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Feasibility of Strength-Balance Training Extended with Computer Game Dancing in Older People; Does it Affect Dual Task Costs of Walking?

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Abstract

Background: It is suggested that one of the reasons for the lack of effect in fall prevention programs is insufficient attention given to cognitive functions in the design of interventions. New treatments have to be piloted to test whether they are feasible and effective. The aim of this pilot study was to elucidate the feasibility and efficacy of an assisted living-based, twelve weeks combined physical-computer-game-training program for older people to inform a future Phase III trial. Secondary aim was elucidating the effects of the training program on brain associated spatial and temporal characteristics of gait.

Materials and methods: We investigated the effects of a program with computer game dancing against usual care physical interventions in Swiss assisted living facilities. A controlled clinical trial experimental design was employed whereby participants in a facility were either allocated to 12 weeks usual care physical training (control group) or to 12 weeks physical training with integrated computer game dancing (experimental group). Main outcome measures were adherence rates, relative dual task costs of walking, and falls efficacy.

Results: Adherence rate of the physical-computer-game-training was excellent with 96%. Results indicate a positive effect of the computer game dancing program on relative dual task costs of walking. The program significantly lowered the fear of falling.

Conclusions: The findings from this pilot study suggests that a multicentre randomized clinical trial comparing usual care with physical-computer-game-training in older people in assisted living facilities is feasible. Pilot studies can improve the design of larger trials. A training programme with computer game dancing affects brain related walking functions, as opposed to usual care that showed no such effect.

Keywords: Strength; Balance; Active gaming; Training; Dual task costs; Gait

Introduction

Even in the absence of overt pathology, motor functioning [cf. International Classification of Functioning (ICF) by the World Health Organisation, Geneva (see http://www.who.int/classification/icf)] can deteriorate, as is illustrated by the incidence and impact of falls in aging populations [1]. Falls are amongst the most common reasons for medical intervention in older people and their occurrence might initiate a vicious circle that causes fear of falling, nursing home admittance and loss of independence [2]. Falls among older adult populations often occur during walking, and gait dysfunction is included among the many risk factors for falls [3,4].

A systematic review and meta-analysis investigating exercise for the prevention of falls states that physical training programs should especially focus on traditional components of exercise programs such as muscle strength and balance [5]. However, there is a wide range in reported effects on fall risk reduction with some well-designed large-scale controlled studies reporting an only 6% reduction of falls among community dwelling older adults [6]. Some other interventions even showed to have no significant effect [7-9]. It is suggested that one of the reasons for the lack of effect is insufficient attention given to cognitive functions in the design of interventions [10].

Until recently, gait was considered an automated motor activity requiring minimal higher-level cognitive input [11]. Maintenance of postural control during activities of daily living does not usually place high demands on attention resources of healthy young or middle-aged people. In contrast, however, when sensory or motor deficits occur due to natural aging processes, the complex generation of movement may have to be restructured, and movements may then be controlled and performed at an associative or a cognitive stage. When the benefits from the movement automation are lost, the postural control of aged people can be expected to be more vulnerable to cognitive distractions and additional tasks [12]. The link between cognition, gait, and the potential for falls is indeed being increasingly recognized [13], and is for example reflected in a special issue in the Journal of Gerontology: Biological Sciences and Medical Sciences (63A (12), 2008).

Although more traditional training programmes are able to increase muscle strength and improve balance and, therefore, positively influence some measures of gait they often do not effect on spatial and temporal characteristics of gait that are associated with distinct brain networks, e.g. gait assessed under dual task conditions [14,15]. Because these gait characteristics are associated with distinct brain networks it can be hypothesised that addressing neuronal losses in these networks may represent an important strategy to prevent mobility disability in older adults [10,16]. This would mean for example that physiotherapeutic interventions should be designed

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that, as previous research suggests, specifically focus on executive functioning processes [17] as training parameters, and especially on divided attention [18]. Intervention settings should thereby include enriched environments that provide physical activities with decision-making opportunities because these are believed to be able to facilitate the development of both motor performance and brain functions [19,20]. Unclear, however, is whether these improvements translate to a more behavioural level, e.g. to gait under dual task test conditions.

New treatments usually have to go through a series of phases to test whether they are safe and effective [21]. The aim of this pilot study was to perform a phase II trial according the model for complex interventions advocated by the British Medical Research Council [22] to test the effects of a traditional strength and balance training program that also included a dance simulation computer game in a group of elderly people. The study aimed to (1) develop an exercise intervention based on principles of exercise physiology and motor learning and to deliver it to older individuals, (2) evaluate the feasibility of the intervention and the ability to recruit and retain elderly subjects, and (3) assess whether the treatment had some effect on relative dual task costs of walking.

Methods

Participants

A sample of 35 older people living in assisted living facilities volunteered to take part in the study. The project was given ethical approval by the Canton Zurich's research ethical committee (EK-Nr. 02/2009 (ETH)), and all volunteers provided written informed consent to take part in the study. The trial was registered under ISRCTN05545178.
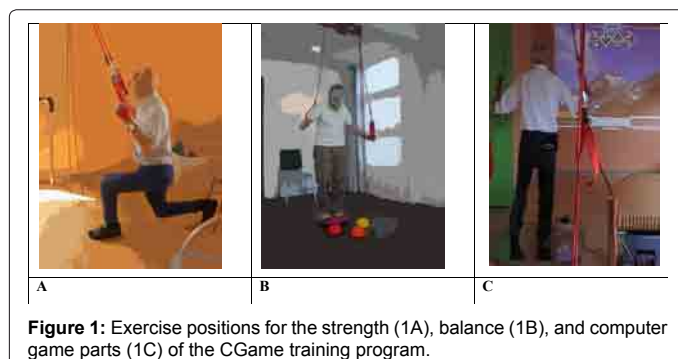
Study design and procedures

Procedures: A controlled clinical trial was conducted where participants were recruited from three senior citizens assisted living facilities (Trotte, Stampfenbach & Oberstrass) in Zurich, Switzerland. Inclusion criteria were residential status, age over 65 years, signed informed consent statement, and the ability to walk 6 m and stand upright for at least 5 minutes. Participants were excluded if they had severe cognitive impairment (Mini-Mental State Examination below 22 points [23]), rapidly progressive or terminal illness, acute illness or unstable chronic illness, and had impaired vision that prevented them to watch a wall screen projection. All eligible residents were invited to attend an information session in which the content of the intervention and the study design were explained. Participants who attended the information session and agreed to participate in the study were allocated into the control group usual care (UC; residents of Stampfenbach) and the exercise-game group (EGame; residents of Trotte & Oberstrass).

Computer game exercise program: Participants allocated to EGame underwent a regimen of twice weekly progressive resistance training of the core and lower extremities muscle groups, progressive postural balance training and progressive computer game dancing for twelve weeks.

The muscle groups for the strength training were chosen because of their importance in functional activities [24,25], and were trained in standing position. During standing participants were secured with ropes they could hold on to (Redcord AS, NO-4920 Staubo, Norway). The ropes were fixated on the ceiling or on frames (Figure 1A). The focus of exercise was on functional activities of daily living such as walking, standing up from a chair, sitting down or stair climbing. The aim for each exercise was to perform two sets of 15 repetitions. To maintain the intensity of the stimulus during training, the load was increased at each training session, as tolerated by the participants, with the help of sand filled cuffs worn on the ankle or waist (Fig. 1A). The increase of load was controlled using a Borg exercise-intensity scale for verbally assessing proper intensity for each exercise during training [26,27].

Balance exercises were performed with a maximum of four individuals training at the same time. All exercises could be adjusted to the individual mobility level. The intensity was gradually increased through applying previously formulated recommendations: participants performed 1-2 sets of 3-5 different exercises emphasizing dynamic postures with progressive difficulty as tolerated [28] (Fig. 1B).

Stimuli in the computerized dancing game were five dance songs with no lyrics (90—130 beats per minute [BPM]; mean = 115 BPM). Songs were edited into 30-s segments and individualized files comprising dance steps synchronized to the music were created using the Dancing Monkeys MATLAB script [29]. Each 30-s of a song segment was triplicated. This resulted in five different songs stimuli, each song 1 min 30 s in length. Each song, thus, contained 3 identical repeats of a song and step-sequence pairing. Songs were then paired with visual cues instructing the participant how to dance to that track. A scrolling display of arrows moving upwards across the screen cued each move, and the participant had to make the indicated step when the arrows reached the top of the screen (Fig.1C). The symbolic arrow sequences were generated for all five tracks. StepMania (www.stepmania.com), a freeware program similar to the video game Dance Dance Revolution (Konami Digital Entertainment, Inc., Redwood City, CA), was used for step file modification and training. Participants performed dance training on a dance pad connected by USB to a desktop computer (Figure 2) and with projection of the symbolic arrows on a wall with a beamer. There was a one minute break between dances. Electronic sensors in the dance pad detected

Figure 1: Exercise positions for the strength (1A), balance (1B), and computer game parts (1C) of the CGame training program.

Figure 2: The dance pad used in the training with the computer game dancing.

position and timing information that was then used to provide participants with real-time visual feedback.

A room in every assisted living facility that was easily accessible to the older people was dedicated for the set-up of the training equipment. All classes started with 5-10 minutes of warm-up activities, followed by 10-15 minutes of strength training exercises, 10-15 minutes of balance skills training, 1.5-7.5 minutes of computer game dancing, and 5-10 minutes of cooling-down activities. Training sessions lasted 45-60 minutes and were separated by at least one day of rest. All exercise sessions were supervised individually by two qualified exercise trainers.

Usual care: All participants in UCare underwent a regimen of once a week 30 to 45 minutes of training that was offered in the assisted living facility under the guidance of qualified leaders in "Sports for Seniors" (Seniorensportleiter). This is a qualification received from the Swiss Federal Office of Sport (BASPO; www.baspo.admin.ch) and acknowledges that the exercise leader has been educated and is qualified to develop and implement health enhancing physical activity programs for adult populations. Participants in UCare were performing exercises in a group while mainly seated on a chair. The seats were aligned circularly. The chairs were used to secure participants for occasional exercises that were performed in standing. Every training session was partitioned in three parts; warm-up, strength & balance, and cool-down. The 5-10 minutes warming-up activities were flexibility exercises that were sometimes combined with cognitive activities (e.g., memorizing animal names whilst throwing each other a ball). The strength and balance part took approximately 20-25 minutes and focused on muscle exercises for the arms and the lower extremities (1-2 sets per exercise were performed with a maximum of eight repetitions per set). The 5-10 minutes cool-down phase consisted of relaxation exercises. The program can be considered as representative for the usual care offered in assisted living facilities [30]. A room in every facility that was easily accessible to the older people was dedicated for the set-up of the training.

Criteria for success: An important part of a pilot study is to state the criteria for success [21]. The criteria for success of this pilot was based on the primary feasibility objective (adherence to the exercise plan) and set according methodological standards for being adherent to training. A 70% attendance rate for the training sessions was set as the definition for being adherent to the training program [31]. There were a total of 24 training sessions scheduled for each individual in EGame.

Measures

Gait assessment: Gait was measured with a GAITRite instrumented walkway (CIR Systems, USA) before and after twelve weeks of training. The GAITRite walkway was extended with a 2.5 meter carpet at the end and beginning of the active area to eliminate the effect of acceleration or deceleration and allow for steady state gait assessment. The validity and reliability of the GAITRite system has been well established [32-35].

Each subject was evaluated individually and tested following a standard protocol. Subjects were tested under a single-task condition (preferred walking) and under a dual-task condition, i.e., preferred walking whilst counting backwards in sevens. The purpose of this procedure was to quantify subjects' ability for executing two tasks concurrently, a common method used to quantify the automaticity of movements [36]. The participants were tested within a single session that lasted about 20 minutes. First, instructions of the cognitive task

were given, followed by a full performance of the cognitive task while seated. Counting backwards in steps of 7's was used as additional task. The starting number was selected at random from a range of 200-250. Thereafter, the participants were instructed to position themselves at the beginning of the walkway and were asked to walk with their comfortable speed without assistive device over the carpet. The temporal-spatial parameters recorded were: velocity (cm/s), cadence (steps/min), stride time (s), step time (s), and step length (cm). Thereafter the participants were asked to perform the same walking task while counting.

The instructions for each test condition were as follows: (1) "Walk with your comfortable speed right to the end of the walkway." (2) "Walk with your comfortable speed right to the end of the walkway counting backwards from [random number between 200-250]." During the counting task subjects had to count aloud while walking otherwise the trial would be recorded as failure. To obtain representative samples, each test condition was repeated three successful times and the means of the three successful trials were used for further data analysis.
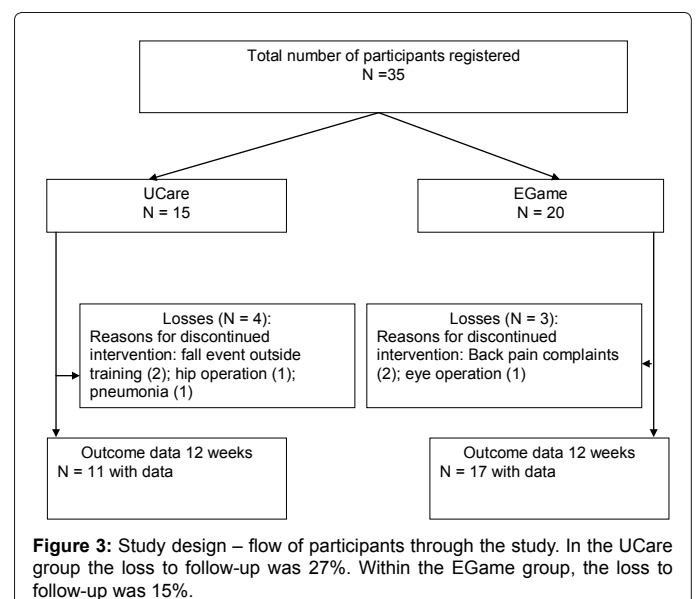
We calculated for each subject and task the relative dual task costs (DTC) of walking, as percentage of loss relative to the single-task walking performance, according to the formula DTC [%] = 100 * (single-task score - dual-task score)/single-task score [36].

Physical performance (ETGUG): The Extended Timed Get-up-and-Go (ETGUG) test measures the overall time to complete a series of functionally important tasks. The ETGUG test is a sensitive and objective assessment of physical function [37]. Older people that need more than 22 seconds for test performance can be regarded "at risk" for falls [37].

Fear of falling: The Falls Efficacy Scale International (FES-I) questionnaire was used as a measure of 'concern' about falling to determine the transfer effects of training to activities of daily living. This scale assesses both easy and difficult physical activities and social activities with a scale of: 1 = not at all concerned, 2 = somewhat concerned, 3 = fairly concerned, 4 = very concerned. The FES-I has excellent internal and test–retest reliability [38].

Data analysis

Data analysis: All statistical procedures were conducted with

Figure 3: Study design – flow of participants through the study. In the UCare group the loss to follow-up was 27%. Within the EGame group, the loss to follow-up was 15%.

the SPSS (version 17.0) software program (SPSS Inc. Chicago, IL, USA). All available data were analysed by initial group assignment. A comparison of the dichotomous variables (male/female gender; walking aids/no-walking aids) was undertaken using the chi squared test. Demographic characteristics were compared with Student's *t*-tests. A repeated-measures general linear model was used to test changes in dual task costs (DTC) of walking from pre- to posttest for the EGame group relative to the UCare group (Time * Group interaction) and for the total sample (main effect of time). Student's t-tests for paired comparisons were used for EGame and UCare separately to assess the significance of changes over time within each group. Results were considered significant at $p < 0.05$. The magnitude of effects (i.e. effect size statistics) [39] were calculated for the pre-test post-test parameters per group with the G*power analysis program [40] and were expressed as Cohen's d. For Cohen's d an effect size of 0.2 is considered a "small" effect, around 0.5 a "medium" effect and 0.8 and above, a "large" effect [41].

Results

The progress of participants through the various stages of the study is presented in Figure 3. Twenty-eight older people successfully completed the program and performed follow-up measurements. Seven individuals discontinued training during the study period. Four individuals in the UCare group stopped because of sustaining a fall event outside the training (n=2), because of a scheduled hip operation (n=1) and because of pneumonia (n=1). Three subjects in the EGame group stopped training because of back pain complaints in the second week (n=2) and because of an eye operation that prevented continuation of training in the third week (n=1). Thus, in UCare the loss to follow-up was 27%. In EGame, the loss to follow-up was 15%. The resulting study compliance for both groups is shown in Figure 3.

Training compliance for EGame was 96% [100/(24 * Mean amount of trainings visited)]. Eight individuals visited al 24 scheduled trainings. One individual reached the 70% minimum amount of

Group	UCare n = 11	CGame n = 17	*p*-value
Age (years) Mean ±SD	85.2 ± 5.5	86.8 ± 8.1	.56*
Gender ♂♂/♀♀	3/8	3/14	.55**
Heights (meters) Mean ± SD	1.62 ± 0.06	1.60 ± 0.07	.36*
Mass (kg) Mean ± SD	62.1 ± 10.7	61.8 ± 8.9	.93*
BMI (kg.m-2) Mean ± SD	23.5 ± 3.3	24.2 ± 3.4	.60*
Mini Mental Status† Mean ± SD	26 ± 2.9	27.6 ± 2.8	.51*
Falls Efficacy Scale-International (FES-I)†† Mean ± SD	25.6 ± 6.1	24.9 ± 4.5	.71*
Amount of daily medication Mean ± SD	4.8 ± 2.8	5.8 ± 2.8	.29*
Amount of individuals using walking aids (%)	18% (2 individuals with walking stick)	17.6% (one individual with a walking stick, two with wheeled walker)	.97**

† Minimum score = 0, maximum score = 30; higher scores indicate better functioning; †† Minimum score: 16, maximum score: 64; the higher the score the less confident the person is in performing both easy and difficult physical and social activities. BMI = body mass index.
* *t* test; **Chi squared test.
Table 1: A summary description of the demographic variables of the groups.

Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	*p*; [95% CI]	*d*
UCare (n = 11)				
DTC velocity (%)	19.9 ± 10.6	23.7 ± 16.1	.248; [-10.7 – 3.1]	-0.33
DTC cadence (%)	11.7 ± 6.7	11.5 ± 8	.929; [-3.4 – 3.7]	0.02
DTC stride time (%)	13.8 ± 8.9	13.7 ± 10.7	.936; [-4.6 – 4.3]	0.01
DTC step time (%)	14.6 ± 8.5	14.9 ±11.3	.878; [-5 - 5.7]	-0.02
DTC step length (%)	7 ± 9.7	10.6 ± 8.3	.201; [-9.6 - 2.3]	-0.41
CGame (n = 17)				
DTC velocity (%)	22 ± 12.1	14.4 ± 8.6	.006; [2.5 - 12.5]	0.66
DTC cadence (%)	15.8 ± 13.7	10 ± 7.3	.06; [-.3 - 11.9]	0.50
DTC stride time (%)	20.7 ± 14.5	11.6 ± 10	.004; [-14.9 - -3.4]	0.72
DTC step time (%)	16.2 ± 16	11.7 ± 10	.362; [-14.4 - 5.6]	0.33
DTC step length (%)	11.1 ± 8.3	5.5± 5.4	.001; [2.7 – 8.4]	0.63

pre, pre-test; post, post-test.
p-value calculated from paired *t*-tests; 95% CI = 95% confidence interval; *d* = Cohen's d effect size.
Table 2: Relative dual task costs (%) for the Gait parameters for both training groups before and after 12 weeks training.

20 trainings. Reasons for not visiting training sessions were health problems or concurrently scheduled social activities that were given priority over training. Table 1 presents the demographics for the remaining older people per training group. The groups were similar at baseline for all measures.

In this pilot study, the primary and secondary outcomes were analyzed both on the entire cohort of enrolled participants and according to the 2 treatment groups.

Effect of exercise on the dual task costs of walking

There was no significant time effect, albeit a trend, (pre- to posttest decrease) in DTC of walking velocity (cm/s) for the whole group, $F(1, 26) = 3.66$, $p=.067$, and a significant interaction, $F(1,26) = 6.25$, $p=.019$. This indicates that the two groups were developing differently over time in favor of EGame. EGame showed a decrease in DTC of walking velocity against no change for U Care (Table 2).

There was no significant time effect in DTC of cadence (steps/min), $F(1, 26) = 2.45$, $p=.13$, nor a significant interaction, $F(1,26) = 2.22$, $p=.148$, indicating no differences between UCare and CGame for this parameter at follow-up.

There was a significant time effect in DTC of stride time (s), $F(1, 26) = 6.13$, $p=.02$, and a significant interaction, $F(1,26) = 5.7$, $p=.025$. This indicates that the whole group is improving. However, this is because of the large improvements in the EGame group. UCare has unchanged values for this parameter (Table 2).

There was no significant time effect in DTC of step time (s), $F(1, 26) = 0.43$, $p=.52$, nor a significant interaction, $F(1,26) = 0.6$, $p=.445$, indicating comparable development over time for both groups.

There was no significant time effect in DTC of step length (cm), $F(1, 26) = 0.49$, $p=.49$, but a significant interaction, $F(1,26) = 11.51$, $p=.002$, indicating that the groups were developing differently over time in favor of EGame.

Table 2 summarizes all measures at baseline and after 12 weeks of training for each group together with the corresponding *t*-test *p*-values and Cohen's *d* effect size. UCare showed no changes in any DTC parameter. EGame exhibited decreases of DTC for velocity, stride time, and step length.

Effect of exercise on the ETGUG

There was no significant time effect for the ETGUG test, $F(1, 26) = 2.91$, $p=.1$, and no significant interaction, $F(1,26) = 0.23$, $p=.639$, indicating a comparable development for both groups. Both groups remained unchanged on the series of functionally important tasks at the end of training.

The *t*-test for paired comparisons for EGame and UCare showed that EGame remained stable in performance (from 27.3 ± 7.7 seconds to 26.3 ± 8.3 seconds from pre- to post-training ($p = .312$)). UCare remained also stable (from 24.9 ± 4.8 to 23 ± 5.5 seconds ($p = .227$)).

Effect of exercise on fear of falling

There was no significant time effect for the FES-I, $F(1, 26) = 2.6$, $p=.119$, nor a significant interaction, $F(1,26) = 2.95$, $p=.098$.

The *t*-test for paired comparisons for EGame and UCare showed that EGame changed from 24.9 ± 4.5 points to 21.9 ± 5.2 points from pre- to post-training ($p = .005$), whereas UCare remained stable from 25.6 ± 6.1 to 25.7 ± 5.5 points in the same time period ($p = .959$). This indicates that the 'concern' about falling decreased in the EGame.

Discussion

The present pilot study aimed to develop and test an exercise intervention based on principles of exercise physiology and motor learning and to deliver it to individuals living in an assisted living facility. The main focus was to evaluate the feasibility of the intervention and the ability to recruit and retain elderly subjects, and to assess the effects of the intervention.

We demonstrated the feasibility of acquiring acceptable compliance rates for older people in assisted living facilities randomized in this trial to the experimental training arm that included strength, balance and computerized dance game components. Our target of 70% compliance for this 12-weeks pilot project was attained. No individuals were to be considered non-compliant for the EGame training. One individual was, with 70% attendance rate, getting near the criterion to be considered non-compliant. Compliance with the exercise intervention and retesting was excellent. Seventeen of initially twenty individuals completed the training and retest data were obtained from all seventeen individuals. We also learned that it is feasible to obtain records of usual care physical training interventions and to characterize preventive rehabilitation programs in assisted living facilities by type of exercise, intensity, duration and frequency.

This pilot study, thus, provided useful information about the feasibility of the experimental intervention. Our subjects tolerated the twice weekly intervention also when it was complemented with a computerized dance game. They were able to progress in intensity and duration of exercises. Furthermore, our experience suggests that our computerized rehabilitation component was of sufficient duration and/or intensity to effect on dual task costs of walking. The amount of training that we set for the EGame of twice a week for 45-60 minutes was both feasible and acceptable to our experimental individuals. Thus, we believe that in future studies we are able to adopt the same intensity and duration for a future Phase III trial training study where the experimental program should be compared to other forms of training.

The aim of this study was to assess and compare the effects of a physical training program that included a dance simulation computer game against usual care for older people in assisted living facilities on relative dual tasking costs of walking. This study showed that older people who were training physically, in combination with a dance game that required decision making, showed significant decreases in the relative DTC of walking. These walking parameters did not change in individuals that exercised under usual care.

The possibility of improving gait while performing dual tasks has not been well-studied in general [11] and this study is one of the first that shows an effect on DTC related walking through training that includes a computerized game. We used a computerized dancing game as dual task training where subjects were expected to observe the environment for drifting arrows and were at the same time initiating dance steps. An important reason for the selection of the computerized exercise component were the findings of a systematic review on three different forms of cognitive and cognitive-motor interventions to improve physical functions that indicated consistent positive findings for computerized interventions as opposed to no or contradictory findings for isolated cognitive and dual-task training interventions respectively [20].

Finding activities that continue to challenge an older person as he/she progresses through a rehabilitative/reconditioning program has importance from a motor learning perspective. The rationale to use our dancing program also stems from an observation of Bock (2008) who observed that especially the motor task of walking in combination with concurrent visual observation may be held responsible for disturbed gait and falls during daily activities in old age [42]. We, therefore, hypothesised that DTC of walking will especially be influenced when combinations of motor activities (stepping) and visual observation (arrow cues) are used in prevention and rehabilitation programs for seniors.

We can only speculate about the underlying mechanisms that are able to explain our findings. It could be that increased coordination during inter-limb coupling tasks, that was needed to perform the dancing game, activates important regions in the brain. Previous research has shown inter-limb coupling tasks to be positively correlated with activation of the brain's motor regions as well as higher-level sensorimotor and prefrontal cortical regions in older adults [43,44] and, through the use of a dance simulation computer game, in young adults [45]. Future research with older individuals that also includes assessments on brain function level should clarify and substantiate this assumption. Game-like interventions have the potential to improve cognitive function in older adults, including attention and executive functions [46,47] and seem to be one of the most promising cognitive-motor interventions [20].

An aspect of this study that should be viewed with caution is the differing frequency of training for both groups. The EGame group trained 45-60 minutes twice weekly during twelve weeks and the UCare group performed exercises once weekly for 30 to 45 minutes for the same time period. It was, thus, expected that we would observe a difference in development between the two groups, because it seemed obvious that the difference in training frequency would be the explanatory factor for the observed differences. We did not expect an effect for usual care because it did not comply with training recommendations to improve gait and to prevent falls in elderly [5]. Future studies should, therefore, compare training groups that achieve similar amounts of strength and balance training, where one group receives additional game like training and the other group a placebo. In this case we expect, however, only marginal effects on dual task costs of walking from the more conventional types of training since the results of previous studies with similar groups, that were performing progressive machine driven resistance training

complemented with functional balance exercises (twice weekly during twelve weeks), revealed no changes in the relative DTC of walking [14,15].

Both groups remained unchanged on the test of functionally important tasks at the end of training. This might be indicative of the fact that the focus of strength training in both groups was divided between core and lower extremity muscle groups. The functional tasks tested mainly depend on the lower extremity muscles and, as a consequence of the divided focus of muscle training, these might have been trained with intensities that were too low. We can also not exclude floor effects for the ETGUG test since our adult population performed relative well compared to previously reported reference values [37]. Factors that may influence the ability of training induced gains in strength or balance abilities that affect physical performance are the initial level of frailty or responsiveness of outcome measures [24]. Future research in larger samples should shed a light on these factors.

The intervention indicated that concern about falling decreased in the EGame group as shown through significant changes in the FES-I and, thus, our findings suggest that the level of fear to perform functional indoor and outdoor activities can be influenced with a combination of strength, balance and computer game dancing training that is performed in standing position. The level of fear remained unaltered in the UCare group that performed many exercises in sitting. Because functional indoor and outdoor activities are in majority performed in standing or walking position it only seems logic that a training that uses these positions is more advantageous compared to a training that is performed in sitting. This finding suggests that the principles of specificity of training may be important in older adults as previously stipulated [48].

Limitations of the study

Although we did not find differences between our training groups related to their demographic characteristics we did not properly randomize our volunteers. This is one of the limitations of this study that should be acknowledged in future Phase III studies where training groups should be formed on the basis of randomization procedures. We implemented a strict as possible study design under the conditions at hand; the residents of each residency had to follow the same exercise program for practical and organisational reasons, to control for threats to validity. A next step would be to replicate the findings in a new exercise group of older people where randomisation procedures are used as an additional control procedure.

Several other limitations of this study should be also mentioned. An obvious limitation is the rather small sample size. This pilot study, therefore, only reveals first estimates for these measures for a consecutive Phase III study [22]. This is an inherent property of a pilot study and our findings warrant further research in a larger Phase III main study that includes a larger sample.

One of the underlying assumptions in this research was that game-like interventions have the potential to improve cognitive function in older adults, including attention and executive functions [46], and that improvements in these functions translate to walking. We can only speculate, however, about the effects of the computer game dance training on cognitive functions since we did not explicitly measure these. Future studies with similar populations should, therefore, include measures of cognitive function, e.g., executive control function, to substantiate our assumption and findings.

Conclusions

We conclude that pilot studies with explicit feasibility objectives and success criteria are important foundation steps in preparing for large trials [21] and for development of Physiotherapy research programs. Ongoing formal review of the multifaceted issues inherent in the design and conduct of pilot studies can provide invaluable feasibility and scientific data for therapists willing to perform clinical trials [49] and may also be highly relevant for furthering the development of the Physiotherapy profession. In this pilot EGame affects the relative dual task of walking compared to usual care training that showed to have no effect. The findings provide support for the proposition that computer game dancing affects brain function related aspects of walking. This study encourages the further development of this intervention, preferably with a randomized control design.

Contributors

Authors' contributions

EDB, the guarantor, conceived and initiated the study, participated in its design, monitored progression and decided on the analytical strategy. He drafted the first version of the manuscript and critically revised the manuscript for its content. AR & MD carried out the study, and critically revised the manuscript for its content. KM critically revised the manuscript for its content. All authors read and approved the final manuscript.

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