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Video Games for Rehabilitation: A New Approach to Influence the Quality of Life in Practically Healthy Elderly Persons

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Abstract

BACKGROUND: Video games are new and potentially useful technology that can be implemented on any computing device. The specific features and role of physical activity in the prevention and treatment of the elderly are well known but its impact on their quality of life is understudied.

AIM: This study aims to investigate the feasibility of 3D camera rehabilitation video games and their effect on quality of life in autonomous, non-institutionalized elderly persons, regularly engaged in structured exercise sessions.

MATERIALS AND METHODS: The type of the research is an experimental single-centered study, pre-test–post-test design, conducted at a physical rehabilitation outpatient center in January−June 2022. Fifty participants out of all 92 subjects visiting medical center for physiotherapy are eligible and voluntarily agreed to be recruited in the research. The assignment into two groups was according to the preference of the participants and inclusion and exclusion criteria. Inclusion criteria are as follows: Age above 65 years, cooperative, agreeing to participate, and willing to sign a consent form. Exclusion criteria are as follows: Current exacerbation of a chronic disease, sudden onset of an acute illness, or trauma. Twenty-four women were included in the experimental group (average age 76.75 ± 6.89) and 26 women in the control group (average age 73.69 ± 6.89). The effect on their quality of life after the application of video rehab games was evaluated and compared with a control group that received conventional, group physiotherapy. The interventions for all participants were applied 3 times weekly for 7 weeks. A modified SF-36 quality of life scale was used to assess the results.

RESULTS: The applied video games positively affected the quality of life of the individuals in the experimental group, most notably regarding limitations in emotional health, strength, pain, and general health ($p < 0.01$). Significant differences between the groups were found regarding pain ($p < 0.02$) and general health ($p < 0.01$), assessed by Mann–Whitney U-test.

CONCLUSION: The observed improvement shows the advantages of rehabilitation video games based on the modern principles of neurorehabilitation.

Introduction

In the aging process, all systems undergo significant morphological and functional changes. The peculiarities of their course are associated with a decrease in the functional capabilities of the organism as a whole due to involution and atrophy of tissues and organs. In elderly and older people, polymorbidity is quite common (chronic diseases that develop against a background of age-related changes) as well as, several times greater susceptibility to immobilization and a reduction, change or lack of motor habits and skills. In this sense, it is important that in the course of aging and the deepening of pathological changes, keeping the same level, or even slowing the deterioration of the above-mentioned indicators, should be considered favorable. Another characteristic feature with advancing age is that people cannot withstand the same amount of exertion for a long time, and in such cases, they quickly become tired, discouraged, and lose interest. This necessitates offering different, interesting forms of physical activity to sustain their motivation [1], [2], [3].

Older and elderly people have been shown to have a much poorer perception of their physical health, emotional state, and social functioning compared to the general population [4], [5], [6]. They are at risk of progression of respiratory, cardiovascular, and metabolic changes, as well as structural and functional disorders of the musculoskeletal system and nervous system. This determines the need for special attention regarding their prevention, early diagnosis, and monitoring [7], [8], [9].

The creation of video game was designed after prior consideration for neurorehabilitation but also with goal to be applied in healthy adults. We have focused on the use, benefits, and design principles of the video games for rehabilitation, namely, to be meaningful and provide the opportunity to increase the level of difficulty so they can remain challenging, tailored to the capabilities of the player.

The new video game software we have created is highly suitable in this respect. A 3D camera with an extremely accurate sensor was used to capture the player's movements. The video games are made on unity platform using c#. Nuitrack libraries allow the connection of video games with a camera. The player is required to make a specific, purposeful movement that is captured by the camera and controls the game. The main advantage of the games is their ability to provoke a high level of interest and motivation over an extended period of time. The camera report the range of movement (in degrees) of the motion being performed, displayed on the screen throughout the game. The games are safe and affordable for prolonged use at home, turning exercise therapy into an enjoyable experience and thus increasing user interest. The players are completely transported into the game as they can play sitting or standing, depending on the available options. Feedback on the result is given through digital and visual cues. Scores can be saved through an available user profile and trends monitored over time. They meet the basic principles for designing video games for rehabilitation, namely, to be meaningful and provide the opportunity to increase the level of difficulty so they can remain challenging, tailored to the capabilities of the player. Furthermore, the games are understandable and can be implemented with specific therapeutic goals in mind. They could apply in healthy people and patients with different disorders in any age [10], [11].

The specific features and role of physical activity in the prevention and treatment of elderly and old people are known, but the role of video games on quality of life is understudied.

Aim

This study aims to investigate the feasibility of 3D camera rehabilitation video games and their effect on quality of life in autonomous, non-institutionalized elderly persons, regularly engaged in structured exercises with no obvious difficulties in usual activities of daily living.

Materials and Methods

The type of the research is an experimental single-centered study, pre-test–post-test with control group design, conducted at a physical rehabilitation outpatient center in January–June 2022. 50 generally healthy elderly and older persons were recruited out of 92 senior subjects who participate regularly in physiotherapy at our medical center, according to the inclusion and exclusion criteria. Inclusion criteria are as follows: Age above 65 years, cooperative, agreeing to participate, and willing to sign a consent form. Exclusion criteria are as follows: Current exacerbation of a chronic disease, sudden onset of an acute illness, or trauma.

Participants

Fifty generally healthy elderly and old subjects living in independent community dwellings (without the presence of any exacerbated illnesses, despite the presence of chronic polymorbidity) were allocated into two groups, depending on their willingness to perform either only physiotherapy or physiotherapy combined with video games. The experimental group consisted of 24 women, mean age 76.75 ± 6.89 years, and the control group consisted of 26 women, mean age 73.69 ± 6.89 years. The independent senior subjects who were involved in the study participate regularly in groups named "Physiotherapy for health" at our medical center. They all are above 65 years, in stable clinical status, and after being informed of the entire protocol, each of them signed a written consent form, reviewed, and approved by the local university ethics committee to declare their willingness to participate.

Measurements

For the purpose of the study, the quality of life of the follow-up subjects was assessed twice at the beginning of the treatment and at the 7 weeks after the treatment. The 36-item quality of life scale [12], modified and described in detail in English in another publication [13], was used. It includes eight tracking domains: Physical abilities; limitations resulting from problems in physical abilities; limitations resulting from problems in emotional state; strength; emotional state; social functions; pain; and general health. Scores on each scale range from 0 to 100 with higher scores indicating better health. Results are processed in two stages. The numerical value of the response is coded into a number of points by a test key, that is, each response has a corresponding number from 1 to 6 or from 1 to 2 to which corresponds a number of points from 0 to 100. The final score is obtained by calculating the total score for each guideline, dividing by the number of questions and determining the average score. Reliability is then reported according to the normal values for the main guidelines in the survey [12].

Intervention

The study was conducted at the NSA-EOOD Medical Center - 1 Gurgulyat Street. The exercise program was carried out 3 times a week for all participants and had a total duration of 7 weeks. The elderly and older adults that were part of the experimental group played video games for rehabilitation with a 3D camera, after written informed consent was given. The 3D

camera rehabilitation video games were with a 30 min duration and moderate intensity. We implemented two games. The first game, catching the ball, was developed to rehabilitate the upper extremity by performing shoulder joint movements (abduction and adduction/flexion and extension). The player's name is entered and the specific parameters of the game are set according to individual capabilities. The player stands in front of the camera at a sufficient distance to fix the three joints of the upper limb. When performing movements in the sagittal or frontal plane, the figure moves its corresponding arm according to the selected parameters and catches the ball.

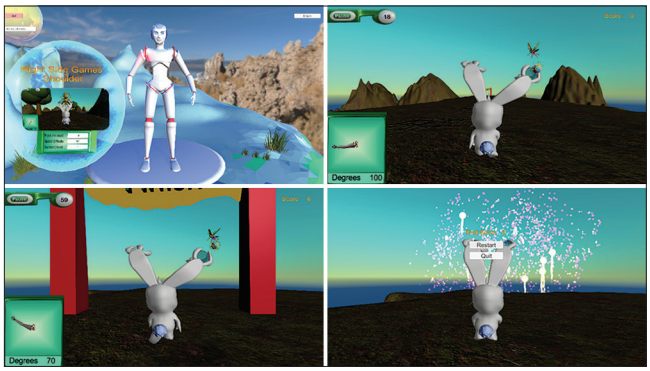

Figure 1: The game "Catching the ball," with initial position assignment, difficulty (determined by speed of execution), and duration

The difficulty can be controlled by setting the number of catching positions (from 2 to 4), the duration of the session, and the speed of execution (from 10 to 100). If the player catches the ball at the right time, he receives a point, and a higher score is associated with better performance (Figures 1 and 2).

Figure 2: Execution of movements in the shoulder joint controlling the catching of the ball in the game

The second game we implemented, "Avoiding Danger," was developed for upper and lower extremity rehabilitation. There are two variations of performance (Figure 3) – performance with flexion/extension at the elbow joint and with flexion/extension at the hip joint. The hazards appear on the screen at random positions (moving forward on the ground or in the air). The purpose of this game is for the player to avoid the hazards

Figure 3: Execution of movements toward flexion and extension at the elbow and hip joint controlling hazard avoidance in the game

by lifting their arm or leg when one of the hazards approaches. In the upper limb version of the game, the player flexes the elbow joint to lift the figure, while in the other version, this is accomplished by flexion at the hip and knee joints. Initially, the difficulty (10−120), duration, and degrees of flexion are set, depending on the player's individual ability. If the hazards touched the figure, the game starts over and the player still has a chance to cover the specified distance in the specified time without being returned to the very start (Figure 4). The score is determined by the number of attempts to cover the specified distance in the specified time. The game has appropriate visual feedback. During the game, the remaining time in seconds and the amount of movement in the moving joint are displayed on the screen. There is an option to temporarily stop the game with a button that is displayed on the screen [10].

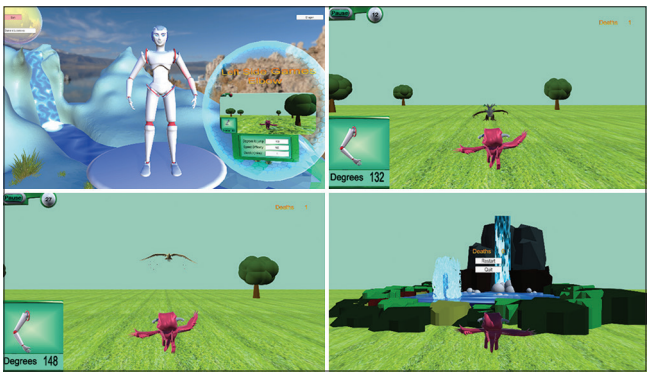

Figure 4: The Hazard Avoidance game, with initial setting of the degree of inflection, difficulty (determined by execution speed), and duration

Control participants were treated in a routine manner with group kinesitherapy including breathing and general constructive exercises with a 30 min duration.

The results were processed statistically using the Wilcoxon test (to determine the significance of changes for each group over the course of treatment) and the Mann–Whitney U-criterion (to determine the significance of differences between the two groups).

Statistical analysis

The analysis of the data gathered was carried out with the SPSS version 19.0. Descriptive statistics (mean and standard deviation), a Wilcoxon test, and

Mann–Whitney U-test to determine the significance of changes in outcome measures were used. The significance was set up at $p \leq 0.05$.

Results

The clinical characteristics of the study cohort are presented in Table 1. Individuals in the two groups did not differ in height, age, body weight, and body mass index.

Table 1: Clinical characteristics of the study population

Indicators	$\bar{X}_1 \pm SD$	
	EG (n = 24)	CG (n = 26)
Height (cm)	149.13 ± 44.81	163.30 ± 14.36
Age (years)	76.75 ± 6.89 (66–89)	73.69 ± 6.76 (63–87)
Body weight (kg)	67.58 ± 8.00 (57–85)	65.50 ± 7.10 (47–78)
BMI	25.69 ± 2.69 (21–32)	24.61 ± 3.10 (19–31)

EG: Experimental group, CG: Control group, n: Number of the participants, $\bar{X}_1 \pm SD$: Mean values and standard deviation, BMI: Body mass index

The aim of the present study was to evaluate the impact of 3D camera rehabilitation video games on quality of life in practically healthy elderly and older adults. It was conducted in 24 experimental and 26 control subjects.

The results of the physical functioning and mental health constructs in eight domains demonstrating the changes in quality of life in the two groups are presented in Table 2.

Table 2: Changes in the quality of life of follow-up subjects in both groups over the course of during the treatment

Indicators	Group	Start (EG = 24; CG = 26), $\bar{X}_1 \pm SD_1$	End (EG = 24; CG = 26), $\bar{X}_2 \pm SD_2$
PAs	EG	78.99 ± 11.06	77.82 ± 9.87
	CG	80.93 ± 11.43	77.70 ± 8.86*
	p	0.552	0.965
LPAs	EG	35.42 ± 22.17	29.17 ± 21.68
	CG	32.69 ± 30.09	25.00 ± 11.69*
	p	0.771	0.657
LES	EG	22.22 ± 21.1	22.21 ± 8.70
	CG	20.51 ± 14.3	20.51 ± 19.3
	p	0.834	0.194
Po	EG	42.50 ± 11.27	42.19 ± 5.92
	CG	43.46 ± 12.31	39.81 ± 12.67
	p	0.780	0.181
ES	EG	32.67 ± 9.21	34.33 ± 7.39
	CG	42.15 ± 17.58	37.08 ± 8.10
	p	0.025	0.227
SF	EG	58.33 ± 19.32	55.21 ± 12.97
	CG	51.92 ± 23.43	58.85 ± 26.70
	p	0.309	0.556
Pe	EG	63.52 ± 20.50	71.88 ± 17.84*
	CG	66.92 ± 23.10	57.77 ± 24.15
	p	0.593	0.027
GH	EG	58.33 ± 13.44	65.00 ± 10.21**
	CG	68.20 ± 21.34	62.69 ± 20.30***
	p	0.063	0.005

**p<0.01, *p<0.05 – significant differences for each group in the course of treatment compared to baseline values. $\bar{X}_1 \pm sd_1$: Mean values and standard deviation in the beginning, $\bar{X}_2 \pm sd_2$: Mean values and standard deviation at the end, p: Significant differences between EG and CG. EG: Experimental group, CG: Control group, PAs: Physical abilities, LPAs: Limitations in physical abilities, LES: Limitations in emotional status, Po: Power, ES: Emotional status, SF: Social functions, Pe: Pain, GH: General health.

The analysis of the obtained results revealed a decrease in the quality of life in all areas in both groups (Table 2), which were more pronounced in regard to limitations in physical abilities, limitations in emotional state, emotional state, and strength in both groups. Significant changes related to pain reduction and improvement in general health were observed after the implementation of the video games for rehabilitation. The other indicators showed insignificant positive changes, as we must bear in mind that in the course of aging and the worsening of pathological changes, keeping the same level, or even slowing the deterioration of the indicators, must be considered favorable. In the control group, there was a general tendency toward retention or deterioration, relative to the baseline, especially significant for their limitations in physical capacity. Improvement is found in their social functions.

Comparison between the two groups over the course of the treatment showed significantly better results on pain (reduced in severity and duration) and general health (defined as better) in participants in the experimental group at the end of the treatment.

Discussion

The results of the present study found that significant changes related to pain reduction and improvement in general health were observed after the implementation of the video games for rehabilitation in the elderly. These findings are similar to changes found in other studies and are associated with reduced functional capacity, particularly after the age of 75 [5], [6], [12]. The extremely low baseline scores that individuals in both groups reported on their quality of life questionnaires are complex and determined mostly by psychosomatic disorders, socioeconomic problems, delay in health-care reform, and personal attributes are all relevant. As other studies have shown, insufficient attention to physical training, financial and organizational difficulties of the elderly and older adults to provide the minimum of necessary medications are relevant [14], [15], [16], [17], [18].

However, our study found that the application of video games for rehabilitation has a supportive effect in terms of emotional health, physical capabilities, and social activities, which we consider a positive effect in the elderly and old people, since even minimal deterioration is associated with positive changes because of the progressive changes that are expected with age and their already existing chronic health issues. Significant reduction in pain and improvement in general health were observed in our participants. This contributes to the preservation and maintenance of their health status and the ability to perform more activities of daily living without difficulty [19], [20], [21], [22].

Group activities with general improvement and breathing exercises administered 3 times a week, with a duration of 30 min, in the control group had a retaining and positive effect at the end of the follow-up. Improvement was found in social functions related to the

group nature of the exercise, providing more opportunity for communication between the participants.

Both motor programs had a beneficial effect, with a more significant improvement in those performing the video games for rehabilitation, which we associate with the increased range of motion, balance, and coordination abilities of the individuals in the experimental group.

The specific type of motor activity is a matter of personal choice but video games for rehabilitation are a suitable alternative because they involve purposeful movements and provide the opportunity to increase the level of difficulty so they can remain challenging, tailored to the capabilities of the player. They are interesting and fun, and can be implemented for extended periods of time at home. This is undoubtedly necessary as it is a way of increasing the active longevity of the elderly population [18], [23], [24], [25], [26].

A number of authors confirm the positive effect of exercise on depression, anxiety, self-esteem, or the extent to which patients perceive life as something they can manage or control, [3], [5], [9], [14].

Evidently, the daily focus of patients on their own health has a positive lasting impact on the quality of life of the elderly. A beneficial effect in the experimental group was found in their physical parameters (pain and general health). This may be related to the changes in the usual lifestyle of the elderly participants brought on by including a new motor activity such as the video games for rehabilitation, which lead to a change in their self-esteem [2], [14], [27]. Thus, the followed persons reported that they felt better, had reduction in pain, and had better self-esteem and confidence, especially in terms of their health condition.

There may be some possible limitations in this study. The followed subjects were predominantly with moderate or minimal motor functional deficits, and it would be of interest for future studies to monitor participants with greater functional limitations. The study did not consider the possible influence of some contextual factors such as body mass index, educational level, social status, and comorbidities, which would provide additional useful information. Men should also be invited to participate in the study.

Conclusion

The results of the study suggest that video games for rehabilitation with a 3D camera contribute to the reduction of the subjective perception of pain and influence lifestyle through compensatory behavioral responses in the context of polymorbidity and chronic deficit commonly found in the elderly and older people.

Implications for further research

This manuscript highlights the need for further research into video games approaches for rehabilitation interventions for subjects in different ages, gender, and more pronounced physical limitations due to neurological, orthopedic, or other diseases. Telerehabilitation with video games should also be taken into consideration.

Consent to participate

Written informed consent was obtained from all patients before their inclusion in the study. Information for informed consent was given before the patients signed the informed consent.

Human and animal rights

No animals were used in this study. All human procedures were followed in accordance with the principles of the Declaration of Helsinki.

Ethical Statement

This study was approved by Faculty of Public Health, Healthcare and Tourism, National Sports Academy, Bulgaria Ethics Committee and has been performed in according ethical standards laid down Helsinki Declaration.

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Authors' Contributions

D.L., A.D., and K.G-P. conceived of the presented idea and planned the experiments and contributed information from literature search. A.D., K.G-P., and M.M. carried out the experiment and data collection. D.L. did the data analysis and supervised the experiments. All authors have made significant contributions to this manuscript and have approved the final version to be submitted.

Conflicts of Interest

The authors declare that there are no circumstances of conflicts of interest and that the subjects have signed declarations of consent regarding the publication of the data found in the study.

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