

Clinical measures of balance and functional assessment in elderly persons

Annette Piotrowski
Joan Cole

The relationship between clinical measures of balance and function in elderly persons was the focus of this investigation. Sixty subjects were assessed on three clinical balance measures, the Balance Scale, the Self Paced Walk Test and the Falls Efficacy Scale and a measure of general function, the Functional Assessment Inventory.

Results demonstrated significant relationships between all measures. The Balance Scale results were highly predictive of function and were predicted by scores on the Falls Efficacy Scale and the Self Paced Walk Test. Only the Self Paced Walk Test was able to discriminate between subjects on the basis of previously reported falls. On the basis of data from this sample of elderly people, it was concluded that the Balance Scale was the most appropriate clinical balance measure for use with older individuals.

[Piotrowski A and Cole J: Clinical measures of balance and functional assessment in elderly persons. *Australian Journal of Physiotherapy* 40: 183-188]

Key words: Accidental Falls; Aged; Equilibrium; Self Concept

A Piotrowski BAppSc(Phty), PGradDipHlthSc, MSc is a Lecturer in the School of Physiotherapy, Curtin University of Technology, Perth.

Joan Cole PhD, BPT, MS, MEd is Professor and Head of the School of Physiotherapy, Curtin University of Technology, Perth.

Correspondence: Annette Piotrowski, School of Physiotherapy, Curtin University of Technology, Selby Street, Shenton Park, WA 6008.

Balance is the complex process regulating the maintenance of positions, postural adjustments to voluntary activity and response to external disturbances (Berg 1989). The ability to balance in both static and dynamic situations is an essential element in the performance of daily physical activities.

Deterioration in balance is widely acknowledged as a significant factor in the high frequency of falls in elderly people, as has been highlighted by Berg (1989). The incidence of falls rises steadily after age 65 years (Patla et al 1990) and it has been estimated that between 20 per cent and 50 per cent of elderly individuals are at risk of falling within a 12 month period (Nevitt et al 1989, Tinetti et al 1988).

Serious consequences, including fractures and pneumonia, follow a small percentage of falls among the older members of the population. Other sequelae include compromised functional independence and mobility, loss of confidence in performing physical tasks and a fear of future falls (Tinetti et al 1990).

Clinical balance assessment

Trends in balance assessment of elderly persons have shifted in emphasis from complex laboratory testing to performance oriented assessment in the clinical setting (Tinetti 1986). Clinical balance assessment methods have involved

measuring the duration of the ability to maintain various positions, with and without external disturbances (Wolfson et al 1986), the measurement of walking speed (Himann et al 1988), mobility tasks (Berg et al 1989, Tinetti 1986) and measurement of self generated perturbations (Duncan et al 1990).

An alternate approach to clinical balance assessment is the application of self-efficacy theory to evaluate fear of falling in elderly individuals (Tinetti et al 1990). Efficacy theory relates an individual's beliefs to performance of a given task or behaviour (Bandura 1986). Persons with low self-efficacy for a particular activity will tend to avoid that activity, while those with high self-efficacy will approach the task with confidence (Bandura 1982).

Fear of falling may adversely affect balance performance and ultimately result in loss of function and independence (Tinetti et al 1990). In the elderly population, individuals expressing fear of falling may prove to be those with marked balance impairments.

To date, no single approach to clinical balance assessment for older adults has proved a clinically useful and valid measure of balance. It is therefore difficult to choose a promising measure of balance for use with the elderly population. Review of the literature

From Page 183

has highlighted three approaches to the clinical assessment of balance in elderly individuals worthy of further investigation.

The Balance Scale

One promising clinical measure of balance in elderly individuals is the Balance Scale developed by Berg et al (1989). The items in the Balance Scale assess the ability to maintain balance, either statically or while performing various functional movements, some requiring an alteration in the base of support.

Reliability and validity of the Balance Scale have been reported (Berg et al 1989, 1992a and 1992b). Results from the scale have demonstrated significant correlations with laboratory measurement of spontaneous postural sway, functional and motor performance. It also appears sensitive to the use of walking aids. Scores have correlated strongly with scores on the balance assessment scale developed by Tinetti (1986) and Tinetti et al (1988), moderately with the Timed "Up and Go" test (Podsiadlo and Richardson 1991) and with caregiver and self ratings of global balance ability (Berg et al 1992a and 1992b). Balance Scale scores of less than 45 (from a possible total of 56), as well as visual deficits and a fall in the preceding three months, have been reported as significant predictors of multiple falls in the next year (Berg et al 1992b).

The Self Paced Walk Test

Independent and safe ambulation depends upon dynamic balance abilities. Ambulation is the activity most commonly associated with falls in the elderly population (Tinetti et al 1988).

One assessment of ambulation status, suitable for use with elderly persons in the clinical setting, is the measurement of an individual's choice of walking pace. Speed of walking has been related to independent living (Bassey et al 1976) and successfully utilised as a measure of mobility and balance in elderly persons (Himann et al 1988, Tinetti 1986).

The modified Self Paced Walk Test (SPWT) involves a timed walk over a central 10 metres of a longer path at the subject's choice of pace. Reliability and validity of the test have been established (Bassey et al 1976, Cunningham et al 1983, Ekblom et al 1979, Himann et al 1988). The SPWT has been identified as a safe and valid measure of ambulation ability for use with an elderly population (Cunningham et al 1983).

The Falls Efficacy Scale

Self-efficacy theory has been used to evaluate fear of falling in elderly individuals (Tinetti et al 1990). The Falls Efficacy Scale (FE Scale) was designed to evaluate an individual's confidence in the ability to avoid a fall during activities of daily living (Tinetti et al 1990). The FE Scale consists of questions related to the individual's concern about the possibility of falling when completing 10 specific daily living activities. Respondents are asked to identify, on a 10 point scale, how confident they feel of not falling when performing each activity, with one indicating extreme confidence and 10 indicating no confidence at all.

Tinetti et al (1990) reported good test-retest reliability in a small community based elderly population. High FE Scale scores correlated with subjective reports of activity avoidance, representing low confidence in those activities (Tinetti and Powell 1993). Predictors of FE Scale scores included usual walking pace, anxiety and depression but not recent history of falls (Tinetti et al 1990). The authors concluded that the FE Scale was a useful measure of efficacy related to fear of falling in an elderly population. Further study evaluating the validity of the FE Scale was recommended.

Functional independence

Measurement of functional independence is widely viewed as the most relevant general assessment for older people (Fillenbaum 1988, Kane and Kane 1981). In comparison with chronological age, functional abilities have been shown to be more strongly associated with care requirements (Cairl et al 1983), level of disability and

service utilisation (Fillenbaum 1990). Measures assessing the functional abilities in older persons have been widely studied and several have been validated for use with elderly individuals (Kane and Kane 1981).

The Functional Assessment Inventory

The Functional Assessment Inventory (FAI) was specifically developed for gerontological application. Reliability and validity have been established for both community and institutional living elderly populations (Fillenbaum 1988). Examining physical and instrumental activities of daily living, the FAI questionnaire measures a person's ability to do those tasks needed for continued independent living (Cairl et al 1983).

The present study was developed to investigate the relationship between clinical assessments of balance and functional independence in an elderly population. The evaluation of the usefulness of different approaches to clinical balance assessment in an elderly population was the primary purpose of this study.

The specific objectives were identified as:

- 1) to examine the relationship between clinical balance measures and a valid measure of function in an elderly population.
- 2) to investigate the relationship between performance on a clinical balance scale and self-efficacy ratings of fear of falling in an elderly population.
- 3) to assess the ability of clinical measures of balance and function to discriminate between elderly individuals with or without reported falls; and between elderly people of different age and gender.

Method

The study employed a cross-sectional design. Information relevant to the study was circulated to hospitals, aged care facilities and community based services, as well as to staff and individuals in retirement villages and senior citizens' clubs. A press release

Table 1
Characteristics of the study population (n=60)

Characteristic	n	%
Gender		
Males	14	23.3
Females	46	76.6
Reported Falls		
Falls	38	63.3
No falls	22	36.7
Living Situation		
Community alone	15	25.0
Community with spouse	13	21.7
Community with others	5	8.3
Retirement Village	14	23.3
Hostel	7	11.7
Nursing Home	6	10.0

was published in two community newspapers to recruit independent elderly participants living in the community. Interested participants volunteered from the community sector and residents of care facilities were invited, by their usual physiotherapist or nurse, to join the study.

Subjects

Individuals were appropriate subjects if they were aged 65 years or older, able to walk 10 metres without the assistance of another person, were not cognitively impaired or currently abusing alcohol. All subjects were required to give informed consent.

Sixty individuals aged from 65 years to 94 years (mean = 78 years, standard deviation = 6.88 years) and representing a broad spectrum of abilities and living arrangements, participated in the study. Characteristics of the subjects are presented in Table 1.

Clinical tests

Balance assessment methodologies were reviewed for appropriateness to the clinical setting. A balance scale examining various functional movements (Berg et al 1989), a walking test (Himann et al 1988) and subjective

ratings of fear of falling (Tinetti et al 1990) were chosen from the literature as clinical measures of balance relevant for use with elderly individuals. A fourth measure of general function (activities of daily living), with established validity, specifically designed for use with elderly individuals (Cairl et al 1983), was also chosen from the literature.

Procedure

Data collection took place in each subject's usual living environment and followed a standard format. Cognition was assessed utilising the Folstein Mini Mental Questionnaire (Folstein et al 1975). All potential subjects scored 24 or above, indicating that no cognitive impairment was present. Information related to age, gender and self-report of falls within the previous 12 months was also recorded.

Specific attention was paid to increasing the accuracy of each subject's recall of falls. Two specific strategies were used, as suggested by Cummings et al (1988). Memorable events during the previous 12 months were discussed to prompt recall of the entire period and, where possible, carers were interviewed to verify the accuracy of falls reports.

Clinical measures were completed in

random order and all subjects completed the study protocol during one visit. Performance on the Balance Scale and SPWT was rated as the best performance observed during three trials. Both time and number of steps to complete the SPWT were recorded.

Statistical analysis

Subject characteristics represented the independent variables. Age had three levels (65-74, 75-84, 85-94) and gender had two (male, female) as did report of falls (fall, no fall). Results on the four clinical measures constituted the dependent variables.

Scores on measures with a finite possible score, such as the Balance Scale, FAI and FE Scale, provided nonparametric data. It was decided to transform these results to allow for the use of parametric analyses for all data. Transformation equations were chosen for each measure such that the data distribution closely approached the normal distribution. The Balance Scale and FAI results were transformed by taking the square of the score (y^2) and the FE Scale results were transformed by taking the square root (\sqrt{y}).

Three statistical analyses were performed to evaluate the data generated by the study. Analysis of variance (ANOVA) was used to determine significant interactions between each dependent variable and subject characteristics. Gender was examined as a covariate of age since the small number of males in the study population made it difficult to examine this variable as a separate factor. Pearson's correlation was utilised to determine the strength of the linear relationship between scores on the four clinical measures. Regression analysis was then used to quantify the relationships between selected dependent variables.

Results

Table 2 summarises the means and standard deviations of scores on the clinical balance and functional assessment scales.

ANOVA indicated three significant

From Page 185

results. The main effect for falls for time taken to complete the SPWT ($F_{(1,58)}=6.63, p=0.013$) and for the number of steps taken to complete the SPWT ($F_{(1,58)}=6.32, p=0.015$) were significant, as was the two way interaction age-gender on the number of steps ($F_{(2,54)}=3.82, p=0.028$). Further post hoc testing, however, indicated that neither age nor gender independently affected the step score on the SPWT.

The two significant results indicated that falls history was the only variable to significantly affect time taken and steps taken in completing the Self Paced Walk Test. Thus a history of falls in the previous 12 months was associated with a decrease in usual walking pace and step length over a 10 metre distance for elderly subjects in this study.

The two significant interactions are presented as histograms in Figure 1. Subjects reporting previous falls completed the SPWT in a mean time of 16.53 seconds (or 1.65 msec^{-1}) \pm 3.55 seconds and 21 steps (step length of 0.476 m) \pm 4 steps. Nonfallers completed the test in an average time of 11.65 seconds (or 1.17 msec^{-1}) \pm 5.38 seconds and 17 steps (step length of 0.588 m) \pm 7 steps. These results indicate that a report of falling within the previous 12 months was associated with a significant decrease in average walking pace and step length.

Results of Pearson's correlation indicated significant linear relationships between all dependent variables ($p<0.001$ for each relationship). These results are presented in Table 3.

Regression analysis was used to determine the ability of one measure to predict performance on the remaining measures. The Balance Scale score was significant ($p=0.000$) in the prediction of FAI scores and accounted for 74 per cent of the variation in FAI scores. This indicates that balance measured by the Balance Scale can be used with considerable confidence to predict functional performance in the elderly study population.

Table 2

Means and standard deviations of scores on the clinical balance measures and the functional assessment scale.

Test	Possible Score	Mean	SD
FAI	30	23.08	5.62
Balance Scale	56	38.07	12.94
FE Scale	100	22.32	19.62
SPWT (time)		14.75	7.41
SPWT (steps)		19.80	6.52

Table 3

Results of Pearson correlation between clinical balance and functional assessment scores.

Test	<i>r</i>	<i>p</i>
BS-FE Scale	.86	<.001
BS-FAI	.86	<.001
BS-SPWT time	.73	<.001
FE Scale-FAI	.72	<.001
FAI-SPWT time	-.66	<.001
FE Scale - SPWT time	-.63	<.001
FE Scale-SPWT step	-.58	<.001
BS-SPWT step	.53	<.001
FAI-SPWT step	-.44	<.001

The FAI ($p=0.000$), FE Scale ($p=0.000$) and the time measure of the SPWT ($p=0.181$) in combination predicted 87 per cent of the variance in Balance Scale scores, indicating that balance performance in elderly persons, measured by the Balance Scale, is related to general function, fear of falling and usual walking speed.

Scores on the FE Scale were predicted by the Balance Scale score ($p=0.000$) and the step measure of the SPWT ($p=0.032$) which in combination accounted for 76 per cent of the FE Scale score variation. Thus it is apparent that fear of falling, measured by the FE Scale, is related to balance abilities and usual step length.

Discussion

Performance on the Balance Scale was not affected by age, gender or reports of previous falls. Balance performance has been reported to decline with age (Tinetti et al 1988), however, the effects of chronic illness or multiple disability may have a more profound effect on balance than does age alone (Nevitt et al 1989). The relationship between disability, chronic illness and balance ability has yet to be established and will likely prove more revealing than a relationship based on age alone. This relationship, however, was not a focus of the present study.

Balance performance measured on the Balance Scale did not differ

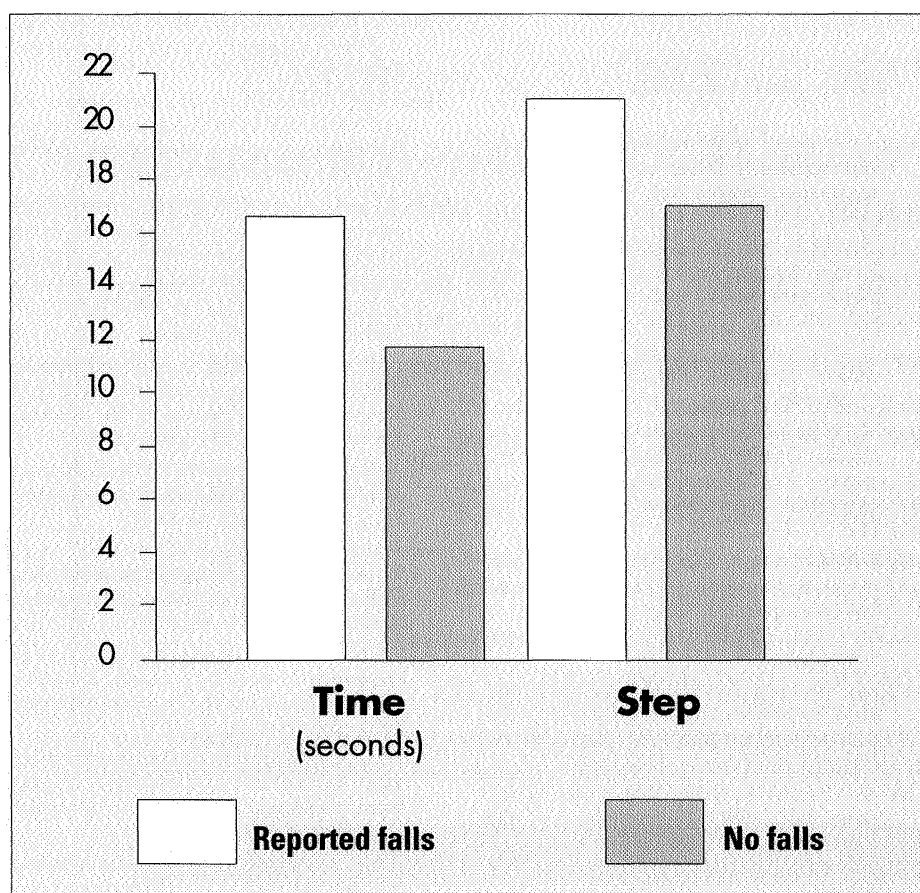


Figure 1.

The two significant interactions between the Self-paced Walk Test scores, time and step (means), and history of falls.

between subjects who had reported a previous fall and those who had not. Balance impairment has been implicated as a significant risk factor for falls in prospective studies (Nevitt et al 1989, Tinetti et al 1988) and Balance Scale scores have been shown to predict future multiple falls (Berg et al 1992b). The present study used a retrospective self-report of falls to establish falls history and this may account for the conflicting findings. While specific attention was paid to improving recall of previous falls, it is possible that not all falls were reported. Some subjects who had experienced falls may not have recalled them and were, therefore, classified as non-fallers. This situation is similar to the clinical setting in which physiotherapists usually rely upon recall of falls by their elderly patients.

Clinical balance performance was

strongly associated with fear of falling. Subjects scoring highly on the Balance Scale scored lowly on the FE Scale, indicating low fear of falling. The reverse was also true. Fear of falling resulted in cautious and limited responses during balance assessment. Efficacy theory hypothesises that an individual's beliefs will affect their behaviour (Bandura 1986). In this study, subjects fearful of falling exhibited poorer balance performance.

Scores on the Balance Scale were predicted by scores on the three other measures. Balance abilities, measured by the Balance Scale, were related to confidence, level of functional independence and usual walking pace. The Balance Scale has demonstrated strong relationships with other aspects of physical performance in elderly subjects. Similarly, Berg et al (1992b) reported strong correlations between

BS scores and functional and motor performance.

This study also highlighted the usefulness of the Falls Efficacy Scale in assessment of elderly persons. Scores on the FE Scale were significantly and strongly associated with scores on the Balance Scale and the FAI. The FE Scale was not, however, able to discriminate between subjects reporting previous falls and those who did not.

The FE Scale results were found to be more relevant to balance and functional abilities than to reports of previous falls. This finding is in agreement with Tinetti et al (1990) who reported that the perception of the fall, rather than the fall itself, influenced future fear of falling more strongly. Therefore, the relationship between reported falls and fear of falling is not necessarily expected to be significant.

The strong relationship between FE Scale and FAI scores indicates that as an individual becomes more fearful of falling during certain activities, performance of those activities declines. This finding is supported by efficacy theory (Bandura 1986) and similar findings have been reported by Tinetti et al (1990).

The FE Scale identified individuals who had limited activities because of anxiety. This compromise of independence is of great importance to physiotherapists working with the elderly population. Use of the FE Scale in the clinical setting will identify those people limiting their activities due to fear of falling. Further research may indicate the effectiveness of intervention directed specifically at improving falls efficacy in older people.

The Self Paced Walk Test proved to be the least useful balance measure. Although results were significantly related to scores on the other clinical measures, the strength of those relationships was generally weak.

The SPWT was, however, the only measure to discriminate on the basis of self reported falls in the study

From Page 187

population. Mean time and step measures for the group of subjects who had reported previous falls differed significantly from those of the group who had not reported falls. Previous falls were associated with a decrease in both walking pace and step length, resulting in a more cautious gait pattern. Similar findings of shortened step length have been reported by Guimares and Isaacs (1980) and Imms and Edholm (1981). This is a significant finding. While not a strong measure of balance abilities, the relationship between ambulation and falls warrants further investigation to ascertain whether the test can identify elderly individuals at risk of falling in the future.

Conclusion

The Balance Scale is recommended as the clinical balance measure of choice for physiotherapists working with elderly persons. The scale is easy to administer, requires no special equipment and is equally applicable to elderly persons living independently in the community and those resident in a care environment. Balance abilities, measured on the Balance Scale, may also be used to predict general function.

The Falls Efficacy Scale is also recommended as a useful clinical assessment of balance performance in elderly persons. It may be of most use for individuals expressing a fear of falling which may be limiting their activities and those experiencing multiple falls. It is quick and easy to use and is a useful addition to the general assessment of the elderly individual.

The Self Paced Walk Test is sensitive to reported previous falls in elderly individuals. In the clinical setting, observation of simple gait characteristics may alert the physiotherapist to the possibility that the elderly individual has a history of falls. The SPWT requires no special environment and can readily be performed by those able to walk 10 metres independently.

References

- Bandura A (1982): Self-efficacy mechanisms in human agency. *American Psychologist* 37:122-147.
- Bandura A (1986): Social foundations of thought and action: A social cognitive theory. Eaglewood: Prentice Hall.
- Bassey EJ, Fentem PH, MacDonald IC and Scriven PM (1976): Self-paced walking as a method for exercise testing in elderly and young men. *Clinical Science and Molecular Medicine* 51:609-612.
- Berg K (1989): Balance and its measure in the elderly: A review. *Physiotherapy Canada* 41:240-246.
- Berg K, Wood-Dauphinee S, Williams J and Dayton, D (1989): Measuring balance in the elderly: Preliminary development of an instrument. *Physiotherapy Canada* 41:304-311.
- Berg KO, Maki BE, Williams JI, Holliday PJ and Wood-Dauphinee S (1992a): Clinical and laboratory measures of postural balance in the elderly. *Archives of Physical Medicine and Rehabilitation* 73:1073-1080.
- Berg KO, Wood-Dauphinee SL, Williams JI and Maki B (1992b): Measuring balance in the elderly: Validation of an instrument. *Canadian Journal of Public Health* 83:S7-S11.
- Cairl RE, Pfeiffer E, Keller DM, Burke H and Samis HV (1983): An evaluation of the reliability and validity of the Functional Assessment Inventory. *Journal of the American Geriatrics Society* 31:607-613.
- Cunningham DA, Rechnittner PA and Donner AP (1983): Exercise training and the speed of self-selected walking pace in men at retirement. *Canadian Journal of Ageing* 5:19-26.
- Cummings SR, Nevitt MC and Kidd S (1988): Forgetting falls. The limited accuracy of recall of falls in the elderly. *Journal of the American Geriatrics Society* 36:613-616.
- Duncan PW, Weiner DK, Chandler J and Studenski S (1990): Functional reach: a new clinical measure of balance. *Journals of Gerontology* 45:M192-M197.
- Ekblom B, Day WC, Hatley LH, Moore F and Wear R (1979): Reproducibility of exercise prescribed by pace description. *Scandinavian Journal of Sports Science* 1:16-20.
- Fillenbaum GG (1988): The OARS Methodology (2nd ed.). Durham: Centre for the Study of Aging and Human Development, Duke University.
- Fillenbaum GG (1990): Assessment of health and functional status: an international comparison. In Kane RL and Evans JG (Eds). *Improving the Health of Older People: A World View*. New York: Oxford University Press, pp. 69-90.
- Folstein MF, Folstein SE and McHugh PR (1975): "Mini-Mental State": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research* 12:189-198.
- Guimares RM and Isaacs B (1980): Characteristics of gait of old people who fall. *International Rehabilitation Medicine* 2:177-180.
- Himann JE, Cunningham DA, Rechnittner PA and Paterson DH (1988): Age-related changes in the speed of walking. *Medicine and Science in Sports and Exercise* 20:161-166.
- Imms FJ and Edholm OG (1981): Studies of gait and mobility in the elderly. *Age and Ageing* 10:145-156.
- Kane RA and Kane RL (1981): *Assessing the Elderly, A Practical Guide to Measurement*. Lexington: Lexington Books.
- Nevitt MC, Cummings SR, Kidd S and Black D (1989): Risk factors for nonsyncopal falls. A prospective study. *Journal of the American Medical Association* 261: 2663-2668.
- Patla A, Frank J and Winter D (1990): Assessment of balance control in the elderly: Major issues. *Physiotherapy Canada* 42: 89-97.
- Podsiadlo D and Richardson S (1991): The timed "up and go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society* 39: 142-148.
- Tinetti ME (1986): Performance-oriented assessment of mobility problems in elderly patients. *Journal of the American Geriatrics Society* 34: 119-126.
- Tinetti ME (1987): Factors associated with serious injury during falls by ambulatory nursing home residents. *Journal of the American Geriatrics Society* 35: 644-648.
- Tinetti ME and Powell L (1993): Fear of falling and low self-efficacy: A cause of dependence in elderly persons. *Journals of Gerontology* 48(Special Issue): 35-38.
- Tinetti ME, Richman D and Powell L (1990): Falls efficacy as a measure of fear of falling. *Journals of Gerontology* 45: P239-P243.
- Tinetti ME, Speechley M and Ginter SF (1988): Risk factors for falls among elderly persons living in the community. *New England Journal of Medicine* 319: 1701-1707.
- Wolfson LI, Whipple R, Amerman RN and Kleinberg A (1986): Stressing the postural response: a quantitative method for testing balance. *Journal of the American Geriatrics Society* 34: 845-850.