ICT Solutions to Develop an Effective Motor and Cognitive Training to Reduce Risk of Falls
The I-DONT-FALL Project

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Abstract: This study shows preliminary results of the multicenter and international I-DONT-FALL (IDF) project, co-funded by the European Union, aiming to offer an integrated Information and Communication Technologies (ICT) solution for fall prevention and detection. Here we assessed the efficacy of a motor and a cognitive treatment delivered through the IDF ICT solution, aiming to reduce the risk of falls through a randomized controlled trial. The outcome was measured with the Falls Efficacy Scale-International (FES-I) and the subscales of the Tinetti Performance Oriented Mobility Assessment for balance (POMA-B) and gait (POMA-G). We compared the effect of a 24-sessions period of motor training delivered through an *i*-Walker vs. a comparable period of non-motor training in terms of frequency and duration of sessions. The same comparison was performed for a period of cognitive training delivered though a touch-screen computer interface vs. a comparable period of non-cognitive training in terms of frequency and duration of sessions. Results showed that motor treatment alone or mixed with cognitive training reduces significantly the fear of falling and the risk of falls. Both cognitive and motor treatments showed a nonspecific positive effect on balance performance of participants. These preliminary results are consistent with previous evidences.

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1 INTRODUCTION

It is estimated that about a third of community-dwelling people over 65 years old fall each year (Gillespie et al., 2012). Falls can have serious physical consequences such as fractures and head injuries (Peel et al., 2002) and psychological consequences as well, particularly fear of falling and loss of self-confidence, thus resulting in a restriction in physical functions and social interactions (Yardley et al., 2002). Moreover, as reported from Peel and colleagues (2002), the rate of fall-related injuries increases with age.

Among the several different definitions of fall, a consensus definition has been suggested by Lamb (2005). According to the author, fall should be defined as 'an unexpected event in which the participants come to rest on the ground, floor, or lower level'. The difficulty to formulate a consensus definition of fall possibly derives from the complexity of evaluating the risk factors for falls. Indeed, risk factors are various and a few comprehensive syntheses of them have been provided (Campbell and Robertson, 2006; Deandrea, 2010). Particularly, it seems that only 15% of falls have a single identifiable cause (e.g., syncopal falls with cardiac pacing or falls related to neurological disease; Campbell and Robertson, 2006) and a similar percentage of falls results from an external event that would cause falling, especially in younger and intellectually able people (Campbell et al., 1989). Interestingly, over 60% of falls result not just from the additive effects of multiple pathologies but from multiple interacting aetiological factors (Fairweather and Campbell, 1991; Campbell and Robertson, 2006). Research on risk factors for falls has received an increasing attention as the evaluation and detection of these are a keypoint to develop effective intervention programs aimed to prevent falls (Gillespie et al., 2012). Indeed, over the last 10 years, several attempts using Information and Communication Technologies (ICT) aimed at falls prevention and detection (Hawley-Hague et al., 2014). Some of these studies delivered ICT-based motor trainings for falls prevention and suggest positive messages about the benefits.

Several studies investigated the possible link between cognition and gait (Verlinden et al., 2014) and its implication in falls (Amboni et al., 2013). Indeed, gait is a complex motor behavior and presents many different measurable facets besides proper motor facets (e.g., velocity), such as an important relationship to different aspects of cognition (Holtzer et al., 2006). Particularly, pace seems to be associated with attention and executive functions and with general cognitive decline and incident dementia as well (Verghese et al., 2007), whereas rhythm seems to be associated to information processing speed (Verlinden et al., 2014). As suggested by Shumway-Cook and Woollacott (2000), indeed, attentional demands for postural control increase with aging whereas sensory information decreases. Moreover, the declines in the ability to allocate attention to postural control under multi-task conditions might furtherly contribute to increase the risk of falls.

Therefore, the development of effective prevention programs should take into account not only motor factors but also cognitive factors. Particularly, it is agreeable that training programs aimed to prevent risk of falls and to reduce number of falls should be focused also on cognitive domains such as attentional-executive functions, thus providing effective results on motor behavior and particularly in pace and rhythm of gait.

The findings that we report in this paper are partial results of the I-DONT-FALL project which is a multicenter and international project co-funded by the European Union. This project aims to offer an integrated system for fall management solution, both in prevention and detection strategies. Moreover, the project aims to assess the efficacy of a motor and of a cognitive intervention and their combination to reduce the risk of falls through an European multicenter randomized controlled trial (RCT). The assessment of treatment effects combined standard scales and ICT assessment tools such as WIMU (Mannini and Sabatini, 2014) and *i*-Walker (Cortés et al., 2008).

The main aim of the present study was to assess the differential effect of motor training and of a cognitive training on risk of falls measured with the Falls Efficacy Scale-International (FES-I) (Yardley et al., 2005) and the subscales of the Tinetti Performance Oriented Mobility Assessment for balance (POMA-B) and gait (POMA-G) (Tinetti, 1986). Therefore, we compared the effect of a 24 – sessions (twice-a-week) period of motor training vs. a comparable period of non-motor training in terms of frequency and duration of sessions. The same comparison was performed for a period of cognitive training vs. a comparable period of non-cognitive training in terms of frequency and duration of sessions.

2 METHODS

2.1 Subjects

The results reported in this paper come from the first subset of 49 participants enrolled in the RCT study of I-DONT-FALL project that completed the assessment at T0 (pre-training) and T1 (post-training). All participants were elderly (mean age 79 years, range 65-96 years), with formal education (mean years 8.8, range 5-18), with high risk of falls (POMA total score ≤ 20 and/or at least one previous fall in the last year – mean score 19, range 10-28; mean number of previous falls 1.2, range 0-9) and without or with only a mild cognitive deficit (mean MMSE 26.3, range 20-30). Moreover, they were free of major behavioural disturbances and not receiving any rehabilitative treatment. All participants gave their written informed consent approved by local ethics committees.

All participants were randomly enrolled in four different kinds of training: a motor training, a cognitive training, a mixed motor and cognitive training and a placebo activity. The randomization was double and stratified for pilot site: a first randomization was done between cognitive intervention or not. After that, a second randomization was done between the motor intervention or not. In this way, those receiving the cognitive training might receive it mixed with the motor (i.e., mixed training) or not (i.e., cognitive training alone), whereas those not receiving the cognitive treatment might receive the motor (i.e., motor training alone) or not (i.e., placebo). This resulted in the four after mentioned conditions (see figure 1). This kind of randomization was adopted to balance the factors that were tested during the analysis, i.e., cognitive (group A) vs. non-cognitive (group B) and motor (group C) vs. non-motor (group D).

2.2 Training and Placebo Activities

Each kind of training (cognitive, motor, mixed) and placebo activity were executed through 2 sessions per week for 12 weeks (24 sessions). Each session lasted 1 hour for a total of 24 hours training. Motor training was administered with an *i*-Walker (Cortés et al., 2008) designed to help and support a user with some mobility impairment. Specifically, it provides assistance to compensate unbalanced muscle force and lack of muscle force on climbs and descendents. Motor training consisted in a set of warm-up procedures followed by exercises dedicated for 1/2 of the session to balance and for 1/2 of the session to gait. Cognitive training sessions consisted of a set of exercises covering all the cognitive functions and it was supported by surface computing (touchscreen-enabled) equipment. Touchscreen computers could be either large-format screens that could be used on tables or standard PCs with touchscreen monitors. Cognitive exercises were dedicated for the 2/3 of the whole session to executive functions and attention exercises and for 1/3 to other cognitive functions (i.e., declarative memory, orientation, language, constructional praxis, abstract reasoning). Executive functions training consisted in exercises practicing abstraction and planning such as sorting cards and grouping them according with a covered criterion or setting up a menu according with some rules and working memory exercises. Attention was trained with exercises of focused attention with distracters or with exercises of sustained attention. Difficulty level of exercises was increased according to participant's performance. Mixed training consisted in the combination of 30 minutes of motor exercises and 30 minutes of cognitive exercises during the same training session. Placebo activity consisted in entering data (i.e., words, names, codes) into a file on the same computer used during the cognitive training.

2.3 Outcome Measures

The risk of falls was measured with the Falls Efficacy Scale-International (FES-I) (Yardley et al., 2005) and the POMA-B and POMA-G subscales (Tinetti, 1986).

We performed a total of 6 analyses of variance ANOVA, resulting from each outcome measure (i.e., FES-I, POMA-B, POMA-G) by each kind of treatment (i.e., motor, cognitive). We used mixed ANOVA with time (T0 vs. T1) as within factor, and the kind of treatment, i.e., motor vs. non-motor and cognitive vs. non-cognitive, as between factor. More specifically, cognitive treatment was obtained collapsing data from cognitive and mixed training (group A) and non-cognitive training was obtained collapsing data form motor and placebo treatment

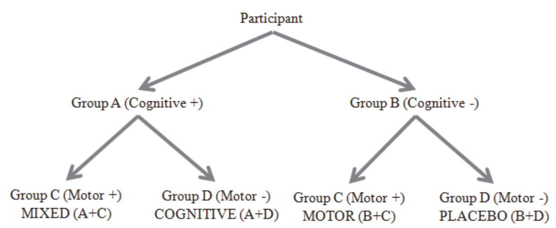

Figure 1: Randomization of participants.

Table 1: Results.

	MOTOR/NON MOTOR		COGNITIVE/NON COGNITIVE	
Scale	TIME EFFECT	TIME X TREATMENT	TIME EFFECT	TIME X TREATMENT
Fear of falling scale (FES-I)	ns	p< 0.012	ns	ns
Tinetti Balance (POMA-B)	p< 0.043	ns	p< 0.047	ns
Tinetti Gait (POMA-G)	ns	ns	ns	ns

(Group B). Conversely, motor treatment was obtained collapsing data from motor and mixed training (Group C) whereas non-motor was obtained collapsing data from cognitive and placebo training (Group D) (Figure 1).

3 RESULTS

3.1 Fear of Falling (FES-I)

We found a significant reduction of the fear of falling by the motor treatment alone or mixed with cognitive training (Table 1). This was showed by the significant interaction between time (T0 vs. T1) and kind of treatment (motor vs. non-motor) on the FES-I scores [F(1,47)= 6.772, p< 0.012] (Figure 2). Post-hoc comparisons with paired t-test showed a significant effect between T0 and T1 only for the motor treatment (t(23)= 2.946, p< 0.007) and not for the non-motor (t(24)= -.921, p< 0.366). The same interaction between time and cognitive treatment was not significant [F(1,47)= .751, p< 0.391]. Main effects of time and group were not significant for motor and cognitive treatments.

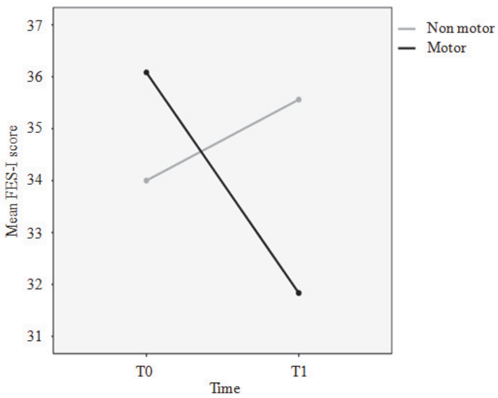

Figure 2: Effect of motor treatment on FES-I mean scores.

3.2 Balance and Gait (POMA-B, POMA-G)

We found a general nonspecific effect of treatment on balance. This was showed by a main effect of time for both motor [F(1,47)= 4.340, p< 0.043] and cognitive [F(1,47)= 4.158, p< 0.047] treatment on the POMA-B subscale. Neither significant interactions nor group effects emerged for both treatments in both POMA subscales.

4 DISCUSSION

This study aimed at assessing the efficacy in reducing the risk of falls of an ICT solution providing a motor and cognitive treatment in a sample of elderly participants at risk of falls. These preliminary data showed that motor treatment alone or mixed with cognitive training reduces significantly the fear of falling and by consequence the risk of falls. This was not the case of the cognitive training focused on attentional-executive functions when administered alone or mixed with the motor one. However, both cognitive and motor treatments showed a nonspecific positive effect on balance performance of participants. These preliminary results accord with the previous published evidence (Huang et al., 2011; Segev-Jacubovski et al., 2011; van het Reve and de Bruin, 2014) about the effect of the motor training in combination with behavioral interventions on fear of falling. To our knowledge, at present this study is the first attempt to evaluate the reduction of risk of falls through a cognitive training focused on attentional-executive functions performed alone or in association with a motor training. Previous evidences (Smith-Ray et al., 2013) partially accord with our results showing a positive effect of cognitive training in elderly on balance when compared with a rest period. Our preliminary data show that this effect is not specific of the cognitive training.

5 CONCLUSIONS

Our preliminary results agree with previous evidences (Huang et al., 2011; Segev-Jacubovski et al., 2011; van het Reve and de Bruin, 2014) and are motivating at pursuing with this study enlarging the sample in order to better investigate the specific role of the cognitive training alone or mixed with motor training in the reduction of the risk of falls.

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