Effects of virtual reality training on bio- and psycho-markers of aging in retired individuals

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Abstract. The aim of this study was to investigate the effect of VR-training on bio- and psycho-markers of aging in elderly people. Thirty women aged 56 to 82 years living in Moscow and participating in the Moscow Longevity programme were examined. The following methods were used: diagnostic (self-assessment of subjective age, measurement of aging indicators included in the system of biological age assessment according to V.P. Voitenko, diagnostics of attentiveness and awareness), methods of experimental influence (training session on the development of spiritual resource of personality), mathematical statistics (Wilcoxon's T-criterion). The results show that virtual reality training improves markers of biopsychological age of retirees: it increases the level of mindfulness, reduces heart rate and increases static balancing time. Although VR training did not have a statistically significant effect on measures of psychological age and blood pressure, the overall findings emphasise the importance and potential utility of virtual reality training for older adults in the context of slowing ageing and improving quality of life. Further research with larger samples and longer follow-up periods is required to fully evaluate the effectiveness of these exercises.

1 Introduction

In recent decades, there has been a worldwide increase in the number of older persons. The phenomenon of population ageing is a significant and integral aspect of the current demographic situation.

According to WHO projections, by 2050 there will be twice as many people aged 60 and older, reaching an impressive 2.1 billion people [1].

The continuous rate of population ageing poses an important task for science, which against the background of increasing working years, is to develop effective methods to improve the quality of life in old age, so to speak "healthy ageing". After all, in old age it is very important to maintain independence, activity and a sufficient level of functionality. All this is based on maintaining physical and psychological health.

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2 Literature review

It has been proven that ageing is an individual process and can occur at different rates. Thus, some people may show more visible signs of ageing at a younger age, while others may remain young and viable for a longer period of time. This is influenced by various factors (biological, psychological, social and environmental) [2].

Often, researchers use biological age measurement as a method of assessing perceived longevity and health status. For example, a study conducted by Korean scientists (n = 101,980) confirmed that biological age is a more accurate predictor of health status than chronological age. They were able to develop a model based on predicting biological age, which has proven to be an effective tool for identifying groups of individuals at high risk of developing chronic diseases. The authors proved that the study of biological age allows a more accurate assessment of the physiological state of the organism, identifying individual characteristics associated with the risk of developing chronic diseases, and preventing potential health problems [3].

Other authors (G.J. Westerhof, S. Wurm) point to the possibility of determining health and premature ageing using the method of self-assessment of health and subjective age [4].

Back in the early 1980s, researchers from the University of Texas, K.S. Markides, J.S. Boldt, conducted a longitudinal study (n = 510) in which they examined the characteristics of older adults. During this study, some participants died before the second phase of data collection. By comparing data from living and deceased participants, the researchers found that those who continued to live initially rated their health more highly and perceived themselves as younger compared to participants who died in the first phase of the study. The results confirmed the importance of subjective perception of one's own age and its impact on mortality in older adults [5].

Similar results were obtained in a 20-year study by Y. Stephan, A.R. Sutin, A. Terracciano (n = 17000). The authors studied the following main variables: subjective age, illnesses, functional limitations, depressive symptomatology, and physical activity. It was found that those participants who subjectively felt older than their chronological age had a higher risk of mortality. The scientists concluded that there was an association of subjective age with disease, physical inactivity, immune dysfunction and mortality [6].

T.N. Berezina proposes to study the aging process, taking into account the biopsychological age. According to the author, biopsychological age is a complex and multifaceted characteristic of an individual's condition, which is important for both physical and psychological health. It indicates the correspondence between personal and physiological features of a person in accordance with age norms. As T.N. Berezina notes, biopsychological age consists of two main components: biological and psychological age [2, 7].

Biological age reflects the physical state of the organism. If biological age corresponds to the calendar age, the aging process proceeds normally and corresponds to the expected. However, if the biological age exceeds the calendar age, the aging of the organism occurs earlier. The state when biological age is less than calendar age is more favourable for the organism, which indicates delayed ageing [7].

Psychological age is an indicator of the level of personal maturity or immaturity and is based on an individual's subjective assessment of his or her life path, achievements and significant events [8].

One of the main directions of the problem of ageing is to find ways to control this process: various external and internal resources that contribute to maintaining a high level of quality of life and psychological well-being [2].

The scientists (N. Rybtsova, T. Berezina, A. Kagansky, S. Rybtsov) emphasise that lifestyle, daily regime have an impact on the rate of biological ageing of a person, including
its genetically determined aspects at the level of chromosomes [9]. Thus, it is scientifically proven that a healthy lifestyle, regular physical activity, sports are effective measures to prevent various diseases, including infectious diseases [10]. Harmful habits (smoking, drug addiction, alcoholism, overeating, etc.), on the contrary, have a negative impact on well-being and life expectancy [2].

The presence of family and children, as well as professional fulfillment are considered by researchers (A.M. Zinatullina, V.P. Melnik, A.A. Zimina) as positive factors that slow down the aging process [11].

Intellectual development is also essential for life expectancy. As a result of his research D. Snowdon revealed that intellectual activity can increase life expectancy. Studying a female sample (on the example of nuns), the author found that having a high intellectual potential reduces the risk of developing Alzheimer's disease and increases life expectancy [12].

Scientific studies confirm the effectiveness of music, art and creativity in slowing down age-related changes, positive impact on health and the course of diseases [13].

Researchers from the USA, studying adult men infected with HIV, found that personal factors such as meaning, control and optimism can slow the progression of the disease. The authors concluded that positive beliefs and optimistic perceptions have a positive impact on a person's health (both mental and physical), which ultimately contributes to increased longevity [14].

Such factors as optimism, social activity, striving to achieve goals, career development (labour), scientists call ambiguous and point to their two-way impact on life expectancy [15, 16].

In real life, a person may lack certain resources that could have a positive impact on well-being, quality of life and its prolongation. As a result, more and more professionals are turning to the use of virtual reality technologies as an alternative solution.

Virtual reality (VR) can be defined as a form of simulation that combines different methods of interaction between devices and sensory display systems [17].

Virtual reality sports simulators can improve physical fitness, motor skills, and cognitive development [18].

The use of VR is being actively implemented in psychological practice in order to reduce depression and increase confidence and positive emotions [19]. Indeed, VR can be used to engage in favourite activities, listen to music, visit museums, enjoy views of nature, travel and much more.

Currently, the scope of VR use is expanding. These technologies are being applied in various clinical fields including physical rehabilitation, as well as in the treatment of neurological and mental disorders [20].

It is known that with age, neurodynamic and cognitive processes slow down, changes in the musculoskeletal system are observed, which together negatively affects the reaction speed and leads to impaired coordination of movements. In this regard, in old age, the risk of falls, which lead to disability and prolonged rehabilitation, increases significantly. Such situations reduce the age of "active" longevity, increase the fear of falls and impair the quality of life [21]. Currently, specialists are increasingly offering methods of correction of balance disorders by means of virtual reality technologies [22]. These methods are effectively used in the rehabilitation of stroke patients and elderly people with movement disorders. The advantage of using VR in this case is the implementation of unified training, which includes both cognitive and motor exercises in one environment [23].

Numerous scientific studies have proven the effectiveness of VR in relieving various types of pain, including chronic and acute pain symptoms, including phantom pain after amputation. In order to help patients manage pain, healthcare professionals are using VR in
perioperative, peri-procedural settings. VR is actively implemented in the therapy of neurological conditions, including Parkinson's disease and phobias [24, 25].

The results of the study conducted by Polish scientists (S. Rutkowski, P. Kiper, L. Cacciante, B. Cieślik, J. Mazurek, A. Turolla, J. Szczepanska-Gieracha) confirmed that the use of specialised virtual reality can improve balance in patients with neurological disorders [26].

VR is a method of visualising brain activity, acts as a non-medication method of anaesthesia. These modern technologies have a positive impact on the physical, cognitive, and psychological well-being of people [20, 25, 27].

3 Materials and Methods.

Purpose of the study: to investigate the effect of VR-training on biological and psychological markers of ageing in elderly people.

Hypothesis: undergoing socio-psychological anti-aging training with the use of virtual reality technologies can have a situational effect on biopsychological age indicators measured at a given moment in time (here and now): self-assessment of subjective age, static balancing, pressure and level of awareness.

3.1 Methods

1. Self-assessment of subjective age. A simplified version of B. Barak's technique was taken as a basis [28].
2. Measurement of aging indicators included in the system of biological age estimation according to Voitenko [29].
   - indicators of systolic and diastolic pressure, pulse. They were measured using an automatic tonometer with a cuff.
   - static balancing (standing on the left leg with closed eyes). Measured in seconds by means of a stopwatch.
4. Experimental methods: a training session on the development of the spiritual resource of the personality. One training session was held with the duration from 1.0 to 1.5 hours. Classes were held on the theme "Kindness as an anti-aging resource", "Beauty as an anti-aging resource", "Art as an anti-aging resource". Before and after the class "health cards" were filled in, in which the above-described indicators were entered.
5. Methods of mathematical statistics. Wilcoxon's T-criterion (taking into account the zero shift).

Subjects: 30 women aged 56 - 82 years, participants of the programme "Moscow Longevity"; and attending a training session in one of the centres in Moscow. Participation in the training sessions was voluntary, by appointment. All participants received information about VR technologies before the training. Participants could leave the training at any time if they wished or refuse any of the exercises (there were no participants who refused or left the training). The participants were divided into 2 groups. Group 1, the experimental group, included participants who had enrolled in the training (mean age 65.2 + 9.40 years). Group 2, the control group (mean age 62.4 + 7.08 years), included participants of the Moscow Longevity programme who did not undergo this training, but were engaged in any of their own activities for an hour: paperwork, rest, and going home. The participants of the control group did not attend any other activities during the measurements either.
4 Results

The results of the experimental and control groups are presented in the tables below.

Table 1. Dynamics of bio- and psycho-markers of ageing during the experiment (experimental group).

<table>
<thead>
<tr>
<th>Markers of aging</th>
<th>Indicators Before training</th>
<th>Post-training performance</th>
<th>Direction of effect</th>
<th>T</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>75.6</td>
<td>73.8</td>
<td>Downward trend</td>
<td>42.5</td>
<td>0.1</td>
</tr>
<tr>
<td>systolic pressure</td>
<td>129.5</td>
<td>124.6</td>
<td>absence</td>
<td>45.5</td>
<td>-</td>
</tr>
<tr>
<td>diastolic pressure</td>
<td>73.7</td>
<td>72.9</td>
<td>absence</td>
<td>57</td>
<td>-</td>
</tr>
<tr>
<td>Static balancing</td>
<td>11.2</td>
<td>18.6</td>
<td>Upward trend</td>
<td>42</td>
<td>0.1</td>
</tr>
<tr>
<td>Awareness</td>
<td>42.6</td>
<td>42.7</td>
<td>raising</td>
<td>34</td>
<td>0.05</td>
</tr>
<tr>
<td>Subjective age</td>
<td>45.6</td>
<td>42</td>
<td>absence</td>
<td>58</td>
<td>-</td>
</tr>
</tbody>
</table>

As can be seen from the table, we have a reliable increase in awareness that occurred as a result of the training and two trends: a tendency for heart rate to slow down during the training and an increase in static balancing time. We performed separate calculations to determine the increased heart rate and blood pressure: heart rate - readings over 80 beats per second, diastolic blood pressure over 135, and for diastolic blood pressure the reading was over 85.

Table 2. Dynamics of overestimated heart rate and pressure indices during the experiment (experimental group).

<table>
<thead>
<tr>
<th>Markers of aging</th>
<th>g</th>
<th>Indicators Before training</th>
<th>Post-training performance</th>
<th>Direction of effect</th>
<th>T</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>5</td>
<td>87</td>
<td>84</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>systolic pressure</td>
<td>4</td>
<td>151</td>
<td>141</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>diastolic pressure</td>
<td>2</td>
<td>94</td>
<td>79</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The indicators improved, but since there were very few examinees with such inflated indicators, it was impossible to calculate statistics for them.

Table 3. Dynamics of bio- and psycho-markers of aging during an hour and a half (control group).
As shown in Table 3, the lack of exposure combined with waiting for a follow-up examination led to an unexpected deterioration in functional performance. Cardiovascular activity index (systolic blood pressure) increased significantly, static balancing time decreased and awareness decreased. The indices of subjective age and the rest of the cardiovascular system activity indices remained unchanged.

We also looked separately at the dynamics of too high heart rate and blood pressure.

<table>
<thead>
<tr>
<th>Markers of aging</th>
<th>Indicators 1 measurement</th>
<th>Indicators 2 measurement</th>
<th>Direction of change</th>
<th>T</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>75.8</td>
<td>74.6</td>
<td>absence</td>
<td>48</td>
<td>-</td>
</tr>
<tr>
<td>systolic pressure</td>
<td>125.6</td>
<td>128.2</td>
<td>augmentation</td>
<td>13</td>
<td>0.01</td>
</tr>
<tr>
<td>diastolic pressure</td>
<td>81.6</td>
<td>80.1</td>
<td>absence</td>
<td>39</td>
<td>-</td>
</tr>
<tr>
<td>Static balancing</td>
<td>12.1</td>
<td>11.7</td>
<td>reduction</td>
<td>19</td>
<td>0.05</td>
</tr>
<tr>
<td>Awareness</td>
<td>47.2</td>
<td>47.1</td>
<td>reduction</td>
<td>25</td>
<td>0.05</td>
</tr>
<tr>
<td>Subjective age</td>
<td>50.2</td>
<td>50.4</td>
<td>absence</td>
<td>41</td>
<td>-</td>
</tr>
</tbody>
</table>

5 Discussion

The findings confirm the potential benefits of VR training for older adults in the context of bio- and psycho-markers of aging. The use of virtual reality helmets allows for the creation of unique visual and sound effects that promote deep immersion of participants in an artificial world. This opens up a wide range of possibilities for exercise, therapy and relaxation for older adults, which may ultimately have a positive impact on quality of life and longevity.
This study used personal spirituality-values training as an experimental intervention. Scientists study spirituality in relation to human needs [31]. And the development of spiritual values can directly influence bio- and psycho-Markers of aging and serve as a resource of longevity. Spiritual values can be referred to as ideals and beliefs that serve as a guide and resource for a person, helping him or her to make the right decisions. They can include such values as love, kindness, knowledge of truth, creativity, art, beauty and freedom [13].

To develop spiritual values, it is suggested to activate supra-situational activity. This involves using VR as a tool to create situations in which older people can develop their spiritual values and put them into practice. This approach opens up new perspectives for strengthening and developing the spiritual aspects of personality in retirees, which may have a positive impact on their overall physical and psychological well-being.

The results of the study showed that VR training can improve mindfulness. A significant increase in mindfulness was found in the experimental group before and after the trainings. VR training provides a unique opportunity for deep immersion in situations that require focus and presence. This can have a favourable impact on participants' development of observation, mindfulness and awareness of their thoughts, emotions and bodily sensations.

In addition, at the trend level, participants in the experimental group showed a slowing of heart rate during training and an increase in static balancing time. The slowing of the heart rate observed during training may be related to the effects on the nervous system. Situations aimed at developing spiritual values, in which participants were immersed, caused relaxation and relaxation, as well as a reduction in stress levels, which in turn may have led to a slowing of the heart rate. The VR simulations used in the training included tasks that required participants to perform spatial virtual movement, maintain a static stance, and balance in a variety of conditions. Increasing static balancing time can improve coordination, muscle strength and vestibular performance.

Changes in heart rate (above 80 beats per minute) and blood pressure (systolic pressure above 135, diastolic pressure above 85) were also found in subjects in the experimental group with initially elevated values. As a result of the training, a slowing of heart rate and a decrease in blood pressure were noted. However, since there was an insufficient number of subjects with overestimated values, it was not possible to perform statistical analysis in this group.

The changes in psychological age and pressure indicators in the experimental group were statistically insignificant.

In the control group after the second measurement there was an unexpected deterioration of some health indicators. A statistically significant increase in the activity of the cardiovascular system was found, expressed in increased values of systolic pressure. At the same time, there was a significant decrease in static balancing time and a decrease in mindfulness. We hypothesise that the repeated measurement, about which all participants were previously informed, caused agitation. Subjects in the control group may have experienced a sense of anticipation of the re-measurement, which caused them to have a stress response. This could have led to an unexpected deterioration in functional measures (static balance, systolic blood pressure, level of awareness). Medical experts have repeatedly emphasised the impact of psychological stress on health indicators [32].

The dynamics of too high heart rate and blood pressure indices in the control group is also observed, as well as in the experimental group, but require further research and confirmation to obtain more accurate conclusions.

Based on the collected data, the effect of VR-technologies on bio- and psycho-Markers of aging can be called positive.
6 Conclusion

Virtual reality training conducted as part of social-psychological training demonstrates a positive effect on markers of biopsychological age in older adults. During VR training of spiritual and personal value orientations, participants' level of mindfulness significantly increased, and at the trend level, heart rate decreased and static balancing time increased. There was no effect of VR training on measures of psychological age and pressure.

Overall, the results of this study emphasise the importance of VR training for older adults and its potential impact on bio- and psycho-Markers of aging. Developing spiritual values and stimulating suprasituational activity through VR represent a promising approach to improve retirees' quality of life and prolong their active and healthy aging. However, more studies with larger samples and longer follow-up periods are needed to fully understand and evaluate the effectiveness of this training.

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