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Effect of exercise and light exposure on sleep and sleep related factors in elderly women

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Abstract---As we enter an aging society due to increasing life expectancy, there are many social pathology problems such as generation conflict. This study is intended to find out the effects of sunlight on elderly women's sleep related elements. Participants of this study are 40 elderly women (age 70.5 ± 3.5 years, height 155.8 ± 4.3 cm, weight 67.8 ± 4.1 kg) who haven't engaged in planned exercise or nourishment control for one year. The participants were randomly divided into four groups of sunlight group, exercise group, sunlight and exercise combination group, and control group, and 10-week-long experiment was done. Regarding sleep quality related items and sleep related hormone changes according to the experiment, One-way ANOVA analysis and Duncan post-hoc were done, and the results are as follows. Regarding the bedtime among the quality of sleep, the combination group fall asleep the soonest followed by the exercise group, the sunlight group, and the control group. The combination group also woke up the earliest followed by the sunlight group, the exercise group, and the control group. Regarding the potential sleep time (time to take until falling asleep), the combination group had the shortest time followed by the sunlight group, the exercise group, and the control group. The combination group also had the highest quality of sleep followed by the sunlight group, the exercise group, and the control group. The sleep time length was in the order of the combination, exercise, sunlight, and control groups. The above results show that the combination group had a more positive effect on the improvement of sleep habit and condition, and the sleep related substances than other three groups.

Keywords---exercise, light exposure, sleep, sleep related factors, elderly women.

Introduction

The OECD countries show rapid increase in average lifespan and life expectancy due to the completion of genome map, the development of medical science technology by the fourth industrial revolution, the increasing interest in health and the practice of healthy life. Especially, Korea started to enter an aging society in 2007, and became an aged society in 2018. By 2025, it is expected that over 20% will be aging population over the age of 65, which is considered as a ultra-aged society(KSIS, 2021). This increasing average lifespan can cause various social pathology problems, so it is necessary to take effective measures.

The aging society can have various social problems such as economic problem and generation conflict. The core of aging problem is the difficulty of the elderly whose physical functions are weakened in economic activities and daily lives. Human aging deteriorates immune system and physical activity ability, greatly affecting the quality of life related to healthy span. Especially, senile disorders, which appear in unhealthy seniors, are more likely to develop in women than men, and about 50% of seniors over the age of 70 suffer from various senile disorders, showing the difference by over 10 years between actual lifespan and health-related lifespan. Therefore, it is urgent to take measures(Neeland et al., 2012).

According to WHO, health defined as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. Exercise, nutrition, and rest are positive elements while obesity, aging and eating habit are negative risky factors. In addition, exercise, nutrition, and rest are important factors on health-related lifespan. Regarding sleep, the elderly more likely to get up earlier than other age groups and to experience fragmented sleep and daytime sleepiness than other age groups. The sleep related disorders cause anxiety, stress, deteriorated immune system and insomnia, and senile sleep disorder is closely related to the expectation of various degenerative conditions. Especially, the disharmony of exercise, nutrition and rest is a major factor of sleep related disorders, and recently, the abnormality of internal secretion (hormone) and lack of getting sunlight have been reported to be important factors(Giovanna et al., 2019).

In general, those who have high health-related lifespan are known to sleep 7-9 hours a day. However, 18% of seniors are suffering from sleep disorder according to Korean National Health and Nutrition Survey by National Statistical Office. There are only 45% who engage in exercise, which is known to have a close relation to sleep and health, and these people exercise for only 15 minutes. There should be improvement measures for this problem. Therefore, this study is intended to research the effects of exercise and sunlight on sleep related elements targeting old women who suffer from sleep disorder.

Materials and Methods

Subjects

Participants of the study are women over the age of 65 who didn't engage in

regular exercise or nutrition management for the last 1 year and suffer from sleep disorder. They are total 40 people (age 70.5 ± 3.5 years, height 155.8 ± 4.3 cm, weight 67.8 ± 4.1 kg) who live in G-city. They were randomly divided into four groups of control group, exercise group, sunlight group and exercise-sunlight combination group. The participants had no physical, medical problem but had sleep disorder. This study was conducted after obtaining approval from the Bioethics Committee (1041478-2018-BR-001) of N University. Before the experiment, they understood the intention and procedure of the study, and submitted a written agreement for the participation.

Methods (exercise program and measurement method)

It was 10-week-long experiment of exercise, getting sunlight, and doing both. The regular sleep length was 8 hours, and they did their sessions for one hour at 11 in the morning five times a week (Mon, Tue, Wed, Thu, Fri). For their diet, they maintained regular meals except drinking alcohol. After they recorded their diet before the first blood gathering, they kept the same while the experiment was implemented. The sunlight group sat under the sun for one hour.

For the exercise group, walking, which is a representative aerobic exercise based on the recommendation of American college of sports medicine (ACSM), was chosen. They walk in an indoor gym only with indirect lighting with curtains closed to block sunlight. They did for one hour a day five days a week (Mon, Tue, Wed, Thu, Fri). One session was composed of 5~10 minutes of warm-up and warm-down, and 40-minute-long main exercise at 11 in the morning like the sunlight group. The intensity of exercise was a medium level (50-60% of maximum heart rate), and walking hour was maintained consistently at each session. The intensity of exercise was adjusted with the wireless heart rate system, and the targeted heart rate was applied after being calculated with the use of the Karvon formula $\{(intensity \times (HR_{max} - HR_{rest}) + HR_{rest})\}$.

The sunlight-exercising combination group walked for one hour under the sun outdoor. The method and intensity of exercise were the same as the exercise groups. The quality of sleep, among the sleep related elements, was measured with the survey method three times, before the experiment, five weeks after the experiment and 10 weeks after the experiment. The questionnaire for the survey consists of questions for simple personal information and normal sleep habit (sleep time, wake-up time, time to take until falling asleep) and PSQI to measure the quality of sleep. PSQI, the measuring tool for the quality of sleep, has 19 questions consisting of seven sub-categories (subjective sleep quality, sleep potential period, sleep quantity, effectiveness, disturbance, use of sleeping pills, disruption of daytime activities). The whole index to evaluate the quality of sleep was calculated as each score was tallied up, and as the score is higher, the quality was poorer. The reliability of this measuring tool was .61.

The change of hormones that control sleep was measured among many factors related to sleep. Those hormones are sleep inducer hormone and sleep-wake hormone. Participants' blood was gathered before, 5 weeks after and 10 weeks after the experiment. They fasted for eight hours overnight, and 10ml of blood was gathered from median cubital vein on the next morning. The process of

centrifugation was done on the gathered venous blood with 3,000rpm for 5 minutes, and the serum was separated. Then it was frozen at $-70\sim-80^{\circ}\text{C}$ and analyzed by the clinical center. For melatonin, the light was shaded, and it was analyzed with radioimmunoassay of γ -counter with the use of IBL, Germany. GHRH was analyzed with radioimmunoassay of ELISA, and IL-6 was analyzed with radioimmunoassay of EIA. In addition, prostaglandin-2 was analyzed with radioimmunoassay of EIA, and Dopamine was analyzed with radioimmunoassay of Plasma catecholamine. Cortisol was analyzed with radioimmunoassay of double antibody procedure, and Orexin was analyzed with radioimmunoassay of ELISA. Norepinephrine was analyzed with radioimmunoassay of HPLC-ECD system.

Statistics

Regarding the design of this study, the factor of independent variable is exercise type or experiment type as factor 1, and the level is level 4 of sunlight, exercise, exercise-sunlight combination, and control groups. The period of measuring dependent variable is also factor 1, and the level is level 3 by measuring three times, before, 5 weeks after and 10 weeks after the experiment. Therefore, this study has one independent variable (level 4) and three times of measuring dependent variable (level 3). For all data, average and standard deviation are calculated with the use of SPSS Statistical Analysis Software. For the comparison of average values of four groups in the three periods and the comparison of average values of three groups in the three periods, One way ANOVA was done, and if there was significant difference, Duncan method was used for Post-hoc. All significance levels were set to be .05.

Results and Discussions

As shown in Table 1 and 2, the exercise group, the sunlight group and the combination group have significant changes in the quality of sleep 10 weeks after the experiment on women who suffer from sleep disorder. Especially, there was no significant difference in wake-up time, bed-time and the time to take until falling asleep among the exercise group, the sunlight group, and the combination group, but they all have significant difference compared to the control group. The combination group has more significant difference in sleep time than the control group. Regarding the quality of sleep, the exercise group, the sunlight group, and the combination group have more significant difference than the control group, indicating that exercise, sunlight, and combination of the two have a positive effect on the quality of sleep. In addition, among sleep related hormones, sleep inducer hormone and sleep-wake hormone brought about significant changes in the exercise group, the sunlight group, and the combination group 10 weeks after the experiment, and especially melatonin, which is a sleep inducer hormone, showed more significant change in the combination group than the control group. Dopamine, a sleep-wake hormone, had more significant change in the combination group and the exercise group than the control group.

Table 1
Sleep related factors after treatment 10 weeks

	wake-time (hr, min)	bed - time (hr, min)	potential-time (min)	sleep-time (hr , min)	quality (score)
COG ^a	4:32 ± 0.17	21:40 ± 0:59	07 ± 1.5	7:08 ± 0:46	4.72 ± 1.52
LEG ^b	4:34 ± 0:22	21:50 ± 1:10	11 ± 2.4	7:01 ± 0:47	6.19 ± 2.37
EXG ^c	4:40 ± 0:29	21:44 ± 0:52	12 ± 1.7	7:02 ± 0:46	6.82 ± 2.41
CNG ^d	5:12 ± 0:32	22:18 ± 0:55	23 ± 3.9	6:54 ± 0:42	8.28 ± 2.75
F-Value	2.59	4.62	3.15	2.67	7.46
Pr > F	0.0371	0.0086	0.0298	0.0161	0.0093
Post-hoc	a, b, c : d	a, b, c : d	a, b, c : d	a : d	a, b, c : d

Values are means ± SEM. COG; exercise plus light exposure group, LEG; light exposure group, EXG; exercise group
CNG; control group, Potential time; time until falling asleep, Quality; quality of sleep.

UN defines a society with more than 7% population aged 65 and over as ‘aging society’, a society with more than 14% population aged 65 and over as ‘aged society’, and a society with 20% population aged 65 and over as ‘super-aged society’(KSIS, 2021). This aging causes various social problems such as economic problem and generation conflict. The core of aging problem is the difficulty of the elderly whose physical functions are weakened in economic activities and daily lives.

As the ratio that the elderly participate in physical activities is lower, the economic burden of a country is higher. That’s because the less the elderly’s participation in regular exercise, the more medical fees for the elderly. In this context, there is increasing attention to the concept ‘healthy aging’ to decrease the medical expenses for the elderly. Although it is impossible to prevent humans from aging, they can have healthy aging by preventing diseases. The core role of healthy aging is exercise. Since exercise is a very effective tool for prevention of diseases and promotion of health, it is important to make efforts to encourage the elderly to engage in regular physical activities(Neeland et al., 2012).

In general, the average life expectancy is getting higher due to the development of scientific technology and medical technology, the recognition changes on health, and various preparations for healthy aging. Nevertheless, there is big difference between the average life expectancy and the healthy lifespan due to disharmony of exercise, nutrition, rest, and sleep, which are closely related to health(Giovanna et al., 2019). In other words, the healthy lifespan that is spent without dependence on medicine is about 10 years shorter than the average life expectancy. Recently, sleep is presented as a major factor of shortening the healthy lifespan, which is used as a criterion of the quality of life.

The healthy sleep has a direct effect on fatigue recovery of body and mind, memory, learning, growth, and healthy lifespan. The proper sleep time is known to be eight hours. Human body has biorhythm of 24 hours per day, and irregular sleeping habit and sleep disorder cause anxiety, stress, overwork, deteriorated

concentration, poor immune system, and disorder of endocrine system, bringing about insomnia or hypersomnia. Especially, the sleep disorder of the elderly is considered as the forewarning of future degenerative conditions(Driver & Taylor, 2000).

Sunlight is often divided into beneficial and harmful ones. While ultraviolet rays lying outside the violet part of sun's visible light are harmful to health, they have some benefits for people. When people are exposed to sunlight, their sleeping patterns, condition, and quality are improved, and furthermore, their quality of life is improved. In addition, some studies report that the effects of exercise become double under the sun, which indicates that sunlight is a great 'nutrient' for human body. The ultraviolet rays from the sunlight have such functions as improvement of brain function, stress relief, creation of vitamin D, promotion of bone health, reduction of blood pressure, depression relief, improvement of sleep quality, Alzheimer's symptom relief, cure of skin diseases, promotion of child growth, strengthening immune system and prevention of certain cancers, so they are called 'medicine from nature'(Mead, 2008; Joan et al., 2008).

Studies on the effects of exercise on sleep have had both positive and negative opinions(Kubitz et al., 1996). The effects of exercise related to sleep are the same as medication and engaging in regular exercise enables people to fall asleep faster. Especially, as the total sleep time is extended by regular exercise, people can have satisfactory sleep. The elderly is recommended to do outdoor activities five days a week for 20-30 minutes per day, in addition to taking enough vitamin D from diet and supplements(Tzu-Chia & Yen-Chi, 2016).

When aged women who suffer from sleep disorder were made to engage in such activities as getting sunlight, exercise and exercise while getting sunlight in this study, there were positive changes in various elements related to sleep as shown in Table 1 and 2. There were improvements in the time until falling asleep, total sleep time and sleep quality after they participated in exercise under the sunlight. In addition, there were significant changes in sleep inducer hormone(melatonin) and sleep-wake hormone(dopamine) among endocrine substances related to sleep, showing similar tendency with precedent studies(van der Rhee, de Vries, & Coebergh, 2016; Naomi, Sian, & Shelley, 2016).

The above results indicate that the participants had more happy feelings in the brain than normal as the secretion of melatonin was changed through exercise and sunlight. In addition, they engaged in exercise with enough sunlight, so melatonin, the sleep hormone, was secreted in the evening, which led to sound sleep. A proper amount of sunlight and exercise plays an important role in strengthening immune system of human body. Therefore, the Vitamin D level that gets higher by the proper amount of sunlight influence the quality of sleep(Magdalen, Katarzyna, & Jerzy, 2017). As human body is exposed to sunlight, the number of white blood cells increases, and they protect body and reduce pains, resulting in maintenance of normal cycle of body and improvement of sleep quality.

Table 2
Sleep related hormone after treatment 10 weeks

	Sleep inducing hormone				Sleep waking hormone			
	Melatonin (pg/ml)	GHRH (ng/ml)	Interlukin-6 (pg/ml)	Prostaglandin-E2 (pg/ml)	Dopamine (pg/ml)	Cortisol (μ g/ml)	Orexin (ng/ml)	Nor-epinephrine (pg/ml)
COG ^a	22.21 ± 3.42	1.41 ± 0.78	1.22 ± 1.08	628.97 ± 164.07	20.21 ± 4.45	10.11 ± 2.31	24.44 ± 8.56	367.48 ± 116.44
LEG ^b	18.35 ± 2.97	1.22 ± 0.17	0.85 ± 0.38	644.65 ± 138.35	18.11 ± 5.12	09.11 ± 1.98	27.22 ± 7.33	355.73 ± 110.74
EXG ^c	16.46 ± 1.45	1.15 ± 0.55	0.98 ± 0.25	657.98 ± 137.81	17.85 ± 4.02	11.32 ± 2.43	26.35 ± 7.21	382.61 ± 119.12
CNG ^d	14.94 ± 1.09	1.05 ± 0.74	0.63 ± 0.42	678.94 ± 175.51	13.75 ± 2.58	16.04 ± 3.01	31.84 ± 4.66	475.59 ± 129.25
F-Value	9.60	0.31	0.29	0.06	8.77	0.52	0.04	1.60
Pr > F	0.0090	0.9807	1.0131	2.9538	0.0485	0.7763	3.0046	0.3507
Post-hoc	a : d				a, b : d			

Values are means \pm SEM. COG; exercise plus light exposure group, LEG; light exposure group, EXG; exercise group
CNG; control group; GHRH; growth hormone releasing hormone.

Conclusion

As a result, exercise and sunlight have a positive effect on sleep of aged women who are vulnerable to sleep problems, and exercise with sunlight brings about an enhanced effect on sleep. According to the above results, there were positive changes in sleep related elements after the experiment of exercise, sunlight and combination of exercise and sunlight was conducted on aged women who suffered from sleep disorder for 10 weeks. Especially, the exercise-sunlight combination group had a significant difference. Therefore, it is important for aged women suffering from sleep disorder to engage in regular exercise like walking along with a proper amount of sunlight for them to maintain their health and to improve the quality of life.

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