# Effects of Cognitive-Motor Dual Task Training with the BioRescue Force Platform on Cognition, Balance and Dual Task Performance in Institutionalized Older Adults

Authors: Tom Delbroek and Wietse Vermeylen
Promoter: Dr. Joke Spildooren

**Acknowledgement**

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Astridstraat 8b, 3120 Tremelo, 04/06/2016 W.V.
Nikkerstraat 1, 3520 Zonhoven, 04/06/2016 T.D.

**Research context**

The scientific research is part of the subject to new insights into rehabilitation for a geriatric audience. The protocol and research project are fully executed by the two authors. Both had a similar impact on the protocol, the study and writing of the thesis. None of the authors dealt exclusively with one of these three parts.

People are gettingolder (Studiecommissie voor de Vergrijzing [SCvV], 2014).The aging process is naturally accompanied by deterioration in several areas causing further research and specialization in geriatric rehabilitation itself. For example, the cognition and balance of older adultsdeteriorate (Tinetti, Speechley, &Ginter, 1988). There exists much literature on general training in this area. However, the authors specifically want to explore the impact of exergaming on the decline in older adults. This research can teach a lot about rehabilitation options.It could give physiotherapists the opportunity to provide older adultsa wider spectrum of rehabilitation methods. It is interesting to investigate whether exergaming is a fun yet effective addition to general training.

This research has been suggested by Dr. Joke Spildooren. It does not form part of an on-going research project and is completely developed by the authors. They studied the effect of training with the BioRescue platform on cognition, balance and dual tasks in a geriatric audience.The BioRescue platform serves as a means of intervention and evaluation.The investigation was conducted in the nursing home St. Elizabeth, Hasselt. It is supported and coordinated by Dr. Joke Spildooren, researcher at REVAL(Rehabilitation Research of the Biomedical Research Institute of Hasselt University). Since 2015, REVAL focuses on the rehabilitation of geriatric patients.

**Abstract**

**Background:** Impairment of balance, cognition and dual tasks are a common problem in institutionalized older adults. Virtual reality training in combination with balance training is an alternative form of therapy which could be an addition to general rehabilitation.

**Objectives:** We investigated whether cognition, balance and dual task performance in institutionalized older adults improved by digital dual task training.

**Participants:** Randomized Control Trial;Twenty institutionalized older adults (13 female, 7 male; average age, 87.2 ± 5.96 years) enrolled in the examination were randomized to the intervention or usual activity control group. The intervention group took part in a 6-week training wherethe BioRescue was used to perform the cognitive-motor dual task program. The control group maintained their daily activities.

**Measurements:**At baseline and after 6-weeks of training, all participants were evaluated with the BioRescue (posturographic parameters), Tinetti and Instrumented Timed Up-and-Go Test (iTUG) for the measurement of static and dynamic balance. In addition, the iTUG in combination with a cognitive task was used for the evaluation of the cognitive-motor dual task and the Montreal Cognitive Assessment (MoCa) for the cognitive function. The Observed Emotions Rating Scale (OERS) evaluated the emotions experienced during the exergaming. Post-intervention the Intrinsic Motivation Inventory (IMI) examined the motivation.

**Results:** The intervention group showed no significant improvements in none of the outcomes, except for the iTUG (p=0.016). The IMI and OERS showed that the BioRescue is a pleasant and interesting treatment method, well suited for institutionalized older adults.

**Conclusion:**The dynamic balance improved in the intervention group. The BioRescue could be a fun alternative exercise tool for institutionalized elderly. More studies with larger sample sizes and a longer training duration are needed.

**Keywords:** Cognition, Balance, Dual task, Dual task training, Institutionalized older adults, Virtual Reality

**Introduction**

The population is ageing. TheStudiecommissievoor de Vergrijzing(SCvV, 2014)reports in his annual report a further increase in life expectancy to an average of 86.1 years for men and 88.5 years for women who will be born in 2060.Ageing is accompanied by deterioration in several areas. Especially deterioration of vision, gait, muscle strength, balance and cognition are common(Chaudry et al., 2010).It often leads to a decrease of physical activity. The elderly ends up in a vicious circle in which the reduced physical activity leads to further deconditioning(Booth enGolnick, 1983).

Balance disorders emerge in the older adult(Tinetti, Speechley, &Ginter, 1988).Muir, Berg, Chesworth, Klar and Speechley (2010)show in their systematic review that the risk of falling incommunity-dwelling older adults increases by balance disorders. A fall is one of the most common accidents inolder adults. 28 to 35 % over the age of 65 fall at least once a year (Expertisecentrum Val- enfractuurpreventieVlaanderen [EVV], 2010).The number of falls ofinstitutionalized older adults (rate: 0.6–3.6 per bed annually, mean 1.7)is higher than these of community-dwelling healthy older adults(rate: 0.3–1.6 per person annually, mean 0.65). In addition, injuries are much more severe (Rubenstein, 2006).

Another problem associated with ageing is the deteriorating cognition.Zorginspectie (2011) states in their report that 45% of the institutionalized older adultsin Flanders has dementia.Dementia and Mild Cognitive Impairment (MCI,a state of altered cognition, characterized by a decline in one or more cognitive domains, including memory, whereby independence in carrying out daily activities remains largely intact) (Daelemans, 2014) are due to atrophy of the hippocampus, located in Medial Temporal Lobes (MTL), and degradation of connections between the brain regions MTL and Prefrontal Cortex (Pihlajamaki, Jauhiainen, &Soininen, 2009). Impairing visual-spatial perception and ability to orient oneself geographically are characteristics of dementia and MCI, which contribute to an increase in the number of falls (Rubenstein, Josephson, & Robbins, 1994).

Balance and cognition, twowell-known characteristics contributing to an increased fall risk, are connected to each other.For instance, one of the reasons for balance problems is cognitive impairment (Horak, 2006).The study of Horak shows that maintaining balance and postural control requires much cognitive input. Postural control combined with a cognitive task, is called a cognitive-motor dual task. Specific brain regions related to dual tasking include the precentral, postcentral, and lingual gyri (Nagamatsu et al., 2016).To complete the secondary task, the older adult uses cognitive resources. This in turn leads to a poorer performance of the primary task and could result in a fall. Along with the overall cognitive decline, this increases thefall risk even more.

General training programs have a positive effect on balance in institutionalized older adults(Chodzko-Zajko et al., 2009). Last decade, we saw the rise of virtual reality in the domain of the physiotherapy.Goble, Cone and Fling (2014)showed that the ‘Wii Balance Board’ has a positive effect on balance in older adults. The introduction of such virtual reality tools could make training more attractive for older adults.

The BioRescue is another balance board that utilizes virtual reality. It can be used to evaluate the balance ability and it can serve as an intervention tool. To perform balance exercises, the participant takes place on the platform in front of a screen.During the exercises, the screen serves as a tool for visual feedback.The BioRescueis suggested to be more patient friendly and safer than the ‘Wii Fit’, as its surface is bigger and lower to the ground, consequently decreasing the fall risk. However, it is way more expensive. Despite that the BioRescue is already incorporated in the clinical practice, there is only little evidence to support it. Only 13 studies report the BioRescue. In all studies, it was used as an evaluation tool. Only one study mentioned it as an intervention tool for stroke patients. The study showed significant improvements in balance and cognition compared to baseline measurements.(Choi, Kim, Han, & Kim, 2015).

This study will examine the effect of dual task training with the BioRescue on cognition, balance and dual task performance in institutionalized older adults with MCI. In addition, the motivation and emotions experienced during the program will be monitored. It is interesting to assess institutionalized older adults because they have a greater risk of falling in comparison with community-dwelling older adults(Rubenstein, 2006).Besides, they live in the same residential care center, so the environmental factors are standardized.

## Methods

### Participants

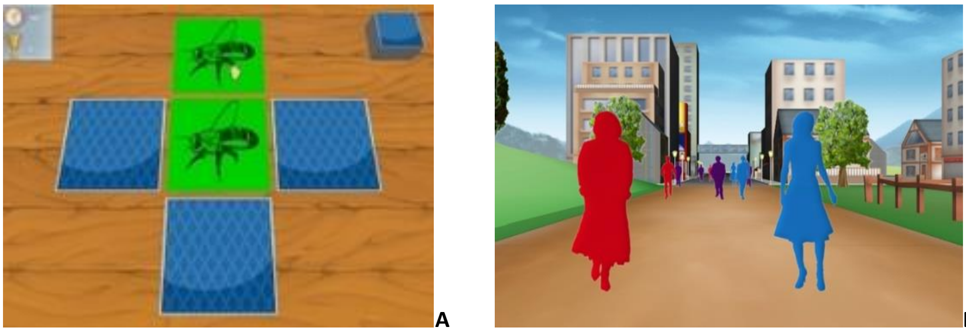
Twenty older adults, aged 65 and over, were recruited from the residential care center St. Elisabeth in Hasselt, Belgium.Participants had to be residential for at least 3 months and be able to walk at least 10 meters independently. However, the use of a walking aid was allowed. Furthermore, they had to be mildly cognitive impaired as defined by the Montreal Cognitive Assessment: MoCa< 26 (Daelemans, 2014).

Exclusion criteria were as following: inability to speak Dutch; still rehabilitating from a hospitalization (e.g., after a neurological disease or orthopedic surgery); diagnosis of dementia; major sensory or motor impairments of the upper or lower extremities which could interfere with the program; any other medical contraindication to physical exercise.Older adults who did not provide a written informed consent were also excluded.

### Exercise protocol

The subjects assigned to the intervention group, followed a training program with the BioRescue, combined with their usual therapy. Participants had to train 2 times a week for 6 weeks. The duration of each session was gradually built up from 18 minutes in week 1 to 30 minutes in week 5. The subjects in the control group continued their usual therapy.

A training session consisted of a number of exercises which were carried out for 3 minutes each. All 10 exercisesused, were aimed at training balance, memory, attention and dual tasking.Figure 1 shows two of these exercises. One exercise (fig. 1A), for example, required the participant to memorize 4 cards during 8 seconds where after the cards were turned. Then a fifth card, matching one of the other 4, was shown at the center of the monitor. The participant then had to perform weight shifts on the BioRescue to move the cursor to the matching card. Another cognitively less challenging exercise (fig. 1B), for example, required the participant to perform weight shifts right and left to avoid collisions with other pedestrians who came walking down the street.The degree of difficulty of each exercise was adjusted to the perceived skill level of each participant separately. If needed, the subjects could take a 90-second break for up to 2 times per session.



A B

**Fig. 1. Examples of BioRescue exercises (http://www.rmingenierie.net)**

(A) ‘Memory’ exercise: the participant needs to find the card that matches the one in the center; (B) ‘Avoidance’ exercise: the participant has to dodge the other pedestrians

### Measurements

The primary outcome measures were static balance, dynamic balance, cognition and dualtasking. Secondary outcomes were motivation and emotions felt during the program.

All pre-tests were carried out by 2 administrators. The post-tests were taken within a week after completion of the training program. Originally, our intention was to let a third administrator, who was blinded to the treatment, do these. However, due to circumstances (i.e., malfunctioning of the equipment and consequently insufficient time), most of the post-tests were done by all 3 administrators (i.e., all tests except for the MoCa and Tinetti).Prior to the pre-tests, to ensure standardization of the measurements, all administrators adjusted their way of testing to one another.It was also made sure that the same footwear and walking aids were used during both pre- and post-testing.

*Cognition*To screen for MCI, all subjects had to complete the MoCa first, as this test proved to be more sensitive than the Mini Mental State Examination (Daelemans, 2014).After the program, the MoCa was administered again to see if cognition had improved.

*Static Balance*To test the static balance, we used the Tinetti and the Free Acquisition test of the BioRescue. For this test, participants had to stand on the BioRescue with their feet in a 30° angle (i.e., heels closer together and toes further apart)(Lee, Lee,

&Park, 2014).They were not allowed to use a walking aid. For 20 seconds, participants had to move as little as possible, while the BioRescue measured the sway area ($mm^2$), sway length (cm) and sway speed (cm/s).

*Dynamic Balance*The dynamic balance was assessed with the Tinetti and the instrumented Timed Up and Go test (iTUG). For this test, 5 APDM-sensors were placed in a standardized manner around ankles, wrists and in front of the sternum to analyze movement of trunk, arms and legs during every phase of the test (http://www.apdm.com). After a demonstration of the test by the administrator, the iTUG was recorded twice. The mean score was the result.

*Dual Tasking*To evaluate the effect of the program on cognitive-motor dual tasking, the Free Acquisition and iTUG were combined with an extra visual task, as research shows that such tasks disturb gait performance more than tasks which involve external interfering factors (e.g., reaction time tasks) (Al-Yahya et al., 2011) For this visual task, 3 A4 papers with 6 different images (e.g., glasses, a key and traffic lights) in 6 different colors were used. The administrator named a color and the participant had to name the matching image within 5 seconds. To get familiarized with the task, we practiced it first while sitting. Afterwards, this dual task was repeated with the Free Acquisition and the iTUG(i.e., Free Acquisiton + DT and iTUG + DT), each with a different paper. The percentage of wrong answers was used as a result of dual task performance.

*Motivation* To evaluate the motivation during the exercise program, we used the Dutch version of the Intrinsic Motivation Inventory (IMI) (Ryan, 1982).The IMI consists of 37 questions, divided over 6 subscales (i.e., interest/enjoyment, perceived choice, perceived competence, pressure/ tension, value/usefulness, effort). It was filled out after the last training session by the intervention group.

*Emotions* To evaluate the experienced emotions during the training with the BioRescue, the Observed Emotions Rating Scale (OERS) was used (Lawton, Van Haitsma, &Klapper, 1996).For this, the intervention group was recorded on tape during a session in the fifth week of the program. The first 10 minutes of these recordings were screened for presence and duration of 5 affects (Pleasure, anger, anxiety/ fear, sadness, general alertness). Additionally, the participants of the intervention group who also received the standard physiotherapy treatment were recorded once during such a session to compare the 2 treatments.

**Ethical approval**

The study received ethical approval by the local ethical committee of Hasselt University and the regional ethical committee of medical research, UZ KU Leuven on 23/09/2015. The register number is B322201525648.

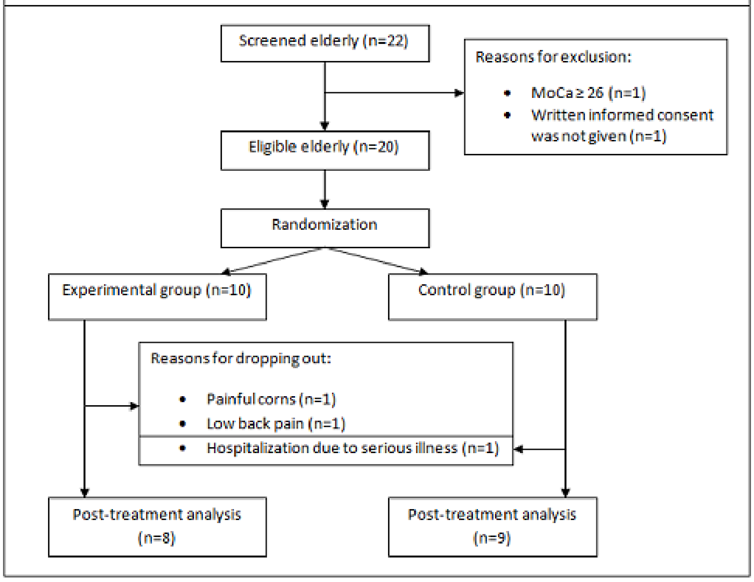
**Statistical analysis**

Statistical analysis was performed using JMP Pro 12.1.0 for Microsoft Windows 10 Home 64-bit. Due to the small sample size, we opted for non-parametric tests. The Wilcoxon signed-rank test was used to compare each variable within-group before and after the program. Differences between the groups were determined with the Mann-Whitney U test. The difference between pre- and post-tests was calculated to evaluate interaction. The level of significance was set at $p < 0.05$ for all statistical analyses.

## Results

### Participants

Table 1. Study flow chart




Of the 22 screened subjects, 20 were eligible for the study. They were randomized using a dice into the following groups: intervention (n=10) and control (n=10). Of the 10 participants in the intervention group, 2 had to discontinue their training due to medical conditions not related to the program, so their results were not analyzed. The 8 others were able to finish their 12 sessions without injuries or other inconveniece. Due to serious illness, 1 participant of the control group could not be retested, resulting in 17 subjects included for the analysis. Table 1 shows the study flow chart and table 2 the baseline characteristics of the 20 participants.

**Table 2. Patient Characteristics at Baseline**

| | Experimental Group (n=10) | Control Group (n=10) | P |
|---|---|---|---|
| Age (y) | 86.90 ± 5.63 | 87.50 ± 6.57 | 0.850 |
| Sex (M/F) | 2/8 | 5/5 | 0.160 |
| Length (cm) | 161.00 ± 7.00 | 164.00 ± 11.01 | 0.758 |
| Moca ( /30) | 17.70 ± 5.27 | 16.80 ± 5.77 | 0.761 |
| Tinetti ( /28) | 24.30 ± 4.74 | 21.60 ± 5.30 | 0.233 |
| Walking Aids (Y/N) | 4/6 | 6/4 | 0.371 |
| Additional PT (Y/N) | 2/8 | 6/4 | 0.068 |

Values are presented as mean ± SD.
After drop-out, P remained not significant for every variable.
Moca = Montreal Cognitive Assessment; M = male; F = female; Y = yes; N = no; PT = physiotherapy

### Measurements

Due to outliers found for all of the variables of the Free Acquisition, both during pre- and post-testing, we chose not to include the results as we feel this would not be a correct representation of the effect of the intervention on static balance. As for the other measurements, no significant differences were found during pre-testing, meaning both groups were similar at baseline.

There were no changes detected over time for both groups with regard to the MoCa and the Tinetti. Due to technical problems with the APDM-sensors, a significant part of the data of the iTUG (with and without visual dual task) was lost. When only 1 trial was missing, the data from the other trial was taken as the result. However, for some trials, all data was lost. The intervention group performed theiTUG significantly faster ($p=0.016$) after 6 weeks training with the BioRescue. The second part from the iTUG (i.e., from the turn up to and including the stand-to-sit transition) improved by almost a second ($p=0.016$), whereas the sit-to-stand transition did not improve. Also, a significant interaction effect ($p= 0.004$)of the duration of the last step before the turn was found, in favor of the intervention group.

All older adults were able to perform the visual task while sitting. However, difficulties were experienced when it was combined with the iTUG. The iTUG + DT proved to be very challenging, as a significant number of them forgot to sit down when they arrived back at the chair. For this reason, the total duration and the parameters from turn to sit of the iTUG + DT were not analyzed. The training did not seem to have any effect on the speed of execution of the iTUG + DT. The percentage of errors did not improve. We did find a tendency towards interaction ($p=0.090$) in favor of the intervention group, of the number of times the participant sat down without additional instructions when he reached the chair.Table 3 shows the results of the primary outcomes.

The IMI was filled out by the 8 participants of the intervention group who had finished their program. For a more detailed description of the results, we refer to table 4. The results show that the program was very interesting and pleasant to do. The participants felt like their performance of the different exercises was good to very good, which shows that the BioRescue is also suited for such a weak population. The participants all did their very best to finish the program. Not because they felt obliged, but because they thought it was useful for their concentration, memory and balance.

**Table 3. Changes over time within and between groups**

| **Parameters** | **Experimental Group (n=8)** | | **Control Group (n=9)** | | **Between groups** | | **interaction** |
|---|---|---|---|---|---|---|---|
| | **Pre** | **Post** | **Pre** | **Post** | **Pre** | **Post** | |
| **Moca ( /30)** | 17.50 ± 5.95 | 18.63 ± 6.99 | 16.33 ± 5.92 | 15.78 ± 6.61 | NS | NS | NS |
| **Tinetti** | | | | | | | |
| Total ( / 28) | 24.25 ± 5.20 | 24.75 ± 5.18 | 21.89 ± 5.53 | 21.22 ± 7.19 | NS | NS | NS |
| Static Balance ( / 16) | 13.50 ± 3.59 | 14.63 ± 3.11 | 12.89 ± 3.14 | 12.56 ± 4.75 | NS | NS | NS |
| Gait ( / 12) | 10.75 ± 1.75 | 10.12 ± 2.64 | 9.00 ± 3.04 | 8.67 ± 2.92 | NS | NS | NS |
| **iTUG** | | | | | | | |
| total duration (s) | 17.17 ± 8.99 | 15.75 ± 9.24* | 22.14 ± 13.84 | 20.06 ± 9.81 | NS | NS | NS |
| turn: duration (s) | 3.24 ± 1.87 | 4.24 ± 3.92 | 3.67 ± 1.26 | 3.74 ± 1.74 | NS | NS | NS |
| turn: number of steps | 5.86 ± 1.44 | 7.07 ± 3.88 | 7.06 ± 1.74 | 6.44 ± 2.05 | NS | NS | NS |
| turn: peak velocity (°/s) | 131.42 ± 52.83 | 129.64 ± 47.34 | 102.72 ± 39.38 | 114.39 ± 42.81 (<0.1) | NS | NS | NS |
| turn: step time (s) | 0.68 ± 0.25 | 0.64 ± 0.18 | 0.71 ± 0.44 | 0.70 ± 0.20 | NS | NS | NS |
| turn: step-time before turn (s) | 0.65 ± 0.22 | 0.54 ± 0.15* | 0.59 ± 0.09 | 0.62 ± 0.11 | NS | NS | * |
| sit to stand: duration (s) | 2.67 ± 1.01 | 2.63 ± 0.66 | 2.51 ± 0.67 | 2.62 ± 0.59 | NS | NS | NS |
| sit to stand: peak velocity (°/s) | 128.51 ± 83.62 | 103.32 ± 93.93 | 88.07 ± 34.40 | 98.28 ± 58.50 | NS | NS | NS |
| turn to sit: peak turn velocity (°/s) | 129.05 ± 48.46 | 145.85 ± 63.61 | 113.68 ± 56.86 | 114.32 ± 44.84 | NS | NS | NS |
| turn to sit: duration (s) | 5.31 ± 2.49 | 4.56 ± 1.97* | 6.40 ± 3.75 | 6.36 ± 3.34 | NS | NS | < 0.1 |
| **iTUG DT** | | | | | | | |
| total duration (s) | / | / | / | / | / | / | / |
| turn: duration (s) | 4.30 ± 3.26 | 4.85 ± 3.13 (<0.1) | 3.57 ± 1.25 | 4.46 ± 3.34 | NS | NS | NS |
| turn: number of steps | 6.20 ± 2.59 | 8.80 ± 2.80 (<0.1) | 6.67 ± 1.37 | 7.17 ± 2.21 | NS | NS | NS |
| turn: peak velocity (°/s) | 118.49 ± 58.64 | 110.00 ± 48.08 | 117.62 ± 39.11 | 110.95 ± 36.25 | NS | NS | NS |
| turn: step time (s) | 0.65 ± 0.20 | 0.61 ± 0.16 | 0.73 ± 0.23 | 0.68 ± 0.18 | NS | NS | NS |
| turn: step-time before turn (s) | 0.69 ± 0.27 | 0.56 ± 0.08 | 0.70 ± 0.28 | 0.63 ± 0.13 | NS | NS | NS |
| sit to stand: duration (s) | 2.71 ± 0.43 | 2.69 ± 1.35 | 2.55 ± 1.00 | 2.71 ± 1.00 | NS | NS | NS |
| sit to stand: peak velocity (°/s) | 103.06 ± 29.49 | 104.34 ± 73.24 | 91.26 ± 44.13 | 90.81 ± 24.98 | NS | NS | NS |
| turn to sit: peak turn velocity (°/s) | / | / | / | / | / | / | / |
| turn to sit: duration (s) | / | / | / | / | / | / | / |
| error rate (%) | 10.11 ± 15.02 | 13.96 ± 15.21 | 26.53 ± 21.91 | 31.40 ± 21.68 | < 0.1 | NS | NS |
| Sit down at arrival ( /2) | 1.13 ± 0.83 | 1.63 ± 0.74 | 1.33 ± 0.87 | 1.22 ± 0.83 | NS | NS | < 0.1 |

Values are presented as mean ± SD.
Moca = Montreal Cognitive Assessment; iTUG = instrumented Timed Up and Go; DT = dual task; < 0.1 = almost significant; NS = not significant; * = significant (p < 0.05)

| Table 4. Descriptive statistics for the Intrinsic Motivation Inventory | |
|---|---|
| **Subscale (items)** | **Score** |
| Interest-enjoyment (7) | 6.23 ± 0.36 |
| Perceived competence (6) | 5.48 ± 0.51 |
| Effort (5) | 6.23 ± 0.38 |
| Pressure-tension (5) | 2.18 ± 1.13 |
| Perceived choice (7) | 6.63 ± 0.34 |
| Value-usefulness (4) | 6.38 ± 0.76 |

Values are presented as mean ± SD
The mean represents a score on a 7-point Likert scale, ranking from strongly disagree (=0) to strongly agree (=7)

The results of the OERS are shown in table 5. Overall, we see that sadness, anger and anxiety were almost never experienced during the training with the BioRescue. Even when these emotions did show, they were just small reactions to the failure of an exercise (e.g., some participants were a bit disappointed or a little angry with themselves as an exercise failed because they knew they could have done better).The participants were very alert during the exercises as they wanted to perform as well as possible. For most of them, it was a pleasant experience to train with the BioRescue, especially compared to the standard physiotherapy in the residential care center (table 5A and 5B).

**Table 5. Observed Emotions Rating Scale (OERS)**

| | Never | < 16" | 16-59" | 1-5' | > 5' |
|---|---|---|---|---|---|
| **A** | | | | | |
| Pleasure | | O | X | | |
| Anger | O | X | | | |
| Anxiety/ Fear | OX | | | | |
| Sadness | OX | | | | |
| General alertness | | | | OX | |
| **B** | | | | | |
| Pleasure | O | | | X | |
| Anger | OX | | | | |
| Anxiety/ Fear | OX | | | | |
| Sadness | OX | | | | |
| General alertness | | | | | OX |
| **C** | | | | | |
| Pleasure | | 1 | 4 | 3 | |
| Anger | 5 | 3 | | | |
| Anxiety/ Fear | 5 | 3 | | | |
| Sadness | 8 | | | | |
| General alertness | | | 1 | 6 | 1 |

5A and 5B represent the scores of the 2 participants who trained with the BioRescue (= X) and received additional physiotherapy (= O)
5C shows all 8 participants who trained with the BioRescue

**Discussion**

The present study was conducted to examinethe influence of cognitive-motor dual task training with the BioRescue on static balance and cognition in institutionalized older adults, and whether there is a carry-over effect to dynamic balance and cognitive-motor dual tasks during walking.

We have shown that training with the BioRescuehas no effect on cognition, static balance and the performance of dual tasks compared toa control group who received no additional training. However, it has a significant effect on dynamic balance during walking. For example, the total duration and turn to sit durationduring theiTUG without dual task, measured with APDM sensors, improved only in the intervention group.This result shows that the intervention group has developed an improved ability during transfers (i.e., turning and sitting down) and that they can better control their body movements within the base of support, in contrast to the controls. In other words, the ability to move their center of pressure within the limits of stability is better. Also, the therapy ensures enjoyment,which is very important forolder adults who live in a residential care center where they receive only little facility activities (Buettner& Fitzsimmons, 2003). It could improve the patient compliance as a similar exergame training program has shown to do so in patients with multiple sclerosis (Kramer, Dettmers, & Gruber, 2014).

Even though the number of participants included for the present study is low, the sample size is comparable to the one study that investigated the effect of the BioRescue as a means of intervention (Choi et al., 2015). However, the resultsof Choi et al**.** are inconsistent with those of the present study. They show, among other things, a significant improvement of cognition and static balance between pre- and post-measurement for the BioRescue training. There are 2 possible explanations for these differences. The first is the patient population. Choi et al. worked with subacute stroke patients, while we studied institutionalized older adults, who were on average 22 years older. Even though there is evidence that cognition and static balance can improve in such an old population (Bherer, 2015), we did not find an effect in our study.A second possible explanation is the training dose. In the study of Choi et al. the training dosage was 3 to 4 times larger as in our study. Each patient trained 30 minutes with the BioRescue and received an additional 30 minutes conventional therapy 5 days a week, for 4 weeks. In our study, the participants trained only

2 days per week with the BioRescue and this for 6 weeks with anincreasing exercise duration up to 30 minutes.

The fact that the iTUG improved after training with the BioRescue, is in line with the results of a recent review that showed significant improvements with the Wii Fit in various balance tests (Goble et al., 2014). Our study is different as it has a higher level of evidence (e.g., randomization) than most of the included studies in that review. In addition, our patient population is much older. Even though we used a different training tool, we chose to follow the guideline given by Goble et al. regarding the training dose for the Wii Fit. They recommended that the optimal training dose for future studies should be 12 sessions of 30 minutes per session. Another study also showed a significant effect on balance, functional walking and quality of life after 6 weeks of virtual reality gaming using the Xbox KinectTM device with a total intervention time of 900 minutes (Karahan et al., 2015). In our study, the total training duration with the BioRescue equaled 300 minutes. We expect that this relatively small training dose is the reason why we found so few effects on the different outcome measures. It may well be that a larger training dose would have led to more results (although this would probably not be case for the Tinetti given the high baseline scores and the ceiling effect). This larger training dose should be achieved by increasing the number of sessions rather than the session duration, as we feel this would not be feasible for such a population.

There are some limitations to note in our semi-blinded study. Due to the small number of subjects and the short total intervention time, we cannot generalize our results to institutionalized older adults. Furthermore, some measurements at baseline were carried out on different days (e.g., for most participants the iTUGand iTUG + DT were administered on different days). Also, during post-testing we did not account for the time of day when the pre-tests were done (i.e., it is likely that some participants were pre-tested in the morning and 6 weeks later in the afternoon). We must keep in mind that physical abilities, mental abilities and fatigue of institutionalized older adults can vary from day to day, even from hour to hour(Widerstrom-Noga& Finlayson, 2010). So, intra-individual variability could have had an influence on the test performances and the results.A fourth limitation is the environmental factor that may have had an impact on the results, as some tests were recorded in a noisy environment, while other tests were conducted in the room of the participant. So, the administration of the tests could be performed in a more standardized manner.A fifth limitation is that the results of the BioRescue regarding the static balance were not included. We detected outliers for every variable measured by the Free Acquisition, and this for different participants. Choi et al. (2014) already suggested that these posturography measures are more sensitive to change than those of other tests. However, we chose not to include the results as the psychometric properties of the BioRescue have not been established to date (as opposed to those of the Wii Fit (Clark et al., 2010)).Finally, due to technical problems with the APDM sensors, a large part of the results from the iTUGand iTUG + DT were not successfully recorded. This had a major impact on our results as there was data missing from up to 6 participants for some parameters (mainly from the iTUG+ DT).

Besides limitations, there are also strengthsrelated to our study. The participants were randomized to one of the 2 groups. The two most subjective tests (i,e,. the MoCa and Tinetti were more subjective than the iTUG and Free Acquisition as the latter two were computerized) wereadministered by a blinded assessor. Further, we have taken into account the footwear and the walking aid of each participant individually (i.e., the same footwear and walking aids were used during pre- and post-testing).Finally, to ensure standardization, all tests were discussed with each other before the first administration.

Future studies should include a larger number of participants and a longer training duration to see if balance, cognition and dual task performance during walking effectively improve by training with the BioRescue.Also, other balance tests should be used as there are no psychometric properties of the Free Acquisition to date. Furthermore, the Tinetti is limited by its ceiling effect. Finally, afollow-up period is recommended to determine to which extent improvements are retained over time, or possibly, to which extent the overall decline is slowed down.

## Conclusion

The results of this study suggest that the dynamic balance of institutionalized elderly improves by training with the BioRescue. It is a fun alternative exercise tool, well-suited for this population. More studies are needed to see if cognition and dual task performance improve as well.

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**Effects of Cognitive-Motor Dual Task Training with the BioRescue Force Platform on Cognition, Balance and Dual Task Performance in Institutionalized Older Adults**

Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
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