Project to prevent mobility-related accidents in elderly and disables

D Alpini[1], A Cesarani[2], L Pugnetti[1], L Mendozzi[1], R Cardini[1], R Kohen-Raz[3], A Hahan[4] and G Sambataro[5]

[1]Institute "S.Maria Nascente" Don C.Gnocchi Foundation,
Via Capecelatro 66, 20148, Milan, ITALY

[2]University Of .Sassari, Via Mancini 5, Sassari, ITALY

[3]Hebrew University Of Jerusalem, Jerusalem, ISRAEL

[4]University Of Prague, Srobarova 50, 100 34 Praha 10, Vinohrady, Prague, CZECH REPUBLIK

[5]University Of Milan San Paolo Hospital, Via Di Rudinì 5, Milan, ITALY

[1]*dalpini@dongnocchi.it*, [2]*acesarani@tiscalinet.it*, [3]*tetrax@netvision.net.il*, [4]*hahn@fnkv.cz*

ABSTRACT

As the elderly and mobility-disabled populations in European countries continue to increase, it is imperative that mobility-related accidents and associated consequences be prevented whenever possible. This multi-modal project is aimed to provide educational, diagnostic and VR rehabilitative approach to prevention of falls in aging.

1. INTRODUCTION

As the elderly and mobility-disabled populations in European countries continue to increase, it is imperative that mobility-related accidents and associated consequences be prevented whenever possible. These events are potentially lethal, have a high social cost, expose victims to social withdrawal and a number of professionals to liability (Hoskin,1998). The risk of mobility-related accidents is frequently determined by the convergence of several factors, some of which are intrinsic to the aging, disability or disease processes, some are disease-specific, but many are environmental (Gill et al, 1998; Sattin et al, 1998). In the last 10 years, a substantial knowledge has been accumulated on the epidemiology of some mobility-related accidents and related consequences among elderly and disabled populations (Cumming, 1998). A variety of preventive programs have been undertaken which have been generally successful in reducing the incidence of falls in groups at risk. Multidisciplinary approaches have shown better results, in keeping with the multidimensionality of the problem and the heterogeneity of the risk profiles of the individuals (Close et al, 1999). Non demented individuals who have never fallen are able to recognize risk factors and acknowledge the importance of prevention programs, but may easily underestimate their personal risk until a fall occurs (Braun, 1998).

A problem with this approach is that it focuses mainly on walking and falls. The concept of mobility is much broader one which encompasses all means allowing direct personal interaction between people. In most civilized countries individuals older than 65 and others with mild mental or even major physical disabilities drive personal cars and utilize other public and personal transportation means (e.g. wheelchairs, bikes, escalators, lifts, underground, trains, buses, …) which are potential sources of injuries not directly related to standing and walking ability strictly defined. What accompanies frequent falls and car crashes, for example, is the inability to recognize one's own physical and behavioral limits while walking and driving, and to make adequate adjustments to one's behavior in order to prevent accidents (Sattin et al, 1998). Furthermore, the psychological consequences of falling or having a car crash may be very similar in terms of restriction of mobility and personal autonomy. The failure to recognize that standing and walking abilities are but one factor in mobility-related problems may explain several negative findings concerning the lack of predictive power of laboratory measures of balance. (Baloh et al, 1998). Even a quite severe impairment of balance does not totally disrupt one's chance of mobility if it is adequately understood and managed. The decline of some specific cognitive abilities such as divided attention, immediate and short-term memory, orientation and planning, and of the ability to sustain adequate alertness on potentially dangerous tasks have been linked to falls and mobility-related accidents in old subjects (Rappaport et al, 1998; Lundin Olsson et al, 1998). Falls and mobility-related accidents in old age and disability can be viewed as the result of inadequate consideration of one's own physical and behavioral limits in relation to the momentary environmental conditions. An explicit example is the reported increase in falls and fall-related injuries which occurs during wintertime in certain geographic areas (Levy et al, 1998). Most - if not all – such events could be prevented simply by adequate information, education and simple environmental modification measures. On the other hand, restriction of a person's mobility is frequently the result of psychological factors - fear, avoidance – that emerge after an accident; the victim becomes suddenly aware of his/her own physical or cognitive impairments, even if no serious physical damage was suffered, and reacts by limiting his/her range of movements (Howland et al, 1998). Alternatively, the person may deny the relevance of his/her own limits and continue to expose him/herself (and the others) to dangerous situations until a major accident occur. Hence complex psychological reactions tend to modulate the risk-taking attitude of persons of all ages and probably more so of old people – and directly affect the outcome of the behavioral pattern of mobility.

The pattern of mobility is dependent on the effectiveness of the balance system, the alterations of which are expressed as dizziness and unsteadiness. Balance disorders are more frequent in aged individuals and their determinants are different. There is evidence that aging affects multiple sensory inputs, as well as muscles, joints, and central nervous system ability to perform sensory-motor integration. Old age is characterized by a perturbation at several levels, including the motor and sensory levels (decreases in muscle mass, increases in the threshold of vibratory sensations) and at the cognitive level (memory processes, attention span). Gait instability, especially in old women, may be impaired by a combination of increased body weight and decreased muscle strength.

1.1 Aims of the project

This project aims to develop and test clinical tools and methodologies to improve the prevention of mobility-related accidents and the diagnosis and rehabilitation of the functional impairments that lead to immobility in elderly and disabled subjects. Some of these tools will be produced as virtual reality applications. This technology is not only apt for educational purposes, but also lends itself to improve current laboratory procedures to test balance, orientation, navigation, spatial memory and executive brain functions. The latter have been linked to mobility-related accidents, are frequently impaired in older people and disabled individuals, but can be improved with specific rehabilitation.

Accordingly, this project aims at the design of improved educational tools to prevent the development of immobility in old subjects, diagnostic tools to test vestibular responses in static, dynamic and cognitively demanding conditions that simulate those typical of everyday life and, finally, rehabilitation instruments and protocols which will include the use of VR-based simulation to retrain specific sensorial-motor, cognitive, psychological and behavioral maladaptive responses previously identified during the educational and diagnostic workouts.

2. PHASES OF THE PROJECT

2.1 Information phase

An initial phase will provide adequate background to collect and disseminate information concerning mobility-related risks among elderly and disabled, to select, adapt and use screening instruments to identify individuals at risk for accidents and consequences of inadequate mobility patterns and habits, and to raise public interest concerning the project's aims.

Two meetings have been organized so far to illustrate general practitioners (GP) recent acquisitions on the equilibrium system and equilibrium strategies. The main aspects of vestibular, vascular and neurological diseases associated to falls in elderly have been also discussed.

A specific questionnaire, the Falling Risk Inventory (FRI), has been developed to allow GPs to select subjects at risk for falls. The questionnaire is a self-administered instrument composed by 32 items. Eight items concern life-style issues (e.g. how many hours an individual spends at home), 4 social and affective issues (e.g. if a subject lives alone most of the day), 4 relate to general mobility issues (e.g. difficulties climbing the stairs), 8 general health conditions (e.g. presence of hypertension, diabetes), 4 relate to daily activities (e.g. difficulties taking a bath), and finally 4 the medications (e.g. hypotensive drugs, benzodiazepines, etc.)

2.2 Educational phase

This phase will differentially address individuals who have never experienced a serious mobility-related accident and those who have already had mobility-related accidents without severe and permanent impairment or disability. It will also address care givers, associations, health professionals and institutions dealing with at risk groups including younger citizens with physical or mental disabilities.

During the meetings GPs were instructed to suggest individualised modifications of life style and/or medications, on the basis of the results of the FRI questionnaire.

2.3 Diagnostic phase

Includes both screening and laboratory diagnostic workouts to identify subjects at greater risk and those amenable to enter the rehabilitation phase. This phase again involves the target groups and their care givers, including family physicians, and the already existing diagnostic services. Those who are identified as being at increased risk for mobility-related accidents according to the results of the previous two phases are offered a specific retraining. Subjects who have already been identified by the GPs as at increased risk for falls are offered an objective diagnostic workout to quantify equilibrium disorders:

- Labyrinth tests: Spontaneous, Positional and Head Shaking Nystagmus are carried out according tostandard clinical methodology.
- Orientation Test: the Cranio-Corpo-Graphic Orientation Test (CCG-OT)
- Posturography

2.4 Rehabilitation phase

The primary end users of the rehabilitation protocols will be the elderly (65 yrs. and over) either community dwelling or institutionalised who maintain a level of autonomy and personal mobility compatible with one or more of the activities of the project. The typical end user will be an elder still able to ambulate and engage into some form of social life activity who has never incurred into mobility-related accidents but is limiting his/her overall mobility pattern due to generic physical or psychological complaints. Another typical end-user will be an elderly on preserved physical and mental conditions who has already incurred into a mobility-related accident without reporting major physical consequences, but who is limiting his/her overall mobility pattern due to a negative psychological reaction. Another category of end users will be those institutionalised elderly who can still ambulate independently or are wheelchair bound who frequently fall or get lost and because of this experience a severe limitation of their mobility patterns.

The success of any prevention depends on the efficacy of the tools used to educate, to increase the personal awareness and the personal relevance of the message, and the long term maintenance of the behavioral adjustments which have been suggested as the most appropriate and which have been trained. Highly effective education can be given using up-to-date information technology such as virtual reality (VR). The superiority of VR as compared to traditional educational and rehabilitation tools is based on rather well-understood factors such as physical and psychological involvement – known as “presence” – free interaction, and build up of knowledge as a result of direct experience with information presented in precisely contextualised ways, yet modifiable and adapted to the individual’s level of comprehension (Lewis, 1998). Because mobility aims to overcome the effect of spatial and temporal distances on human activities and social interaction, it is a highly contextualised activity and its patterns depend on the environment as well as on other factors such as previous experience, availability of transportation means, weather conditions, time limitations, physical and other types of resources. A number of research teams all around the world are producing scientific evidence that learning is not only possible in VR, but it is also cot-effective, well accepted and motivating (Rizzo et al, 1997).

The use of VR applications of the immersive type (IVR) have been shown to cause a significant incidence of unwanted physical symptoms during the immersion and of aftereffects (Regan and Price, 1994*).* Experts agree that the use of non-immersive VR setups is highly advisable when dealing with patients or other disadvantaged individuals. Accordingly, all educational VR applications for this project will be developed to insure maximal diffusion and cost-effectiveness, will run on any standard Windows ‘98 or better OS version operating PC without any major hardware/software adjustment. A new computerized equipment is being refined to improve the range of dynamic tests of balance for the screening of individuals at risk for falling (Alpini et al, 1998; see also Cattaneo and Cardini, this volume). The equipment will be expanded to control navigation of virtual environments by means of displacements of the center of gravity in a standing position. The range of movements allowed is still limited, but the equipment has successfully passed the first validation studies when used to diagnose patients presenting mild-to-moderate impairments of balance resulting from neurological diseases. It is however still unknown whether it is more effective than visual-feedback posturography and traditional training in static upright position using multi-sensorial movement control when used to retrain patients suffering from disturbed balance.

Italian Sample	**Israeli Sample**

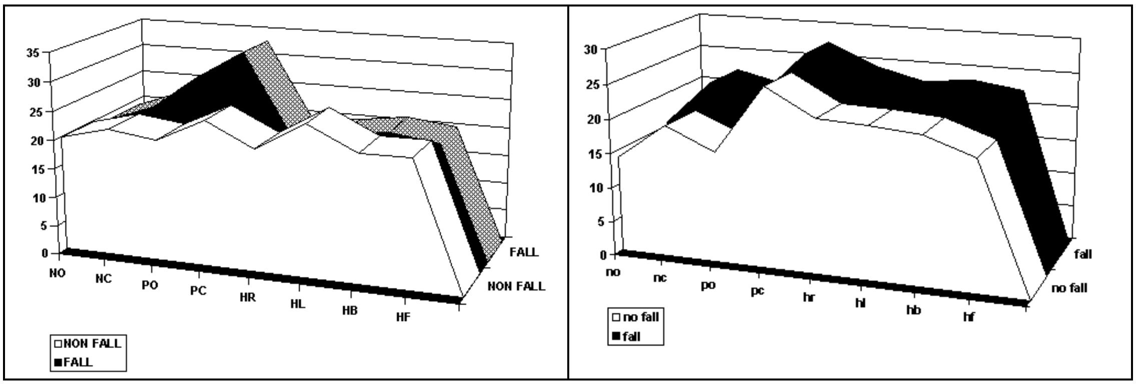

Figure 1a-b. G*eneral stability: falling elderly are less stable than non-falling during standing test on pads. Percent instability index displayed on ordinate (0= normal stability; 100=fall)*

3. METHODOLOGY AND INITIAL RESULTS

3.1 Assessment of orientation

The assessment of orientation relates to the cognitive aspects of the equilibrium function. A typical OT is carried out in a large darkened room where the patient stands blind-folded wearing a walkman with headphones to receive instructions recorded by the examiner and to eliminate external auditory cues. The patient must follow the instructions and perform all the requested movements inside the environment trying to determine his position relative to external points of reference, and to return to the starting position at the end of the test. Then the patient is asked to draw the path on a sheet. By means of this two-phases assessment (guided path and reproduction of it from memory) the most important processes that determine orientation in an environment spatial orientation and spatial memory can be easily evaluated. Initial results have been already published elsewhere (Alpini et al, 1999).

3.2 Posturographic Assessment

The postural control of a standing individual can be partly considered as a dynamic feedback control involving somatosensory, cervical proprioceptive, vestibular and visual information. Measurement of body movements during stance are used to objectively assess postural control, and responses led to the development of posturography. Tetraataxiometry (by Tetrax, Israel) is the last developed posturographic set which consists of two pairs of single piezoelectric sensor platforms that record posturographic heel and toes, right and left applied forces on the ground at the same time.

Posturographic findings of falling and non falling old women belonging to two culturally different populations, the Italian and Israeli, have been compared, and preliminary results are presented here. Twenty-four italian women, aged 73.1± 12.5 yrs., 11 reporting falls and 13 who never fell, and a group 37 israeli women (12 reporting previous falls) of comparable mean age (72.5 yrs) participated. Posturographic measurements have been carried out in 8 different conditions: eyes open (NO for Normal Open); eyes closed (NC for Normal Closed); standing on foam pads (PO for Pads eyes Open) and PC (Pads eyes Closed); bending the head forward (HF) and backward (HB); turning the head left and rightward, HL and HR.

A dedicated software computed different parameters:

1. general stability (ST)
2. Fourier sway frequencies ranging form 0 to over 3Hz and their harmonics derived from spectral analysis and divided into 8 bands (F1 0- 0.10 Hz , F2 0.10-0.25, F3 0.25- 0.35, F4 0.35-0.50, F5 0.50- 0.75, F6 0.75-1.00,F7 1.00-3.00, F8 greater than 3 Hz., along with indices of harmonic distortion.

The main findings are:

1) Falling Subjects are less stable than non falling elderly only when they stand on pads, i.e. they are over-dependent on somato-sensory input and have difficulty to compensate using visual input and/or vestibular control (Fig. 1A and B)
2) In falling subjects, age correlates positively with instability, as may be expected.
3) The Fourier Harmonic Index is lower in falling subjects, which indicates a weaker “systeme postural fin” and probably a weaker postural “feed forward” mechanism, when anticipating dangers which

threaten the equilibrium (Fig. 2 A and B)

4) In non-falling subjects there is no – possibly even a negative - correlation between age and instability. This seems to indicate that a proportion of the elderly - for a hitherto unknown reason - is relatively immune to destabilization, hence to falls (Fig. 3 A and B).

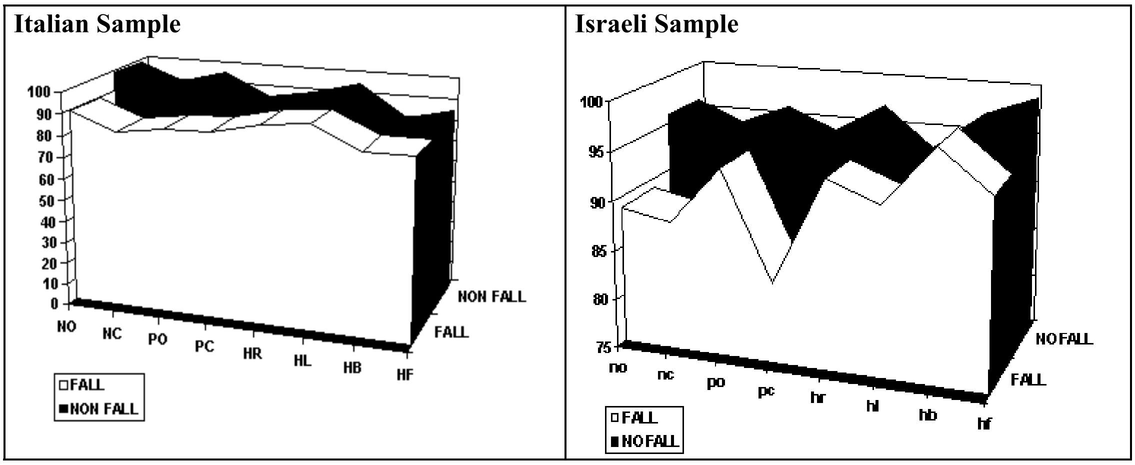

Figure 2A-B. *Fourier harmonic index. Israeli falling subjects are less stable than non falling controls when the head is bent or turned laterally. Falling subjects show an increase of medium-low sway frequencies as compared to controls which is more evident in Israeli subjects, especially when standing on pads. Percent of max harmonic index displayed on ordinate (100=no harmonic distortion; 0 =max harmonic distortion)*

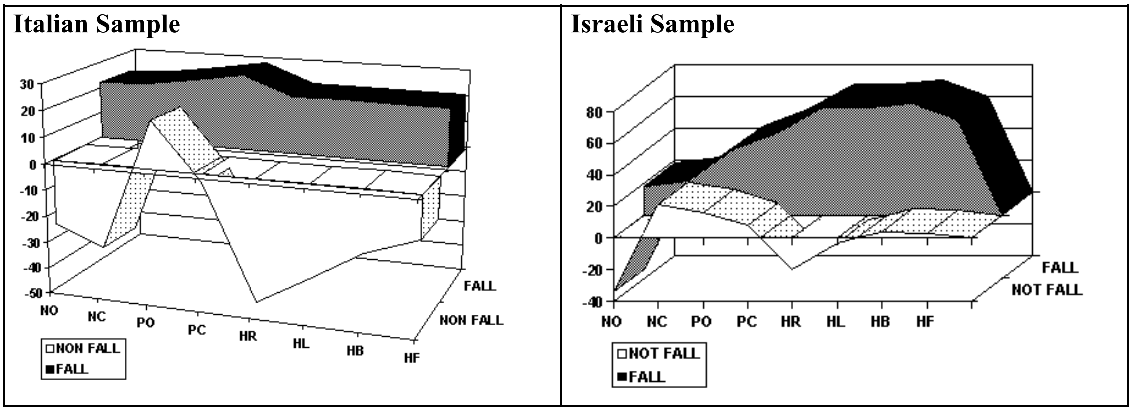

Figure 3A-B. *Correlations between chronological age and stability. Age is correlated to instability only in falling subjects while a paradoxical negative correlation is evident in non-falling subjects, regardless of their nationality. Percent instability index displayed on ordinate (0= normal stability; 100=fall)*

4. CONCLUSIONS

As the project is still in its initial days, we can only draw very preliminary conclusions concerning the activity related to the educational and diagnostic phases:

- The project is based on close collaboration between different specialists and general practitioners.
- The Falls Risk Inventory is a valid tool to select patients with life-style or medical problems making them at increased risk of falls, and to plan individualized programmes aimed at decreasing this threat.
- Tetra-Ataxiometry seems able to identify postural disturbances connected with increased risk of falls and to indentify equilibrium disorders in aged individuals.
- Orientation test is a asimple test to identify cognitive problems that could increase risks of falls.

- Virtual reality will be used in addition to traditional retraining programmes to assist cognitive rehabilitation of falling subjects and to educate subjects at risk.

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