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Virtual Reality Intervention for the Psychological Well-Being of Medical College Pupils in the COVID-19 Outbreak

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Abstract: Psychological well-being problems in medical students exacerbated by COVID-19 epidemic, necessitating innovative interventions. During the COVID-19, the number of medical students with depression and anxiety increased. In recent years, immersive virtual reality (IVR) interventions have many advantages and can provide players with more realistic experiences than non-IVR. IVR systems using head-mounted display (HMD) devices have proven effective in ameliorating mental illness. The feasibility and usability of virtual reality interventions among medical students, particularly IVR experiences, have not been explored. This study examines the efficacy of an IVR intervention for the reduction of psychological distress during the lockdown. The study aims to prove that an IVR programme using an HMD can be as effective as traditional virtual reality rehabilitation, which is expensive and has high set-up costs. The design of the randomized controlled study was to conduct the study on the reduction of anxieties and depressions in 26 medical college students to test a feasibility and a usability of the IVR interventions. Individuals who gave informed consent were randomized on a 1:1 basis to the test group or the reference group. Only treatment groups were intervened with IVR, while control groups were not intervened. One intervention consisted of two sessions per week for six weeks. Each session consisted of trying out a standalone IVR (i.e. Oculus Quest II) followed by relaxing cybernetic content (i.e. Nature Treks VR). By comparing the preliminary test and the follow-up test results of the depression or fear tests, an analysis upon the results of the IVR intervention programme to overcome fear and depression in medical students due to COVID-19 was verified. In the treatment group, a t-test on the anxiety scale showed a significant decrease in anxiety with a t-value of -3.71, indicating a highly significant change (p <.001). The reference group had no substantial increase about anxiety. A depression scale for the experimental group showed a significant decrease in depression levels, with a t-value of -2.98 indicating a significant change (p < .01). In the reference group, levels of depression did not change substantially. These results suggest that HMD-based IVR interventions, as well as those using other modalities, can significantly reduce depressive and anxious disorders in medical students during a pandemic. A limit of this study is that the number of subjects was too small for generalization of the results. There is a need for a larger trial with a larger number of students in the near future.

Keywords: COVID, Medical Undergraduates, Depressive Disorder, Anxious Mood Disorders, Immersed Virtual Realities

1. Introduction

In recent years, "no contact" and "social distancing" have become a way of life in the outbreak of COVID-19[1]. Particularly as the certain COVID-19 pandemic continues, psychological disorders such as fear and depressive disorders are on the rise among young people, especially students[2]. There is

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something particular about medical school, although all college pupils are at high danger of tension[3]. A follow-up research of scholar depression of a medical college reported that while rates of depressive symptoms and fear at the beginning of medical school are about the same as in other age groups, the prevalence of depressed mood and fear in medical school students increased disproportionally over the period of their course[4]. When looking at recent research on medical pupils, especially in the environment of COVID19, most studies have focused on educational outcomes delivered in a virtual online context, such as classroom performance, classroom satisfaction, and the development of new pedagogical approaches suitable for online virtual classes, with only a few studies focusing on the psychological aspects of medical college students[5]. Therefore, finding methods of guiding the medical students to effectively and appropriately regulate their emotions during COVID-19 has become an urgent problem. But conventional treatments which were placed prior to pandemic, are inefficient and ineffective for medical students who relied on isolation and remote learning now.

In this regard, new psychological interventions that involve modern machineries, such as cybernetic realities (VR), can be serious[6]. In technical terms, VR was the collection of techniques, plus head-mounted demonstration (HMD), CPU and portable equipment, which could enable handlers to explore or communicate with a three-dimensional (3D) world in real time. From simple display on a level screen arrangement (ex. desktop VR), to what is often referred to in the industry as room-sized systems (ex. semi-immersion VR), to high immersion arrangements (ex. immersive VR; IVR) based on HMDs, VR machineries could offer their handlers different immersion levels in a virtual setting. IVR interventions have many benefits over non-IVR. They can offer players a more realistic environment than non-IVR[7]. But most of IVR methods utilized were too expensive and huge to be performed in ordinary offices or homes. Studies show that IVR therapy using HMDs has advantages in terms of safety, economic cost, and accessibility than other equipment of IVR[8].

Recent work has been carried out on the use of VR for the reduction of both stress and fear in various populations under the phenomenon of COVID-19 epidemic[9]. However, the use of IVR interventions has not yet been fully explored. Recently, the utilization of completely IVR with HMD for treatment of stress and anxiety, has been suggested as a replacement with non-IVR[10]. Cho and Lee examined IVR therapy affected the cognitive abilities and everyday activities of individuals with neuropsychological disorders[11]. In this study, researchers used virtual IVR training to help patients with mental illness in the ordinary occupational population. The experimental groups improved their depression, anxiety, and daily living activities. This suggests that IVR training could be a cost-effective way to boost recovery in mental illness patients[12].

However, the benefits of IVR therapy for medical students having mental illness have not yet been fully investigated; therefore, the usefulness of IVR in rehabilitation of psychopathology in medical students needs to be investigated in COVID-19. In this regard, the present randomized measured trial aimed to estimate the usefulness and acceptance with an IVR-based treatment for depressive and anxious disorders in a population of medical undergraduates in answer to the COVID-19. Present study questions and hypotheses are as follows. First, can IVR on HMDs be effectively used to reduce depressive symptoms and fear in a group of medical students compared to a control group? Second, are IVR intervention programs using HMDs as effective as conventional virtual reality experiments, which are expensive and have a higher setup cost? Finally, can the benefits of IVR interventions for the improvement of mental health extend beyond medical students to other college ones?

2. Research Methodology

2.1 A Research Design

Current study was a trial study conducted through a six-week study on the reduction of fear and

depressive mood levels in medical undergraduates to test their feasibilities and usability about the IVR interventions. The intervention consisted of two sessions per week for six weeks. Each session involved experimenting with certain immersive standalone VR structure (i.e. Oculus Quest II), followed by relaxing computer-generated content (i.e. Nature Treks VR).

2.2 Respondents of the Study

Twenty-six medical students were the subjects of this study. They voluntarily participated in the intervention program for overcoming anxiety and depression due to COVID-19 conducted by the Psychological Counseling Center at Dankook University in South Korea between March 2022 and January 2023. Medical students at Dankook University were made aware of the opportunities to enroll in the treatment experiment through both verbal message and an official email from the organized experiment contact. They should reply to this email confirming their intent to participate in the study, and the referrer will schedule the screening meeting as explained below. Participants' suitability was confirmed through a screening talk with the psychologist conducting the research, who explained the aim and the actions of the exercise and carried out a valuation to determine which contestants could be involved in the treatment. Those who were identified as partaking a level and signs of stress or fear of medical concern were transferred to the Mental Aid Desk at the institution to be eliminated from this treatment.

Addition criteria included (1) a current medical student, (2) a maximum age of thirty-five years, (3) no medical disorders (cardiac disorders, nervous diseases, epileptic disorders), (4) no medico-pharmacotherapy to interfere with measurements (psychotropic medications, antihypertensives, and antidepressants), and (5) no major visual disturbances (all having normal or near-normal visual acuity). Only suitable subjects who consented were randomized 1:1 to treatment or control. Participants will then be informed of the allocation result. At the beginning, 26 subjects were enrolled that were randomly allocated to either the controller (number = 13) (CG) or the VR treatment cluster (number = 13). A computerized fixed-block randomization algorithm, which stratified the blocks by age, sex, disease duration, and enrollment site, was employed to randomly assign members to the CG or VR groups. Mean member age was 23.5 ± 6.31 years ((mean ± standard deviation (SD)). This approach ensured that participants were assigned to groups in a way that balanced important factors like age, sex, disease duration, and participating center.

2.3 Ethical Considerations

Ethical approval (number 2202-023) was granted by the Ethical Committee of the Institution Review Boarding of Dankook University Hospital prior to starting the study. It was completely anonymous, collecting no information to identify individuals. Respondents were made aware that their answers were voluntary and anonymous and that they had a right to refuse. In accordance with Data Protection Regulations, data has been collected, processed and stored. The Ethical Guidelines have offered an opportunity for the development of research ethics capacity in the research world. Researcher had always respected subjects' fundamental rights. Researcher documented the informed consent processes by get participants to sign a consented form typed bold. The participants had got allocated to various treatment group in fair. The design of the study was chosen to protect the participants from discomfort, minimizing harm in specific circumstances where it is necessary to discontinue or change a treatment. The procedure was appropriate to ensure the confidentiality of the data. Those assigned to collect the data were adequately trained to be respectful and polite.

2.4 Data Gathering Procedures

Only the experimental group got the IVR intervention, whereas the control group got no intervention. The treatment was conducted for sixty minutes per week for a total of six sessions. The program's efficacy was evaluated by gauging depression and anxiety levels before and after the program. Participants' opinions were also analyzed through a satisfaction survey at the end of the program. Eligible subjects were given the IVR intercession two times a week (however, not the same day) for six workweeks. Approximately 30 minutes of IVR experiences using HMD was scheduled for each treatment. At the conclusion of the last session, subjects finished the post-experiment survey that measured fear and depression, and acceptance and ease of use of the game. Participants tried one virtual reality game for about 15 minutes each session. They then used "Nature Treks VR" virtual relaxation content for approximately 10 minutes. The control group received no training during the time of intervention and completed baseline, post-intervention, and post-treatment surveys.

Relaxing virtual experience: "Nature Treks VR": Nature Treks VR is a virtual reality experience that allows users to explore and meditate in a beautiful natural environment. With nature sounds, landscapes, animals, and even guided meditations to help you reduce stress and find peace, the game offers the same peaceful experience as exploring real natural environments. Specifically, the induction aims to deactivate the human danger defenses system and activate the soothing system (with a mindset concerned with providing and getting care, influencing and nurturing).

The hardware: The Oculus Quest II (sold as Meta Quest II as of Nov. 2021) was used to deliver the virtual experiences. Released in Oct. 2020, with an inner Android-based functioning system, it is a standalone headset. It practices an only fast-switch LCD plate with 1831 × 1920 per ocular resolution and provisions a 90Hz rejuvenate rate, manufacturing it lighter than the 1st-Gen. Quest[13].

2.5 Research Instrument

Each patient has gotten a total neuropsychological assessment sometime recently and promptly at the end of the study (i.e., T0 and T1, separately). The experiment was planned to evaluate the efficiency of the IVR-HMD interferences in improving mental health conditions (depression and anxiety) by measuring changes from baseline to the end of the study using the following scales.

The scales utilized were the Korean edition of the State-Trait Anxiety Inventory (STAI-I) and the Center for Epidemiologic Studies-Depression Scale (CES-D), which are self-report measures. The depression scale is a non-diagnostic test developed through epidemiological research on depression in the general public and measures the presence and severity of depression. It has a total of 20 questions and a 0–3-point Likert scale rating. The total number of points is 60, and the larger the sum of points, the higher the degree of depression. A State Anxiety Scale contains a total of twenty questions and is rated upon a Likert scale expanding from one to four, with a larger sum representing greater nervousness[14].

2.6 The Statistical Tools

All evaluations were 2-tailed with an alpha equal of .05. IBM SPSS Measurements for Windows, adaptation 25.0, 2017 program bundle was used to analyze all measured studies (SPSS Inc., Chicago, Illinois, USA). The Cronbach's α value for anxiety was .81. Shapiro-Wilk tests were done to test the normal distribution within the data. This study used two-tailed matching t-tests, using period (week one: pre-test; week six: post-test) because the within-participant adjustable when differences in the reliant on variable quantity between pre-test and post-test were normally scattered. The Wilcoxon signed-ranks test was used in all other cases. Autonomous t-test or chi-squared test was done to measure differences between zero (intercession start) factors. An iterative estimation ANOVA demonstration was utilized in order to perform group-to-group comparisons of nonstop factors. Period was treated as a clear-cut

variable, and the evidence involved groups, duration, and group-specific intelligence as secure effects. Deductions regarding the adequacy of the IVR mediations were grounded on a group comparison of variation from baseline to six weeks in mental disorders such as depression and anxiety, as assessed by the CES-D and STAI-I. The CES-D and STAI-I were used to assess the adequacy of the IVR mediations.

3. Results

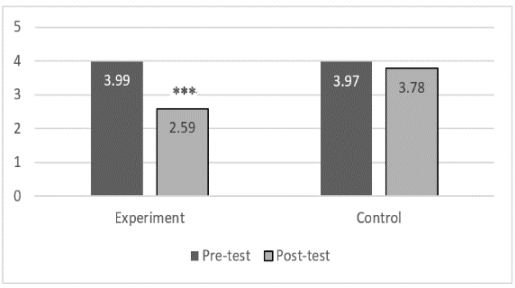
At baseline, the IVR and control groups had no critical differences in parameters. The study enrolled a similar number of participants in both the IVR treatment and control groups, with slightly more males in the control group (9 vs. 7). Additionally, the average age, height, and BMI were quite similar between the two groups, indicating that the randomization process successfully balanced these factors. Both groups had similar baseline values for weight, height, and BMI. These values fall within a relatively healthy range, suggesting that the participants had reasonably good overall health.

The results showed improvements in anxiety and depression levels for medical undergraduates who joined in the anxiety and depression studies. The pre and post results of the depression and anxiety tests are shown in [Table 1], and summarized graphs are depicted in [Fig. 1] and [Fig. 2]. Depression and anxiety scores for these 26 medical students differed statistically significantly between the pretest and post-test. The anxiety test showed a statistically significant decrease from pre-test (Mean=3.99, SD= .76) to post-post (Mean=2.59, SD= .53) in the IVR treatment group, which means that the anxiety of the medical students who experienced psychological distress due to anxiety caused by COVID-19 improved significantly after completing the program. In contrast, the control group did not demonstrate an important change within the level of nervousness. For the sadness test of the IVR treatment group, the post (Mean =2.29, S.D.= .33) was greatly lower than the pre (Mean=3.11, S.D.= .57, *** denotes high significance, $p < .001$). This means that the 13 medical college students who were mentally distressed by depression due to COVID-19 improved their depression after completing the program for overcoming depression. On the contrary, a control group could not show a important variation in depression. Group*time interaction was significant ($p = .01$), indicating that the improvement in anxiety was more marked in the IVR treatment group.

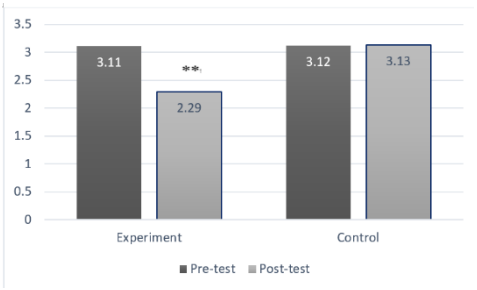
[Table 1] Comparison of Results of an IVR Intervention Program for Anxiety and Depression in Medical College Students Affected by COVID-19

Scale	Pre-	Mean (S.D.)		Post-test Mean (S.D.)		t
Anxiety	Experiment	3.99	(±0.76)	2.59	(±0.53)	-3.71***
	Control	3.97	(±0.74)	3.78	(±0.58)	
Depression	Experiment	3.11	(±0.57)	2.29	(±0.33)	-2.98**
	Control	3.12	(±0.62)	3.13	(±0.55)	

**p<.01 , ***p<.001



[Fig. 1] Comparison of Results of an IVR Intervention Program for Anxiety in Medical College Students Affected by COVID-19. ***p<.001



[Fig. 2] Comparison of Results of an IVR Intervention Program for Depression in Medical College Students Affected by COVID-19. **p<.01

4. Discussion

The primary goal of this Random Controlled Trial is to determine the usefulness and acceptability of IVR training, specifically HMD, for managing depression and burnout in medical students. In this study, standalone VR systems were used. In comparison to other types of immersion systems, these systems offer a higher quality of experience with more possibilities for engagement[15]. The consequences of this experiment suggest that HMD-based IVR interferences, as well as those using other modalities, can significantly reduce depression and fear in medical students during the pandemic. These results are consistent with previous studies on depression and stress in the general population[16], which have demonstrated that VR treatment can be active in reducing the points of fear and sadness in test subjects. It may deliver valued insights for the growth of innovative psychological interventions to help medical students, as depression and fear got augmented after the occurrence of the COVID-19, and both the health and work performance of this group can be adversely affected by these conditions[17].

The psychological and behavioral status of many medical students changed after the onset of the COVID-19 epidemic. Due to COVID-19, medical college students have had to adapt to the rapid changes in college life and face stressful situations. As all classes were suddenly changed to online non-contact classes, and this change was prolonged, medical college students complained of many psychological burdens such as excessive workload, accumulated fatigue from recorded lectures or live video classes, difficulty concentrating in non-contact classes for a long time, and even if they did not understand the class content, they had to give up credits due to lack of communication. These symptoms can lead the medical students to severe depression and sleep disturbance if not treated quickly[18]. There is an urgent need for more attention and research to treat it. However, empirical research on mental health services for medical students is severely lacking.

VR is progressively utilized in health-related areas and intercessions and may be a compelling instrument to delay the progress of degenerative brain and psychiatric diseases[19]. However, existing VR therapy equipment and programs are expensive, inaccessible, and boring for patients. Therefore, implementing VR-based interventions in healthcare settings may require considerations such as cost, technical infrastructure, and training for both users and administrators. Ensuring the efficacy, safety, and ethical use of VR technology in mental health interventions is crucial. There was a need to develop a cheaper, more accessible, and less boring treatment. The author believes that IVR treatments using HMDs can meet this need.

Here's how it compares to rehabilitation using traditional virtual reality devices: VR using HMDs provides a high level of realism. This helps stroke patients to rehabilitate in a more realistic environment. This realism helps stroke patients with the recovery of brain function and the improvement of motor skills. The level and difficulty of the game can be adjusted to focus on what the patient needs, depending

on their physical ability and level. HMDs and VR games give patients a sense of immersion. They help neuropsychological patients stay engaged and motivated in their rehabilitation. Patients are encouraged to stay engaged and work harder for longer through the game-like elements and reward system. As this IVR training could substantially reduce depression and anxiety, it may be a viable option to protect the mental health of other college students during and after a pandemic. The proposed IVR intervention can be used as part of depression and anxiety management programs for anyone who has been forced into isolation or prolonged hospitalization because of COVID-19 infection or other physical ailments[20].

While IVR has tremendous potential, it's essential to complement these interventions with traditional mental health services. Integrating IVR interventions within broader mental health support structures can offer a comprehensive approach to supporting the mental well-being of medical students. In addition, understanding the long-term impact and effectiveness of IVR-based mental health interventions among these populations will require continued research and evaluation[21]. If the data collected demonstrate the efficacy and acceptability of this IVR exercise for handling depression and anxiety, the anticipated method can be fast and inexpensively implemented because an adjunct or/and ongoing treatment to augment the efficiency of present evidence-based interferences for medical students. The results showed that during and after a pandemic, IVR training may be a practical choice for caring the mental well-being of pupils of other colleges. In addition, the training proposal could easily be adapted for other classes of people who want to support in managing depression and worry.

There are some limitations to this study protocol. For example, there is no guarantee that the training sessions were carried out by the individuals themselves or by another human being on their behalf. The number of test subjects was too small to generalize these results to the entire population. Finally, The results may be vulnerable to a bias because the medical school students who voluntarily participated may have been more distressed and/or susceptible to the IVR session.

To summarize, it can be said that three of the hypotheses raised in this experiment were met. First, compared to the controls, the IVR on an HMD would be effective in reducing depression and distress in a sample of medical students. Second, the hypothesis that an IVR intervention program using an HMD would be as effective as a traditional virtual reality experiment, which requires an expensive set-up, has been fulfilled. Finally, the results raise the possibility that the benefits of IVR-based mental health interventions extend beyond medical students to other students.

5. Conclusion

There have been few studies about mental disorder treatment based on IVR using HMD. The present study conducted an IVR intervention program to overcome anxiety and depression among medical students, who are most likely to experience mental health difficulties due to COVID-19, and analyzed its effectiveness to see if it can be a means to improve their mental health. In the experimental group, a t-test on the Anxiety Scale showed that anxiety decreased by a significant amount. No statistic significant change in anxiety was observed in the controlled group. The depression scale for the experimental group showed a significant decrease in depression levels, with a t-value of -2.98 indicating a significant change. In the control group, depression levels did not change significantly. This suggests that the IVR intervention could significantly reduce depression and anxiety in medical students. The IVR can be expanded to become a useful alternative for protecting the psychological health of other students both during and after COVID-19 pandemic. The number of people participating was too small to generalize the results, which is a limitation of this study. There is a strong need for a large-scale study with a higher number of medical students in the future.

References

[1] D. H. Lee, Y. J. Kim, D. H. Lee, H. H. Hwang, S. K. Nam, J. Y. Kim, The influence of public fear, and psycho-social experiences during the coronavirus disease 2019(COVID-19) pandemic on depression and anxiety in South Korea, The Korea Journal of Counseling and Psychotherapy, (2020), Vol.32, No.4, pp.2119-2156.
DOI: 10.23844/kjcp.2020.11.32.4.2119

[2] Y. Park, Y. Kim, Effect of family stress on family functioning during the COVID-19 pandemic: mediation effects of cognitive coping and depression, Korean Journal of Human Ecology, (2022), Vol.31, No.2, pp.219-236.
DOI: 10.5934/kjhe.2022.31.2.219

[3] H. Park, N. Jung, H. Jo, A survey of Korean college students' anxiety and depression in Covid-19, Journal of Asia Pacific Counseling, (2021), Vol.11, No.2, pp.41-55.
DOI: 10.18401/2021.11.2.3

[4] M. C. Rosal, I. S. Ockene, J. K. Ockene, S. V. Barrett, Y. Ma, J. R. Hebert, A longitudinal study of students' depression at one medical school, Academic medicine, (1997), Vol.72, pp.542-546.
DOI: 10.1097/00001888-199706000-00022

[5] F. Pallavicini1, E. Orena, S. di Santo, L. Greci, C. Caragnano, P. Ranieri, C. Vuolato, A. Pepe, G. Veronese, S. Stefanini, F. Achille, A. Dakanalis, L. Bernardelli, F. Sforza, A. Rossini, C. Caltagirone, S. Fascendini, M. Clerici, G. Riva, F. Mantovani, A virtual reality home-based training for the management of stress and anxiety among healthcare workers during the COVID-19 pandemic: study protocol for a randomized controlled trial, Trials, (2022) Vol.23, pp.451.
DOI: 10.1186/s13063-022-06337-2

[6] G. H. Lee, Effect of virtual reality-based training program on patients with mild cognitive impairment, Asia-Pacific Journal of Convergent Research Interchange, (2021), Vol.7, No.1, pp.71-80.
DOI: 10.47116/apjcri.2021.01.07'

[7] A. Gupta, K. Scott, M. Dukewich, Innovative technology using virtual reality in the treatment of pain: does it reduce pain via distraction, or is there more to it?, Pain Medicine, (2018) Vol.19, No.1, pp.151-159.
DOI: 10.1093/pm/pnx109

[8] O. O'Neil, M. Fernandez, J. Herzog, M. Beorchia, V. Gower, F. Gramatica. Virtual reality for neurorehabilitation: insights from 3 European clinics, PM & R, (2018), Vol.10, No.9, S198-S206.
DOI: 10.1016/j.pmrj.2018.08.375

[9] F. Zeidan, D. Vago, Mindfulness meditation-based pain relief: a mechanistic account, Annals of the New York Academy of Sciences, (2016), Vol.1373, No.1, pp.114-127.
DOI: 10.1111/ nyas.13153

[10] L. N. Dyrbye, C. P. West, D. Satele, L. Tan, J. Sloan, T. D. Shanafelt, Burnout among U.S. medical students, residents, and early career physicians relative to the general U.S. population, Academic Medicine, (2014), Vol.89, No.3, pp.443-451.
DOI: 10.1097/ACM.0000000000000134

[11] D-R. Cho, S-H. Lee, Effects of virtual reality immersive training with computerized cognitive training on cognitive function and activities of daily living performance in patients with acute stage stroke:A preliminary randomized controlled trial, Medicine, (2019), Vol.98, No.11, e14752.
DOI: 10.1097/MD.0000000000014752

[12] N. Baghaei, V. Chitale, A. Hlasni, L. Stemmet, H. M. Liang, R. Porter, Virtual reality for supporting the treatment of depression and anxiety: Scoping review, JMIR Mental Health, (2021), Vol.23, No.9, e29681.
DOI: 10.2196/29681

[13] E. R. Høeg, T. M. Povlsen, J. R. Bruun-Pedersen, B. Lange, N. C. Nilsson, K. B. Haugaard, S. M. Faber, S. W. Hansen, C. K. Kimby, S. Serafin, System Immersion in Virtual Reality-Based Rehabilitation of Motor Function in Older Adults: A Systematic Review and Meta-Analysis, Frontiers in Virtual Reality, (2021), Vol.2, pp.39-56.
DOI: 10.3389/frvir.2021.647993

[14] L. J. Julian, Measures of anxiety: State-Trait Anxiety Inventory (STAI), Beck Anxiety Inventory (BAI), and Hospital

Anxiety and Depression Scale-Anxiety (HADS-A), Arthritis Care & Research (Hoboken), (2011), Vol.63, Suppl 11, S467-S472.
DOI: 10.1002/acr.20561

[15] G. H. Lee, Effects of Wii virtual reality exercise program on the balance function of elderlies living alone with high fall risk, Asia-Pacific Journal of Convergent Research Interchange, (2021) Vol.7, No.4, pp.1-12.
DOI: 10.47116/apjcri.2021.04.01.

[16] T. Z. C. Htut, V. Hiengkaew, C. Jalayondeja, M. Vongsirinavarat, Effects of physical, virtual reality-based, and brain exercise on physical, cognition, and preference in older persons: A randomized controlled trial, European Review of Aging and Physical Activity, (2018), Vol.15, No.10, pp.1-12.
DOI: 10.1186/s11556-018-0199-5

[17] J. M. Rogers, J. Duckworth, S. Middleton, B. Steenbergen, P. H. Wilson, Elements virtual rehabilitation improves motor, cognitive, and functional outcomes in adult stroke: Evidence from a randomized controlled pilot study, Journal of NeuroEngineering and Rehabilitation, (2019), Vol.16, pp.16-56.
DOI: 10.1186/s12984-019-0531-y

[18] W. Xu, HN. Liang, Z. Zhang, N. Baghaei, Studying the effect of display type and viewing perspective on user experience in virtual reality exergames, Games for Health Journal, (2020) Vol.9, No.6, pp.405-414.
DOI: 10.1089/g4h.2019.0102

[19] A. Elor, S. Kurniawan, M. Teodorescu, Towards an immersive virtual reality game for smarter post-stroke rehabilitation, IEEE International Conference on Smart Computing (SMARTCOMP), (2018), pp.219-225.
DOI: 10.1109/SMARTCOMP.2018.00094

[20] M. Farrow, C. Lutteroth, P. C. Rouse, J. L. J. Bilzon, Virtual-reality exergaming improves performance during high-intensity interval training, European Journal of Sports Science, (2019), Vol.19, No.6, pp.719-727.
DOI: 10.1080/17461391.2018.1542459

[21] S. Lisa, B. A. Rotenstein, A. Marco, M. Ramos, T. Matthew, S. Bradley, J. Michael, G. Constance, S. Srijan, A. Douglas, Prevalence of depression, depressive symptoms, and suicidal ideation among medical students, JAMA, (2016), Vol.316, No.21, pp.2214-2236.
DOI: 10.1001/jama.2016.17324

