

Virtual Reality for Relaxation: Types and Factors of Efficiency

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T. A. Lepilkina¹, A.G. Beniashvili¹, A.V. Starodubova², R.A. Cheremin³,
N.G. Malyukova³, N.N. Shaposhnikova², M.A. Bogdanov³, S.V. Rodkina³

¹ Mental Health Research Center, Moscow, Russia

² Federal research Centre of Nutrition and Biotechnology, Moscow, Russia

³ Speech Pathology and Neurorehabilitation Center, Moscow, Russia

SUMMARY

Background. Although there is an increasing number of studies exploring virtual reality (VR) tools for relaxation in practice, there is a shortage of methodological and theoretical guidelines for the development of such programs and a gap in understanding of the mechanisms of their effectiveness in general.

Aims: (i) to consider the psychological mechanisms of VR relaxation and describe factors of the virtual environment and scenario that contribute to its effectiveness, and (ii) to study the effectiveness of a short-term course of VR relaxation based on the indicated methodological premises concerning anxiety, asthenia and other parameters of well-being in three groups of patients and healthy participants as compared to the control group.

Methods. (i) The key psychological mechanism of therapeutic VR and subtypes of VR instruments based on it are identified. The factors of relaxation efficiency in VR that were implemented in developing the Flow application are analyzed and specified. (ii) The course of five daily relaxation sessions in VR was attended by patients of the somatic hospital (group 1), patients diagnosed with obesity (2) and healthy subjects (3) (123 people in total); 20 patients of the somatic hospital were included into the control group (4). State-Trait Anxiety Inventory; the Fatigue Symptom Rating Scale; the Well-being, Activity, Mood questionnaire; and the Depression Anxiety Stress Scale were used as the assessment scales. Statistical methods were used.

Results. The main types of VR applications for relaxation are described, as well as the factors of their effectiveness, such as specific characteristics of the VR environment and the scenario that promotes relaxation. In the empirical part of the study, the data of 143 participants were analyzed. Positive changes have been noted after the completion of the first VR session, the whole course of VR therapy and a few days after the course in all experimental groups, whereas the condition of patients did not change in the control group.

Conclusion. Described application for VR relaxation is a promising tool for somatic patients and healthy users, showing signs of anxiety and asthenia.

KEYWORDS: virtual reality methodology, inpatient treatment, obesity, comorbid mental symptoms, nonpharmacological therapy

CONTACTS: Lepilkina Taissia Alekseevna, lepilkina@hotmail.com, ORCID: 0000-0002-2640-4658
Beniashvili Allan Gerovich, beniashvilia@yandex.ru, ORCID: 0000-0002-5149-3760
Starodubova Antonina Vladimirovna, avs.ion@yandex.ru, ORCID: 0000-0001-9262-9233
Cheremin Roman Avenirovich, drcher@yandex.ru, ORCID: 0000-0001-6018-6327
Malyukova Natal'ja Georgievna, maliukova@rambler.ru, ORCID: 0000-0003-1142-0804
Shaposhnikova Natal'ja Nikolaevna, buchкова@mail.ru, ORCID: 0000-0003-4964-3800
Bogdanov Mihail Aleksandrovich, mbOgdanov@yandex.ru, ORCID: 0000-0002-5033-7221
Rodkina Svetlana Vladimirovna, svetlana@mail.ru, ORCID: 0000-0002-0478-1380

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Introduction

Over the past decades, a significant number of virtual reality-based relaxation techniques have been developed, tested in studies, and implemented. The development of such tools is sorely needed both in clinical practice — since anxiety, tension, and affective symptoms are common occurrences in patients with various diseases — and in society in general, where these manifestations are a natural consequence of the daily stress that comes with complex social, economic, and epidemiological processes, and their attending restrictions. Non-pharmaceutical therapies have a number of advantages in such cases. For example, they can free up healthcare providers and remove the need for drug selection, dose titration, and waiting for the effects of drug therapy. They can also eliminate the need to worry about drug-drug interactions, potential side effects, and drug resistance.

Virtual reality (VR) relaxation interventions are based on the creation of a VR-based environment, circumstances, and user experience in order to take the person in a VR session to a new functional reality which is more comfortable, resource-rich, and relaxing in terms of subjective experience and closer to the normal state in terms of psychophysiological parameters. Some published systematic reviews have demonstrated positive outcomes in the use of VR relaxation techniques both in the general population [1] and in out- and inpatients who experience anxiety or stress-related conditions or those diagnosed with eating disorders, depression, bipolar disorder, or psychotic disorders [2]. These reviews include studies that had utilized virtual natural environments such as beaches, forests, mountains, etc. The authors came to the conclusion that VR relaxation could be used to achieve actual relaxation and reduce stress, although the degree of this improvement varied.

Despite the increasing recourse to VR-based tools and accumulation of empirical data, the issues of the theory and methodology of VR-based techniques remain important but poorly covered in the available literature. We have used our experience in developing Flow relaxation scenarios¹ to evaluate the psychological mechanisms and some aspects of the VR therapy methodology that could have a significant impact on achieving user relaxation.

The objectives of the study were as follows: (i) to evaluate the psychological mechanism of VR relaxation and describe the characteristics of the virtual reality and scenarios that promote therapeutic relaxation, and (ii) to assess the effectiveness of a short-term course of VR relaxation intervention using a Flow application designed according to the above-mentioned principles in respect to changes over time in the symptoms of anxiety, asthenia, and other well-being parameters in three patient groups and healthy subjects compared with the control group. **Study hypothesis:** undergoing a course of VR relaxation sessions improves the functional state of the users and reduces their anxiety and the severity of asthenia and affective symptoms.

¹ Istok-reatech [Internet]. Hardware-software multimedia complex using virtual reality technologies "Flow". Available from: <https://www.istok-reatech.ru/catalog/item/4549/>

Methods

(i) In order to address the first (theoretical) issue, we analyzed the psychological processes that occur within the user during a VR session and outlined the psychological category by which these processes can be described. Based on the identified psychological mechanism, we described the subtypes of therapeutic VR tools. We also provide a list of characteristics of the virtual environment and the constituents of the scenario implemented when designing the Flow VR application, in order to ensure that relaxation is achieved (i.e. the VR relaxation effectiveness factors).

(ii) For the empirical part of the study, we used the data of two earlier studies; the results of one of them (a pilot study) have been published elsewhere [3]. The study protocols were similar in terms of the duration of the course of VR intervention, the schedule of tests, and the most effective assessment tools.

Sample

The participants were recruited in March-September 2021 in the clinics of Speech Pathology and Neurorehabilitation Center and Federal research Centre of Nutrition and Biotechnology.

The main inclusion criteria were as follows: complaints of anxiety, low mood, signs of asthenia in healthy volunteers (or the presence of such symptoms accompanying the underlying disease of the patients); signed informed consent for participation in the study; understanding of the instructions and study procedures, willingness and ability to undergo VR sessions, and completing questionnaires and filling out scale forms.

The exclusion criteria were as follows: pronounced cognitive, motor, and/or speech impairment that interfere with understanding the instructions and completing the study procedures; diagnosis of epilepsy or a history of seizures; diagnosis of a psychiatric disorder (schizophrenia, schizoaffective disorder, bipolar disorder, major depressive disorder, etc.); and severe, inadequately controlled or unstable somatic disorders.

The study included four groups of participants: (1) general hospital patients; (2) obese patients in inpatient settings; (3) healthy subjects (healthcare providers) undergoing VR sessions; and (4) control group of general hospital patients not undergoing VR sessions.

All patients were receiving conventional drug therapy in accordance with their diagnosis and the routine practice adopted at their respective healthcare institutions.

Enrollment

Prior to the study, all participants read the program information sheet, received the necessary explanations, and signed a voluntary informed consent form. The general hospital patients (1) and the control group patients (4) were included in the study using a randomization table [3]. The patient did not know in advance whether he/she would be included in the study or the control group. All patients in the control group could undergo a course of VR relaxation intervention after the end of the program if they wanted to. After the inclusion of each new partici-

pant, the investigator determined a code for one of two groups using the randomization table. After receiving the group code for a new patient, the patient was made aware of this information. The inclusion of patients in the study was continued until the ratio of male and female patients in each group was equal.

The participants in the groups (2) and (3) were included in the study without any additional restrictions until the end of enrollment at the study site.

If a patient withdrew from the study prematurely, the data collected by the time of their withdrawal were used for the analysis. The most common cause of premature withdrawal was the end of hospital stay; in healthy subjects, these cases were rare and were related mostly to personal circumstances.

Tools

The following methods were used to evaluate changes over time in patient condition: Spielberger State Anxiety Inventory [4]; The Fatigue Impact Scale for Daily Use (D-FIS) [5]; The Well-being, Activity, Mood (WAM) questionnaire [6]; The Depression, Anxiety and Stress Scale (DASS-21) [7].

Virtual reality scenario and order of procedures

All study participants were informed of the upcoming course of VR intervention and the schedule of assessments before the start of the study. Each relaxation session was supervised by an administrator who helped the participants to sit comfortably in their chair, put on and take off the equipment, ensured the hygiene of its use, and monitored proper operation of all technical components of the program.

A VR program is an intervention intended to ensure guided relaxation that combines the methods of body therapy, hypnotherapy, and work with negative emotional states and images. During the study, two virtual locations were used - a tropical beach and a mountain landscape (Figure 1), which uniformly alternated for all study participant.

The session lasted from 20 to 30 min. VR sessions were conducted on a daily basis for 5 days. The participants were asked to complete questionnaires before and after the first VR session, after the fifth session – five days after the end of the course (except for group (3) obese patients).

The patients in the control group (4) were asked to complete the questionnaires at the same time points as other participants. On the first day of the study, there was at least a 6-h interval of quiet wakefulness between the assessments.

Equipment description and specification

During the study, a specially designed capsule chair, an Oculus Rift S VR headset with a built-in tracking system, a NZXT H1 650W PC with Intel Core i5-10600kf, a Samsung Galaxy Tab A7 32GB LTE (SM-T505N) tablet, and a Huawei e3372 modem were used.



Figure. Screenshots of Flow locations

Analysis

The results are described using mean values (M) and standard deviation (SD). The analysis of source data was carried out using the statistical software package Statistica 6.0, Windows version (StatSoft Inc.).

Ethical issues

The studies were approved by the Ethics Committees of the Federal research Centre of Nutrition and Biotechnology and the Speech Pathology and Neurorehabilitation Center. Prior to the study beginning, all participants read the program information sheet and signed an informed consent form.

Results

In accordance with the study goals, we present the description of some aspects of the VR relaxation technique by specifying the leading psychological mechanism, the subtypes of therapeutic VR that are based on this mechanism, and by listing the effectiveness factors applied in one of the software products. In the second part of the section, we present the results of the study aimed at justifying the implemented technique.

(i) The psychological changes that occur during the VR relaxation intervention can be considered as dynamic adaptation to the conditions and activities modeled by the relaxation program. Therefore, the components of virtual environments and elements of relaxation programs should be evaluated in the context of their effects on the natural adaptation of the psychophysiological processes required to achieve relaxation.

The ability to change under the influence of external or internal circumstances is an intrinsic property of the human mind as a comprehensive dynamic system; this property broadly describes the concept of self-regulation — a voluntary and involuntary mental and personal self-organization mechanism [8]. Self-regulation is considered “a systemic process that provides flexibility (that is adequate to the conditions), and plasticity of the subject’s life activities at any level” [9]. Self-regulation processes can occur at different levels of the organization of activities, such as the regulation of conditions and maintenance of the best state of mental activity, as well as at the operational-technical and personal-motivational levels [9, 10].

Type of VR-based relaxation scenarios

Depending on whether self-regulation processes are conscious, we can distinguish between levels of background (unconscious) and arbitrary (conscious) regulation. Background regulation involves the processes of natural psychophysiological adaptation, adjustment to the environment and current activities (activation/inhibition), changes in the state of wakefulness, blood pressure, respiratory rate, muscle tone, etc. The arbitrary level of self-regulation implies conscious and purposeful actions to change one’s state in accordance with the current circumstances and conditions of activity; i.e., in the case of relaxation intervention aimed at achieving relaxation. We believe that all VR-based relaxation programs can be divided into two groups based on the type of self-regulation model involved in the achievement of relaxation.

1. *Environment-based programs* bring the user to a calm, peaceful, and usually natural environment such as wooded meadows, tropical coasts, foothills, river and lake shores, grasslands, coral reefs, etc. Visuals are more often created graphically or using special 3D cameras. The user can explore landscapes, sometimes moving short distances, and may observe moving objects — animals, fish or birds, swirling leaves, or floating clouds. The visual component can be complemented by nature sounds or calm, quiet music. The main task for the user is to immerse themselves in contemplation of the virtual environment while a natural synchronization of one’s psychophysical state with the surrounding landscape takes place through the processes of background regulation.

2. *Scenario-based programs* imply involvement in a certain sequence of actions according to the logic of the specific relaxation intervention. The user, guided by visual or vocal instructions, can perform breathing exercises or engage in physical activity, interact with elements of the environment, and direct and maintain attention on certain external or internal processes. VR relaxation techniques tend to use interventions that have been proven to be good relaxation tools such as relaxation breathing, yoga exercises, neuromuscular relaxation, and various types of meditation. Relaxation mechanisms depend on the specific scenario; the processes of conscious self-regulation play a leading role. Since the intervention is

usually “placed” in a certain accompanying environment, regulatory processes at different levels may be involved and, in this case, more pronounced results in achieving relaxation can be expected.

Factors of efficiency of VR-based relaxation programs

When modeling user experience in a VR-based intervention, the elements of the environment and the VR program scenario are not a random set of elements but must be subordinated to the task at hand; i.e., contribute to the achievement of relaxation. We provide a list of general characteristics of the environment and the scenario of virtual relaxation programs which, from our point of view, have a significant impact on the effectiveness of the VR procedure.

Environment

Unlike gaming, entertainment, and educational VR products, where virtual space has more of a decorative, “framing” function, the environment of therapeutic VR interventions has a specific function and (together with the scenario) should be considered from the viewpoint of the effect it may have on the user. A quality VR environment can create a feeling of complete immersion, the effect of being “here and now” in a completely different place and, accordingly, the impression of “switching off” the familiar surroundings for the period of the session. In some aspects, the VR environment can be seen as a symbolic model of “mental space.”

Specific characteristics of the virtual environment that contribute to the achievement of relaxation include:

Safety. Making a person feel safe is one of the key requirements for any psychotherapeutic intervention to be effective. In addition to basic safety features (a stable support surface, absence of potential threats such as sharply moving objects, reproduction of daylight hours, etc.), there are specific factors that can cause anxiety. For example, being at a high altitude on an barren plateau in a mountain landscape can activate the fear of heights; intense sunset hues can evoke associations with fire; therefore, such elements should be avoided, if possible, when modeling the environment of the relaxation intervention.

Comfort. The average characteristics of a comfortable environment include balanced lighting, a comfortable temperature expected on the basis of visual information, a moderate intensity of sound and visual stimulation, open and free but not infinite space, etc. Comfort parameters can be customized, but when creating the scenario for mass use, it is important to recreate conditions that are amenable to most people. Compare, for example, being in a wooded meadow in a warm season, with moderate light and little movement of grass and foliage creating a feeling of soft shade and a pleasant breeze, to being in winter twilight in the mountains or on a tropical beach with overly contrasting light, which can convey an impression of uncomfortable cold or debilitating heat.

Natural environment. Studies have shown [11] that the natural environment contributes to the achievement of relaxation (as opposed to urban or fiction landscapes). There may be signs of human activity in the field of view, traces of cultivation of the space — pavilions, benches, paths, trimmed trees, etc. However, shifting the balance to the opposite direction (closer to wild nature) is undesirable, as it may create a sense of potential threat (see paragraph 1).

Ensuring an immersive experience. The depth of immersion in the virtual environment is more a matter of technical equipment, quality of the software product, and organization of the intervention. In general, employing as many sensory systems as possible with the creation of a realistic and synchronized sensory flow with the user's attention focused on the processes of simulated reality contributes to better immersion. From a psychological viewpoint, the most relevant aspects here are the processes of focusing, directing, and redirecting, maintaining user concentration, and avoiding any letup. From this viewpoint, the elements of the environment can be seen as supporting concentration or distracting, the environment can be overloaded with stimulation or not filled enough to support it; the changes over time in these processes can be excessive and overstimulating or understimulating. Any object can act as a focal point or as a distractor, and so on.

Maintaining the integrity of the process. The experience of integrity as opposed to disintegration, is part of the basic aspect of creating the feeling of safety, but the specificity of the VR experience requires that we talk about it in a specific paragraph. If we set aside technologies like artificial skin, which are still in gestation and not yet widely used, the perception of one's own body inside a VR environment relies only on proprioceptive sensations; there is no visual confirmation of physical presence in space, although it is possible to conjure images of hands synchronized with hand movements, which are directed by controllers (joysticks) in the user's hands. This largely creates a feeling of immersion into the virtual space, merging with it, which in itself promotes relaxation, but for some users, as well as some groups of patients (e.g., those with dissociative, borderline or psychotic disorders), can have the opposite effect, increasing anxiety and defeating the goal of achieving relaxation. Maintaining a balance between "pure perception" and the sense of whole self (through periodic activation of proprioception, feedback from the physical body in one way or another) can solve this problem in most cases.

Scenario

As has already been noted, relaxation scenarios are often VR-adapted interventions for relaxation that are already widespread and have proven to be effective in many cases. Although various scenarios exist, let us try to focus on a number of factors that contribute to reaching the target of better relaxation.

1. **Directed attention.** Switching the user's attention to his/her own internal processes — bodily sensations (feeling of support, warmth, body position in space), emotional (presence of certain emotions, states), psychophysiological rhythms (breathing, pulse), arbitrary physical actions (muscle contraction and relaxation) — and staying on them promotes their awareness and creates conditions for purposeful changes to achieve a more comfortable state and relaxation. The processes of conscious self-regulation are activated. Despite all the opportunities offered by visualization, the intervention should seek to retain internal processes, thus creating an "expanded internal environment." A wholesome nature of the visual, proprioceptive, and auditory components supports unidirectional, focused attention.

2. **The limits of intervention and control elements.** The presence of information about the upcoming stages, their duration and possibility to slow down/speed up a number of processes (e.g., to delay the transition from one stage to another) inside the VR session allows users to focus more on the content of the session and to reduce their discomfort associated with unfamiliar activities, and compensate for the external management of concentration by maintaining a sufficient level of control and randomness.

3. **Pace and rhythmic characteristics of the scenario.** The content and intensity of episodes, the alternation of active/interactive participation and passive activities should be aimed at achieving relaxation and a more resourceful state and contribute to the retention of active concentration during the VR session. The scenario should not be too long, monotonous, or oversaturated. In order to achieve relaxation, the overall rhythm of the intervention should decrease as the patient moves forward; metaphorically, we can say that as a result of the intervention, the user should switch to another "frequency" of functioning — with a clearer, slower, stable, "rooted" rhythm with which he/she adjusts during the procedure.

4. **Feedback.** The presence of quality biofeedback or its elements and the availability of information about

Table 1. Characteristics of the treatment groups

Parameter	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Number of subjects	40	62	21	20
Sex ratio	50% males, 50% females	17.7% males, 82.3% females	19% males, 81% females	50% males, 50% females
Age, years ($M \pm SD$)	44.8 $\pm$ 15.9	57.56 $\pm$ 12.24	36.9 $\pm$ 10.34	39.0 $\pm$ 14.7

changes in psychophysiological parameters (blood pressure, heart rate and respiratory rate, cognitive load, etc.) and emotional state during or after the intervention are additional factors that support the processes of self-regulation, which also, in case of improvement, strengthen the effect and user compliance with the intervention.

5. Training elements. The use of clear instructions, concentration and retention of the target state, repetition of activities during one VR session or in the course of several sessions lengthens the effect of VR relaxation and create an opportunity to transpose the experience of virtual environment to actual life.

The presented list of factors influencing the effectiveness of a VR relaxation session is not exhaustive and needs to be expanded and clarified. In our turn, we made an attempt to take them into account when developing programs for the Flow VR platform, and the results of the evaluation of one of its scenarios are given below.

(ii) Patients with the following diagnoses (according to the International Classification of Diseases, 10th revision) from the Speech Pathology and Neurorehabilita-

tion Center, were enrolled in the study: Stuttering (F98.5), $n = 23$ (38,3%); Other mental disorders due to brain damage and dysfunction or due to physical disease (F06.x), $n = 16$ (26.7%); Personality and behavioral disorders due to brain disease, damage and dysfunction (F07.x), $n = 15$ (25%); COVID-19 (U07.1) or other viral pneumonia sequelae (J12.8), $n=3$ (5%); Somatoform autonomic dysfunction and somatoform respiratory disorders (F45.38), $n = 2$ (3.3%); and Adjustment disorders (F43.2), $n = 1$ (1.7%). Patients underwent a course of therapy for obesity due to excess calories (E66.x) at the Federal research Centre of Nutrition and Biotechnology, and healthy subjects (physicians and nurses who had not sought medical attention for their mental health issues and were not receiving any clinically significant treatment at the time of the study) were enrolled.

The results obtained at the Federal research Centre of Nutrition and Biotechnology have been fully presented in the pilot study [3]. For the purposes of this study, previously published data on participants age, scale scores, and significance values for differences between the groups (1) and (4) [3] were used.

Table 2. The Spielberger State Anxiety Inventory scores in different patient groups during the study, $M \pm SD$

Study period	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Baseline	42.93 $\pm$ 11.43	42.18 $\pm$ 11.83	40.67 $\pm$ 11.14	39.45 $\pm$ 9.87
After the 1st session/in at least 6 hours for the group without the use of VR	40.83 $\pm$ 9.6	35.17 $\pm$ 9.78	32.86 $\pm$ 9.81	39.68 $\pm$ 10.07
Significance of changes, p	0.94	0.000006*	0.00026*	0.944
After a 5-session course/in 5 days for the group without the use of VR	39.05 $\pm$ 9.45	31.61 $\pm$ 7.91	33.81 $\pm$ 11.05	38.8 $\pm$ 8.76
Significance of changes, p	0.006*	0.000000026*	0.024*	0.679
10 days after baseline	38.54 $\pm$ 8.99	No data available	34.67 $\pm$ 11.07	40.06 $\pm$ 10.55
Significance of changes, p	0.026*	Not applicable	0.013*	0.753

Note. * — the statistical significance of the differences at $p < 0.05$.

Table 3. The results of the study of patients of different groups using the DASS-21 during the study $M \pm SD$

Study period	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Baseline	22.05 $\pm$ 16.12	22.13 $\pm$ 12.4	16.43 $\pm$ 13.63	16.76 $\pm$ 11.91
After the 1st session/in at least 6 hours for the group without the use of VR	19.46 $\pm$ 15.69	No data available	No data available	13.54 $\pm$ 8.67
Significance of changes, p	0.04*	Not applicable	Not applicable	0.657
After a 5-session course/in 5 days for the group without the use of VR	16.9 $\pm$ 11.9	16.6 $\pm$ 12.17	10.95 $\pm$ 10.13	13.85 $\pm$ 12.03
Significance of changes, p	0.01*	0.00011*	0.71	0.011*
10 days after baseline	14.18 $\pm$ 11.72	No data available	8.0 $\pm$ 9.0	12.88 $\pm$ 9.21
Significance of changes, p	0.009*	Not applicable	0.0038*	0.075

Note: * — the statistical significance of the differences at $p < 0.05$.

Table 4. The results of the study of patients from different groups using the D-FIS during the study, $M \pm SD$

Study period	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Baseline	12.05 $\pm$ 9.31	11.6 $\pm$ 6.64	6.62 $\pm$ 6.16	7.01 $\pm$ 4.29
After the 1st session/in at least 6 hours for the group without the use of VR	10.65 $\pm$ 8.62	8.76 $\pm$ 6.01	3.62 $\pm$ 3.43	7.68 $\pm$ 4.53
Significance of changes, p	0.33	0.00042*	0.011*	0.328
After a 5-session course/in 5 days for the group without the use of VR	8.0 $\pm$ 5.27	8.31 $\pm$ 6.74	4.14 $\pm$ 4.94	7.96 $\pm$ 5.2
Significance of changes, p	0.003*	0.00003*	0.031*	0.57
10 days after baseline	6.94 $\pm$ 4.76	No data available	3.5 $\pm$ 4.76	6.76 $\pm$ 5.03
Significance of changes, p	0.006*	Not applicable	0.0022*	0.563

Note: * — the statistical significance of the differences at $p < 0.05$.

Table 5. The results of the study of patients from different groups using the Well-being, Activity, Mood questionnaire, Well-being scale, during the study, $M \pm SD$

Study period	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Baseline	44.30 $\pm$ 14.54	44.86 $\pm$ 13.42	52.26 $\pm$ 14.16	53.7 $\pm$ 10.91
After the 1st session/in at least 6 hours for the group without the use of VR	47.51 $\pm$ 14.37	51.45 $\pm$ 12.01	58.25 $\pm$ 10.39	55.56 $\pm$ 9.3
Significance of changes, p	0.01*	0.000005*	0.039*	0.972
After a 5-session course/in 5 days for the group without the use of VR	50.53 $\pm$ 11.4	57.79 $\pm$ 10.5	56.95 $\pm$ 13.98	56.0 $\pm$ 9.88
Significance of changes, p	0.007*	0.0000000064*	0.12	0.096
10 days after baseline	51.67 $\pm$ 12.52	No data available	56.72 $\pm$ 13.37	53.69 $\pm$ 7.86
Significance of changes, p	0.003*	Not applicable	0.053	0.221

Note: * — the statistical significance of the differences at $p < 0.05$.

Table 6. The results of the study of patients from different groups using the Well-being, Activity, Mood questionnaire, Activity scale, during the study, $M \pm SD$

Study period	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Baseline	42.50 $\pm$ 11.89	38.84 $\pm$ 12.03	47.53 $\pm$ 10.07	47.9 $\pm$ 10.94
After the 1st session/in at least 6 hours for the group without the use of VR	44.41 $\pm$ 12.87	44.02 $\pm$ 10.21	50.3 $\pm$ 9.54	49.83 $\pm$ 10.72
Significance of changes, p	0.89	0.000028*	0.5	0.894
After a 5-session course/in 5 days for the group without the use of VR	47.05 $\pm$ 10.1	50.41 $\pm$ 10.45	48.9 $\pm$ 11.04	49.8 $\pm$ 11.05
Significance of changes, p	0.03*	0.000000015*	0.9	0.478
10 days after baseline	49.67 $\pm$ 9.12	No data available	52.83 $\pm$ 10.16	48.56 $\pm$ 8.14
Significance of changes, p	0.0008*	Not applicable	0.083	1.0

Note: * — the statistical significance of the differences at $p < 0.05$.

Table 7. The results of the study of patients from different groups using the Well-being, Activity, Mood questionnaire, Mood scale, during the study, $M \pm SD$

Study period	General hospital patients (1)	Inpatients diagnosed with obesity (2)	Healthy subjects (3)	General hospital patients without VR (4)
Baseline	48.28 $\pm$ 13.88	52.7 $\pm$ 11.82	55.32 $\pm$ 12.62	56.05 $\pm$ 11.07
After the 1st session/in at least 6 hours for the group without the use of VR	50.33 $\pm$ 13.58	56.42 $\pm$ 9.92	58.4 $\pm$ 11.47	58.61 $\pm$ 9.02
Significance of changes, p	0.04*	0.022*	0.1	0.529
After a 5-session course/in 5 days for the group without the use of VR	53.03 $\pm$ 10.05	59.57 $\pm$ 9.39	57.95 $\pm$ 11.12	57.75 $\pm$ 9.08
Significance of changes, p	0.015*	0.000089*	0.22	0.66
10 days after baseline	54.09 $\pm$ 10,2	No data available	58.67 $\pm$ 11.47	57.93 $\pm$ 9.4
Significance of changes, p	0.023*	Not applicable	0.031*	0.701

Note: * — the statistical significance of the differences at $p < 0.05$.

The number of subjects, mean age, and sex ratio of the treatment groups are presented in Table 1.

Below are the results of the evaluation of all the parameters in the study group participants according to the Spielberger State Anxiety Inventory (Table 2), the Depression, Anxiety and Stress Scale (DASS-21) (Table 3), the Fatigue Impact Scale for Daily Use (D-FIS) (Table 4); and the Well-being, Activity, Mood (WAM) subscales (Tables 5–7). We present the data collected at baseline (first examination), after one VR session, after a course of 5 sessions, and 5 days after the end of the course, and the results of the statistical analysis of changes over time in the study groups compared to the baseline. The patients in the control group (not undergoing a VR course) completed the questionnaires at the same time points.

The results demonstrate that according to most of the evaluated parameters, the use of VR relaxation intervention resulted in improvement as early as after the first session in both healthy subjects and patients regardless of their diagnosis. Significant changes in the Spielberger State Anxiety Inventory scores were observed in the groups of obese patients and healthy subjects. The Depression, Anxiety, and Stress Scale (DASS-21) scores were found to significantly change in the group of general hospital patients (this assessment was not conducted in obese patients or healthy subjects). The severity of fatigue decreased significantly in obese patients and healthy subjects. The scores on the Well-being subscale of the WAM questionnaire demonstrated improvement in all study groups; the scores on the Mood subscale (WAM), in the general hospital patients, and obese patients.

After the end of a 5-day course of VR intervention, improvement was observed in the following groups: in terms of the Spielberger State Anxiety Inventory and D-FIS scores — in all study groups; in terms of the DASS-21 and WAM scores — in the groups of general hospital patients and obese patients.

Changes over time 5 days after the end of the VR relaxation course were evaluated only in the group of gen-

eral hospital patients and healthy subjects. According to the Spielberger State Anxiety Inventory, DASS-21, D-FIS, and WAM scores, all participants demonstrated significant improvement relative to their baseline. According to the Well-being and Activity subscales of the WAM questionnaire, significant improvement was observed in the group of general hospital patients.

In the control group, no significant changes from the baseline were observed in terms of any of the evaluated parameters (except for the DASS-21 score on Day 5).

Discussion

The results of our study indicate that a course of VR relaxation intervention modeled on the identified factors is effective in terms of reduction of anxiety, depression, and asthenia, as well as improvement of well-being, activity, and mood in patients with various disorders. Even a single VR relaxation session resulted in significant improvement of the participants' condition. After the end of the therapeutic course, the number of improved psychological parameters increased. These changes persisted even several days after the end of the course, indicating the sustainability of the improvement.

Our data are consistent with the results of other studies evaluating the effectiveness of VR programs in various groups of patients and healthy users [1, 2]. In the inpatient setting, we observed positive results in the use of VR-based intervention in terms of pain relief [12–14], treatment of eating disorders, cognitive and motor neurorehabilitation [13], decreased severity of anxiety [14], or palliative care outcomes [15]. In patients with eating disorders, excess weight, obesity, VR applications are used to work with the body image as part of a cognitive-behavioral exposure-based body image therapy [16, 17] that helps stick to a diet and engage in physical activity [17]. VR programs have proven to be effective in healthy subjects under stressful conditions (particularly healthcare professionals) in terms of reducing negative emotions, tension, and fatigue [18].

Thus, VR-based applications help improve the condition of users exposed to unfavorable conditions or suffering from a wide range of disorders. One of the difficulties associated with the analysis of sources is the heterogeneity of the papers included in reviews: it is not always specified whether the VR program offers a simple immersion in nature, specialized training in self-regulation skills, or whether it is based on distraction or, on the contrary, on keeping the focus on certain activities. However, since the majority of studies demonstrate improvement after the use of the VR applications, these applications can be considered effective at least because of the baseline regulation mechanisms associated with various clinical conditions.

As for the specific factors influencing the effectiveness of VR programs, the number of studies in this area remains limited and only a few aspects are described in the literature. Relatively consistent are the data on the positive effects of natural (as opposed to urbanized) environments on users' well-being, both in terms of psychological and physiological parameters [19, 20]. The effect of immersion in and distancing from habitual activities, supported by a combination of several sensory streams (visual, auditory, olfactory), contributes to more pronounced stress reduction and relaxation compared to standard resting conditions [21].

Many studies on the use of psychotherapy (especially psychodrama psychotherapy) have put a lot of attention on the effects of the environment on the effectiveness of the intervention. Kellerman [22] quotes the classics that "the configurations of space as part of the therapeutic process are of the utmost importance" (Moreno & Moreno, 1969). According to him, "...the success of a psychological intervention depends significantly on the setting in which it is delivered...For example, a large and spacious room can evoke feelings of freedom, optimism, and joy, whereas a small windowless room evokes feelings of a prison cell in some people...Whereas (working in a) bomb shelter evoked fantasies of destruction and protection, a mountain resort evoked...the ability to observe perspective and inner growth" [22, p. 25]. Not enough attention, however, has been paid to the evaluation of the effects of the modeled digital environment on users' condition, and identification of these effects is a subject for future research.

We can say that there is a clear need for the development of VR-based tools for clinical and recreational purposes. Currently, a significant number of VR relaxation techniques have been developed and empirical data summarizing the experience of their use are being ac-

cumulated. At the same time, there remains a significant gap in our understanding of the psychological mechanisms that underwrite the effectiveness of VR-based techniques, as well as the specific factors that determine the achievement of improvement. This may be partly due to the fact that VR-relaxation techniques do not represent a homogeneous category and have in common only the intended effect and the use of VR technology itself; however, the user experience may vary considerably. Therefore, there is a need to spell out the specific factors that determine the effectiveness of therapeutic VR and to clarify the mechanisms of the relationship between technical solutions and the psychological effects that follow for virtual reality users.

Strengths and limitations

When developing VR relaxation techniques as a medical intervention tool for therapeutic, rehabilitative and/or scientific purposes, it is important to provide a justification of their methodology by describing their mechanisms and effectiveness factors. This study represents one of the first attempts to systematize the key factors that determine the achievement of relaxation using VR-based techniques. The use of the VR scenario developed based on these factors was studied in different clinical groups, as well as in healthy subjects, and the data were compared to those in the control group, which supported the validity of the methodology.

The limitations of the study include the lack of direct assessment of the identified factors of VR application effectiveness: the role of each factor in the achievement of relaxation remains to be further investigated. As for the empirical part of this study, we should note the insufficient homogeneity of the study groups, as well as the lack of consideration of the diagnoses and drug therapy used. This was part of the reason why we did not present the results of intergroup comparison — the baseline levels of the evaluated parameters, the extent of changes etc.

Conclusion

VR-based relaxation techniques represent a promising type of care for patients with various conditions, and their further development as a medical intervention tool implies the need to clarify their psychological mechanisms and effectiveness factors, and to lay out the conditions for and means of their implementation and the final scenario of the digital product (VR application).

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