The Effects of Full Immersion and Semi-Immersion Games on Autonomic Nervous System of Healthy Adult

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Abstract: ***Background/Objectives: This study attempts to confirm the safety of immersion and semi - immersion game through participatory tasks. Methods/Statistical analysis: The subjects were 12 male and 18 female.The study subjects were selected as those who had no problems in participating in the experiment. Before the experiment, the temperature and humidity of the experiment room were controlled. Behavior affecting the experiment was also controlled. All subjects first measured the autonomic nervous system status at rest in a pulse wave system. On the same day, semi-immersive participatory virtual reality was applied. The next day, the subjects applied a fully immersive participatory virtual reality. Each experiment was performed on different dates to avoid the interference effect of subject's experiment. Findings: The task of participating in the virtual reality game increased the activity of the sympathetic nervous system in both full immersion and semi – immersion environments. Changes in the autonomic nervous system were within normal ranges without significant differences. However, in the case of a complete immersion type task, sympathetic nervous system hyperactivity is great. And the parasympathetic nervous system deteriorated more easily. Improvements/Applications: As a result of this experiment, autonomic nervous system change is considered to be somewhat safer in the virtual reality situation.***

Keywords: pulse autonomic nervous system, full immersion, semi-immersion, heart rate variability, participation type game.

I. INTRODUCTION

Researchers have recently conducted a variety of studies on exercise and rehabilitation. Particularly, a variety of exercises are being implemented that are fused with audiovisual techniques rather than simple exercises. One of the most popular techniques is exercise through the task. The exercise method through games or video tasks progresses while solving various performance factors as the task progresses. These performance factors are helpful for exercise and rehabilitation. Typical methods used are Nintendo Wii or XBOX. They provide an environment similar to the real world. It also increases motivation and concentration.[1,2].

Recent developments in technology have created technologies that make the environment more realistic. The technology, called virtual reality, causes a visual illusion that seems to touch the actual environment. The movement through this virtual reality increases immersion. The increased immersion is similar to the actual exercise, as the task progresses. It also has spatial and temporal advantages and is convenient to use. However, there are many disadvantages in virtual reality exercise. Dizziness, pain in the eyes, blurred vision of the eyes, and motion sickness. This virtual reality side effect is caused by the difference between actual body movement and visual information[3,4].Previous studies have studied the safety of virtual reality tasks and general tasks. Safety was measured mainly through heart rate variability. Heart rate variability is a way to identify the state of autonomic nervous system. This is an efficient way to see the detailed changes and proportions of sympathetic and parasympathetic nervous systems. Virtual reality is assumed to be a complete immersion task, and the general task is assumed to be semi - immersion. A fully immersed virtual reality task is an exercise in which a virtual reality device is worn. Semi-immersion tasks can be observed in the surrounding environment by work such as watching TV. However, the methods used in most of the studies were not the same. The virtual reality task was mainly focused on non-participatory methods such as watching movies or observing three-dimensional roller coasters. In the case of the general task, I directly participated in the reaction. The autonomic nervous system is very sensitive. Personal habits such as human motion, drugs or Tabaco products, environment such as temperature and humidity, and time to be affected by rays are very diverse.[5,6]

Generally, the autonomic nervous system changes when stress is increased. Heart rate variability increases the low frequency oscillation power (LF) value, which is indicative of a rise in the sympathetic nervous system. The increase in sympathetic nervous system is the body's response to overcome stress. However, excessive activity of the sympathetic nerve can disrupt the balance of the body. In this situation, the parasympathetic nerve is increased and balanced. The increase in parasympathetic nerve leads to an increase in the high frequency oscillation power (HF) value. The balance of autonomic nervous system can be confirmed by the ratio of LF / HF. If this balance goes down, issues can range from minor, such as nausea, to major, such as heart attack[7-9].

The effect of the virtual reality task is positive, but the issue of safety has not yet been proven. As it is known, virtual reality nausea occurs because it is not the same between real environment and task. Due to the development of technology, the actual implementation of the environment is evolving.

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But the difference between reality and virtual reality is still far. This is because there is a significant difference between the somatosensory in the real environment and the somatosensory in the virtual environment. Therefore, this study carried out the participation type of full immersion type and semi - immersion type. We want to identify changes in the autonomic nervous system that change as the task progresses.

II. MATERIALS AND METHODS

2.1. Subjects

The subjects of the study, 30 healthy adults in their twenties, met the following requirements.

1. No neurological problems
2. No issues with the vestibular organ
3. No abnormality in the autonomic nervous system
4. No problem with applying virtual reality
5. Nonsmokers

In order to control the autonomic nervous system factors, excessive exercise and drinking were prohibited from 48 hours before the experiment. Caffeine beverages were discontinued 3 hours before the experiment. Also, to avoid being affected by the situation before the experiment, the subjects sat for 10 minutes after arrival and had enough rest state. All subjects were informed about the progress of the experiment and voluntarily agreed to the experiment. The general characteristics of the subjects are shown in table 1.

Table 1. General characteristics of the subject

	Age	Height(cm)	Weight(Kg)
30 (male 18, female 12)	23.13±2.97	164.7±8.8	62.31±9.84

2.2. Environmental control

The laboratory temperature was maintained at 23 ° C and the humidity was fixed at 65%. The experiment was conducted between 3 pm and 5 pm.

2.3.Measurement tools and measurement methods

First, when the subject arrived in the laboratory, they were rested for 10 minutes while sitting and measured heart rate variability using a pulse oximeter device on the left hand index. The equipment used for the experiment was a pulse wave analyzer (ubpulse T1, Laxtha, Korea). The height of the measurement was kept the same as the heart, and the measurement posture was measured in sitting position. The measuring equipment is as follows(Figure 1.).

Figure 1. Ubpulse T1

For the experiment, the program was unified in all tasks. The software used VR Traffic bike (Traffic bike, babloo inc.). This program is designed to move the bike in the virtual reality to the left and right by detecting the change in the angle of the left and right through the gyro sensor of the smartphone without complicating the movement.

On the same day, I wrote a headset device (VR box, Coms, China(Figure 2.)) that can convert a smartphone into a virtual reality. I used a blue touring mirror device (Miracast V2 , Cozy, Korea(Figure 3.)), and the task was performed for 10 minutes. The autonomic nervous system data was measured immediately.

Figure 2. VR BOX

Figure 3. Miracast V2

The next day, the headset equipment and the smartphone were combined to provide a virtual reality situation. The task lasted for 10 minutes, and the autonomic nervous system was measured immediately. This experiment was carried out for two days to prevent inter - effect between two tasks.

Two areas were used to measure heart rate variability. The LF of the low frequency region was 0.04-0.15Hz and the HF frequency region of the high frequency region was used in the range of 0.15-0.4Hz.The ratio of these two areas was also derived as a result.

All experimental values were subjected to a corresponding sample t test:

A Comparison of pre - experimental, semi - immersive participatory tasks.

A Comparison of Pre –experimental, full immersive participatory task.

A comparison of the values of semi - immersive and full immersive participatory tasks.

Statistical significance level α=05.The order is as follows(Figure 4.).

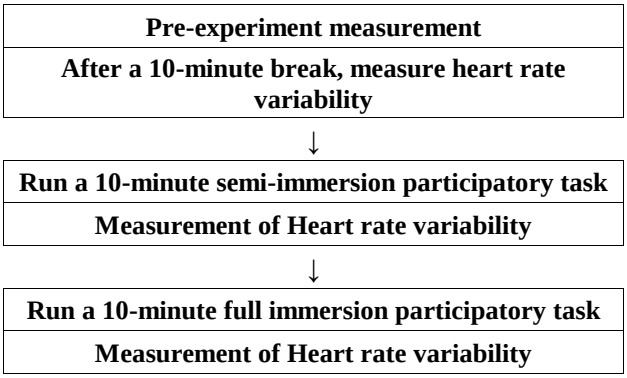

Figure 4. Experimental procedures

III. RESULTS AND DISCUSSION

The comparison before and after the half-immersion task is as follows: The LF value increased from 6.1 ± 0.8 to 6.6 ± 0.8 and the LF / HF also increased from 1.0 ± 0.1 to 1.1 ± 0.1(Table 2.).Although not significant, HF decreased.

The comparison before and after the full immersion task is as follows: The LF value increased from 6.1 ± 0.8 to 6.8 ± 0.6 and the HF value decreased from 6.0 ± 0.7 to 5.7 ± 0.7. The LF / HF value increased from 1.0 ± 0.1 to 1.1 ± 0.1(Table 3.).

The results of the two experiments were compared and the LF / HF value increased from 1.1 ± 0.1 to 1.2 ± 0.1(Table 4.). Although not significant, LF increased and HF decreased at full immersion.

Table 2. ANS change by semi-immersion

	before	after	t	p
LF	6.1±0.8	6.6±0.8	-4.974	.000*
HF	6.0±0.7	5.9±0.7	1.115	.274
LF/HF	1.0±0.1	1.1±0.1	-5.076	.000*

Table 3. ANS change by full immersion

	before	after	t	p
LF	6.1±0.8	6.8±0.6	-4.739	.000*
HF	6.0±0.7	5.7±0.7	2.356	.025*
LF/HF	1.0±0.1	1.2±0.1	-6.840	.000*

Table 4.Comparison of ANS with semi-immersion and full immersion

	Semi	Full	t	p
LF	6.6±0.8	6.8±0.6	-1.224	.231
HF	5.9±0.7	5.7±0.7	1.484	.149
LF/HF	1.1±0.1	1.2±0.1	2.548	.016*

Virtual reality equipment is already widely used. Simple, inexpensive devices such as the smartphone virtual reality equipment used in this study, and expensive equipment such as Sony's PlayStation VR devices, are already on the market. The advantage of such equipment lies in the immersion of the subject. As the immersion level increases, the concentration of the subject increases. Increased concentration increases task performance. In the method of enhancing the effect of the exercise function of the subject using the existing semi-immersion equipment, the virtual reality has shown a further increase in the immersion[4-6].

But there are some problems here. The immersion of virtual reality equipment is overly focused on the visual field. Humans have diverse senses, with the including of vision, hearing, tactile sensation, and various inherent receptive senses. In virtual reality equipment, realistic visual stimuli and somewhat ordinary sensory stimuli make a difference in sensory integration, and the sensory stimuli thus made represent a virtual reality motion sickness[4].

However, there are now various ways of using virtual reality. Observational virtual reality is already available on YouTube or in movies. In participatory virtual reality, content is mainly made up of applications such as games. The virtual reality environment, which is being offered in a variety of ways, makes us somewhat confused, but we need to concentrate on the fact that the content needed for exercise or rehabilitation should definitely be provided. Therefore, this study examines autonomic nervous system response in order to confirm the safety of the task and to provide both the participative fully-immersive virtual reality task and the participative semi-immersive virtual reality task.

In this study, autonomic nervous system changes appeared in both full-immersion and semi-immersion. Especially in the case of the full-immersion task, HF, LF, and LF/HF all showed significant changes. In the semi-immersion task, the HF and LF/HF changes were significant. In the case of semi-immersion, the change was smaller than with full immersion. These results show that the complete immersion task increased the autonomic nervous system stress response. According to previous studies, sympathetic nervous system hyperactivity and parasympathetic nervous system depression are explained by the stress response of the subjects. The results are the same as the results of this study. In addition, Kim et al. reported that the same pattern was observed in pathological phenomena[10].

There is a close relationship between the visual and vestibular systems. The Caloric stimulation may show that vestibular system not only induces eye shaking, but also changes the autonomic nervous system. The method of performing the task presented in this study seems to be that the head is moved to the left and right so that the vestibular stimulation is enough, and continuous visual stimulation is also input. Although the same stimulus was given in both the full-immersion task and the semi-immersion task, it was thought that the visual stimulus was stronger in the complete immersion task than in the semi-immersion task[11,12].

Nunan et al. reported that healthy adults had LF of 2.05 to 7.31, HF of 0.08 to 6.95, and LF/HF of -0.16 to 1.98. However, the results of the experiment are all in the normal range. Therefore, it is considered that the participatory task of virtual reality is somewhat safer. However, the 10-minute virtual reality adaptation time applied in this study is considered rather short, and it is difficult to assess the long-term virtual reality stimulation side effects. In the present study,

it is considered that shortening the experiment time is a limitation of the study in consideration of safety. In addition, since the subjects were all healthy 20s, it was difficult to generalize the experimental results because the researchers could not observe various conditions of all ages requiring actual exercise[13].

Virtual reality is evolving and can be seen as a technology with high development value in the future. More experiments and research will be needed to use these technologies more safely and effectively.

IV. CONCLUSION

Two types of virtual reality tasks show changes in the autonomic nervous system. A greater sympathetic nerve change occurred when performing a complete immersion task. In the case of semi-immersion tasks, there was little change. However, the autonomic nervous system changes were in the normal range in the two types of virtual reality tasks. Therefore, participating in virtual reality tasks can be safely applied to adults when they are in the normal category, i.e., healthy adults. However, it will be necessary to check the long-term application in the case of minors and elderly persons.

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