Prediction of Risk of Falling among Institutionalized Elderly People in Iran

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Abstract:

Aging declines abilities and leads to increased risk of falling and subsequently poorer quality of life. The objective of this study was to identify a proper assessment for risk of falling among institutionalized elderly. In order to accomplish this aim, two functional assessment methods, Berg Scale and Tinetti Scale, were used and the validity indices of these methods were calculated.

Prospective non-interventional methodological discriminative-validation study in order to make a comparative assessment of the discriminative validity of the two clinical assessment methods among the elderly people with/without history of falling.

The frequency of falls within 6 months among institutionalized elderly individuals was prospectively studied. Finally, those having had two or more falls within 6 months were enrolled in the faller group and those having no falls within 6 months were enrolled in the non-faller group.

Twenty-one women and 33 men (mean age: 75.79, standard deviation [SD]: 8.47, range: 61-98) independent in their daily activities and able to walk 10 meters using/without assistive devices volunteered to participate in the study with awareness.

Background variables included age, gender, use/nonuse of assistive devices, height, weight, number of the drugs used, and number of the diseases; independent variable was history of falling; and dependent variables were the results of the two functional assessment methods.

Independent t test indicated a significant difference between the two groups of fallers and non-fallers in the mean scores on Berg Balance Scale (P=.0001) and Tinetti Scale (P=.0001). The results of logistic regression test indicated much more discriminative validity for Berg Balance Scale test than Tinetti Scale test. Studying the validity of Berg Balance Scale assessment method showed that all validity indices should be regarded as bases for clinical decision.

Key words:

Elderly people, fall(s), functional assessment method(s).

Introduction:

Decreased mortality and increased life expectancy has led to enlargement of the population of the elderly. At the beginning of the year 2000, the population of people older than 65 comprised one-eight of the world's total population, i.e. 750 million people.

Beside the ethical perspective and the fact that the elderly should be provided with appropriate physical and psychological health, their social and economic efficacy is also essential. To accomplish this objective, it is necessary to prevent their disabilities and this needs appropriate knowledge of the problems involving the elderly and identification of those who are at risk of such problems.

Falls, considering the frequency of occurrence, associated adverse events, and the costs imposed, are of most significance for the elderly. The frequency of these significantly increases with aging. [2-11]

The studies demonstrate that 25-47% of the elderly in the community have one fall or more falls per year and this even reaches 50% among those institutionalized. [1, 4, 5, 8, 9, 12-15]

Falls constitute a threat to the elderly people's health, as they alter the quality of life and increase the care costs, and this leads to bodily, psychological, social, and economic consequences, and even death. [3, 6, 13, 15, 16] For example, the American Association of Otology has declared that falling is the most frequent cause of accidental death and disability among the elderly, as the injuries due to falls impose a cost of more than 60 million dollars per year on health systems, [17] which is estimated to reach 32.4 million dollars at 2020.

Since falls may constitute a threat to an individual's function and independence, identifying the elderly people at risk is essential [19] and is the first step in preventing these accidents and eventually the associated adverse events. [17]

Development of diagnostic and therapeutic methods for identifying those at risk of falling makes a foundation for promoting independence and the quality of life and reducing care costs.

Thus, the motive for this study was the question that which of the assessment methods studied identifies more old people who are at risk.

Not only is this method useful in identification of those at risk, but it also makes a basis for designing therapeutic and assessment programs. The assessment methods studied are simple clinical methods which do not need any special equipment or much effort by the elderly. Each of these methods assesses a group of activities with which the elderly have problem rather than assessing a single type of activity. In Berg Balance Scale method, presented by the Canadian physiotherapist Kathy Berg, 14 types of activity such as standing off a chair, sitting on a chair, turning 360 degrees, and standing on a single leg have been included as the components of the test.

Tinetti Scale method, presented by Mary Tinetti, MD, Yale University,

includes the two components of balance and gait (considering the availability of several issues, the 28-score issue in which at most 16 scores are assigned to the balance component and at most 12 scores to the gait component). In this method, different types of activity needed to maintain balance are included.

Methods and Materials

Design:

This study was a prospective non-interventional methodological study carried out in order to comparatively assess the discriminative validities of the two clinical assessment methods in elderly people with/without history of falling.

Sample:

Seventy eligible elderly people from the Institution for the Elderly and Handicapped, Kahrizak, Tehran who volunteered to be studied for 6 months (from September 23 to March 20, 2001) were included after preinforming about the study and the frequency of falls among them was studied. A physiotherapist working in the Institution registered the frequency of falls per month through direct monthly visits to the participants and the care personnel. At the end of 6 months, eight of the participants having fallen once within the period were excluded in order to increase the precision of the study (n1=8), four participants died (n2=4), two participants were hospitalized in the special care unit for injuries due to falls and diseases (n3=2), one participant had become wheelchair-bound (n4=1), and one participant was unable to walk due to disablement (n5=1).

The participants were divided into two groups based on the frequency of falls: those with histories of 2 or more falls within the study period as the faller group, and those with no history of falling as the non-faller group.

Procedures:

In order to eliminate the possible defects, all the stages of assessment were conducted to 10 eligible elderly people in a pilot study after preinforming about the study. The advantages of the pilot study were that the investigators achieved enough skill in performing the assessment methods and that the investigator and his assistant performed all the stages of assessment according to the instructions while they were unaware of the grouping pattern of the participants.

Instrumentation:

At the end of a 6-month follow-up, first, the assistant registered the demographic data including age, gender, weight, height, number of the drugs used and number of the diseases using a questionnaire through interviews and referring to medical files and medications. Then, each participant was assessed by the investigator using the assessment methods studied according to the instructions (the investigator was unaware of the grouping pattern).

In Berg Balance Scale, 14 activity items, including standing up from seated position, standing without support, sitting without support, sit-

ting down, transfer, standing without support with the eyes shut, standing without support with the legs fixed together, bending forward with the arms stretched out, lifting an object off the ground, turning to the left and the right and looking back, turning 360 degrees, touching the stool with the legs for several times, standing without support with the feet along each other, and standing on a single leg, were measured according to the instructions.

Each activity item was scored as 0-4, where score of 0 meant inability to perform the item, and score of 4 meant complete ability to perform the item. The total score of this method was 56.

In Tinetti Scale method, the following activity items were measured according to the instructions:

"On balance: balance at sitting, standing up and effort to stand up, balance at immediate standing (the first 5 seconds), balance at standing and pushing, standing with the eyes shut, turning 360 degrees, and sitting down.

"On gait: starting to walk, length, height, symmetry and succession of the steps, route, oscillation of the trunk, and width of gait.

According to the instructions for the test, each activity item was scored 0-1 or 0-2, where score of 0 meant inability to perform the item and score of 1 or 2 meant complete ability to perform it. The score was 16 for the balance items and 12 for the gait items, and the total score was 28.

Analysis:

Statistical analysis were performed using the software SPSS, version 10. Descriptive data including the means, standard deviations (SD s), and the ranges of quantitative variables and the distribution of the frequencies of the qualitative variables were used to display the properties of the sample.

Kolmogrov-Smirnov test was employed to study the distribution of the quantitative variables and deciding on use of parametric or non-parametric tests, and t test and a chi square test were employed to determine the quantitative and qualitative variables in which significant difference ($P<.05$) between the two groups studied were present, respectively.

Backward stepwise logistic regression was performed in order to determine the better method for discriminating between the faller participants from the non-fallers. Finally, in order to make the best clinical decision, validity indices including sensitivity, specificity, predictive value and likelihood ratio were studied.

Results:

As mentioned before, the discriminative validities of the two assessment methods, Tinetti Scale and Berg Balance Scale, were studied in 54 elderly individuals with/without history of falling.

In Table 1 are displayed the demographic and clinical properties of the sample studied are displayde. The results of Kolmogrov-Smirnov test demonstrated that the variables of age, weight, height, and number of

Table 1: Association of risk factors with fall classification

Risk factor	Non fallers (n=34)	Faller (n=17)	P value (test)
Age factor X(mean) SD	73/32 7/72	80/53 8/11	0.003 (t)
Gender (%) Female Male	35 65	52/9 47/1	0.404 (X2)
Weight (Kg) X(mean) SD	58/43 11/48	56/29 11/21	0.525 (t)
Height (Cm) X(mean) SD	156/51 8/40	154/06 10/50	0.261 (t)
Assistive device (%) (Cane)	0	53	0.0001 (X^2)
No. of medications [1] X(mean) SD	3.79 2.17	4.06 3.05	0.722(t)
No. of diseases [2] X(mean) SD	1/27 0.8	1.50 1.21	0.437 (t)
Berg Balance Scale X(mean) SD	51/46 4.25	39.29 5.07	0.0001(t)
Tinetti Scale X(mean) SD	25.62 2.96	18.29 3.64	0.0001(t)

the drugs had normal distribution and the variables of number of the diseases and Tinetti Scale did not. Considering that the number of the variables with normal distribution were more than the variables without normal distribution, parametric tests were employed so that the results correspond with each other.

In Table 1 the results of independent t test and chi square test (are displayed) in order to determine the variables that had significant difference.

According to Table 1, there were significant differences in the variables of age, using assistive devices, Berg Balance Scale, Tinetti Scale, Tinetti Balance Subscale, and Tinetti Gait Subscale between the faller and non-faller groups, so that the individuals of the faller group were older, used assistive devices more frequently, and had lower mean scores in Berg Balance Scale, Tinetti Scale, Tinetti Balance Subscale and Tinetti Gait Subscale.

Moreover, according to Table 1, there were no statistically-significant differences in the variables of gender, weight, height, number of the drugs used and number of the diseasees between the two groups.

Table 2: Results of logistic regression

Variable	Log likelihood	-2logLR	SE	DF	Significance
Age	-10.077	5.408	.18	1	.02
Use of assistive devices	-11.687	8.67	63.11	1	.0033
Berg Balance Scale	-14.25	13.754	.61	1	.0002
Tinetti Gait Subscale	-9.504	4.262	1.001	1	.039

Backward stepwise logistic regression was performed to determine a method for discriminating the elderly people with history of falling from those without such history. The variables used were those factors having a P value of less than.05 according to Table 1. These included age, use of assistive devices, Berg Balance Scale, Tinetti Scale, Tinetti Balance Subscale, and Tinetti Gait Subscale. The results are displayed in Table 2.

The results displayed in Table 2 show that Berg Balance Scale is several times more important in discriminating between the fallers and non-fallers (-2log LR=13.75), i.e. the discriminative validity of this test is several times more than the other variables studied in the two groups of fallers and non-fallers.

In order to make the best clinical decision in discriminating the elderly individuals with history of falling from those without such history, the validity indices including the sensitivity, specificity, predictive value, and likelihood of Berg Balance Scale assessment were calculated. The results are displayed in Table 3.

Table 3; Validity indices according to different cut-off points

Cut off point	41	43	45	47	49
Sensitivity (%)	58.82	70.59	88.24	94.12	94.12
Specificity (%)	100	91.89	89.19	86.49	83.78
Positive predictive value (%)	100	80	76.95	76.19	72.73
Negative predictive value (%)	84.09	87.18	94.29	96.97	96.87
Likelihood ratio for a positive test	Undetermined	8.71	8.16	6.96	5.80
Likelihood ratio for a negative test	.41	.32	.132	.068	.07

Discussion

As mentioned before, Berg Balance Scale assessment method is of more discriminative validity in differentiating those elderly people with history of fall from those without such history (Table 2). This finding contradicts the findings of Rose, Riddle [20], Stanford [21], Newton, and Thorbahn [22], and favors the findings of Satterfied [17], Whitney [23] and Shumway-Cook et al [8]. Among the causes of difference between the findings of this study and of other studies is the difference in properties of the subjects and their life environments.

According to Table 2, the gait component of Tinetti Scale assessment method is more valid than Tinetti Scale and Tinetti Balance Subscale in discriminating fallers from non-fallers. Moreover, the validity of Tinetti Gate Subscale (12log LR=4.61) is less than Berg Balance

Scale (-2log LR=13.75). This finding favors the findings of Satterfied [17], which indicate that one of the disadvantages of Tinetti Scale method is its scoring, in which, instead of considering the spectrum of the changes in the activities studied, only presence or absence of the expected changes in those activities are considered in many cases.

This study also indicated that the frequency of use of assistive devices and mean age are more in the elderly individuals with history of falling than those without such history (-2log LR: 8.62 and 5.408, respectively). Therefore, the risk of falling for an individual can be estimated according to use/nonuse of assistive devices and his/her age.

In this study, the percentage of the two genders indicated no significant difference between the two groups, although percentage of falls in women was higher than in men. More research is needed to judge the effect of gender on the risk of falling.

Mean height was less for those with history of falls than those without (154.06 vs 156.56), but there was no significant difference between the mean heights of the two groups. More research is needed to judge the effect of height on the risk of fall.

There was no significant difference between the mean weights of the two groups, although those with history of fall were of greater weights than those without (58.43 kg vs 56.29 kg). As far as we know, no previous study has been done on this issue; therefore, more research is needed to judge the effect of weight on the risk of falling.

There was no significant difference in the number of the drugs used and number of the diseases between the two groups, although the mean number of the diseases and the mean number of the drugs used were larger for those with history of falling than for those without such history (Table 1). This finding favors the findings of Satterfied who found no significant association between the frequency of falls and suffering from disease. [17] Although it is generally believed that the frequency of falls increases with increased number of the drugs used, previous studies have not confirmed this attitude. [17]

As mentioned before, the validity indices of Berg Balance Scale assessment method were studied in order to make the best clinical decision in discriminating between the elderly people with history of falls from those without such history.

The gold standard measure of this study was the history of falling during the study period. Kathy Berg declares that the best method for interpretation of Berg Balance Scale scores is using the cut-off point of 45, so that those with scores less than 45 are considered fallers and those with scores equal to or more than 45 are considered non-fallers. Using the cut-off point of 45, the sensitivity and specificity of Berg Balance Scale assessment method are 88.24% and 89.19%, respectively.

Since therapists should make their clinical decisions according to the

results of diagnostic tests and not those tests based on gold standard measures, some researchers believe that positive and negative predictive values are more beneficial than sensitivity and specificity.

In this study, using the cut-off point of 45, positive predictive value was 78.95% (Table 3). This positive predictive value indicates that 78.95% of the patients positive in the test (scores less than 45) had been classified as fallers and 21.05% of the patients had been wrongly judged.

Using the cut-off point of 41, the positive predictive value was 100% (Table 3), i.e. 100% percent of those positive in Berg Balanced Scale (scores less than 41) had been classified as fallers. Using the cut-off point of 49, the negative predictive value was 96.87% (Table 3), i.e. 96.87% of those negative in Berg Balanced Scale (scores equal to or less than 49) had been classified as non-fallers and 3.13% of the subjects had been wrongly judged as non-fallers. Unfortunately, predictive values do not estimate the risk of falling according to the patient's signs and symptoms, and are affected by prevalence. If the prevalence of falls in the study is different from the whole society were the individual belongs, the predictive values calculated in the study do not make an accurate estimation of the risk of falls for the individual.

Using the cut-off point of 49 and the predictive value of 94.12%, the negative predictive value was 96.87% (Table 3), i.e. 96.87% of those with positive test results were non-fallers and 3.13% of them were fallers. Two other validity indices which should be used in clinical decision making are positive and negative likelihood ratios. The results of likelihood ratios indicate how much the test results change the risk of falling estimated before performance of pretest probability test.

Since likelihood ratios can also be used in tests with continued formats for measuring the distances, Riddle and Stratford [21] believe that they are more beneficial than sensitivity, specificity and predictive values, which are confined to tests with double formats. For example, positive predictive value changes 2.36 from the cut-off point of 45 to 49, i.e. the risk of falling for an individual with a score of 45 is 2.36 times greater than for an individual with score of 49 in Berg Balanced Scale.

According to the results of the study, the risk of falling in an elderly individual with a score less than 43 is 8.71 times (positive likelihood ratio) greater than the probability of not falling. And in an elderly individual with a score equal to or more than 43, the negative likelihood ratio is .32, i.e. the risk of falling in a patient with a negative Berg Balanced Scale score (equal to or more than 43) is .32 times greater than the probability of not falling; in other words, positive likelihood ratio of 8.71 in a patient with a score less than 43 increases the pretest probability, and negative likelihood ratio of .32 in a patient with a score equal to or more than 43 decreases the pretest probability.

Another advantage of using likeli-

hood ratio is that it can determine post-test probability when associated with a therapeutic monogram.

Since determining the prevalence does not change the likelihood ratios, they can be generalized to other patients too. The pretest probability must be estimated before using the monogram.

This probability is estimated on the basis of the therapist's education and experience. Unfortunately, in many cases the pretest probability is not estimated according to the patient's condition but according to the results of the available literature. Therefore, therapists are recommended to first estimate the risk of falling according to the patient's condition and then estimate the post-test probability according to the results of Berg Balance Scale test using a monogram.

Conclusion:

Berg Balance Scale assessment method is an appropriate method for identifying the elderly people at risk of falling. However, indices other than indices such as sensitivity and specificity should also be considered when studying the validity indices of this method. Moreover, likelihood ratios seem to be of more importance as they assess the risk of falling for the individual according to his/her signs, symptoms and history. Of course, performing an estimation of the pretest probability as accurately as possible needs experience and education.

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