.26	A
Weight	100	1.0	18.0	6.20	3.33	A
North	100	0.0	18.0	5.65	3.35	A
Central	100	1.0	15.0	6.16	3.03	A
South	100	2.0	18.0	6.16	3.10	A
Old	105	1.0	18.0	6.80	4.08	B
Middle	99	1.0	14.0	5.61	2.34	A
Young	96	0.0	13.0	5.50	2.55	A

(5) PSQI score:

The overall PSQI score was calculated from various questions. Table 6 showed the statistical results of the overall PSQI score.

Table 6 compares the PSQI scores by the stratified variables. The mean PSQI score of all of the subjects was 5.99. The mean score was greater than 5, indicating that the overall sleep quality of the subjects was slight poor.

The PSQI score of female was greater than that of male indicating the sleep quality of male was better than that of female.

The PSQI score of the older people was greater than that of middle age and young people. This indicated that the sleep quality of middle age and young people were better than the old people.

However, the sleep qualities of people who live in northern, central, and southern Taiwan were not different. Also no difference was found in different body weight.

4. CONCLUSION AND SUGGESTION

The survey indicated that the subjects usually went to bed at 23:24 and got up at 7:43. They slept 7h 5min a night and took 18.8 min to fall asleep. This was shorter than the average of Asian people.

The results of the PSQI analysis are summarized as below.

1) The overall PSQI of the subjects was 5.99 indicating that the sleep quality of the surveyed Taiwanese citizens was worse than average.

2) The sleep quality of the young group was better than that of the middle age and old groups.

3) The sleep quality of the male was better than that of the female.

4) There was no difference in sleep quality between the residential districts, and between the bodyweight.

5) The female went to bed earlier than male, got up later then male, and took more time to fall asleep than male.

6. ACKNOWLEDGEMENT

The authors thank to the support from project of Ministry of Science and Technology of ROC (Taiwan), the number of research project is NSC-103-2221-E-224-050. Furthermore, the study can be completed smoothly should thanks for the members' participation of this research group, including, Chien-Fu Chen, Ting Shao, Ting-Kai Chang, and Ru-Jyun Huang.

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The effects of walking in place before sleep on sleep quality

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Abstract. Sleep is one of the most essential factors for human health. Exercise can enhance sleep quality. In order to provide a simple and natural exercise for promoting sleep quality. This study explored the sleep quality of walking in place before sleep.

Twenty voluntary subjects (10 male and 10 female) aged 22-36 years, participated in the study. The exercise was working in place with raising leg to 45°, and was down for 30min (120strides/min) and finished 30min before sleep each day. A TXEK3 in-house Sleep Quality Examiner used to measure the sleep quality of the subjects. The sleep quality was recorded before (stage 1), during (stage 2), and stop (stage 3) doing exercise for five days respectively.

The results demonstrated that the sleep quality, duration of stable sleep, sleep onset latency and sleep apnea of the subject doing exercise were better than that of before exercise. The effect of walking in place is able to sustain for 5 days after exercise.

Keywords: exercise, health, ergonomics, sleep investigation, sleep quality.

1. INTRODUCTION

Adequate amount of sleep is crucial to physiological and psychological development because sleep deprivation can cause daytime sleepiness, which engenders cardiovascular diseases, obesity, and depression (Sigurdson, 2007). In addition, sleep deprivation negatively influences cognitive abilities such as the ability to memorize, learn, deduce, and calculate. Sleep quality is closely related to people's quality of life (Pilcher, 1997); specifically, a poor sleep quality reduces quality of life and delays the process of recovery from a disease.

Numerous studies have examined how engaging in various types of exercises (e.g., Tai-Chi, Qigong and Baduanjin) influences the quality of life of a specific subject. The results revealed that both types of exercises enhanced sleep quality. According to the American Academy of Sleep Medicine (2001), regular physical activity is an effective method of improving sleep quality. Exercises of distinct intensity positively influence sleep quality (Youngstedt, 1997). In addition, exercising plays a critical role in preventing and treating sleep-related problems. However, in Taiwan, complex exercise methods and space limitations have discouraged Taiwanese people to continue engaging in regular exercises. Li et al. (1995) surveyed the health behavior of 2,565 adults in Taiwan. They identified that 41.1% of these adults never exercise, 44.2% exercise occasionally, and only 14.7% exercise regularly, and that never exercising is one of the health behaviors commonly observed among Taiwanese citizens (Lee, 1995).

This study examined whether performing a simple movement exercise, walking in place, before sleep can enhance sleep quality. The results can serve as a reference for establishing exercise methods that require no learning and that can be performed anytime and anywhere. Consequently, such method would increase the proportion of citizens in performing regular exercises and overcome the problem concerning exercise complexity and space limitation, thereby motivating people to improve their sleep quality by exercising.

Sleep quality is influenced by social and psychological factors, health conditions, external sleep environment, lifestyle, and daily habits. According to a study, 44% of middle-aged Finnish participants (n=1600) stated that exercise is a method of improving sleep quality and a third

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of these participants believed that exercising is a crucial factor facilitating sleep (Urponen, 1988).

Chu and Fang (1997) indicated that sleep physiology involves non-rapid eye movement (non-REM) sleep and REM sleep.

(1) Non-REM sleep accounts for 75% of total sleep and is divided into four stages: Stages 1 and 2 are the initial stage of sleep (or sleep latency period; 5%) and unstable sleep (50%), respectively, and Stages 3 and 4 are referred to as stable sleep or slow wave sleep (SWS; 20%). During SWS, electroencephalogram (EEG) activity produces slow waves with a low frequency and high amplitude. At this stage, the sleeper is in a stable sleep, which is beneficial for regaining physical strength. Multiple studies have verified that prolonging SWS duration enhances sleep quality.
(2) REM sleep occupies 25% of total sleep and is associated with dreaming. In this sleep state, the central and peripheral nervous systems are highly active; thus, the sleeper typically tosses and turns and tends to wakes up suddenly. Most sleepers who were woken up from a REM sleep state have reported that they were dreaming.

Poor sleep quality is predicted by a sleep duration of shorter than 6 hours, sleep latency period longer than 30 min, and nighttime awakening of more than 3 times (Cohen, 1983).

A poor psychological and physical health is a high risk factor of insomnia. A study has shown that physical activity is effective for enhancing sleep quality (Singh, 1997). In addition, the Pittsburgh Sleep Quality Index (PSQI) scores of individuals who often engage in physical activities were significantly higher than those of individuals who seldom exercise (Lee, 2001). An epidemiology survey reported that exercising improves sleep quality and reduces daytime sleepiness (O'Connor, 1995). Chu and Fang (1997) indicated that regularly exercising reduces the frequency of daytime dozing, promotes SWS, and shortens the time required to fall asleep, thereby enhancing sleep quality. By conducting a subjective perception survey, Shapiro and Bachmayer (1988) determined that 83% of outpatients and general citizens (n=544) believed that exercising is beneficial for helping them to sleep well(Shapiro, 1988).

A habit of exercising regularly is generally considered to be one of the key factors for obtaining adequate sleep (Vuori, 1988). Furthermore, aerobic exercise might be the medium to improving sleep quality; however, engaging in long-term regular exercise is actually the key to enhancing sleep quality (Wang, 2006). A study reported that compared with those who never exercise, people who exercise more than 3 times a week sleep better and experience no sleep disturbance and daytime dysfunction. In addition, (Brand, 2010) revealed that in contrast to non-athletes, athletes possess positive sleep mode and superior sleep quality and seldom experience anxiety and depression.

According to Vuori et al. (1988), among people who exercised more often than they did 3 months ago, 43% of these people believed that their sleep quality improved and only 1% thought their sleep quality deteriorated. Conversely, among those who exercised less often than they did 3 months ago, 30% asserted that their sleep quality deteriorated and only 4% said their sleep quality improved.

Exercise Intensity

Caspersen, Powell, and Christenson (1985) revealed that physical activity can be categorized into 3 intensity levels, namely, light, moderate, and heavy intensity. Furthermore, moderately intense activity is more beneficial to health than heavily intense activity is (Blair, 1992).

A research reported that an exercise of light to moderate intensity is considered to be optimal for maintaining health (Vuori, 1988), stimulating endorphin production, yielding a sense of relaxation and pleasure, helping muscle relaxation, reducing central body temperature, and facilitating the act of falling asleep. It also prolongs the stable sleep stage, which enables uninterrupted sleep and adequate rest (Chen, 2005).

Studies investigating the relationship between exercise and sleep quality have focused on various types of exercise. Typically, an exercise of adequate intensity positively influences sleep. Scholars have indicated that exercise intensity has no significant influence on overall sleep quality and its constituents (Chu, 1998). Therefore, people who wish to improve their sleep disorder and enhance their sleep quality by exercising should adopt a step-by-step approach to prevent exerting excessive pressure on the body, which would cause muscle pain and thereby disrupt sleep (Wang, 2006).

Optimal Exercise Time

Several people believe that morning exercises are most beneficial to health, whereas exercising before sleep causes sleep disturbance. However, studies have suggested that the optimal time to exercise for enhancing sleep quality is in the afternoon or evening for at least 3 times per week, and each exercise duration must be 20 to 30 minutes (Wang, 2006; Chen, 2005). Vuori et al. (1988) also proposed that evening is the optimal time to exercise.

However, a study argued that exercising before sleep can shorten sleep latency period. In a study, O'Connor et al. (1998) requested men aged18–35 years to ride on stationary cycles for 1 hour 30–90 min before going to sleep. The results showed that the increase in body core temperature after the exercise exerted no effect on sleep efficiency. Furthermore, sleeping 30 min after performing moderately intense exercise shortened sleep latency.

Exercise Type

The effects that exercise method, activity experience, physical fitness, and exercise duration, frequency, and intensity have on sleep vary in terms of degree(Chu, 1997). Aerobic exercises (e.g., jogging, swimming, aerobics, and cycling) are highly effective for improving sleep quality (Wang, 2006).

To satisfy the needs of people who exhibit distinct sleep quality, scholars have investigated how various types of exercises influence the sleep quality of specific subjects. Chen et al. (2012) administered a 12-week Baduanjin routine to 55 elderly people above 60 years old. The results indicated that this type of exercise enhanced their sleep quality and efficiency and reduced their sleep latency period and daytime dysfunction. Moreover, when primiparous postpartum women engaged in pilate exercises, their sleep quality was enhanced, which strengthened the effects of maternal obligations(Ashrafinia, 2013).

2. METHODS

2.1 Participants

In this study, 20 participants (10 men and 10 women) with no physical disabilities aged 22–36 years (average age was 27.9 years) were recruited.

2.2 Experimental Equipment

A TXEK3 in-house Sleep Quality Examiner was used in this study. It's was an electrocardiogram based examiner built with a cardiopulmonary coupling technique (CPC) developed by DynaDx Corporation to assess sleep quality automatically. The validity and reliability of the CPC technique to record psychophysiological measurements and phenotype sleep apnea have been tested in previous studies.

This recorder has been used as sleep quality examiner for homecare. The items of the reorder included sleep quality, sleep duration, sleep latency, stable sleep duration, unstable sleep duration, paradoxical stage time, and sleep apnea.

2.3 Test Duration

Pretest, experiment, and posttest were conducted for a total of 15 days (each for 5 days), and the test was administered 30–60 min before sleep.

2.4 Walking In Place Exercise

Before going to sleep, the participants were instructed to perform walking in place (WIP) exercises. The exercise was performed 30 min per day for 5 days, working with raising leg to 45°and at pace of 120 step/min.

2.5 Experimental Procedure

A 15-day test was administered to the study participants, in which the participants performed no exercises during the first 5 days. From Day 6 to Day 10, they practiced WIP exercise for 30 min, after which they went to sleep 30 min after the exercise. Following 5 days of exercise, they continued to receive sleep tests for another 5 days, during which they were observed to determine whether the effects of the exercise were sustained even after they ceased exercising.

During the exercise period, the participants were required to rest for 30 min after completing the exercise; in addition, a cardiopulmonary sleep quality examiner (TXEK3) was attached to the subjects to record their sleep quality during their sleep. Overall, this study determined whether engaging in simple WIP exercise can improve sleep quality. If the participants experienced a major incident on the day of the test that might influence their sleep duration, no test was conducted on that day.

3. RESULTS

The results of this study analyze 7 sleep quality items from the subjects in three experimental exercise states. The sleep quality items include: Sleep quality score, Total sleep time (h), Sleep onset latency (min), Stable Sleep (h), Unstable Sleep (h), Paradoxical stage (h) and Sleep apnea.

Table 1 is the results of ANOVA test of sleep indexes. It shows significant differences in the four items which are the Sleep quality score ($p=0.000$), Sleep onset latency ($p=0.045$), Stable Sleep ($p=0.006$) and Sleep apnea score ($p=0.002$). The interaction effect of sex and exercise states was significant in Sleep onset latency ($p=0.020$). Table 2 is the results of t-test in multiple comparison of sleep indexes. The results are below:

Table 1: ANOVA test of sleep indexes.

Sleep Index	Variation	SS	df	MS	F	p
Sleep quality score	Sex	345.613	1	345.613	0.539	0.465
	Subjects*Sex	62875.067	98	641.582		
	Exercise States(E)	6224.747	2	3112.373	8.750	0.000
	Sex*E	978.107	2	489.053	1.375	0.255
	Subjects*Sex*E	69717.813	196	355.703		
	Total	140141.347	299	4944.325		
Sleep onset latency (min)	Sex	3326.670	1	3326.670	3.393	0.068
	Subjects*Sex	96076.993	98	980.377		
	Exercise States(E)	5016.127	2	2508.063	3.153	0.045
	Sex*E	6386.660	2	3193.330	4.014	0.020
	Subjects*Sex*E	155914.547	196	795.482		
	Total	266720.997	299	10803.923		
Stable Sleep (h)	Sex	1.643	1	1.643	0.834	0.363
	Subjects*Sex	192.974	98	1.969		
	Exercise States(E)	14.239	2	7.119	5.315	0.006
	Sex*E	7.615	2	3.807	2.842	0.061
	Subjects*Sex*E	262.540	196	1.339		
	Total	479.010	299	15.878		
Sleep apnea score	Sex	97.812	1	97.812	2.322	0.131
	Subjects*Sex	4127.591	98	42.118		
	Exercise States(E)	247.551	2	123.776	6.629	0.002
	Sex*E	53.866	2	26.933	1.442	0.239
	Subjects*Sex*E	3659.910	196	18.673		
	Total	8186.730	299	309.312		

Table 2: t-test in multiple comparison of sleep indexes.

Sleep Index	Exercises	N	Mean	t-test	
Sleep quality score	No	100	68.38		B
	WIP	100	78.9	A	
	Stop	100	76.86	A	
Sleep onset latency in men (min)	No	50	21.04	A	
	WIP	50	21.66	A	
	Stop	50	23.82	A	
Sleep onset latency in women (min)	No	50	40.58	A	
	WIP	50	20.06		B
	Stop	50	25.86		B
Stable Sleep (h)	No	100	2.98		B
	WIP	100	3.5	A	
	Stop	100	3.33	A	
Sleep apnea score	No	100	5.02	A	
	WIP	100	2.97		B
	Stop	100	3.26		B

(1) Sleep Quality Score

Participants exhibited significantly improved sleep quality after engaging in WIP exercise before sleep. When they stopped exercising, this improved sleep quality maintained for 5 days. The mean score in the three exercise states are 68.38, 78.9 and 76.86 respectively (table 2).

(2) Sleep Onset Latency

Participants in women exhibited significantly reduced time of falling asleep after engaging in WIP exercise before sleep. The mean time of sleep onset latency (min) in women in the three exercise states are 40.58, 20.06 and 25.86 respectively.

The sleep onset latency in 3 exercise states was all in the normal range in men. So it's not significant differences in men. The mean time of sleep onset latency (min) in men in the three exercise states are 21.04, 21.66 and 23.82 respectively.

(3) Stable Sleep

Participants exhibited significantly improved stable sleep duration after engaging in WIP exercise before sleep. When they stopped exercising, this improved stable sleep duration maintained for 5 days. The mean time of stable sleep (h) in the three exercise states are 2.98, 3.5 and 3.33 respectively.

(4) Sleep Apnea Score

Participants exhibited significantly reduced the score of sleep apnea after engaging in WIP exercise before sleep. When they stopped exercising, this reduced sleep apnea score maintained for 5 days. The mean score in the three exercise states are 5.02, 2.97 and 3.26 respectively.

4. CONCLUSION

Based on the experimental results, compared with those who do not engage in any exercise before sleep, participants who exercised WIP for 30 min and 30–60 min before sleep demonstrated significantly improved sleep quality and the situation of difficulty falling asleep, prolonged stable sleep duration, and reduced sleep apnea. This improvement effect was sustained for 5 days after the exercise was discontinued.

Overall, the results showed that the WIP exercises working with raising leg to 45° in pace of 120 step/min can improve sleep quality. In addition, the effects of the WIP exercises sustained for 5 days. The findings of this study can be used as an exercise reference for citizens to improve their sleep quality, thereby resolving the problems that they encounter regarding complex exercise routines and space limitation.

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Effect of ergometer exercise on sleep quality

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Abstract. Sleep is one of the basic needs of human physiological. Having good exercise habits is helpful to change the quality of sleep, shorten the time of falling asleep and release the situation of being drowsiness during the daytime. The purpose of our research is discussing that whether short-term ergometer exercise training program can effectively improve the sleep quality or not. We expect to bring up a short time exercise training program to make people improve their sleep quality immediately.
Our research asks for ten subjects, five each for men and women. All of them are twenty years old or elder with no physical handicaps and critical illness. Experiment lasts fifteen days, five days for a period which includes not doing ergometer exercise for five days, doing ergometer exercise for five days and stop doing ergometer exercise for five days. During the experiment, we use a device base on cardiopulmonary coupling technique to record the sleep quality every day.
The result shows that doing ergometer exercise for thirty minutes at night can improve the sleep quality effectively, shorten the sleep latency, increase the time of Stable sleep and release the situation of sleep apnea. Furthermore, the effect can last five days not only for the men but also for the women. The result of the research can provide people an exercise training program which is easy, effective and can improve their sleep quality immediately

Keywords: sleep quality, ergometer exercise, cardiopulmonary coupling

1. INTRODUCTION

Sleep is one of the basic physiological needs of human and also essential to promote personal health and develop the best physical and mental functions. The main function of sleep is to modulate our ability of cognition in daily life and work which includes judgement and the ability of memory and so on. People who own better sleep quality whose health condition and life quality will be better. (Kyle, Morgan & Espie, 2010; Fletcher, 1986)

Poor sleep quality problems are common to Taiwan people in all age groups. (Asian Sleep Research Society, 2000) People who are lack of good sleep ability can reduce attention, reaction speed, cognitive ability, the ability to judge and increase the accident rate, also lower the quality of life, and defer the recovery of disease. (Athanasios et al., 2010; Pilcher, Ginter & Sandowsky, 1997) The research shows that people who own good exercise habits is helpful for improve the quality of sleep, shorten the time to fall asleep, and reduce drowsiness in daytime. (American Academy of Sleep Medicine, 2001) However, the period of exercise training program using in nowadays are all four to six months, which is longer that cannot improve the sleep quality immediately in a short time.

The main purpose of research is to explore three points: (1) To investigate the relation between doing ergometer exercise for thirty minutes at night and sleep quality. (2) To investigate the effect to the sleep quality after stop doing ergometer exercise. (3) To investigate the similarities and dissimilarities and association between male and female after doing ergometer exercise.

We expect to propose an exercise program which is with simple condition, fast and effective by this research. And increase the effective of improving the sleep quality, lower the restriction, increase the number of people who improve their sleep quality by exercisin

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2. Method

The study includes three experimental exercise state levels.

No exercise state: measure the sleep quality without doing any exercise. Ergometer exercise state: measure the sleep quality from doing ergometer exercise. Stop exercising state: measure the sleep quality from stop doing ergometer exercise.

Each level for five days, the experiment is for fifteen days in total.

1. Subjects

Our research asks for ten subjects, five each for men and women who are twenty to thirty years old, healthy, with no physical handicaps and own their behavioral capacity.

2. Experiment Equipment and Place

1. Experiment Equipment:

(1) In-house Sleep Quality Examiner: combining In-house Sleep Quality Examiner and the analyze software, we use Cardiopulmonary Coupling; CPC technique to analyze. The result include seven indexes which is Sleep quality score, Total sleep time (h), Sleep onset latency (min), Stable Sleep (h), Unstable Sleep (h), Paradoxical stage (h) and Sleep apnea score .

(2)Heart Rate Monitor: it can monitor subjects' heart rate during exercise in real time, control and keep subjects' heart rate in aerobic interval.(60~85% of the top heart rate)

(3)Ergometer: it can set the time of exercise and record calorie consumption.

2. Place: Testers will do ergometer exercise at human factor lab in National Yunlin University of Science and Technology and measure the sleep quality at their home.

3. Experiment Task

This study conducts ergometer exercise and tests its effect on sleep quality. Testers will use In-house Sleep Quality Examiner to record the sleep quality during the experiment. They will do ergometer exercise for thirty minutes at night during seven to nine o'clock.

4. Experiment Situation

1. Experiment Description: Explain to the subjects the purpose of this study, the content of the experiment, confirm the subjects' willingness and make sure they meet the limitation of this experiment.

2. Establish subjects' personal profile: establish subjects' height, weight, gender, age to establish their personal account to facilitate the subsequent measurement data upload and analysis.

3. No exercise state (Day1 to 5): Subjects should put the patches on In-house Sleep Quality Examiner and put it on their chest to record any physiological data during sleep. And stop record after they get up next morning then remove the instrument. Forbid doing any activity that may disturb subjects to sleep in this period.

4. Ergometer exercise state (Day 6 to 10): Subjects should do ergometer exercise for thirty minutes at night during seven to nine o'clock and measure the sleep quality during this period.

5. Stop exercising state (Day 11 to 15): Subjects stop doing ergometer exercise and measure the sleep quality during this period.

3. Result

The result of this study analyze seven sleep indexes from the subjects in three experimental exercise state levels which include Sleep quality score, Total sleep time (h), Sleep onset latency (min), Stable Sleep (h), Unstable Sleep (h), Paradoxical stage (h) and Sleep apnea score .

Table 1 means the result of ANOVA test of sleep index. It shows significant differences in the four items which are the Sleep quality score, Sleep onset latency (min), Stable Sleep (h) and Sleep apnea score. ($p=0.000$, $p=0.002$, $p=0.002$, $p=0.000$)

Table 2 means the result of T-test in multiple comparison of sleep index. Table 3 means the result of coefficient of variation of sleep index.

The result is below:

(1) Sleep quality score shows significant differences in three exercise levels. ($p=0.000$) Subjects own better sleep quality in doing ergometer exercise state and stop exercising state. And there is no significant difference between ergometer exercise state and stop exercising state. The average score in the three levels are 73.5, 88.9 and 86.4. Also, the variation in sleep quality is less after doing ergometer exercise.

(2) Sleep onset latency (min) shows significant differences in three exercise levels. ($p=0.002$) Subjects own shorter sleep onset latency (min) after doing ergometer exercise state and stop exercising state. And there is no significant difference between ergometer exercise state and stop exercising state. The average time of sleep onset latency (min) in the three levels is 17.7, 11.5 and 11.7 minutes. Also, the variation in sleep onset latency (min) is less after doing ergometer exercise.

(3) Stable Sleep (h) shows significant differences in three exercise levels. ($p=0.002$) Subjects own longer stable sleep (h) after doing ergometer exercise state and stop exercising state. And there is no significant difference between ergometer exercise state and stop exercising state. The average time of stable sleep (h) in the three levels is 3.3, 3.9 and 3.8 hours. Also, the variation in stable sleep (h) is less after doing ergometer exercise.

(4) Sleep apnea score shows significant differences in three exercise levels. (p=0.000) The situation of sleep apnea happened less after subjects doing ergometer exercise state and stop exercising state. And there is no significant difference between ergometer exercise state and stop exercising state. The average score of sleep apnea in the three levels is 4.8, 1.7 and 2.1. Also, the variation in sleep apnea score is more after doing ergometer exercise.

Table 1. ANOVA test of sleep index.

Sleep Index	variation	SS	df	MS	F	p
Sleep quality	Sex	133.33	1.00	133.33	0.51	.477
	Subjects*Sex	19343.47	53.00	364.97		
	Exercise state(A)	13793.06	2.00	6896.53	49.04	.000*
	Sex*A	334.41	2.00	167.20	1.19	.307
	Subject * Sex * A	25626.25	98.00	261.49		
	Total	59230.52	156.00	7823.53		
Sleep latency	Sex	120.68	1.00	120.68	0.67	.414
	Subjects*Sex	15970.74	89.00	179.45		
	Exercise state(A)	2487.38	2.00	1243.69	6.58	.002*
	Sex*A	669.50	2.00	334.75	1.77	.173
	Subject * Sex * A	37027.12	196.00	188.91		
	Total	56275.42	290.00	2067.48		
Stable sleep time	Sex	0.08	1.00	0.08	0.06	.808
	Subjects*Sex	126.88	98.00	1.30		
	Exercise state(A)	16.23	2.00	8.12	6.34	.002*
	Sex*A	1.51	2.00	0.76	0.59	.555
	Subject * Sex * A	251.06	196.00	1.28		
	Total	395.76	299.00	11.53		
Sleep apnea score	Exercise state(A)	562.35	2.00	281.18	18.97	.000*
	Sex*A	47.22	2.00	23.61	1.59	.206
	Subject * Sex * A	2905.29	196.00	14.82		
	Total	5715.73	297.00	344.33		

Table 2. t-test in multiple comparison of sleep index.

Sleep Index	State of exercise	N	Average	t-test
Sleep quality	No exercise	10	73.5	B
	Ergometer exercise	10	88.9	A
	Stop exercising	10	86.4	A
Sleep latency (min)	No exercise	10	17.7	A
	Ergometer exercise	10	11.5	B
	Stop exercising	10	11.7	B
Stable sleep time (h)	No exercise	10	3.3	B
	Ergometer exercise	10	3.9	A
	Stop exercising	10	3.8	A
Sleep apnea score	No exercise	10	4.8	A
	Ergometer exercise	10	1.7	B
	Stop exercising	10	2.1	B

Table 3. Coefficient of Variation of Sleep index

Sleep index	No exercise	Ergometer exercise	Stop exercising
Sleep quality	0.21	0.13	0.15
Total sleep time	0.21	0.17	0.17
Sleep latency	1.06	0.99	1.15
Stable sleep time	0.42	0.24	0.27
Unstable sleep time	0.48	0.38	0.51
Paradoxical stage	0.50	0.51	0.49
Sleep apnea score	1.05	1.99	1.93

4. Discussion

The result shows that doing ergometer exercise for thirty minutes at night can improve the sleep quality effectively, shorten sleep latency, increase the time of Stable sleep, release the situation of sleep apnea and also stabilize the index of paradoxical stage (h). Besides, the effect is the same for men and women. Furthermore, it can last five days even you stop exercising.

The result of the research can let people realize th at exercise can improve sleep quality and provide an exerci se training program which is easy, effective and can improv e their sleep quality immediately.

ACKNOWLEDGEMENT

Thanks to the support from project of Ministry of Science and Technology, the number of research project is NSC-103-2221-E-224-050. Furthermore, the study can be completed smoothly should thanks for the members' participation of this research group, including Hsiao-Lin Chen, Jhongpei Wu, Ting Shao, Ting-Kai Chang, and Ru-Jyun Huang.

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