# Individualized Computer-based Training for Elderly in Nursing Homes: A Pilot Study

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Abstract: In older ages, the people are affected by limitations referring to physical and cognitive functions of the body. These limitations can lead to falls, which can be prevented by different types of physical training. Some studies showed that different kinds of physical activity have a positive effect on the equilibrium as well as on cognitive function. During a project an individualized computer-based training was developed. The developed application was examined during a pilot study in a local nursing home. The results indicate that the training intervention based on the computer-based training has a positive effect on different parameters (balance, TUG test). The limitation of the pilot study is the small sample size, which is additionally reduced due to dropouts. In further studies the effect of a balance training with the computer-based training will be done in other nursing homes.

## 1 INTRODUCTION

The ability to keep the human body balanced is a very complex interaction of different components: the organ of equilibrium of the inner ear, the visual system as well as the proprioceptors within the joints and muscles ensure that the body stays upright and balanced. In older ages, limitations of the sensorimotor functions can lead to dizziness and falls (Buchner et al., van Doorn et al.) whereby persons affected are endangered to loose the ability to lead a self-determined and thus independent life. Different studies show that physical training has a positive effect on the general fitness, the static and dynamic equilibrium (gait parameters) (Boa Sorte Silva et al., Hortobágy et al, Heath et al.) as well as an impact on cognitive performance (Huxhold et al., 2008, Didczuneit-Sandhop, 2018).

Persons aged 70 years or older have an increased risk of getting problems with dizziness. Sixty percent of women and 50 % of men in that age group suffer from dizziness (Schaaf et al., 2009). In that those cases, Schaaf et al. (2009) recommend a periodically conducted balance training, which has a positive influence on the equilibrium and leads to prevention of 50 % of the falls.

In this paper, the pilot study including an invention utilizing an individualized computer-based balance training is presented. This paper focuses on the impact of the balance training on the ability to keep up or even improve the individual balance, which is considered as static and dynamic balance.

## 2 MATERIALS & METHODS

The pilot study was conducted in a nursing home in Brandenburg/Havel, which provides an accommodation for 14 elderly persons. At the starting point only 12 residents could have participated in the pilot study, however, two of whom were not able to walk or to stand independently since they were wheelchair users. From the remaining ten subjects six (2 m, 4 f, mean age: 85.3 (± 5.96) years, Karnovski Index 60-70 %, level of dizziness: 5 no, 1 light to moderate) were willing to participate in the intervention with the individualized computer-based training. The remaining four elderly persons (1 m, 3 f, mean age: 88.3 (± 8.49) years, Karnovski Index 60 %, level of dizziness: 4 no) could be motivated to serve as control group participating in the pre- and post-intervention test setting. All participants or their legal representatives gave written consent to participate in this study after having been informed about the procedure, its purpose and possible risks related to the participation. The study was approved by the local ethics committee



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of the Brandenburg Medical School Theodor Fontane and was carried out in line with the Declaration of Helsinki (no. E-01-20181030).

The training intervention with the computer-based balance training was planned to last for six weeks with three training sessions per week. Each training session was conducted in the same environment of the nursing home at approximately the same time of the day. The computer-based balance training requests the user to move his/her center of gravity (COG) throughout the training with the result that step by step a hidden image becomes visible. Additionally, music plays as long as the user moves his/her center of pressure. Both factors, utilizing visual and auditive stimuli, were intended to increase the test persons' motivation, since it was shown, that the application of socioemotionally relevant aspects result in an increased effect of the respective intervention (Carstensen, 2003, Mather & Carstensen, 2005).

If the extend of the motion was too small, the music softens away before it finally stops. In that case, the user was asked to move his/her COG again.

Figure 1: Setting of the training sessions. The elderly stands on the force plate, which is surrounded with a safety construction. A coach, nurse or caregiver supervised the elderly during the training. During playing the elderly sees the changes made by moving the center of gravity on the screen and step-by-step the hidden image becomes visible.

As shown in figure 1 the elderly persons were supervised during the training sessions by a coach (or a nurse/caregiver).

In order to assess the impact of the balance training using the individualized computer-based training, different tests were exerted before and after the intervention. In the pretest scenario all ten test persons took part and completed the Timed-Up-and-Go (TUG (Podsiadlo & Richardson, 1991) test and a balance test. Additionally, different cognitive test, such as the Mini-Mental-State-Test (MMST (Folstein et al., 1975)) or Trail-Making-Test (TMT, (Reitan, 1992)) were performed (results not presented).

During the TUG, the time for standing up from the chair, walking a three meters distance, turning 180°, going back to the chair and sitting down was registered using a stop watch. In addition, the performance of the subject was captured with a video camera in order to be able to evaluate the gait (dynamic balance) of the subject.

The static balance test was conducted using a PLUX force plate (PLUX-Wireless Biosignals S.A, Lisbon, Portugal (Plux, 2019)) and an in-house developed software called BALANCE. The balance was examined under four different conditions:

(1) standing on both feet with a defined distance between the feet and eyes opened,
(2) standing on both feet with a defined distance between the feet and eyes closed,
(3) semi-tandem stand with right foot in front, and
(4) semi-tandem stand with left foot in front.

Each standing position was captured for 20 seconds and the maximum variations of the center of gravity in the left-right (medio-lateral) as well as theback-/forwards (anterior-posterior) direction was registered with the BALANCE software. During the balance test, a safety construction and if necessary an examiner supported the test persons in order to avoid falls (see figure 1). Complementary to the objective values of the COP variations, the examiners documented the level of support by using a subjective scale: without, little, medium or large (great, major) support.

Due to the small size of the groups (experimental and control group), the parameters of the tests were only considered with descriptive methods of statistics. The difference of the values from pre- and post-test settings were compared.

# 3 RESULTS

*Training Sessions*

During the six-week intervention, 18 training sessions were conducted. Table 1 gives an overview on how many sessions each subject participated in and how long the mean training sessions lasted. While two subjects took part in almost all training sessions, one subject missed five training sessions and three subjects were absent for seven to eight training sessions. Considering the mean time per training session, three groups were apparent: Three subjects had a mean session time of twelve or thirteen minutes, while one subject played the game for seven minutes on average while the remaining two subjects with the lowest number of training sessions were also having the lowest mean session times of one or two minutes. Consequently, only three subjects were to be considered as forming the experimental group during the further analysis.

Table 1: Number of training sessions conducted from the six subjects during the six-week intervention. Additionally, the mean session time in minutes is given for each subject.

| Subject | Number of training sessions | Mean session time (min) |
|---|---|---|
| **S01** | 16 | 13 |
| **S02** | 10 | 2 |
| **S03** | 11 | 1 |
| **S04** | 17 | 12 |
| **S05** | 13 | 12 |
| **S06** | 10 | 7 |

*User Feedback*

All the participants of the EG were motivated during the whole intervention and gave a positive oral feedback to the caregiver or examiner. Surprisingly the motivation was maintained and even increased by changing the music and/or the images weekly as well as choosing music and images suited to seasonal or special events during the intervention period. The initial scepticism of the participants regarding the new and unknown technology changed to a pleasant anticipation of the next training.

*Balance Test*

For the static balance test two different aspects had to be considered: On the one hand, the objective measurement of the variations of the COG by means of the force platform and, on the other hand, the level of individual support documented subjectively by the examiner, which provides insight into the (potential) improvement of physical function during the intervention.

Table 2 shows the level of support of the examined subjects. The examiner used a scale of four items to document the level of support. As it is clearly visible, there is only one subject (S01), who was able to conduct all test settings without any help and was standing during all test positions upright and free in the pre- and post-intervention tests. A second subject (S03), who could not take part in the post-intervention test due to general health reasons, also did not need any support during the pretest. The subjects (S04, S05) of the EG showed a reduced level of support in the post-intervention test in one or even all settings. In all of the other subjects the level of support was unchanged (S06, S09) or even increased (S07, S08) in the post-test scenario. Furthermore, it has to be noted that the subject S08 had to be supported throughout the three standing positions “closed eyes”, “tandem left” and “tandem right”. We therefore decided that the data of S08 could not be considered for further analysis, especially since the TUG test could also not be conducted.

Table 2: Level of Support (subjective assessment of the examiner) during the static balance test conducted on the force plate for the four standing positions. The * means that the subject have to cancel the trial before the end of the measurement was reached.

| Group | Subject | Level of support | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Opened Eyes | | Closed Eyes | | Tandem left | | Tandem right | |
| | | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| EG | S01 | without | without | without | without | without | without | without | without |
| | S04 | without | without | medium | little | little | little | little | little |
| | S05 | little | without | medium | little | large | medium | medium | little |
| CG | S07 | without | without | medium | medium | little | little | little | medium |
| | S08 | without | medium | medium | large | medium | large | medium | large* |
| | S09 | without | without | little | little | little | little | little | little |

Table 3: Variations of COP in anterior-posterior direction and medio-lateral direction considered as area (in mm) and given as relative difference between pre- and posttest (in %).

| Group | Subject | Opened Eyes Change of the area (%) | Closed Eyes Change of the area (%) | Tandem left Change of the area (%) | Tandem right Change of the area (%) |
|---|---|---|---|---|---|
| EG | **S01** | -41.0 | 63.3 | 45.8 | 49.5 |
| | **S04** | -34.7 | -39.9 | -85.5 | -74.0 |
| | **S05** | -29.4 | 9.7 | 4.6 | 22.9 |
| CG | **S07** | -11.8 | 32.4 | 65.1 | 51.7 |
| | **S09** | -43.9 | 12.0 | 17.1 | 26.8 |

Table 4: Time needed for the task of the TUG test presented in time format (mm:ss.msms) for pretest and posttest and as relative change between pre- and posttest (in %). Additionally, the kind of support used by the subject is given.

| Group | Subject | TUG time pre (mm:ss.msms) | TUG time post (mm:ss.msms) | Relative Change (%) | Support during Pre-/Posttest |
|---|---|---|---|---|---|
| EG | **S01** | 00:16.33 | 00:11.27 | -31.3 | No / No |
| | **S04** | 00:25.00 | 00:37.53 | 48.0 | Walker / Crutches |
| | **S05** | 01:00.12 | 00:46.31 | -21.7 | Walker / Walker |
| CG | **S07** | 00:35.19 | 00:32.02 | -8.6 | Walker / Walker |
| | **S09** | 00:12.45 | 00:10.15 | -15.4 | No / No |

In table 3 the relative changes between the results of the pre- and post-intervention tests are given for the area calculated from the maximum variations of the COG in anterior-posterior and medio-lateral direction. All analyzed subjects (EG: 3; CG: 2) improved their balance during normal standing with opened eyes, whereby the balance test rather deteriorated in subject S07 (-11.8 %) (range: -43.9 to -29.4 %).

*Timed-up and Go Test*
For the TUG test the individual time needed is presented in the table 4. Besides the raw time each subject needed during the pre- and post-intervention test, the relative change in time was calculated. The calculation was based on the rounded time values and is given as percentage. Additionally, the kind of support, which was used by each subject, is listed for the pre- and posttest scenarios. As shown in the column "relative change", an improvement can be seen in four of five subjects (EG: 2 (-31.3% to -21.7 %), CG: 2 (-15.4 % to -8.6 %)). Only the subject S04 needed a longer time (38 vs 25 sec, deterioration: 48 %) for the TUG test post-interventional compared to the pretest. It has to be noted, that with exception of subject S04 all the other subjects used the same means of support in the pre- and posttest setting.

## 4 DISCUSSION

As our preliminary results show no generalized conclusion can be drawn based on the intervention utilizing the individualized computer-based training. At the beginning of the six-week intervention, the experimental group consisted of six subjects. Due to the fact, that three of these six subjects only attended a small number of the training session and had a very low mean training time, they could not be considered as part of the experimental group in the data analysis (balance test, TUG test). Consequently, at the end of the pilot study only the data of three subjects who had a considerable number of training sessions and mean duration of the training where analyzed as experimental group. Initially, four subjects were considered as control group, only two of whom could be included in the final analysis.

One of the most striking positive effects of the intervention we would attribute to the level of support provided by the coaches while investigating the balance. While the level of support given to the subjects of the EG during the post-intervention test is the same or even lower compared to the pretest setting, the subjects of the control group needed at least partly more support in the post-intervention test as compared to the pretest.

*Balance Test*
Concerning the results of the balance investigations (table 3), it can be seen that all subjects show improvements in the setting "eyes open". However, only one subject of the EG showed also a reduction in the variation area in all the other settings ("eyes closed", "tandem left", "tandem right"). Small changes in the

variation area in the setting "eyes closed" and "tandem left" and a moderate decline (22.9 %) can be observed for a second subject of the EG. Almost the same results were found in one other subject of the CG with a moderate decline in the three settings "eyes closed", "tandem left", "tandem right". All of the other subjects showed greater declines. Based on the data of the two subjects of the EG, it has to be at least considered that the intervention may have a positive effect on the equilibrium of the subject, which, however, has to be proven in a larger prospective randomized trial.

*Timed-up and Go Test*

Improvements in the time needed for the TUG test can be noticed for both groups (EG, CG). For one subject of the EG a deterioration were registered, which can be explained with the changed walking support. While the subject used a walker during the TUG test, he chose crutches as support during the posttest. It is assumed that the process of standing up from a chair is much easier using a walker than using crutches.

*Methodological Critique*

The main critique is the small group of subjects included in the study. The second problem refers to the kind of support (wheeler, crutches) used by the subject during the TUG test. In further examinations it should be noted, that the subject uses the same kind of support in pre- and posttest. However, in the case a subject used no support and walks freely in the TUG test, and needs crutches or a walker in posttest, it should be realized due to safety aspects.

## 5 CONCLUSION

Based on the very preliminary results of this pilot study, we nonetheless feel encouraged to further investigate the effects of a computer-based balance training on the physical and cognitive function in elderly people with beginning dementia. Due to the low number of subjects included in the study and the high rate of dropouts, the informative value remains very low. Nevertheless, we could gain a lot of experience conducting the test scenarios with elderly and partially handicapped persons. These experiences will be integrated in the further development and improvement of the computer-based training. Furthermore, the tests conducted in the pre- and post-intervention test settings, will be revised critically and adjusted to the abilities of the test persons.

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