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Assessment of the impact of interactive console games on the balance, fitness, fall risk reduction, and quality of life in older adults with cardiovascular diseases undergoing early post-hospital rehabilitation

Abstract

Introduction

In Poland, the largest group undergoing long-term hospitalization consists of the elderly (77.9%). Older individuals are particularly susceptible to the long-term effects of hospitalization, such as balance disorders, increased risk of falls, frailty syndrome, and mood deterioration. The causes of this situation may include prolonged immobilization and the medications taken. Individuals over the age of 65 are at risk of experiencing at least one serious fall annually. On a population scale, this generates both social (exclusion, immobilization, increased healthcare costs) and health issues (reduced quality of life, long-term injuries, hospitalizations). According to the recommendations of the European and American Cardiac Societies, the comprehensive rehabilitation process, including cardiac rehabilitation, should incorporate coordination and balance exercises to minimize the aforementioned problems as much as possible.

Objective of the Study

The primary objective of the study was to assess the impact of interactive console games on balance, physical fitness, fall risk, and quality of life in elderly individuals with cardiovascular diseases undergoing early post-hospital rehabilitation.

Specific Objectives

1. To assess the impact of balance training on parameters evaluated using the CQ Stab platform, as well as in the Berg Balance Scale and FallSkip tests.

2. To evaluate the impact of the applied training methods on grip strength and exercise tolerance in the studied groups.

3. To analyze the impact of the applied training methods on the quality of life in the studied groups.

4. To analyze the impact of the applied training methods on the risk of frailty syndrome in the studied groups.

5. To compare the effects of training with the use of interactive console games versus traditional physiotherapist-planned training on the studied parameters: exercise tolerance, balance parameters, grip strength, quality of life, and risk of frailty syndrome.

6. To assess the usefulness and safety of the ActivLife interactive console game system in the process of comprehensive cardiac rehabilitation.

Application Objective

1. To introduce interactive console games as a permanent element of the comprehensive cardiac rehabilitation process.

Materials and Methods

The study included 83 patients, comprising 33 women (39.8%) and 50 men (60.2%), with an average age of 71.9 ± 5.7 years. The study group consisted of 42 individuals who had experienced an acute coronary syndrome, 31 who had undergone cardiac surgery, and 10 who had suffered from an exacerbation of heart failure or coronary artery disease.

In the study group, comorbidities were observed, most commonly hypertension (79.5%), diabetes (36.1%), and chronic lung diseases (12%).

All patients were rehabilitated at the Clinic of Coronary Artery Disease and Cardiac Rehabilitation and the Day Rehabilitation Center of the National Institute of Cardiology between 2021 and 2023. Participants were randomly assigned to one of two groups.

Group 1 (study group) consisted of 43 individuals (46.5% women), with an average age of 72.6 ± 6.2 years. This group underwent the standard rehabilitation program supplemented with exercises using the ActivLife interactive console gaming system.

Group 2 (control group) included 40 individuals (32.5% women), with an average age of 71.3 ± 5.2 years, who were rehabilitated according to the standard comprehensive rehabilitation program.

Patients were assigned to the appropriate rehabilitation models (A, B, C) by a cardiologist, based on the risk of adverse cardiac events and an exercise test. All patients underwent a series of tests assessing balance (using the CQStab stabilometric platform and the Berg Balance Scale), physical fitness (6-minute walk test), fall risk (using the FallSkip® biomedical application), and psychological aspects (Groningen Frailty Index, WHO Quality of Life - Age) both before and after completing the rehabilitation process.

Results

The average number of training sessions during the entire rehabilitation cycle was similar in both groups: 13.2 ± 0.6 in the study group and 13.0 ± 0.5 in the control group ($p = 0.787$). No significant differences in systolic and diastolic blood pressure or heart rate were observed between the groups, both before and after training. The groups differed in the degree of fatigue before and after training. The control group experienced greater fatigue, but median values indicated that before training, fatigue was at level 0 (no noticeable fatigue) in both groups, while after training, it was at level 2 (slight fatigue) in the study group and level 3 (moderate fatigue) in the control group.

Posturographic Tests

Statokinesigram Analysis with Eyes Open: In the study group, there was an improvement in stability in both lateral and sagittal directions, with a significant reduction in path length ($p = 0.004$) and mean sway ($p = 0.027$) in the X direction, with unchanged maximum sway ($p = 0.190$). In the Y-axis movement, all three parameters improved, resulting in an enhanced 2D assessment. In the control group, only mean sway ($p = 0.004$) and maximum sway

(p = 0.038) in the sagittal direction improved, which only led to an improvement in mean sway in the 2D assessment (p = 0.018).

Statokinesigram Analysis with Eyes Closed: In the study group, all three analyzed parameters (path length (p = 0.005), mean sway (p = 0.009), and maximum sway (p = 0.002)) improved, but only in the lateral direction. This resulted in a statistically significant reduction in mean sway (p = 0.017) and area (p = 0.029) in the 2D evaluation. In the control group, no changes were observed in these parameters in both tests (differences before and after the rehabilitation cycle were not significantly different from zero).

Postural Stability Tests with Eyes Open

In the study group, there was only a significant reduction in the statokinesigram path length in both 2D axes after rehabilitation (a 56 mm reduction in the upper quartile and a 33 mm reduction in the median, p = 0.020), as well as a tendency to reduce the path length in the sagittal axis (p = 0.081, a 21 mm reduction in the median) and maximum sway in the lateral axis (p = 0.096), with a reduction in the upper quartile by 1.6 m. In the control group, there was only a tendency to reduce the path length in the X-axis (p = 0.075, a 9 mm reduction in the median).

Postural Stability Tests with Eyes Closed

In the study group, after rehabilitation, there was a statistically significant reduction in path lengths in both axes (ML: a 52 mm reduction in the upper quartile and a 9 mm reduction in the median, p = 0.030; AP: a 61 mm reduction in the median, p = 0.040) and in the 2D dimension (a 76 mm reduction in the median, p = 0.020), with no changes for mean and maximum sway or area. In the control group, after rehabilitation, there was a statistically significant reduction in path lengths (ML direction: 19 mm, p = 0.019; AP direction: 27 mm, p = 0.021; both axes: 76 mm, p = 0.008) along with changes in maximum sway in both the lateral (3.7 mm, p = 0.017) and sagittal (12.4 mm, p = 0.008) axes, as well as mean sway in the lateral axis (8 mm, p = 0.045).

6-Minute Walk Test

Both groups performed the 6-minute walk test before and after rehabilitation. Before rehabilitation, there were no significant differences between the groups; the distance covered by the study group was 386 ± 109 meters, and by the control group, 420 ± 127 meters. After rehabilitation, the distance in the study group increased to 462 ± 102 meters, and in the control group to 493 ± 135 meters, representing a significant increase compared to baseline values (76 meters in the study group and 73 meters in the control group).

Handgrip Strength

Handgrip strength of the dominant hand increased in the study group by 2.4 ± 3.8 kg (from 30.5 ± 9.2 kg to 32.9 ± 8.7 kg, p < 0.001) and in the control group by 2.1 ± 2.7 kg (from 32.6 ± 9.4 kg to 34.7 ± 9.8 kg, p < 0.001). The handgrip strength of the non-dominant hand increased by 2.6 ± 4.2 kg (p < 0.001) in the study group and by 1.5 ± 3.2 kg (p = 0.004) in the control group, with no significant differences between the groups.

Frailty Syndrome – GFI Questionnaire

Based on the adopted cut-off point of the index (>4), frailty syndrome was diagnosed prior to inclusion in the study in 23 (53.3%) individuals in group 1 and in 21 (52.5%) individuals in

group 2. It should be noted that the rehabilitation models used resulted in a change in category for 14 individuals in group 1 and 8 individuals in group 2, with 12 individuals in group 1 showing improvement and 2 showing deterioration (p=0.007). In group 2, improvement was observed in 6 patients, while deterioration was observed in 2 (p=0.157).

FallSkip®

The study group showed significant improvement in balance stability assessed by the FallSkip® device after rehabilitation. Only in group 1 was there a significant improvement in all the examined indicators after the rehabilitation cycle, all at the $p < 0.001$ level.

In group 2, the task execution time improved both in absolute measurement in seconds (reduction in task execution time, $p = 0.007$) and in the percentage of norm achievement ($p = 0.004$, an increase in the percentage of norm - approaching the norm of the healthy population). The risk of falls also decreased ($p = 0.002$). No changes were observed in static balance, gait quality, response time to auditory stimuli, and sit-to-stand task quality.

After the rehabilitation, the groups differed in balance (center of gravity position in the standing phase, $p = 0.010$), with desired values more frequently achieved in group 1, and gait, which still appeared better in group 2.

In terms of balance, gait, and fall risk, the changes observed between the two measurement points (after and before) were greater in group 1 than in group 2, favoring group 1 – an increase in the percentage of norms achieved for balance and gait, and an absolute reduction in fall risk scores.

Quality of Life – WHOQoLAge Questionnaire

After completing the rehabilitation, the study group showed significant improvement in five domains: ability to perform daily activities, personal relationships, living conditions, energy in daily life (for all mentioned domains: $p = 0.025$), and perceived opportunities for further professional success ($p = 0.003$). Additionally, there was
a tendency ($p < 0.10$) to improve quality of life in three areas: general satisfaction with life quality ($p = 0.083$), sensory satisfaction ($p = 0.053$), and self-satisfaction ($p = 0.096$).

In the control group, significant improvement after the rehabilitation period was observed in only two domains: satisfaction with health ($p = 0.018$) and self-satisfaction ($p = 0.007$). No improvement trends were observed in any of the other areas.

A comparison of the achieved quality of life results after rehabilitation showed significantly better satisfaction with daily life energy ($p = 0.044$) and belief in the ability to achieve life successes ($p = 0.048$) in group 1 compared to group 2.

Conclusions

1. Training with ActiveLife results in significantly greater improvement in most parameters assessed on the stabilometric platform compared to traditional balance training.

2. ActiveLife training leads to a significantly greater reduction in fall risk measured by the Fallskip device than traditional balance exercises conducted in the control group.

3. Rehabilitation using the ActivLife system significantly improves quality of life, specifically in areas such as daily energy levels, life control, developmental opportunities, financial situation assessment, and intimate relationships, compared to traditional balance exercises.

4. Training with ActiveLife results in significantly greater improvement in subjective mood assessment than traditional balance exercises.

5. Comprehensive cardiac rehabilitation that includes both forms of balance training leads to significant improvements in exercise tolerance, balance levels, physical fitness, handgrip strength, quality of life, and significantly reduces the risk of falls and the occurrence of frailty syndrome in the studied groups.

6. Interactive console games can replace traditional balance and coordination exercises in the process of comprehensive cardiac rehabilitation.

7. ActivLife® is a safe and effective training method for patients with cardiovascular diseases.