



## Fall risk assessment and training in an elderly neurological patient: a case study

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*In this case report we present a very interesting and valid method of assessing fall risk and consequently training the patient to reduce the probability of future falls. This method is called silver index, a structured approach to fall prevention. We decided to evaluate a case of stroke survivor using the silver index specific assessment program which requires the use of an innovative robotic device to analyze functional deficits related to falls with numerical parameters. Our goal was finding the patient's most impaired functional areas that affect mostly balance components and increase the probability of falling. Once we found the impaired areas, the silver index method suggested us the appropriate training. In this case report we present the patient's data who resulted impaired deeply in 2 functional areas compared to the non-fallers model. After a focused training on hunova the subject's performance got better and the fall risk index decreased in a significant way. The improvements we observed encouraged us to share this experience: in response to the robotic training program the patient's dynamic balance skills were into normal limits and felt more confident walking.*

### Introduction

Falls result from various combinations of factors. An effective and efficient clinical strategy for risk assessment and management must address all these factors. The structured approach of the silver index easily identifies the impaired functional areas that contribute the most at increasing the risk of falling. Certainly, the areas that contribute the most at increasing the probability need rehabilitation. This is way silver index provides together with the risk evaluation, also a suggested personalized training program. The aim of this experience was to initially evaluate the patient's fall risk and physical state using a multidimensional standardized test battery denominated silver index performed on an innovative robotic device called "hunova". The assessment is a multidimensional evaluation that combines the results from all the tests grouped into 7 functional areas: Static Balance, Dynamic Balance, Reactive Balance, Sensory Integration, Limits of stability, Sit to stand and Gait speed. Each functional dimension, that contributes to the

calculated percentage of risk, is characterized comparing the data of the subject with appropriate ranges of normality. The way in which each result is weighted in the overall calculation was determined using machine learning algorithms based on data from 150 elderly subjects without related pathologies (community dwelling elderly subjects). This means that the elderly subject who is being tested is compared with a population of the same age group but with low risk of falling. The silver index method contains: the global index of risk of falling, a personalized analysis of functional deficits and the suggested personalized prevention training program. It was developed with the goal of having a simple and fast tool to evaluate fall risk, identify impaired functional areas and focus training on them. The overall view, decomposed in the previously listed functional areas, is represented in the form of a 7-point radar graph as shown in Figure 1. For each area (tip of the graph) a colored dot is represented which shows how the subject positions

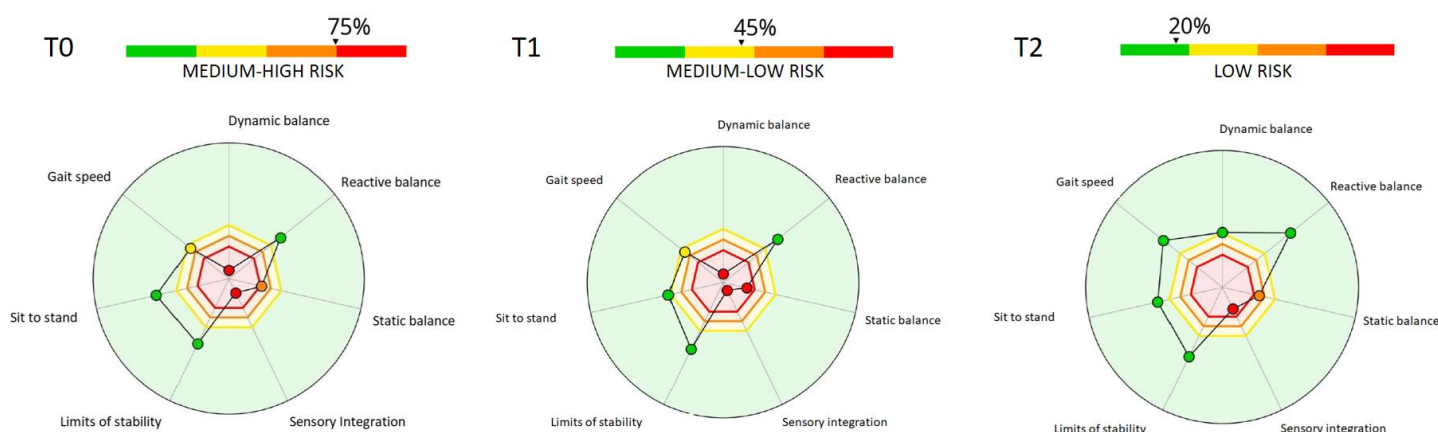


Figure 1: The total scores and the radar graphs results at T0, T1 and T2. Each radar graph represents the scores in the 7 functional areas. Color legend: Red = very far from normality; Orange = far from normality; Yellow = close to normality; Green = normal.

himself with respect to normality in each functional category. If the dot is green, the performance in that area is excellent and does not require specific training; if yellow the performance is good, if orange is fair, if red is poor. For these last 3 colors the method recommends a specific training different in difficulty depending on the level of impairment. In this case report we present data collected from a 60 years old stroke survivor patient at the beginning (T0), in the middle (T1) and at the end (T2) of the rehabilitative treatment.

## Patient

Male, 60 years old. In 2007, he suffered of a retro-ocular frontal aneurysm with hemorrhage at the level of the frontal lobes bilaterally. The subject underwent surgery and subsequently started an intensive rehabilitative treatment. At the end of the procedure, the patient recovered gait without aids. In 2015 he had another surgical treatment to lengthen the Achille's tendon. In 2016 he fell to the ground and consequently fractured his femur. The fracture was treated with osteosynthesis. Silver index evaluation and treatment was performed in 2019.

## Evaluation and treatment

Our clinical evaluation showed spastic hypertension of the right lower limb, clonus at the level of the sural triceps. Hyposthenia was found at the level of the muscles of the right lower limb with the following segmental strength: at iliopsoas equal to 4.5/5, at the level of the femoral rectum 4/5, 1/5 at the level of the anterior tibialis, 4/5 at the level of the sural triceps. Hypotrophy of the muscles of the sural triceps was found on the right side. During walking without aid, the right step was made supporting only on the foot tip and the instability was very high. A future fall was very probable in these conditions. Evaluation in form of silver index was performed at the beginning (T0 – July 2019), in the middle of the treatment (T1 – August 2019) and at the end of the training period (T2 – September 2019) after a 3-month interval. The assessment required 15 minutes. For the computation of

the global index of risk of falling and for the functional areas indexes, the patient must report the number of falls in the last 12 months, perform the 10 Meters Walking Test (10MWT) to calculate gait speed and undergo a set of robotic evaluations present on hunova. These assessments are:

1. *Balance test on static base* OE - CE (open and closed eyes): the subject must maintain their balance on a static surface in standing position. Evaluators include the area and the range of oscillation, the length of the trajectory of sway. In addition, trunk compensations are evaluated.
2. *Balance test on elastic base* OE (open eyes): the surface is unstable and follows the subject's oscillations who must actively maintain the platform horizontal in the center. This test evaluates dynamic balance controlling the area and the range of sway of the platform together with trunk compensation parameters.
3. *Balance test on passive base* OE (open eyes): the platform moves in circular trajectories. The subject must try to avoid following the movement staying as still as possible with the trunk. Trunk oscillations are evaluated.
4. *Reactive balance in standing position*: The test quantifies the patient's ability to quickly recover their correct posture after an unexpected external perturbation using sequences of impulses in the various directions (left, right, forwards) that arouse automatic postural responses.
5. *Limits of stability*: The subject must move the load as far as they can in the indicated directions (right, left, forwards and backwards). The test calculates the range of movement of the load in the different directions.
6. *Five Times Sit to Stand*: The purpose of this test is to evaluate the time needed by the subject to reach the standing position from the sitting one for a set number of times (5). It measures the duration of the task that is an indirect evaluation of the functional lower extremity strength.

Functional area	Level	Suggested macroarea	Starting activity	Starting difficulty
Static balance	recommended	Fall risk – Static balance	Activity 1	Medium
Sensory integration	necessary	Fall risk – Sensory integration	Activity 1	Easy
	necessary	Fall risk – Dynamic balance	Activity 1	Easy
Dynamic balance	necessary	Fall risk – Dynamic balance	Activity 1	Easy
Gait speed	suggested	Fall risk – Dynamic balance	Activity 2	Medium
	suggested	Fall risk – Reactive balance	Activity 2	Medium

Figure 2: training suggestions based on the results of the silver index.

The results of these evaluations are combined in a unique score that provides the fall risk index. The total score is divided in 7 functional areas scores represented in a radar plot (Figure 1). As far as functional areas graph (Figure 1), the more distant the dot is from the center, the smaller is the contribution of that specific area to the risk of falling. A red dot means that the score is very out of range in the specific functional area. Orange means that the value is far from the normality range within a certain amount. A yellow dot means that the value is close to normality. Green dotted areas are situated inside normality ranges and do not require specific training. Each functional area has a dedicated training macroarea. The colors of the dots of the radar plot are associated with the training advice. If the dot is green, no specific training is necessary. If the dot is yellow the training using the recommended macroarea is suggested, if the color is orange the use of the macroarea is recommended, if red the training is necessary. We decided to focus the training on all the functional areas which resulted inferior in performance in respect to the non-fallers model. The combination of these macroareas created the training session. The proposed macroareas started from the suggested activity levels with the advised difficulty but had an increasing progressive difficulty for each training session. Each training session on hunova lasted 1 hour, twice a week for a total of 11 sessions.

## Results

### The first evaluation and the planning of the treatment

The results of the initial assessment (T0) are reported in Figure 1 in a radar plot representing the functional areas scores that make up the silver index. Each area has a score in the form of a colored dot. The subject affirmed he never fell in the last year and his gait speed was initially 0.86 m/s in the 10 Meters walking test. The percentage of risk of falling came out to be 75% from the model i.e. a medium-high risk of falling in the next year (Figure 1). The radar plot shows a very poor performance in dynamic balance and sensory integration (red dots), a low performance in static balance, a gait speed close to normality. Sit to stand, Reactive balance and limits of stability do not require specific training (green dots). The medium – high risk of falling probability (75%) result was mainly due to dynamic balance and sensory integration

components. Dynamic balance involves inability of balancing with eyes open on an unstable surface i.e. in case of a somatosensory perturbation: less accurate sensory information from the feet and ankles require higher adaptation. Sensory integration is related to equilibrium with eyes closed in static conditions: without vision the patient stands with a very large amount of sway. The combination of the macroareas with the lowest performance created the training session: Static balance, Dynamic balance, Sensory integration and Reactive balance (Figure 2). The proposed macroareas started from the suggested activity levels with the advised difficulty but had an increasing progressive difficulty for each training session.

### Benefits of the treatment

After 5 sessions and at the end the treatment the patient repeated the evaluation test. In Figure 1, the results from the silver index at T0, T1 and T2 are represented. The overall silver index score improved from 75% (medium-high risk of falling) to 45% (medium-low) and finally to 20% (low risk). Dynamic balance and gait speed functional areas improved and, at the end of the training program, are inside the normality range (green color) (Figure 1). The gait speed increases after the treatment (50% of improvement) and reached 1.2 m/s in the last evaluation. Static balance and sensory integration improve in respect to T0 but are still far from non-fallers normality. The patient still needs to work on the quantity of sway in standing position both with eyes open and closed: reducing the sway range both in antero-posterior and mediolateral direction is the goal of the next maintenance rehabilitation cycle.

### Conclusions

Following the focused rehabilitative treatment, the patient has an important improvement in the percentage of risk of falling. Each functional dimension result, that contributes to the calculated risk, was compared to the non-fallers ranges of normality. This personalized analysis of the functional deficits helped us to create the appropriate treatment for our patient in order to reduce the risk of falling specifically working on his impaired areas. The silver index method was very effective with this chronic stroke survivor, who was also very happy to see his improvements on the report. At T2, the patient resulted faster at walking and more confident with dealing with dynamic balance situations. We kindly suggest using silver index with all elderly patients to assess their physical state as a function of their advancing age.

### About us

Riattiva started its activity in 1997 in Lavagna (Italy), becoming the region reference center for rehabilitation activities. It provides avant-garde spaces and equipment and specialized professional figures. The patient is followed and treated with a detailed rehabilitation program with a view to obtaining results that are increasingly in line with the patient's expectations, thus expanding the positive outcome of the various therapeutic interventions.  
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