Prediction and Prevention of Falls among Elderly People in Residential Care

by

Lillemor Lundin-Olsson
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Umeå 2000
When going round a spinney of larch trees
Tracking Something, be sure it isn't your
own footprints you are following.

—Winnie-the-Poh

To Tommy

Sara Anton and Anna
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References

Original Papers

Dissertations

• from the Department of Community Medicine and Rehabilitation, Geriatric Medicine, Umeå University, 1983-2000
• written by physiotherapists at Umeå University
Prediction and Prevention of Falls among Elderly People in Residential Care

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Lillemor Lundin-Olsson

Fakultetsopponent: professor Marianne Schroll,
Köpenhamns Universitet
Prediction and Prevention of Falls among Elderly People in Residential Care

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Abstract

Among elderly people, falls lead to a considerable amount of immobility, morbidity, and mortality. The purpose of this study was to develop and evaluate methods for predicting falls, and to evaluate a fall prevention program among elderly people living in residential care facilities. A fall was defined as any event in which the resident unintentionally came to rest on the floor or the ground regardless of whether or not an injury was sustained.

In developing the prediction methods, it was hypothesised that older persons showing difficulties in performing a familiar second task while walking were more likely to fall within six months. For residents who stopped walking when talking, the relative risk of falling was 3.5 (95% CI:2.0–6.2) compared to those who continued walking. For residents with a time difference (diffTUG) of at least 4.5 seconds between two performances of the Timed Up & Go test, with and without carrying a glass, the hazard ratio for falls was 4.7 (95% CI:1.5–14.2) compared to those with a shorter diffTUG.

A screening tool, the Mobility Interaction Fall (MIF) chart, was developed and evaluated, then validated in a new sample. This tool included a mobility rating, ‘Stops walking when talking’, ‘diffTUG’, a test of vision, and a concentration rating. In the first sample, the hazard ratio was 12.1 (95% CI:4.6–31.8) for residents classified as ‘high-risk’ compared to ‘low-risk’. The positive predictive value was 78%, and the negative predictive value, the sensitivity, and the specificity were above 80% for falling in six months. In the second sample the prediction accuracy of the MIF chart was lower (hazard ratio 1.7, 95% CI:1.1–2.5) and a 6-month fall history or a global rating of fall risk by staff were at least equally valuable. A combination of any two of the methods – the MIF chart, staff judgement, fall history – was more accurate at identifying high risk residents than any method alone. Half of the residents classified by two methods as ‘high risk’ sustained a fall within 6 months.

In a randomised study a prevention program directed to residents, staff, and environment resulted in a significant reduction in the number of residents falling (44% vs. 56%; odds ratio 0.62, 95% CI:0.41–0.92), the incidence of falls (incidence rate ratio IRR 0.80, 95% CI:0.69–0.94) and of femoral fractures (IRR 0.25, 95% CI:0.08–0.82) in the intervention compared to the control group.

In conclusion, a large proportion of residents at particularly high risk of falling can be identified by a combination of staff judgement, fall history, and the MIF chart. A multidisciplinary and multifactorial fall prevention program directed to residents, staff, and the environment has the potential to reduce the number of residents falling, of falls and of femoral fractures.

Keywords: accidental falls, risk factors, movement, equilibrium, predictive value of test, accidental falls: prevention & control, randomised controlled trials, frail elderly, residential facilities.
ABSTRACT

Prediction and Prevention of Falls among Elderly People in Residential Care

Lillemor Lundin-Olsson, RPT, MSc, Physiotherapy and Geriatric Medicine, Department of Community Medicine and Rehabilitation, Umeå University, SE-901 87 Umeå, Sweden

Among elderly people, falls lead to a considerable amount of immobility, morbidity, and mortality. The purpose of this study was to develop and evaluate methods for predicting falls, and to evaluate a fall prevention program among elderly people living in residential care facilities. A fall was defined as any event in which the resident unintentionally came to rest on the floor or the ground regardless of whether or not an injury was sustained.

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In a randomised study a prevention program directed to residents, staff, and environment resulted in a significant reduction in the number of residents falling (44% vs. 56%; odds ratio 0.62, 95% CI:0.41–0.92), the incidence of falls (incidence rate ratio IRR 0.80, 95% CI:0.69–0.94) and of femoral fractures (IRR 0.25, 95% CI:0.08–0.82) in the intervention compared to the control group.

In conclusion, a combination of any two of the staff judgement, fall history or MIF chart has the potential to identify a large proportion of residents at particular high fall risk. A multidisciplinary and multifactorial fall prevention program directed to residents, staff, and the environment can reduce the number of residents falling, of falls and of femoral fractures.

Keywords: accidental falls, risk factors, movement, equilibrium, predictive value of test, accidental falls: prevention & control, randomised controlled trials, frail elderly, residential facilities.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADL</td>
<td>Activities of Daily Living</td>
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<tr>
<td>AIS</td>
<td>Abbreviated Injury Scale</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>DSM-III-R</td>
<td>Diagnostic and Statistical Manual of Mental Disorders</td>
</tr>
<tr>
<td>diffTUG</td>
<td>Difference in time between TUG with and without carrying a glass of water</td>
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<tr>
<td>FICSIT</td>
<td>Frailty and Injuries: Co-operative Studies of Intervention Techniques</td>
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<td>FR</td>
<td>Functional Reach</td>
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<td>HR</td>
<td>Hazard Ratio</td>
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<tr>
<td>ICC</td>
<td>IntraClass Correlation</td>
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<tr>
<td>κ</td>
<td>Kappa value</td>
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<tr>
<td>MADRS</td>
<td>Montgomery-Åsberg Depression Rating Scale</td>
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<td>MIF chart</td>
<td>Mobility Interaction Fall chart</td>
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<tr>
<td>MMSE</td>
<td>Mini-Mental State Examination</td>
</tr>
<tr>
<td>SWWT</td>
<td>Stops Walking When Talking</td>
</tr>
<tr>
<td>TUG</td>
<td>Timed Up&amp;Go</td>
</tr>
<tr>
<td>PY</td>
<td>Person Years</td>
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<tr>
<td>Q1–Q3</td>
<td>Interquartile range</td>
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LIST OF ORIGINAL PAPERS

The dissertation is based on the following papers which will be referred to in the text by their Roman numerals:


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INTRODUCTION

Falls affect the lives of many old people and constitute a major public health problem. The importance of a fall lies in its effect on the elderly person’s health, functioning and independence, and on costs for the society. In people aged 60 years or more, falls present the most common cause of injury (1). In the near future, the number of hip fractures is predicted to increase substantially with ensuing increasing costs (2, 3).

Research on falls in elderly people has escalated in the past 20 years. Formerly falls in older adults were generally seen as an unfortunate consequence of advancing age and unpredictable incidents (4). Today, researchers consider falls as potentially preventable (5).

Fall prevention is of a multidisciplinary nature, which is reflected in the researchers’ variety of backgrounds. Physicians, nurses, physiotherapists, occupational therapists and biomedical engineers are all tackling the problem of falls in elderly people, and their efforts have mainly focused on identifying risk factors for falls and injuries but also on evaluating preventing programs.

Numerous risk factors for falling have been identified but results vary widely (6). For elderly people living in the community prevention programs have proved to be effective (5). However, for people living in institutional care, only one controlled trial of fall prevention has reported decreased falling, and that solely regarding recurrent fallers (7). Thus knowledge of how to successfully prevent falls and injuries is limited in the sphere of institutional care.

Common definitions of falls and fall-related injuries

In 1987, the Kellogg International Group on the Prevention of Falls formulated a definition of falls which has influenced the research since then (8). A fall was defined as “an event which results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of the following: sustaining a violent blow, loss of consciousness, sudden onset of paralysis, as in stroke, and an epileptic seizure”. Nevitt (9) defined falls that occurred because of loss of consciousness (syncope or seizure) or sudden paralysis as ‘syncopal falls’.
Studies including people living in the community tend to exclude 'syncopal falls' (9-13) whereas studies in nursing homes tend to include them (14-16). However, often the authors do not mention how they deal with syncopal falls, either in the community (17-19) or in the nursing homes (20, 21) which makes evaluation of earlier studies cumbersome.

Injury as a consequence of a fall is usually classified as minor or trivial and major or serious. Minor injuries often denotes bruises or superficial lacerations not requiring sutures, and major injuries refers to fractures, joint dislocations, sutured lacerations, or other injury requiring hospitalisation (12, 13, 16, 18, 19, 22, 23).

**Distribution of falls and fall-related injuries**

**Falls**

Elderly people in institutional care, i.e. residential care facility, nursing home, and hospital, experience falls three times as often as elderly people living in the community (approximately 1500 versus 450-500 falls per 1000 person-year, PY) (18, 24). The incidence rate is even higher in psychogeriatric care (5954 falls/1000 PY) (25).

About one-third of community-living persons aged 65 or older experience a fall event annually and half of those who fall, do so more than once (17, 24, 26, 27). Vigorous people are less likely to fall (17%) than are frail people living in the community (52%) (10). Two-thirds of those in residential care facilities and nursing homes fall annually, and half of them fall more than once (28-31). Thus the proportion of residents falling in this setting is double that of elderly people in the community.

Among community-living people, higher age implies a higher risk of falling (24). Some reports indicate that elderly women tend to fall more frequently than elderly men do (24, 32, 33), while others show no difference between gender (26, 34). In institutional care, the association between age and falls is less pronounced (24, 25, 35) and here the incidence rates have been reported as higher among men than among women (22, 25).

**Fall-related injuries**

Among community-living elderly people, almost half the falls lead to an injury (9). One in three falls leads to a minor injury, one in ten to a major soft tissue injury, and one in 20 to a fracture (17, 26, 36, 37).

The incidence rate of major injurious events has been reported as 57/1000 PY (22), and also as to 64.5/1000 PY (26). For people in institu-
tional care, the corresponding figures are more than twice as high (163 for women and 189 for men/1000PY respectively) (22).

Overall, women have a three times higher incidence rate for fractures (25.1/1000 PY) than men (8.2/1000 PY) (27). The risk of sustaining a hip fracture is substantially higher in institutional care (38). In Umeå, almost half of those who suffer a fracture of the femur live in residential care facilities or in nursing homes (39) although only 8% of elderly people live there.

Besides the physical consequences of a fall, fear of falling again is commonly reported (26, 40) and many limit their normal activities because of fear of falling or of injury (9, 41).

Differences between countries

There is some evidence that differences between countries exist regarding the occurrence of falls. In community-living elderly people in China and Japan, and among residents in nursing homes in Japan, the incidence rate was two to four times lower than among Americans (20, 40, 42). Among the residents who fell, a similar proportion was injured in Japan and in the United States (20).

Risk factors for falling

Knowledge of risk factors for a certain disease or injury is used to develop prevention programs and implement them for persons who are at special risk of suffering the actual disease or injury (43).

A risk factor has been defined as “an aspect of personal behaviour or life-style, an environmental exposure, or an inborn or inherited characteristic, which on the basis of epidemiologic evidence is known to be associated with health-related conditions considered important to prevent” (44).

The term ‘risk factor’ can be rather loosely used and include the meaning of ‘risk markers’ and the synonym ‘risk indicator’, and ‘determinant’. A risk marker/risk indicator is an associated but not necessarily causal factor. A determinant is “an attribute or exposure that increases the probability of occurrence of disease or other specified outcome” and also “a factor that can be modified by intervention and thereby reduce the risk of occurrence” of the specified outcome (44). In the literature about falls, the terms ‘factors associated with’ and ‘risk factor’ are often used seemingly synonymously, and therefore this usage will also be applied in this review.

Factors associated with falls have been studied both retrospectively and prospectively. Because elderly adults may have great difficulty in recalling previous falls, prospective studies are preferable (45, 46).
The time of the follow-up for falls, and hence for prediction, has most frequently been six months or one year (9, 10, 17), but has also covered one day (47), one week (48), three months (49) as well as five years (50). To my knowledge, the only risk factor for falls that has been critically evaluated in structured meta-analyses is medication use (51, 52).

Patterns of risk factors

In the following review only prospective studies are included presenting models including factors independently associated with falls and fall injuries in elderly people in institutional and community living.

Falls and fall injuries result from the accumulated effect of several factors (10-12, 14-19, 23, 26-28, 35, 36, 42, 49, 50, 53-57). These factors cover many domains such as mobility problems, sensory deficits, cognitive difficulties, medical conditions, medication use, and behavioural and environmental factors and the factors are combined in a variety of ways (6). Some factors are related to chronic conditions and thus regarded as predisposing factors. Others are only temporary, such as an acute illness, and may be a precipitating factor.

The importance of identifying risk factors for different kinds of falls in different groups of old people has been stressed (8). One argument has for example been that the risk factors for fall-related injuries are not necessarily the same as the risk factors for having a fall (28). The results are divergent and highlight the necessity for structured meta-analyses including all the probable risk factors. However, some patterns seem to be identifiable:

1. The most frequently documented factors are gait and balance problems, concurrent with an ambulatory activity that provides the opportunity to fall, both regarding falls (9, 11, 15, 23, 17, 35) and injurious falls (16, 17, 28, 56) in elderly people in nursing homes as well as in the community.

2. Mobility factors cover a broad range of difficulties, e.g., wheelchair and transfer independence (16, 35), impaired chair stand (9, 15, 23, 57), unsteady gait (35), trouble walking 400 m and trouble bending down (17), poor tandem stance or -gait (9, 56, 57). One screening tool of mobility showed that those with an ability to stand but not to walk normally were at the highest risk of falling (11). Currently there is thus good evidence that an ambulatory ability of independent transfer combined with gait problems, decreased leg muscle strength, and lateral instability are related to falls and fall injuries. A performance scale including balance in sitting and standing, gait flow and endurance, has been developed specifically for the prediction of falls and injuries (18, 26, 49). However, different scores have been used to imply an increased risk and therefore results are difficult to interpret.
3. The relations between physical ability, physical activity, falls and fall injuries are complex. Frail elderly people fall more frequently than those who are vigorous. They tend to fall during routine daily activities while vigorous elderly people fall in the presence of environmental hazards away from home. When vigorous people fall they are more likely than frail people to sustain a severe injury (10). Also, frequent participation in physical activities (17) and falling while being engaged in an unusual activity (23) implies a higher risk of injuries. Ambulant nursing home residents have a higher injurious fall-rate than nonambulant residents (16) and those who suffer a serious injury tend to be more independent, yet have weaker leg muscles than those who fall without injury (28).

It seems as if injuries occur when the activity level is higher than the person can cope with. However, few authors have focused their analyses on this particular issue. To my knowledge, in one study only, an activity score adjusted for mobility impairment was used to analyse whether activity with respect to physical potential was a risk factor for recurrent falls. It was found that ‘overactivity’ did not increase the risk of falling (57).

4. Some other suggested risk factors for falls are visual deficits, cognitive impairment, dizziness, and postural hypotension. Regarding all these factors, results are varied. Different aspects of visual function have been tested: near and distant vision acuity, visual field, depth perception, and contrast sensitivity. In univariate analyses, different kinds of visual deficits have been reported as both connected (9, 18, 26, 27, 55, 56, 58, 59) and not connected (23, 26, 57, 58) with falls and injuries. Also, results regarding cognition and falls/injuries report both an association (18, 26, 35, 57) and no association (14, 16, 23, 55). Similarly, dizziness has been reported to be associated (17, 35, 57, 58, 60) and not associated (15, 26, 55) with falls and injuries. Postural hypotension has only seldom shown an association with falls and injuries (57), and more often the result has been a lack of association (14, 15, 18, 26, 30). Also other factors such as psychological, behavioural, and social, have been suggested as associated with falls (11), but these are studied to a lesser degree.

It is worth noting that these results are based on a comparison of the variables measured at baseline between those who later sustained a fall and those who did not. The analyses, particularly regarding fluctuating symptoms, thus do not guarantee the presence or absence of the symptoms at the time of the fall.

5. Falls occur more often during acute illness in people living in institutional care than in the community. In institutional care, acute illness has been reported to be present when one-third of the recurrent fallers fell (49) as well as in 25% of the falls (61). In the community the corresponding figure is about 10% of the falls (26).
6. Some medications are weakly associated with falls. The association between drug use and fall in elderly people has been studied in two meta-analyses (51, 52): one regarding psychotropic drugs (40 studies) and the other regarding cardiac and analgesic drugs (21 studies). A weak association was found between falls and the use of many classes of psychotropic drugs (anti-depressants, neuroleptics, sedative hypnotics, benzodiazepines) and of digoxin, type IA antiarrhythmics, and diuretics. No association was seen between falls and the use of nitrates, beta-blockers, calcium channel blockers, ACE inhibitors, or centrally acting antihypertensives. Taking more than three medications indicated an increased risk of recurrent falling.

7. The risk factors appear to be the same for one fall and recurrent falls (23, 26). However, drawing conclusions regarding similarities or differences in risk factors for one fall and recurrent falls is extremely difficult. The samples are usually divided into ‘no fall compared to any fall’ and ‘no or one fall compared to at least two falls’. ‘One fall’ is thus combined either with no falls or with recurrent falls. In addition, in studies of fall events the number of falls is recorded during a certain period of time and those with a recent history of falls are usually not excluded, which makes it even more difficult to interpret the results.

8. Given the fall, additional factors increase the risk of serious injuries. Cummings and Nevitt suggest that, for a fall to result in a hip fracture, the faller must be oriented so that the point of impact is near the hip, the protective responses fail to reduce the energy of the fall, and bone strength is decreased (62). Presumably because of these factors, people with a previous stroke are particularly vulnerable regarding the risk of suffering a hip fracture (39). It has been found that falling while turning was much more likely to lead to a hip fracture than falling when walking in one direction (63). Also, female fallers were more likely to suffer a serious injury, although women were no more likely to fall than men (18). Furthermore, a low BMI increased the risk of serious injury but not of falls (18, 23).

9. Previous falls are associated with higher risk of falls and fall injuries in older adults both in residential care facilities and in nursing homes (16, 35, 57, 64), and in the community (9, 17, 23, 26, 65). However, serious injuries are not necessarily related to previous falls. An increased risk is reported both in the first fall (10) and after several falls (63), as well as no difference at all in a sequence of falls (18).

10. The combinations of risk factors for falling seem to be similar for elderly people living in institutional care and in the community. In nursing home studies including samples with a mean/median age of approximately 88 years, gait and balance problems concurrent with transfer independence comprised the only characteristic for an increased risk of falls, while cognition, vision, and postural hypotension were not
associated with falls (14, 15, 35). Among the somewhat younger elderly adults in nursing home/residential care an increased fall risk was associated with mobility impairment, poor mental state and postural hypotension, whereas results regarding vision, morale score and medication were inconclusive (49, 57). Among elderly people in the community, an increased fall risk was consistently seen regarding mobility problems and occasionally seen regarding dizziness upon standing, postural hypotension, impaired vision, poor mental and morale score, medication use, and a high level of physical activity (17, 23, 26). Thus only impaired mobility was consistently reported, although measured in different ways.

**Summary**

In summary, falls and fall injuries result from several factors in combination. These factors cover several domains but impaired mobility is the only factor consistently reported as an independent contributor to falls and fall injuries. However, impaired mobility embraces a broad range of assessments. No pattern of combinations between the mobility factor and other factors is obvious, neither in elderly people in institutional care nor in those in the community.

The risk factors appear to be the same for one fall and recurrent falls. Given the fall, additional factors increase the risk of sustaining a serious injury. Previous falls are associated with high risk of future falls and fall injuries. However, in a sequence of falls, injuries are reported in all falls. With this summary in mind, a plausible hypothesis is that impaired mobility is a necessary but usually not a sufficient risk factor for falling, and that other factors alter the fall risk in the presence of impaired physical function. This hypothesis corresponds to a model proposed by Studenski in which the risk of falling in physically impaired persons is increased by non-physical factors such as behavioural, social, and environmental factors (66). To my knowledge this theory has not been further developed for application in practical use.
Postural control and attention

Falls tend to occur at times when the activity on the ward is at its greatest (67, 68) or while the person is engaged in an activity or confronted with an obstacle (49). A perspective not investigated as a risk factor for falls is postural control in combination with attention. According to theories of attention, attentional processes are competing for a limited capacity (69). At least one task requires no or only minimal attention when two tasks can be performed simultaneously. Interference between tasks becomes obvious when the performer simultaneously perform two actions each requiring mental operation.

Maintaining postural stability in frequently performed tasks such as sitting and standing has been considered automatic, but today we know that cognitive information processing is required, although not necessarily a conscious awareness. During walking, the requirements of information processing are higher (70). A walking person must look ahead to pick up relevant information because conditions critical for movements change while walking. Adjustment strategies are to vary the speed, change the method of scanning the environment or change the risk level (71).

An age-related decline is shown in systems important in postural control (72) and the integration of these systems seems to be reduced (73). With ageing the anticipatory control becomes slower and the selection of a priori strategies is safer, i.e., a slower gait, shorter single-leg support time, and walking around instead of over an obstacle (74). Also healthy elderly persons’ attentional demands increase with the difficulty of the postural task, thus walking requires more attention than sitting (75). In addition, they are more distracted by unexpected stimuli in the environment, for example when stepping over suddenly appearing obstacles, than are young adults (76). Even when the instability is self-generated by an arm swing, and as such is predictable by the person, healthy elderly people occupied with an attention-demanding task recover from the postural instability more slowly than younger ones (77). Furthermore, a concurrent cognitive task as an external disturbance to balance in standing seems to decrease muscle activity in the lower legs (78) and bring forward the need to regain stability by taking a step instead of adjusting balance while maintaining the feet stationary (79).

When the balance is impaired even simple cognitive tasks seem to affect postural stability in quiet standing (80). Elderly adults with a recent history of falls, who were able to maintain stability when the visual or the somatosensory input was blocked or disturbed, were likely to lose balance when performing a secondary task under the same sensory conditions (81). Consequently, it might be difficult for frail persons to allocate sufficient attention to postural stability while distracted by doing a second task or by an event in the environment and thus this inability appears to contribute to imbalance and falls in some elderly adults.
Fall risk assessment

The risk factors for falling are usually presented as a model of the logistic regression or the Cox regression technique. However, these results may be difficult to incorporate into practice, partly because of the multitude and the inconsistency of risk factors found in the literature, but also because of difficulties in interpreting the models and transferring the results to guide therapy.

Fall risk assessment tools

On the assumption that the combination of predisposing factors concurrently present more adequately identifies those who are at high risk of falling, a number of fall risk assessment tools based on scoring systems have been suggested (Table 1). Thus, fall risk factors are put together as a list in protocols and each factor is scored. The scores are added together and the obtained sum is assumed to correlate with the person's level of fall risk.

There is some evidence that assessment tools developed for one setting may not be appropriate for another setting (82). Today, most tools are developed in hospitals (48, 83-87). Only one has been developed for predicting falls among elderly people in residential care (49). However, this tool has some disadvantages. First, four of the nine items are based on other assessment scales and thus quite a comprehensive and time-consuming assessment is required. Second, the tool is aimed at predicting recurrent falls within three months, i.e. it identifies only residents who fall very frequently. Finally, the tool has not been evaluated prospectively in an independent sample regarding the accuracy of the prediction. Results of evaluations of other tools used in clinical circumstances by ordinary staff most often show a decreased predictive accuracy (88).

Clinical judgement

Instead of aggregating predisposing risk factors, the predictive accuracy of nurses’ clinical judgement has been studied, however only in one small study (89). The nurses’ judgements were compared to a fall risk assessment tool in a geriatric hospital unit. The results indicate that the factors influencing nurses’ judgement of fall risk differ from those included in the tool. To optimise the prediction a combination of a fall risk assessment tool and the nurses’ judgement was suggested.
Determining high and low risk of falling

Given the multitude of risk factors, a common problem is the over-targeting of persons as having a high risk of falling. In choosing the cut-off score that defines the ‘high risk level’ there is an inevitable compromise between predictive values, sensitivity and specificity. It is desirable that means of prevention, which often are limited, should be of use to the persons who have a high risk of falling. Thus the main goal is a tool with both a high positive predictive value and a high sensitivity. A low positive predictive value results in a distribution of preventive means to persons not needing them and a low sensitivity results in missed persons who would fall. Some authors recommend the cut-off score to be decided at each unit (47, 48) and by the administrators who are responsible for the care and preventive means (47).

In all protocols in Table 1 the risk of falling is classified according to whether the sum of the list of risk factors is over or under a cut-off score. This is based on an assumption that all factors can be combined with any of the others and, thus none of the factors is viewed as the indispensable factor. A flow chart would make it possible to assume that one factor is necessary but not sufficient and that other factors increase the risk in the presence of the first factor.
<table>
<thead>
<tr>
<th>Study</th>
<th>Fall data collection; sample size</th>
<th>Target group</th>
<th>Scoring protocol</th>
<th>Predictive accuracy* %</th>
<th>(to be continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>original sample</td>
<td>new sample</td>
</tr>
<tr>
<td>Tinetti</td>
<td>prospective; first 3 months at residence n=79; 25 recurrent fallers</td>
<td>intermediate care facility residence</td>
<td>mobility, vision, hearing, morale, mental status, back extension, ADL, orthostatic blood pressure, medication</td>
<td>sens†† 56 spec†† 100ppv†† 100 npv†† 83</td>
<td>not evaluated</td>
</tr>
<tr>
<td>1986</td>
<td>(49)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moore</td>
<td>prospective; a) n=200; 100 fallers b) n=4100; 100 fallers</td>
<td>hospital: acute care, long-term geriatric centre, Veteran's home</td>
<td>fall history, secondary diagnosis, ambulatory aids, intravenous therapy, gait, mental status</td>
<td>sens 78 spec 83 pppv 10 npv 99</td>
<td>sens† 70 spec† 76 pppv† 11 npv† 98</td>
</tr>
<tr>
<td>1989</td>
<td>(83)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schmid</td>
<td>retrospective; n=204; 102 falls, 102 matched controls</td>
<td>hospital</td>
<td>mobility, mental status, elimination, fall history, medication</td>
<td>data not available</td>
<td>sens 93 spec 78 pppv 37 npv 99</td>
</tr>
<tr>
<td>1990</td>
<td>(84)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heslin</td>
<td>retrospective; n=855 falls, no controls</td>
<td>hospital: acute care, long-term care, residential care beds</td>
<td>age, confusion, attempts to get out of bed, fall history, mobility, weakness, elimination, medication</td>
<td>data not available</td>
<td>sens 50 spec 52 pppv 16 npv 85</td>
</tr>
<tr>
<td>1992</td>
<td>(82)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downton</td>
<td>retrospective; falls last year n=28; 17 fallers</td>
<td>continuing care ward</td>
<td>fall history, medication, sensory deficits, mental status, gait safety</td>
<td>sens† 100 spec† 9 pppv† 63 npv† 100</td>
<td>sens† 91 spec 27 pppv† 45 npv† 81</td>
</tr>
<tr>
<td>1993</td>
<td>(90)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Sens = Sensitivity, Spec = Specificity, PPV = Positive Predictive Value, NPV = Negative Predictive Value.
<table>
<thead>
<tr>
<th>Study</th>
<th>Fall data collection; sample size</th>
<th>Target group</th>
<th>Scoring protocol</th>
<th>Predictive accuracy* %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studenski</td>
<td>prospective; 6 months n=306; 44 recurrent fallers</td>
<td>ambulatory clinics: male veterans ≥70 years</td>
<td>mobility screen including 6 items</td>
<td>sens** 84 spec** 53 ppv** 23 npv** 95 not evaluated</td>
</tr>
<tr>
<td>Hendrich</td>
<td>retrospective; n=338; 102 fallers</td>
<td>hospital: acute care</td>
<td>fall history, depression, dizziness or vertigo, confusion, elimination, mobility</td>
<td>sens 77 spec 72 ppv† 54 npv† 88 low predictive accuracy, modified after evaluation (92)</td>
</tr>
<tr>
<td>MacAvoy</td>
<td>prospective; n=88; 44 falls</td>
<td>hospital: acute care</td>
<td>age, mental status, elimination, fall history, sensory impairment, activity, medication</td>
<td>sens 43 spec† 70 ppv† 59 npv† 55 not evaluated</td>
</tr>
<tr>
<td>Nyberg</td>
<td>prospective; n=135; 49 fallers</td>
<td>hospital: stroke rehab ward</td>
<td>sex, ADL, incontinence, postural stability, motor impairment, visuospatial hemineglect, bilateral brain lesion, medication</td>
<td>sens 73 spec 77 ppv 66 npv 86 cut-off ≥8 not evaluated</td>
</tr>
<tr>
<td>Oliver</td>
<td>prospective; a)n=232; 116 fall events, 116 non-fallers b) n=217; 71 fallers</td>
<td>hospital: elderly care unit</td>
<td>falls as a present complain, agitation, visual impairment, frequent toileting, transfer and mobility</td>
<td>sens 93 spec 88 ppv 62 npv 98 cut-off ≥2 score ≥2 elderly care unit (48)</td>
</tr>
</tbody>
</table>

* sens=sensitivity, spec=specificity, ppv=positive predictive value, npv=negative predictive value.

The accuracy of the prediction is calculated according to the time that the prediction is assumed to be valid of each study, e.g. during the hospital stay as well as one year.

† not reported in the referred article. Calculated from data given in the article.

‡ regarding recurrent fallers.

§ risk preference score not added. Data not available.
Prevention of falls

Two general strategies for preventing disease and injuries are generally discussed: the population and the high-risk strategy (43).

The population strategy is based on the recognition that common diseases or injuries reflect the behaviour and circumstances of society as a whole and that a large number of people with a small risk generate more cases than a small number with a high risk. According to this strategy, a lot of people must take precautions in order to prevent disease or injury in a few individuals. For example, to prevent one death due to a car accident, many hundreds of people must wear seatbelts.

The high-risk strategy focuses on those individuals who are judged most likely to develop the disease or suffer the injury. Those who are at special risk are segregated, commonly through some form of screening assessment, from those who are regarded as not needing attention. Thus, the advice can be matched to the individual. This might induce powerful motivation and simultaneously avoid the wastefulness of the mass approach. However, one may argue that the high-risk strategy only deals with the margin of the problem.

There is thus a dual implication for preventive strategy. High-risk individuals should be offered guidance and support but most people in fact face a small and potentially avoidable problem, which should also be reduced if possible (43).

Randomised controlled trials

Randomised controlled trials, mainly according to the high-risk strategy, have shown some promising but also non-successful results in the prevention of falls and fall-related injuries (5, 93, 94). Differences in approach, target groups, settings, interventions and outcome measures may explain the heterogeneity.

Only a few controlled trials have focused on old people living in residential care facilities or nursing homes (7, 95-97). One study targeting nursing home residents at high risk reported a beneficial effect but solely with regard to recurrent fallers (7). Another trial with a post-fall geriatric assessment led to fewer hospital admissions and hospital days (95), and yet another including an exercise program improved mobility and reduced use of assistive devices (96), but neither study resulted in a significant reduction of falls or the number of persons falling. Intervention programs directed to this group of old people are bound to be complicated by the vulnerability of the residents (49, 98) which may possibly explain the lack of results.

In contrast, community-living elderly people at high risk of falling sustained markedly fewer falls according to a randomised controlled trial, a pioneer work by Tinetti and colleagues in 1994 (99). The trial used a
high-risk strategy and targeted risk factors were medication use, environmental hazards and transfer skills, gait, balance and strength. These results were supported by others regarding falls (100) or persons falling (101). Also controlled trials using a single measure, such as exercise (102-105), medication withdrawal (105), or reduction in environmental hazards (106) have recently proved effective when directed to community-living elderly people.

Regarding injurious falls, a significant reduction in moderate injuries was achieved by reducing the fall risk of community-living elderly people (104, 105), but similar results have not been shown for old people in nursing homes or residential care (7, 95-97). As a complement to fall reduction, hip protectors worn by residents at high risk of sustaining a hip fracture appear to decrease the incidence of hip fractures following a fall (107-109). However, a low long-term compliance in wearing the hip protectors has also been reported (107, 110, 111).

There is thus currently good evidence that a targeted multifactorial strategy directed to risk factors in community-living elderly people will have the potential to reduce falls but we still lack knowledge about how to prevent falls among elderly people living in institutional care.

Rationale for this thesis

The incidence rate for falls is very high in institutional long-term care such as residential care facilities. Many of the residents have a fluctuating health status and a decreased ability to interact with the environment. For them a fall may result in particularly severe consequences and a hip fracture is often a threat against life. The main objectives of this thesis were to develop instruments to identify residents prone to falls in order to prevent falls among people in residential care facilities.

Great efforts have been made to identify risk factors for falls and injurious falls. However, in previous studies the ability to walk and simultaneously interact with the environment has not been taken into consideration although many falls occur while the person is engaged in an activity.

The ability to use the body in a purposeful way in relation to the physical and social environment is a main focus of physiotherapy. The human walking pattern is closely associated with the environment. It is characterised by changes in direction and speed to avoid obstacles in the travel path and to accommodate varying surfaces of the floor or ground. Often we execute a concurrent task such as talking to someone, turning to look at something, carrying objects or planning what to do next. For a frail, elderly person these things might constitute a threat to balance and result in a fall. It would therefore be of great importance to gain knowledge of a possible association between postural control, multitasking and the risk of falls.
To determine the risk of falling in everyday work there may be difficulties in using knowledge about risk factors presented as statistical models. In order to overcome these difficulties, some fall risk assessment scoring systems have been developed. However, only one is aimed at predicting falls among elderly people in residential care (49). This scoring system is extensive and not evaluated prospectively in an independent sample. Hence, to prevent falls in residential care it was of great importance to set out and validate a system that could be easily used to classify the residents according to their risk of falling.

Many preventive programs for falling have been developed but until recently they were not evaluated in randomised controlled trials (5, 93, 94). Today, we know that when a targeted intervention program is directed to elderly people living in the community it has the potential to be effective. However, we still lack knowledge how to prevent falls and injuries among elderly people living in residential care facilities. This knowledge is of great importance for the life quality of individuals as well as for society considering the costs associated with falls and injuries.
AIMS OF THE STUDY

The general purpose of the present thesis was to develop and evaluate methods for predicting falls, and to evaluate a program in fall prevention among elderly people living in residential care facilities.

The specific aims for the five papers were:

• to investigate the predictive validity regarding falls of the observation ‘Stops walking when talking’ (Paper I)

• to investigate the effect of a well-known manual task on a movement sequence including transfer and gait and its association with falls (Paper II)

• to develop and test a screening tool, the MIF chart, for assessing the fall risk among old people regardless of walking ability (Paper III)

• to evaluate the accuracy of fall prediction by the MIF chart, staff judgement, and a history of falls (Paper IV)

• to evaluate a multidimensional fall prevention program that both targeted residents’ fall-risk factors and included measures directed to staff and residential environment (Paper V)
RESIDENTS AND METHODS

Residents

Two main samples of residents, 65 years or older, living in residential care facilities in Umeå, a city in northern Sweden, were included in this thesis. The first sample comprised one facility with 78 residents and the other sample comprised nine facilities with 402 residents (Figure 1).

The residents had a wide spectrum of disabilities. Some were independent in activities of daily living (ADL) while others were cognitively and functionally impaired and required substantial care and functional support (Table 2) and only a few were able to leave the facility unsupervised. The residents lived in private apartments or in private rooms with shared dining and living rooms. In all facilities there were access to help with ADL, housework, medical care, and supervision as required. There was no clear distinction in characteristics between the residents living in an apartment or in a room. Residents from both kinds of accommodation were included in all five studies.
<table>
<thead>
<tr>
<th>Paper</th>
<th>Number of facilities</th>
<th>Female sex, %</th>
<th>Age, years mean±SD</th>
<th>Diagnosis, %</th>
<th>Signs, %</th>
<th>Cognitive and functional status</th>
</tr>
</thead>
<tbody>
<tr>
<td>I n=58</td>
<td>1</td>
<td>72</td>
<td>80.1±6.1</td>
<td>Dementia 45</td>
<td>Impaired vision 21</td>
<td>MMSE score median; Q1–Q3* 22; 18–26</td>
</tr>
<tr>
<td>II n=42</td>
<td>1</td>
<td>71</td>
<td>79.7±6.1</td>
<td>Depression 43</td>
<td>Impaired hearing 36</td>
<td>21; 17–27</td>
</tr>
<tr>
<td>III n=78</td>
<td>1</td>
<td>72</td>
<td>81.0±6.5</td>
<td>Previous stroke 35</td>
<td>Urinary incontinence 41</td>
<td>21; 12–26</td>
</tr>
<tr>
<td>IV n=208</td>
<td>4</td>
<td>73</td>
<td>83.2±6.8</td>
<td>Heart failure 26</td>
<td>Episodes of delirium 31</td>
<td>12–26</td>
</tr>
<tr>
<td>V n=194</td>
<td>5</td>
<td>71</td>
<td>82.3±6.8</td>
<td>Lung disease 12</td>
<td></td>
<td>66–99</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>range 69–90–90</td>
<td>Dementia 36</td>
<td></td>
<td>65–97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Depression 36</td>
<td></td>
<td>65–97</td>
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<td></td>
<td>Previous stroke 36</td>
<td></td>
<td>65–97</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Heart failure 36</td>
<td></td>
<td>65–97</td>
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<td></td>
<td>Lung disease 36</td>
<td></td>
<td>65–97</td>
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<tr>
<td></td>
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<td></td>
<td>Dementia 36</td>
<td></td>
<td>65–97</td>
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<td></td>
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<td></td>
<td>Depression 36</td>
<td></td>
<td>65–97</td>
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<tr>
<td></td>
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<td></td>
<td>Previous stroke 36</td>
<td></td>
<td>65–97</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Heart failure 36</td>
<td></td>
<td>65–97</td>
</tr>
</tbody>
</table>

* interquartile range
† able to perform the TUG:
Papers I and II: 100%, Paper III: 78%, Paper IV: 67%, Paper V: 70%
Papers I – III

The first main sample comprised 78 residents, 65 years or older, who were living in one residential facility. Of these residents, 58 were able to walk, with or without a walking aid, and able to follow simple instructions and lived in the facility during the follow-up period for falls. They were included in Paper I (Table 2).

In Paper II, residents who were able to carry a glass while walking and able to follow simple instructions were included (n=42; Table 2).

In Paper III all 78 residents were included (Table 2). Three residents declined to participate in the assessment of balance and gait but they agreed to participate in the medical examination.

Papers IV – V

The second main sample comprised 402 residents, 65 years and older, from nine residential care facilities.

In Paper IV, 208 out of 219 eligible residents were included from the four facilities that constituted the control group in Paper V (Table 2).

In Paper V, residents from all nine facilities were included. At baseline, before the intervention program started, 402 out of 439 eligible residents were screened regarding fall risk (Figure 2). The nine facilities were clustered in two similar groups based on previous falls according to compulsory fall incident reports, age of residents, and type of setting, (care and service offered, corridors or a more home-like design). The two clusters were randomised by lot drawing to an intervention group and a control group (usual care). When the intervention (11 weeks) was completed, 384 residents were followed up for falls to the end of the study (34 weeks) or until the resident moved or died. The reduction of the sample size by 18 residents did not result in any significant differences between the clusters compared to the condition at baseline.

Ethical approval

The Ethical Committee of the Faculty of Medicine at Umeå University approved the studies (§84/94 and §3/98). All residents included were given written and oral information. All of those who participated, or the relatives of residents with severe cognitive dysfunction, gave their consent.
Figure 2 Trial profile of Paper V. ‘n’ refers to ‘number of residents’
Methods of data collection

The data collection of Papers I–III was carried out in 1994–1995 and of Papers IV–V in 1998–1999. An overview of the measures undertaken in each study is provided in Table 3.

Table 3 Overview of assessments and rating of fall risk in Papers I–V

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hearing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Barthel ADL Index</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MMSE*</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MADRS†</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line bisection test</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional Reach, FR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Gait safety</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stops Walking When Talking, SWWT</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Timed Up&amp;Go, TUG</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DiffTUG‡</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>MIF chart</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Staff judgement</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiotherapist judgement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of falls</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mini-Mental State Examination
†Montgomery-Åsberg Depression Rating Scale
‡Difference in time: TUG with and without carrying a glass with water
||Mobility Interaction Fall chart (includes rating of mobility, SWWT, DiffTUG, test of vision and rating of concentration)

Diagnoses

All participants in Papers I–III were thoroughly examined by a physician. Depression and dementia were diagnosed according to DSM–III–R criteria (112). Medical data were also collected by means of interviews with the participants’ relatives, carers, and from medical records. In Papers IV–V, physicians registered the diagnoses.
Vision and hearing

Vision and hearing were assessed by a physician in Papers I-III and by a physiotherapist in Papers IV-V.

Vision was rated as impaired when the participant, with or without spectacles, could not see a word written in 5 mm capital letters at normal reading distance. Hearing was rated as impaired if the participant, without a hearing aid, did not hear when the assessor spoke in a normal voice from a distance of one metre.

Activities of daily living

The Barthel ADL Index (113-115) was used to assess the residents’ level of independence in activities of daily living. The index includes ten items, which are scored according to the degree of independence from any physical or verbal help. The items are continence of bowel and bladder, grooming, toilet use, feeding, transfer, mobility, dressing, using the stairs and bathing. The maximum score is 20, which implies independence in self-care and indoor ambulation. The validity of the Barthel ADL Index is well established and it is considered reliable on test-retest, between observers and in different settings (115). In Papers I–III, the responsible nurse at the residential facility, who also was part-time employed on the project, performed the assessment. In Papers IV–V the score was based on an interview with the nurse’s aides and the licensed practical nurses, who were familiar with the residents’ abilities.

Cognitive status

The Mini-Mental State Examination (MMSE) was used to assess cognitive difficulties (116, 117). MMSE includes six sections (orientation, registration, attention and calculation, recall, language and copying) and the maximum score is 30. It is widely used and a score of less than 24 indicates cognitive impairment. MMSE was used by a physician in Papers I–III and by a physiotherapist in Papers IV–V.

Symptoms of depression

The Montgomery-Åsberg Depression Rating Scale (MADRS) was used by a physician in Papers I–III to assess depressive symptoms (118, 119). The MADRS includes 10 items and each item is scored on a 7-grade scale (0–3 including half-number, or 0–6) with a maximum score of 30 or 60. In this thesis, the maximum score of 30 is used in Papers I–II and of 60 in Paper III. Higher scores indicate a more severe depression. The
items are apparent sadness, reported sadness, inner tension, reduced sleep, reduced appetite, concentration difficulties, lassitude, inability to feel, pessimistic thoughts, and suicidal thoughts. The scale has shown good validity and reliability (118, 119).

Visuospatial neglect

In Papers I—II, visual spatial neglect was assessed by a physician using the Line bisection test (120). The resident was asked by a physician to bisect each of three horizontal lines spread in a staircase fashion across a paper. Deviations from the mid-point drawn by the resident to the actual mid-point were measured. The score of the Line bisection test ranges from zero to nine and seven or less is taken to indicate visuospatial neglect.

Medication use

The residents’ prescribed drugs were recorded at baseline.

Dynamic balance in standing

Functional Reach (FR) was used in Paper II to measure dynamic balance in standing. FR is defined as the distance one can reach forward beyond arm’s length while maintaining a fixed base of support (121). The resident was asked by a physiotherapist to raise the arm to 90° flexion in the shoulder and reach as far forward as possible in a plane parallel with a yardstick which was mounted on the wall, without taking a step. Reach strategy was not otherwise controlled. The result was expressed as the mean of three trials. FR has showed high test-retest reliability and high correlation with established force platform measures of dynamic balance (121), ADL and with mobility skills (122).

Walking ability

In Paper I the resident’s ability to walk safely was rated by a physiotherapist according to the scoring of the Downton Fall Risk Index (90): safe without walking aids, safe with walking aids and unsafe. In the present study a safe gait was scored when the resident gave no evidence of being at risk of falling as well as being able to move easily when for example opening and closing the door, meeting people in the hallway and approaching a chair to sit down. Unsafe gait was when the resident moved in an uncontrolled way, staggered or stumbled.
In Paper I, an accompanying physiotherapist observed the resident’s walking behaviour on the way to an indoor destination. During the walk the physiotherapist started an occasional conversation. A record was made of whether or not the resident stopped walking when the conversation started. Neither the residents nor the staff, nurse, or physician were aware of the observed walking-behaviour. We called this observation ‘Stops walking when talking’ (SWWT). SWWT is included in the Mobility Interaction Fall chart (MIF chart) and thus also registered in Papers III–V.

Timed Up&Go

The Timed Up&Go (TUG) was assessed to quantify basic mobility (123). A physiotherapist gave verbal instructions and also demonstrated how the test should be performed. The residents were instructed to rise from an armchair, walk three metres as fast as possible, cross a line that contrasted with the colour of the floor, walk back and sit down again. They wore their regular footwear and used their customary walking aids if necessary. To familiarise themselves with the TUG and to demonstrate that they understood the instructions, the residents performed the test once or twice before they were timed. The timing, with a digital stop-watch, started when the resident’s back left the back of the chair and stopped when the resident’s buttocks touched the seat of the chair again. No physical assistance was given. It has previously been shown that healthy elderly people perform the TUG in 10 seconds or less and that the reliability and validity of the TUG is high in a sample of old people living in the community (123). In the present thesis the inter-observer reliability of the TUG was examined. Two physiotherapists timed the same performance of 32 residents. The intraclass correlation coefficient (ICC) was 0.99, which indicates a very high level of agreement (124). Thus the end-points of the TUG, i.e. starting the timing when the resident’s back left the back of the chair and stopping when the resident’s buttocks touched the seat of the chair, were sufficiently defined.

The difference in time between the TUG and the TUG with a second task was assessed. The resident performed the TUG twice, the second time while carrying a glass. The instruction was to stand up, pick up a glass containing 5 centilitres of water placed on a small table just beside the chair, carry the glass while crossing the line, return it to the table and sit down. The surface of the liquid was 5 cm from the top edge of the glass. We called the difference in time between the two performances ‘the diffTUG’.

In Papers I–III the TUG was assessed in the same room (4.5m X4.5m) and the same chair was used (seat height 47 cm). In Papers IV–V the diffTUG was included in the Mobility Interaction Fall chart. The assessment took place in the residents’ home or in a corridor and chairs of standard height were used.
Screening of fall risk

In Papers IV–V the residents’ risk of falling was classified by three different means: the MIF chart, the staff’s judgement, and the history of falls. The MIF chart, a screening tool for fall risk in elderly people living in residential care facilities, is developed in this thesis and presented in Paper III. The staff judgement and a history of falls are based upon two questions. The nurse’s aides or the licensed practical nurses, who knew the resident well, were asked: “How do you judge the risk that Mr/Ms X will fall within 6 months – high or low?” and “Has Mr/Ms X sustained a fall indoors during the last six months?” (yes/no/do not know). In addition, in Paper V, the physiotherapist rated each resident’s fall risk (high/low) from a professional estimation of balance including risk-taking behaviour.

Follow-up for falls

The follow-up periods for falls were a priori decided to 6 months in Papers I–IV and to 34 weeks in Paper V. A fall was defined as an event in which the resident unintentionally came to rest on the floor or ground, regardless of whether or not an injury was sustained. This definition thus included falls as a consequence of acute illness such as a stroke or an epileptic seizure. However, coming to rest or tumbling against a piece of furniture, wall or other structure was not considered as a fall. During this period the staff were instructed to register on a structured fall report every fall they observed, or when they found residents unaccountably on the floor or ground, or when the residents reported own falls. In Papers I–IV only in-door falls and in Paper V all falls were analysed.

In Papers I–III, the nurse, who was on the permanent staff and also employed part-time on this project, examined the resident after each fall and called for a physician if necessary. At least once a week a physician reviewed all the fall reports and supplemented them when information was missing and when new information had emerged.

In Paper IV the fall reports were collected every week by the research team.

In Paper V, there were different routines in the intervention and the control groups. In the intervention group, a post-fall assessment was performed. Also, a team consisting of a physician, nurse, physiotherapist, and sometimes nurse’s aides, met every or every other week to discuss the fall reports and tailor additional means of preventing further falls. In the control group the fall reports were collected every week by the research team.

In Papers IV–V, the residents’ charts were reviewed halfway through and at the end of the follow-up. In these charts the staff were obliged to note down events such as a change in the resident’s health status and
falls. Notes of 25 (Paper IV) and 33 (Paper V) falls, representing 8.6% and 5% of the total number of falls, were found which were not registered on a fall incidence report. These falls are included in the analyses.

The participants’ absences from the residential facility more than three days were also recorded (Papers I–V) and the use of physical restraint was registered on the basis of observation and interviews with staff (Paper V).

Injuries related to a fall were defined according to the categorisation of the Abbreviated Injury Scale (AIS) (125) as minor when the injuries were limited to superficial wounds and bruises, as moderate when resulting in less serious injury (e.g. closed wrist fractures, major lacerations, two or three rib fractures) and as serious when resulting in major fractures (e.g. hip fractures, femur shaft or condular fractures). If more than one fall injury occurred related to a fall event, only the most serious injury was scored.

Intervention and follow-up

In total, the study lasted for a year including assessments, an 11-week intervention, and a 34-week follow-up period (Figure 2).

Program policy

The policy was to prevent falls and continuously target deleterious fall risk factors through the use of individually tailored strategies. Increased knowledge about fall prevention among the staff was thought to improve the implementation of the program and to be the start of a process producing long-term results. The strategies were designed to be meaningful to the resident and to improve safety without compromising the resident’s mobility.

Individually tailored strategies

Residents screened as being at high risk of falling (n=89) were initially the focus of the intervention. The measures comprised training of physical function and motor behaviour in interaction with the environment, tailoring of supervision, optimising medication, providing aids and improving environmental safety in the flat. In addition, each resident who was considered particularly prone to sustaining hip fracture was offered hip protectors.

Training of physical function and motor behaviour was suggested to 80 residents. Seventy-one residents carried out supervised individual training 2-3 times a week (86%) or less frequently, for a mean period of
9.1 weeks (SD±2.5). Environmental adjustments in the resident’s accommodation and supply or repair of aids were effected for 46 residents. Hip protectors were offered to 47 residents and 34 agreed to use them. No physical restraints were suggested.

General strategies – staff and facilities

More than half the staff working at the intervention facilities attended a 4-hour educational session. The sessions were led by a physician and a physiotherapist, and covered risk factors for falls and strategies for preventing falls. In addition, the physiotherapist and staff held on-going discussions about the fall risk of individual residents. As well as this, environmental hazards in areas outside the flats were taken care of.

Post-fall assessment

During the 11-week intervention every fall was followed up the same day by the physiotherapist and the nurse. A team comprising a physician, nurse, physiotherapist and sometimes licensed practical nurse, met every week to discuss the fall report of any resident who had fallen. The most plausible explanation for the fall was determined and risk factors were addressed. Moreover, whenever a resident’s medical condition was reviewed, the physician and nurse paid special attention to the risk for falls.

Follow-up for falls

Post-fall investigations continued for the 34-week follow-up and recommendations were subsequently given to the staff.

Control group

The residents assigned to the control group received the usual care. The only additional routine was that the fall reports were collected and, if necessary, completed once a week by a member of the research team.
Data analyses

The statistical significance level was set at 0.05. The SPSS software package was used for computerised statistical analyses (126).

Difference between groups

In Papers I–III the sample was divided into two groups with regard to estimated fall risk. In Paper I, those who stopped walking when a conversation started were considered to have a high risk of falling. In Paper II, the difference in time (diffTUG) was calculated between the two performances of TUG, with and without carrying a glass. A cut-off was set at the third quartile of the diffTUG. The sample was then divided into two groups according to the cut-off. In Paper III, every participant was classified according to the MIF chart.

In Paper IV, the residents were grouped according to occurred falls during follow-up (no fall vs. any fall). In Paper V, baseline data for the residents were compared by assigned group (intervention vs. control).

In Papers I–V, possible group differences were calculated by the Student’s t-test, the Mann-Whitney U test, and the Chi-square test. When the expected frequency was less than five in any cell the Fisher’s exact test was used.

In Paper V, the number of residents who fell at least once versus those who did not fall were compared by study group in a logistic regression analysis (odds ratio), adjusted for baseline differences (MMSE score, Barthel Index score, physical restraints, episodes of delirium) and age, sex and history of falls. Similarly, residents with less than two falls versus at least two falls (recurrent fallers) were compared by study group using the same analysis.

Incidence rate

In Papers IV–V the incidence rate was calculated as the number of falls divided by the total number of observation days and was expressed in 1000 person-days. Number of observation days included the days from the start to the end of the study or until the resident moved or died; days (if more than three) spent outside the facility were subtracted. In Paper IV the follow-up started in March and lasted 6 months and in Paper V it started in June and lasted 34 weeks.
Two approaches to analyse the accuracy of the prediction were used: to view the 6-month follow-up period as a whole and to analyse what happened within this period.

1. **Prediction at 6 months.** The predictive values, sensitivity and specificity were calculated in Papers I, III, and IV. In these calculations all the residents assessed at baseline were included.

2. **Time to first fall.** For each resident who had experienced a fall the number of days from inclusion in the study to the first fall was calculated; absence days were subtracted if more than three. If no falls occurred during the study period, observations were censored either at the endpoint of the study or when the resident changed residence or died.

   The Kaplan-Meier survival analysis was used to describe the time to first fall. The considered fall risk in Papers I, III, IV was used as the factor variable and the log-rank test was used to compare the distribution of falls in the groups. Furthermore, the relative risk was calculated in Paper I. In Papers II–IV the Cox regression analysis was used to calculate the hazard ratio (HR) with 95% confidence interval (CI) for falls for residents classified as being at high risk of falling compared to those at low risk. No adjustments were made.

   In Paper IV, the risk scores (MIF chart, staff judgement, history of falls) were added together. The scores of two means of classification (0-2) resulted in one low (0), one intermediate (1), and one high-risk group (2). The low-risk group included residents who, using both means, were classified as ‘low risk’, and the high-risk group residents classified as ‘high risk’. In the intermediate group the residents were classified as ‘high risk’ by one of the means. When three means were added together the classification (0-3) resulted in one low-risk group, two intermediate groups, and one high-risk group.

**Development of a flow chart**

In Paper III, the purpose was to develop a screening tool to identify the residents’ risk of falling which included only a few assessments that could be easily performed in everyday practice. A flow chart was the form considered to meet these requirements.

   The participants were divided into three groups according to their level of mobility. In group A the residents were rated for the risk of falling according to previous results (SWWT and diffTUG) and in group B according to previous knowledge that those who cannot sit independently are at low risk of falling (11). In group C the fall-related factors
were identified by means of new analyses. Every participant was classified (1=high risk, 0=low risk) according to the flow chart.

A) The most skilled group: The participants could walk independently, with or without a walking aid, and were able to understand a simple instruction such as the TUG. These participants were analysed with regard to fall risk using the SWWT and the diffTUG.

B) The least skilled group: The participants were immobile, that is they sat in a wheelchair in a half-lying position or were long-term bedridden and needed two helpers to transfer between chair and bed. They were considered to be exposed to a minimal risk of falling.

C) The intermediate skill group: ‘in between group A and group B’. The participants were unable to walk independently and/or unable to understand a simple instruction but they were not immobile. Three residents who refused to participate in the assessment of physical ability, but attended the examination by the physician, were also included in this group. Also, the participants who could walk and talk but not carry a glass were analysed in both the most skilled and the intermediate skill group. Fall-related factors in the intermediate skill group were initially identified one by one using the Cox regression analysis. The sum and the score on each item were analysed in the Barthel ADL Index (113), MMSE (116) and MADRS (118). Variables associated with a significantly increased risk of falling in these analyses were then dichotomised (independent or no difficulties versus dependent and difficulties) and analysed by the prediction outcome cross tables in logistic regression. A combination of variables with both high sensitivity and specificity regarding falls was chosen.

Evaluation of the MIF chart

In Paper III, four years after the first baseline assessments an inter-rater reliability test of the flow chart was performed at the same residential facility. Thus, some residents from the first sample were dead or had moved and new residents were included. Altogether, fifty residents, 16 men and 34 women, aged 60-96 years (mean±SD 83,7±7,5 years) and four physiotherapists participated. Two physiotherapists rated, in different pairs and independently of each other, the same resident on two consecutive days. The physiotherapists were familiar with the flow chart and they had also discussed the scoring. However, they were not trained together in practice. The kappa statistic (k) was used to calculate the inter-rater agreement (127).
In Paper V, the results were analysed using the intention to treat approach. Thus, the residents were grouped according to initial randomisation (intervention vs. control group) and not to the actual level of subsequent adherence to the intervention strategies.

Time to first fall was calculated and the Cox regression analysis was used to compute the HR with 95% CI for falls for residents in the intervention group compared to the control group. Adjustments were made for baseline differences (MMSE score, Barthel Index score, episodes of delirium, physical restraints) and age, sex and history of falls. The Cox regression analysis was also used to present the HR for falling for each facility compared to the intervention and control groups respectively. This analysis was adjusted for history of falls. In Paper V, the survival plots presented are based on the adjusted values.
RESULTS

‘Stops walking when talking’ (SWWT) – Paper I

Twenty-one of 58 residents (36%) suffered at least one indoor fall and eleven (19%) fell twice or more during the six months of follow-up.

Twelve residents stopped walking when an occasional conversation started and ten of them fell. The positive predictive value of the SWWT was 83% (10/12) and the negative predictive value was 76% (35/46). The specificity was 95% (35/37) and the sensitivity was 48% (10/21).

The relative risk of falling for those who stopped walking compared to those who continued was 3.5 (95% CI: 2.0–6.2).

The Kaplan-Meier distributions of falls differed significantly between those who stopped walking and those who continued walking when a conversation started (Figure 3: log-rank test 17.46, p≤0.001).

![Figure 3](image-url)
Those who stopped walking were more likely to have an unsafe gait, a slow TUG, a low ADL score and a low line bisection score, and more depressive symptoms than those who continued walking (Table 4). There was no difference between the groups regarding age, sex, the prevalence of residents with dementia, depression, dizziness, previous stroke, impaired hearing and vision, a history of falls the previous year, indoor use of walking device and the MMSE-score.

Table 4 Difference between residents who stopped walking and who continued walking when an occasional conversation started

<table>
<thead>
<tr>
<th>Walking Behaviour</th>
<th>Stops walking n=12</th>
<th>Continues walking n=46</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait: safe/safe aids/unsafe, n</td>
<td>0/0/12</td>
<td>21/14/11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Timed Up&amp;Go, sec mean±SD</td>
<td>28.7±7.0</td>
<td>16.7±9.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Barthel ADL Index median; interquartile range</td>
<td>15; 9–17</td>
<td>18; 14–19</td>
<td>0.008</td>
</tr>
<tr>
<td>Line bisection test median; interquartile range</td>
<td>5; 3–9</td>
<td>9; 6–9</td>
<td>0.036</td>
</tr>
<tr>
<td>MADRS</td>
<td>6; 1–11</td>
<td>2; 1–4</td>
<td>0.047</td>
</tr>
</tbody>
</table>

*Refers to the difference between the groups of walking behaviour

The diffTUG – Paper II

Forty-two residents performed the diffTUG. The median (interquartile range) of the TUG was 13.1 (10.3–18.3) seconds and of the TUG with the second task, 15.6 (11.6–23.3) seconds. Ten residents took at least 4.5 seconds more to perform the TUG and simultaneously carry a glass than to perform the TUG alone, i.e., had a long diffTUG.

In all, 13 residents (31%) fell at least once indoors and seven of them had a long diffTUG. Four residents with a long diffTUG took less than 20 seconds to perform the TUG. Three of them fell, all in reported circumstances requiring divided attention (rising from a chair to answer the phone; walking and putting clothes into the wardrobe; standing and reaching for a photograph).

The hazard ratio for falls among residents with a long diffTUG was 4.7 (95% CI: 1.5–14.2), compared to those with a short diffTUG (<4.5 seconds). Residents with a long diffTUG were more likely to have a low line bisection score, to be more dependent in ADL and to have balance difficulties in standing. Furthermore, they had more cognitive difficulties and depressive symptoms than those with a short diffTUG (Table 5). Age and sex did not differ between the groups.
Table 5  Characteristics of residents grouped by the difference in time between TUG with and without the second task

<table>
<thead>
<tr>
<th></th>
<th>DiffTUG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 4.5 sec</td>
</tr>
<tr>
<td></td>
<td>n=32</td>
</tr>
<tr>
<td>Line Bisection test†</td>
<td>8.0;  6.3– 9.0</td>
</tr>
<tr>
<td>Barthel ADL Index†</td>
<td>18.0; 16.0–20.0</td>
</tr>
<tr>
<td>Functional Reach‡, cm</td>
<td>23.0; 19.7–29.9</td>
</tr>
<tr>
<td>MMSE†</td>
<td>23.0; 18.0–27.0</td>
</tr>
<tr>
<td>MADRS†</td>
<td>1.8;  1.0– 4.5</td>
</tr>
</tbody>
</table>

* refers to the difference between diffTUG of <4.5 or ≥4.5 seconds
† median; interquartile range
‡ 29 residents with a short diffTUG and 9 with a long diffTUG

The Mobility Interaction Fall (MIF) Chart – Paper III

Thirty-three of 78 residents (42%) suffered at least one fall indoors in six months; 18 (23%) fell twice or more. Seventy-two falls occurred and the number of falls among fallers ranged from 1–11.

Figure 4 shows the MIF chart. The participant is classified as being at high or at low risk of falling on a minimum of one assessment and a maximum of three. There are four ‘exits’ for high risk of falling and three ‘exits’ for low risk.

Sixty residents formed the most skilled group ‘walks independently and understands’. Twelve stopped walking when talking and were classified as being at high risk of falling. Of those residents who could carry a glass, six were classified as high-risk and 29 as low-risk. The 13 residents who were unable to carry a glass were further assessed.

The least skilled group, the ‘immobile’ consisted of three residents who needed two helpers to transfer between chair and bed and sat in a wheelchair in a half-lying position or were long-term bedridden (low risk).

The 28 residents not classified in the previous groups formed an intermediate skill group. Impaired vision and concentration difficulties constituted the combination of variables which correctly classified most residents who had fallen (concentration difficulties = when the resident reported difficulties in following a TV programme or reading an article or if she was observed to lose the thread of a conversation). Seven residents had impaired vision, and of the remaining 21 residents, 11 had concentration difficulties. They were classified as being at high risk. Ten residents had neither impaired vision nor concentration difficulties (low risk).
Figure 4  The Mobility Interaction Fall (MIF) chart for assessing fall risk in elderly people living in residential care facilities. The figures in brackets refer to the number of residents from which the chart was developed.
Evaluation of the MIF chart

According to the MIF chart, 28 of the 33 participants who fell were categorised as being at high risk of falling and 37 of the 45 non-fallers were classified as being at low risk.

The positive predictive value of the classification was 78% (95% CI: 67–87%) and the negative predictive value was 88% (95% CI: 79–95%).

Figure 5 shows a significant difference in fall rate between the groups of participants who were classified as being at high or low risk of falling (log rank test 39.1, p<0.001; HR 12.1, 95% CI: 4.6–31.8).

The test-retest of the MIF chart showed 80% agreement between raters for the classifications in a high or a low risk of falls (κ = 0.60). Both physiotherapists in the pair of raters classified 22 residents as being at low risk and 18 as being at high risk of falling. In 10 classifications there was a disagreement between the raters.
Fall prediction by MIF chart, staff judgement, and fall history – Paper IV

In six months, 104 residents (50%) fell at least once indoor and 57 (27%) fell twice or more. The number of falls for each resident ranged from 0 to 16. A total of 290 falls were registered during the 34,837 observation days, which corresponds to an incidence rate of 8.3 (95% CI: 8.2–8.5) falls per 1000 person-days.

Seventeen residents died and 10 moved from the facility during the follow-up. Almost half of them (n=13) experienced a fall after the baseline assessment.

Most of the putative factors associated with falls showed a similar distribution between the group of residents who fell at least once during the follow-up and those who did not fall. There was no statistical difference between the groups regarding the prevalence of sex, impaired hearing and vision, urinary incontinence, depression, previous stroke, heart failure, lung disease, osteoarthritis, and number of diagnoses and of drugs. Similarly, there was no difference in MMSE score or in ADL score. However, the residents who fell were more likely to have dementia (43% vs. 30%; p=0.05) and to perform TUG more slowly (31.7±19.0 vs. 24.9±18.3; p=0.03). There was also a trend that they were older (84.1±7.3 vs. 82.4±6.2 years; p=0.07) and more likely to use benzodiazepines (39% vs. 27%; p=0.06).

Classification of high fall risk

The MIF chart, the staff judgement and a history of falls classified altogether 135 residents as being at high risk of falling. The three methods classified the same resident in 35 cases (Figure 6).
Prediction accuracy at 6 months

The MIF chart resulted in somewhat lower sensitivity and predictive values than the other two means of prediction (Table 6). Staff judgement and a history of falls showed a similar predictive accuracy. Data were missing regarding one resident in ‘staff judgement’ and one in ‘a history of falls’. Twenty-two residents who fell, representing 21% of the fallers, were not classified by any of the methods as being at high risk of falling.

Table 6 The accuracy of the fall risk prediction by the MIF chart, staff judgement, and a history of falls

<table>
<thead>
<tr>
<th></th>
<th>Positive predictive value*</th>
<th>Negative predictive value†</th>
<th>Sensitivity‡</th>
<th>Specificity§</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>MIF chart</td>
<td>58</td>
<td>45/77</td>
<td>55</td>
<td>72/131</td>
</tr>
<tr>
<td>Staff judgement</td>
<td>67</td>
<td>62/92</td>
<td>64</td>
<td>74/115</td>
</tr>
<tr>
<td>Fall history</td>
<td>68</td>
<td>54/80</td>
<td>61</td>
<td>77/127</td>
</tr>
</tbody>
</table>

* correctly classified 'high risk' residents  
† correctly classified 'low risk' residents  
‡ residents classified as 'high risk' /all residents who fell  
§ residents classified as 'low risk' /all residents who did not fall

The MIF chart

According to the MIF chart, the residents were classified as being at high risk of falling when they ‘stopped walking when talking’, had a diffTUG of at least 4.5 seconds, impaired vision or concentration difficulties. Residents with a shorter diffTUG, immobility and no concentration difficulties were classified as ‘low risk’. In Table 7 is shown that the exit ‘impaired vision’ had the highest positive predictive value (72%) because the largest proportion in this group fell during the follow-up. Among the low risk groups, fewest residents with ‘immobility’ experienced a fall, thus this exit showed the highest negative predictive value (81%). When a history of falls before baseline also was taken into account the proportion of fallers became greater in both the high and the low risk groups. All the residents who ‘stopped walking when talking’ had fallen before baseline or fell during follow-up.
Table 7 Proportion of residents in each exit of the MIF chart who experienced at least one fall during the 6-month follow-up; and in 6 month before the baseline assessment or during follow-up. n=208

<table>
<thead>
<tr>
<th>At least one fall</th>
<th>High risk of falling</th>
<th>Low risk of falling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SWWT ≥4.5s</td>
<td>Impaired vision</td>
</tr>
<tr>
<td></td>
<td>n=11</td>
<td>n=20</td>
</tr>
<tr>
<td>During follow-up %</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Before baseline or during follow-up %</td>
<td>100</td>
<td>45</td>
</tr>
</tbody>
</table>

Time to first fall

The predicted high and low fall risk groups differed significantly in the probability of experiencing a fall regardless of classification means (MIF chart, staff judgement and a history of falls) (Figure 7 a–c).

The three pair-wise combinations (MIF chart–staff judgement, MIF chart–a history of falls, and staff judgement–a history of falls) resulted in similar proportions of identified fallers. In the ‘high risk’ groups the median time without falls was two months in all combinations (Figure 8 a–c).

In three months, the probability of falling for the ‘low risk residents’ was 22–26% depending on classification method, and 46–51% for the ‘high risk residents’ (Table 8). The corresponding figures in six months were increased by approximately 20%. The HR for a fall event ranged from 1.7 to 4.5 for the high-risk group compared with the low-risk group depending on the means of classification and combination (Table 8).
Figure 7 Kaplan-Meier curves of the fall risk among old people living in residential care facilities assigned to low and high risk groups by a) MIF chart, b) staff judgement, and c) history of falls.
Figure 8 Kaplan-Meier curves of the fall risk among the residents assigned to low, intermediate, and high-risk groups by a) MIF chart and staff judgement, b) MIF chart and history of falls, and c) staff judgement and history of falls.
Table 8  Number of residents in different groups of fall risk, number of fall events, hazard ratio and probability for falling in 3 and in 6 months according to the MIF chart, staff judgement and a history of falls

<table>
<thead>
<tr>
<th></th>
<th>Residents at start</th>
<th>Fall events 6 months</th>
<th>Hazard ratio (95% CI)</th>
<th>Probability of falls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n</td>
<td></td>
<td>3 months</td>
</tr>
<tr>
<td>MIF chart</td>
<td></td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Low risk</td>
<td>131</td>
<td>59</td>
<td>1.0</td>
<td>26</td>
</tr>
<tr>
<td>High risk</td>
<td>77</td>
<td>45</td>
<td>1.7 (1.1–2.5)</td>
<td>46</td>
</tr>
<tr>
<td>Staff judgement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low risk</td>
<td>115</td>
<td>41</td>
<td>1.0</td>
<td>24</td>
</tr>
<tr>
<td>High risk</td>
<td>92</td>
<td>62</td>
<td>2.6 (1.7–3.9)</td>
<td>46</td>
</tr>
<tr>
<td>History of falls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low risk</td>
<td>127</td>
<td>50</td>
<td>1.0</td>
<td>22</td>
</tr>
<tr>
<td>High risk</td>
<td>80</td>
<td>54</td>
<td>2.5 (1.7–3.6)</td>
<td>51</td>
</tr>
<tr>
<td>MIF chart + Staff judgement</td>
<td></td>
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</tr>
<tr>
<td>Low risk</td>
<td>84</td>
<td>28</td>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>Intermediate risk</td>
<td>77</td>
<td>43</td>
<td>2.2 (1.4–3.5)</td>
<td>35</td>
</tr>
<tr>
<td>High risk</td>
<td>46</td>
<td>32</td>
<td>3.3 (2.0–5.5)</td>
<td>56</td>
</tr>
<tr>
<td>MIF chart + history of falls</td>
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<tr>
<td>Low risk</td>
<td>91</td>
<td>35</td>
<td>1.0</td>
<td>18</td>
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<tr>
<td>Intermediate risk</td>
<td>75</td>
<td>39</td>
<td>1.7 (1.1–2.7)</td>
<td>40</td>
</tr>
<tr>
<td>High risk</td>
<td>41</td>
<td>30</td>
<td>3.2 (1.9–5.2)</td>
<td>57</td>
</tr>
<tr>
<td>Staff judgement +history of falls</td>
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<td></td>
<td></td>
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<tr>
<td>Low risk</td>
<td>95</td>
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<td>1.0</td>
<td>22</td>
</tr>
<tr>
<td>Intermediate risk</td>
<td>48</td>
<td>26</td>
<td>1.7 (1.0–2.9)</td>
<td>27</td>
</tr>
<tr>
<td>High risk</td>
<td>62</td>
<td>45</td>
<td>3.6 (2.3–5.6)</td>
<td>57</td>
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<tr>
<td>MIF chart + Staff judgement +History of falls</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Low risk</td>
<td>71</td>
<td>22</td>
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<tr>
<td>Intermediate risk 1</td>
<td>56</td>
<td>28</td>
<td>1.9 (1.1–3.3)</td>
<td>27</td>
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<tr>
<td>Intermediate risk 2</td>
<td>44</td>
<td>26</td>
<td>2.7 (1.5–4.8)</td>
<td>45</td>
</tr>
<tr>
<td>High risk</td>
<td>35</td>
<td>27</td>
<td>4.5 (2.6–8.0)</td>
<td>61</td>
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</table>
In the 34-week follow-up period, 273 falls occurred during 40,898 observation days in the intervention group and 346 falls during 41,590 observation days in the control group. The corresponding incidence rates of falls were 6.7 and 8.3 falls per 1000 person-days for the intervention and control group respectively. The resulting incidence rates ratio of the study groups was 0.80 (95% CI: 0.69–0.94).

Three fractures of the femur occurred in the intervention group, and 12 in the control group. The incidence rates of fractures of the femur per 1000 person-days were 0.07 in the intervention group, compared to 0.29 in the control group, which corresponds to the rates ratio of 0.25 (95% CI: 0.08–0.82).

Minor or moderate fall-related injuries did not differ in incidence rates between the study groups. The incidence rate of the intervention group was 1.52 injuries per 1000 person-days and the rate of the control group was 1.64 per 1000 person-days.

Residents falling

Fewer residents in the intervention group, 82/188 (44%) were found to experience a fall event compared with 109/196 (56%) in the control group (odds ratio OR, 0.62 95% CI: 0.41–0.92). This difference remained after adjustment for baseline differences and age, sex and history of falls (OR 0.48 95% CI: 0.31–0.77).

The number of residents who sustained recurrent falls in the intervention group was 48 (26%) compared with 64 (33%) in the control group; unadjusted OR 0.71 95% CI: 0.45–1.10, and adjusted OR 0.58 95% CI: 0.35–0.96.

Hazard rates of falls

The hazard rates of falls for the intervention and control groups differed significantly in an unadjusted Cox regression analysis (HR 0.71; 95% CI: 0.54–0.95). The difference remained after adjustment (Figure 9; HR 0.65 95 % CI: 0.48–0.89).
Resident at risk | Day 0 | Day 80 | Day 160 | Day 240 |
--- | --- | --- | --- | --- |
Intervention group | 188 | 130 | 102 | 74 |
Control group | 196 | 124 | 90 | 53 |

Figure 9  Survival analysis of days to the first fall in the intervention and control group, according to the multiple Cox regression model with adjustments for differences in baseline variables and age, sex and previous falls.

When the residents of each intervention facility was compared to the control group there was a consistent trend showing that the HRs of each intervention facility was higher than that of the control group and vice versa. Two facilities reached statistical significance (Table 9).
The subgroups of residents classified as low and high risk of falls were analysed separately. A lower hazard rate in the ‘intervention group:low risk’ compared to the ‘control group:low risk’ was found (Figure 10; adjusted HR 0.75; 95% CI: 0.59 to 0.96). The hazard rate for falls in the ‘intervention group:high risk’ was slightly lower than in the ‘control group:high risk’; the effect approached significance (Figure 11; adjusted HR 0.83; 95% CI: 0.68 to 1.03).

The low risk groups were younger (mean 81.9±7.1 versus 83.8±6.3; p=0.007), had higher scores in MMSE (mean score±SD 19.5±8.1 versus 15.9±7.5; p<0.001) and fewer medical diagnoses (median, 3.0 versus 4.0; p<0.001) compared to the high-risk groups.
Figure 10  Survival curves for time to first fall among residents classified as low risk of falls in intervention group (101 residents) and control group (106 residents). Adj HR 0.75; 95 % CI: 0.59–0.96

Figure 11  Survival curves for time to first fall among residents classified as high risk of falls in intervention group (87 residents) and control group (90 residents) Adj HR 0.83; 95 % CI: 0.68–1.03
DISCUSSION

This thesis showed that, in elderly people in residential care facilities, commonly presented risk factors for falls were of limited value in separating individuals prone to falling from those not prone to falling. Initial findings revealed that difficulties in walking and simultaneously interacting with a person (SWWT) or an object (diffTUG) implied an increased risk of falling. In addition, the Mobility Interaction Fall (MIF) chart showed a high predictive accuracy but in an ensuing validating sample the predictive accuracy was lower. By use of a combination of any two methods of the MIF chart, staff judgement, or fall history, the correct identification of individuals with a particularly high risk of falling was good; half of these residents sustained a fall within two months. The thesis also showed that a fall prevention program that both targeted residents’ fall risk factors and included measures directed to staff and residential environment significantly reduced the numbers of residents falling, of falls and of femoral fractures.

Walking and interacting with a person or an object

It was my clinical experience that some persons with impaired gait encountered further difficulties when they were expected to walk and do something else at the same time, such as talking with a person or carrying an object. One aim of the present thesis was to explore how this phenomenon was related to falls and frailty. Campbell and Buchner (128) emphasise the ability to interact with the environment as central to ‘frailty’ and that markers of frailty are risk factors for falls. They suggest that frailty can be measured clinically by components required for successful interaction with the environment: musculoskeletal function, aerobic capacity, balance, and cognitive and nutritional state. However, none of the methods used for measuring these components includes the effect of a ‘second task’ on walking. Nevertheless this appears to be important because many falls occur when the person is engaged in an activity or confronted with an obstacle (49). The initial findings of this thesis revealed that the SWWT and the diffTUG were valid markers of frailty and had a potential for fall risk screening efficacy. The validating
study of fall prediction did not support these results and thus questions about the predictive accuracy of the observations must be raised.

**Stops walking when talking (SWWT)**

The SWWT is an observation of a ‘real life situation’ as opposed to a standardised procedure in which the resident is expected to follow instructions. In the first study, the observation of walking behaviour took place on the way from the residents’ home to an assessment room. In the second study, the physiotherapists were instructed to arrange a walk to a certain indoor destination, which the resident had agreed upon. The content of the conversation was not decided in advance and consequently varied. The guidelines for the accompanying, physiotherapist who also observed the walking behaviour, were to start a conversation that would feel natural in the initial contact with each resident and to avoid questions requiring the resident to remember a particular thing. Whether it makes any difference to start a ‘natural conversation’ or to ask certain questions remains to be further evaluated.

There are several possible reasons to stop walking when talking with a companion. One is impaired hearing. However, hearing impairment did not differ between the ‘stoppers’ and the ‘non-stoppers’ in either of the two studies and thus impaired hearing was not a common reason for stopping.

Another possible reason is that people with gait difficulties have to pay much attention to the task of walking. When a second task then arises, they may give this second task priority and consequently have to stop walking. This is in accordance with a discussion about skilled motor performance by Schmidt (129). He describes a theory of attention in which the amount of information processing capacity is fixed. When the main task is relatively simple and does not require much attention, there is attentional capacity remaining for other tasks. But when the main task is experienced as more complex, as walking with an impaired gait would be, more attention is needed for the walking and less is left for the second task. The processing can occur in parallel in the early stage when the signals are identified (stimulus identification stage) but there is considerable interference in the stage of initiating movements (response programming stage). The attentional processes then compete for the limited capacity and thus the person may choose to change the object of her/his attention. In the case in question that would entail stopping walking and starting a conversation with the companion. However, attention is not a unitary concept. Even though psychologists for a long time have attempted to explain the nature of attention, the principles of its operation and even its definition are unclear (69, 130).

A further possible cause of stopping walking, which also may relate to attentional demands, is that elderly people with vestibular asymmetry experience an increased imbalance when they turn their heads to talk and so they stop walking (131).
Schmidt stresses that in learning new high-level motor skills the performer has to learn what to attend to (129). This could also be the case when movement ability is decreased. In the validating study, all residents who stopped walking when talking sustained at least one fall either six months before or after the baseline assessment. It is possible that those who fell before the baseline observation had learned that they had to shift from one object of attention to another, i.e. from walking to talking.

Attentional demands while walking and performing a second task have not previously been studied in old people with gait difficulty. However, the effect of cognitive tasks on postural stability has been studied in standing, and measured by centre of pressure displacement. It was found that when postural stability is impaired, even relatively simple cognitive tasks can further affect balance also during quiet stance (80).

The diffTUG

TUG was chosen as a measurement suitable for modification with a second task because it includes a combination of familiar, relatively routine and important manoeuvres used in everyday life and is still quick and requires no special equipment. The TUG has also been shown to be a valid and reliable measurement (123).

The second task, carrying a glass of water, was selected for several reasons. A glass containing water cannot be ignored at any time while it is being carried. Also, carrying a glass is a familiar task so no new learning has to take place. Furthermore, the upper limb both operates as part of the postural system and manipulates objects (71). Consequently, the manipulation with an object makes it more difficult for the upper limb to act as a component of the postural system and gait difficulties might be made more obvious. Only 5 cl of water was poured into the glass. It was considered sufficient to require some attention, yet the risk that residents with tremor of the upper limb would spill water was small. Nevertheless, it is not known what the optimal level of water in the glass would be.

In using the diffTUG, the completion time is registered. However, during the walking process, conditions critical for movement change and the individual must continuously pick up new relevant information. To adjust to the requirements of this information-processing several strategies appear possible to use such as changing the speed, the method for scanning the environment, or the risk level. It is thus possible that individuals with gait difficulty use other strategies than a slower gait to accomplish the TUG with the second task. It is also possible that those who actually walk more slowly when carrying the glass do so because they experience a fear of falling. Recently, it has been found that changes in gait cited previously as risk factors for falling, i.e. decreased stride length and speed and prolonged double support, may in fact be stabilising adaptations related to fear of falling (21). A fear of falling may in some residents imply a more careful way of moving and thus serve as a protection against falling. These aspects remain to be further studied.
Prediction of falls by a screening tool

Prevention according to the high-risk strategy focuses on those who are considered to have a high risk and thus the identification of these individuals becomes important. For the prediction of falls among elderly people in residential care facilities, there was to my knowledge only one fall risk index available (49). This index is extensive, time-consuming to use and not validated in a new sample. It was therefore important to develop and validate an easily administered fall risk assessment tool.

Development of the MIF chart

A person classified as being at high risk of falling will probably receive a lot more fall-preventive attention from all members of the staff than someone classified as being at an intermediate risk. In the development of the screening tool it was thus considered important that the classification of fall risk was clear, and consequently a dichotomous classification was preferable to a classification by increased fall risk in steps. In using a dichotomous classification a separation between ‘high risk’ and ‘low risk’ could be obtained by use of the screening tool only, and the uncertainty and indecision created by one or more categories of moderate fall risk could be avoided. It was also of major importance to acquire a tool that was easy to use in everyday practice. A flow chart was found to fulfil these requirements.

By use of the MIF chart, the residents were divided into groups according to their mobility skill level. This is in accordance with a model proposed by Studenski (66), in which it was suggested that impaired physical function is a necessary but not a sufficient factor, and that other factors increase the fall risk in people with limited mobility. In the present study, various factors proved to change the fall risk. At the highest skill level, the inability to walk and interact simultaneously with a person or an object were relevant factors, and at the intermediate skill level, impaired vision and concentration difficulties increased the likelihood of falls. At the lowest skill level (immobile) there were only three residents, none of whom fell. The ‘mobility-skill-level’ approach made it possible to classify each resident’s risk of falling by using only one to three assessments. This approach has not hitherto been used in predictive tools for fall risk. Previously all the factors included have been listed and thus no factor has been regarded as of cardinal importance.

The predictive values, sensitivity and specificity were all approximately 80%. The test-retest agreement between raters was 80% ($k=0.60$). The initial findings thus indicated a promising way of classifying elderly people in residential care facilities as having a high or low fall risk. However, the MIF chart was not validated in an independent sample.
Few models and tools have been tested in a different location and over a different time-period. To my knowledge, only six of many published predictive models and fall risk assessment tools have undergone a predictive validation (47, 48, 84, 89, 91, 92). All of them are directed to the identification of patients falling in hospitals. As a consequence of the validation, one of the tools was substantially modified with half of the factors exchanged (92). Regarding the others, data are provided for three of them so that a comparison of sensitivity, specificity, and predictive values can be made; it is common that a reduction of 10-20% is seen (47, 48, 91). Also regarding the MIF chart, the high predictive accuracy in the developmental sample was not repeated in the validating sample.

In a new sample, all predictive models and scoring tools are expected to be overoptimistic regarding predictive performance since the methods used to derive them are dependent on the data of the developmental sample (88). Apart from case-mix differences between the developmental and validating samples there are several possible reasons for a reduced predictive power in a new testing process.

Elderly people in residential care are often frail with fluctuating abilities. One fluctuating example is episodes of delirium experienced by 33% and 22% of the residents in the developmental and the validating sample respectively.

An important factor is the definition of a fall. In the present studies a definition that included all indoor falls was used, thus also including when the residents were unaccountably found on the floor and falls due to loss of consciousness or sudden paralysis, called ‘syncopal falls’ (9). Motives for including these falls are that most falls are unwitnessed and the frail old person may have difficulty in remembering or describing the circumstances of the fall. Thus, the cause of the fall may be difficult to elicit. It has been found that in institutional care a quarter of all falls are caused primarily by environmental factors or unanticipated physiological factors like syncope or acute illness (61, 132). There is further support for this in the finding that acute illness was present when one of three recurrent fallers fell (49). In the present thesis, neither acute illness nor drug side-effects at the time of the fall were recorded and they could thus have influenced the results. Consequently, the developmental sample as well as the validating sample in this thesis most probably included falls not predictable with the use of predisposing factors like those in the MIF chart, and thus these falls had an adverse effect on the predictive accuracy of the MIF chart.

Another possible reason for a lower predictive power in a new sample is a reduced reliability of the assessment when it is completed by others than those who developed the method (48, 88). In the present studies, administration of the assessments differed between the developmental and the validating sample. When developing the MIF chart, the assessments of mobility were carried out in a certain room, the same for all residents, with no disturbances in the environment. Only three physio-
therapists carried out the assessment, always in pairs and thus reaching a consensus on how to demonstrate and instruct residents about the measures. The testing of vision and rating of concentration was performed by two physicians. In the evaluating sample, all the assessments were carried out in the residents’ home or in a corridor by six physiotherapists. The physiotherapists were instructed in the use of the MIF chart, but none had had any clinical experience of using it before the baseline assessment started.

Only a few common putative predisposing risk factors for falling differed between residents who sustained a fall and those who did not. The time to first fall differed significantly between residents classified by the MIF chart as being at high or at low risk of falling. However, a routine screening using only the MIF chart at one point in time is considered to provide insufficient predictive accuracy.

Combination of methods predicting falls

The three evaluated methods – MIF chart, staff judgement, and fall history – did in part identify the residents’ fall risk in the same way but there was also a considerable difference. This is in accordance with a small study including a formal risk assessment tool and nurses’ clinical judgement. It was suggested that factors influencing nurses’ judgement differ from those included in a tool consisting of well-documented factors of fall risk (89). In the present study, a combination of methods was more accurate than any one method alone. Half of the residents predicted as high risk in any combination sustained a fall within two months.

There are some possible reasons for this disparity in classification. One is that in using the MIF chart, the classification is based on the assessment at one particular point in time. In research concerning the prediction of falls, the most common method is to investigate probable predisposing factors for sustaining a fall, after which the occurrence of falls is monitored for a certain time. This method might be insufficient in residential care facilities because many residents have a fluctuating function. Thus, an assessment made only once may give a finite picture. Because of the fluctuating function it is possible that the predictive accuracy of the MIF chart increases if the screening is repeated.

In contrast, staff who know the resident well have knowledge that has been gained over time and would thus perceive changes in ability of frequent occurrence and in the diurnal rhythm. In the present study, staff had not been offered any information on how to identify residents at risk of falling. They were asked how they estimated the residents’ fall risk without any preceding discussion about the residents’ health and abilities. In some cases the classification according to ‘staff judgement’ and ‘fall history’ differed. It is possible that knowledge of risk factors would promote awareness of the fall problem and potentially increase the predictive accuracy of the staff judgement.
Prevention of falls

The prevention program resulted in a significant reduction in the number of residents falling, the number of falls and of femoral fractures. The basis of the program was a combination of targeting risk factors of high-risk residents and of measures directed to staff and residential environment. Hence, it is not possible to estimate the effect of individual preventive measures (95, 99). As both staff and residents were active participators, the assumption was that a positive process would be developed among all those involved. This assumption was given some indirect support by the shape of the survival curves for time to first fall, which showed a growing gap during the follow-up period.

Although the individual intervention measures mainly targeted residents judged to be at high risk for falls, the effect on the low-risk group reached statistical significance whereas the high-risk group approached significance. This result among the low-risk group may be related to sensitivity to the general measures such as education of the staff and environmental measures. Also the weekly medical team review and a post-fall investigation were offered to these residents. Some residents screened as ‘high risk’ may have failed to remember safety measures because of cognitive impairments or have been too frail to benefit from exercise. Other authors have suggested that the optimal population for exercise is one that is ”not too fit and not too frail” (94). Thus the apparent difference in intervention effect between the risk groups could be related to better responsiveness of the low-risk group, but may equally well be associated with a discrepancy in statistical power as the residents at high risk were fewer than those at low risk.

A reduction in the number of femoral fractures was revealed. The use of hip protectors may have contributed to this result because the proportional reduction of hip fractures was larger than the proportional reduction of falls. However, the confidence interval of the difference was large. Trials using hip protectors have previously reported significant results although there have been problems in compliance in wearing them (107, 108). In the present study, hip protectors were initially offered to 47 residents judged by a global rating as being at high risk of sustaining a hip fracture, and 34 agreed to use them. Nevertheless, further analyses are required to explore compliance in this sample.

This intervention program led to consistent effects in most outcome measures, which strongly supports the validity of the results. To date, only one randomised controlled trial aimed at preventing falls among old people in nursing homes or residential care has reported positive effects, and this solely regarding recurrent fallers (7).
Follow-up of falls

It is acknowledged that falls might be underreported although the reporting of falls was emphasised in all the studies. In Papers I-III, the nurse who followed up every fall was part of the permanent staff as well as employed part-time on this project. In Papers IV and V, a member of the research team collected the fall reports once a week. The residents’ charts were also reviewed twice during the study period. In these charts the staff is obliged to make notes about important events such as changes in the resident’s health status and falls. In Paper IV notes of 25 falls were found, representing 8.6% of the total number, which were not registered on a fall incidence report. The corresponding figure in Paper V was 2% in the intervention and 8% in the control facilities. These falls were also included in the analyses. The accuracy of reporting falls on an ‘incidence report’ has been evaluated in the FICSIT studies (133). It was found that even in institutions well attuned to the importance of reporting the falls, reliance on the fall incidence reports only missed 10-15 % of falls. Compared to their result, the reporting of falls was higher in the present studies, particularly in the intervention facilities.

Prediction

It is acknowledged that the MIF chart is developed from a fairly small sample and the first evaluation of the MIF chart used the same dataset from which it was derived.

Two methods were used to select the assessments included in the MIF chart. First, on the basis of clinical experience hypotheses were formulated signifying that residents who stopped walking when a conversation with a companion started (SWWT), and those who were more distracted by a manual task while performing a basic functional movement sequence (diffTUG), were also more prone to falling. Second, several possible risk factors for falling were explored. Factors such as urinary incontinence, cognitive impairment, indoor use of a walking device, and dizziness, shown in several previous studies to be associated with falls (6), showed no such connection in this study. In selecting the final variables (vision and concentration) of the tool, the overall purpose was to find variables with the highest possible combination of predictive values, sensitivity and specificity divided only into a high and a low risk of falling and no intermediate groups.

In the validating study of the MIF chart it was found that a combination of any two of the evaluated methods – the MIF chart, staff judgement, fall history – was more accurate in identifying residents at high risk of falling than any method alone. Thus the initial ambition to have only a high- and a low-risk group was not achieved. Most probably,
risk forms a continuum of severity, but its management requires a system of unambiguous labels (43), and this creates a situation that is more difficult to interpret. A classification of more than two categories makes it impossible to express predictive accuracy by means of the widely-used concepts of sensitivity, specificity, positive and negative predictive values.

One major difference between the present studies and other predictive studies is the time for which the prediction is expected to be valid – 6 months as opposed to the length of hospital stay (84, 91, 92), one week (48, 89) or one day (47). Thus the time must be taken into consideration when interpreting the predictive accuracy. Since half the residents at particularly high risk fell within two months, data suggest that screening for individuals at high risk among elderly people living in residential care facilities should be carried out at shorter interval than six months, maybe every second month.

An obvious concern is the inter-rater reliability of the staff judgement of fall risk and the staff’s recollection of previous falls. Nevertheless, the staff judgement of fall risk has been a neglected topic and it may be a relevant contributor to future prevention of falls, either alone or incorporated into a formal risk assessment. Clearly, replication is needed in another location, with respect both to prognostic validity and reliability.

Randomisation of clusters of facilities

In the prevention study it was considered necessary to avoid contamination of treatment condition between the intervention and the control facilities. Some staff members were responsible for several facilities and consequently had to be part of the same cluster. Moreover, the focus of this intervention on all staff and the environment in each facility made individual randomisation inappropriate. All facilities had the same management, staff administration, care policy, criteria for admission to the facility, and registered frequency of falls. In spite of this, the results should be interpreted bearing in mind the cluster randomisation method.
Implications

Prediction and prevention in everyday work

The high frequency of falls and injuries in residential care facilities should be recognised as a major problem urgently requiring prevention.

In the community, prevention according to the high-risk strategy has showed positive effects. In residential care facilities it can be assumed that the great majority of residents will fall within a period of time. As was shown in the survival curves in the present thesis, residents classified as low-risk also fell but at a slower rate. If the screening tool classified future fallers and non-fallers with extreme accuracy it might be argued that the high-risk strategy of prevention should be the first-hand choice also in residential care facilities. Today, the purpose of screening for falls is primarily to identify those residents who are at particularly high risk of falling and are in urgent need of interdisciplinary efforts to reduce this fall risk. The other residents should also be offered individually tailored advice and support.

Staff’s judgement of fall risk and their knowledge of previous falls appear to be important in the identification of residents at particularly high risk. However, it has to be the judgement of staff who know the resident well. It is possible that the accuracy of staff judgement could be increased by education about risk factors for falling. Also the MIF is valuable in identifying residents at particularly high risk of falling especially in combination with staff judgement or fall history. As frail residents’ health status fluctuates, the usefulness of the MIF might increase if repeated at two different points of time within a couple of days.

Individually tailored measures and general strategies proved to reduce the number of residents falling, and the incidence of falls and hip fractures. A screening of the fall risk of all residents followed by discussions among the residents and several occupational groups on how to decrease fall risk could potentially contribute to a raised awareness of the problem of falls and the variety of solutions. Since falls are caused by many factors the knowledge of residents, nurses aides, licensed practical nurses, licensed nurses, physiotherapists, occupational therapists, doctors, technicians and janitors might be needed. In implementing a fall prevention program a screening can serve as a starting-point for a fundamental process of co-operation. In addition, detailed fall reports, carefully followed up in order to reduce the risk of repeated falls, will promote such a co-operation. It might be most important that attention be paid to the risk of falls on a daily basis, in the same way as eating and toileting are today in many residential care facilities and nursing homes.

An intervention program that reduces falls and injuries without the use of physical restraints means that more residents may be spared the anxiety of unsafe transfer and locomotion. Also worried relatives need
not feel so anxious. Furthermore, staff may benefit from an effective program in several ways including a decreased burden of guilt feelings as well as of physical effort when someone falls. The program can also be encouraging for staff when their pre-existing knowledge in identifying residents prone to falling is taken seriously and a plan of action is established. On the other hand, an effective fall prevention program might require increased staffing. However, such a program would also mean savings for society with reduced costs for acute hospital care and for residents with increased need of assistance.

Research in prediction and prevention

In this thesis the importance of validating predictive models and tools has been made clear. Consequently, further studies remain regarding the predictive accuracy of staff judgement and also whether staff trained in estimating the risk of falling are superior to untrained staff. Moreover, the efficacy of staff judgement in combination with a modified version of the MIF chart in identifying residents particularly prone to falls should be further explored. Also, the optimal time interval of the prediction is still unknown and needs clarifying.

The basis of the intervention program was a combination of targeting risk factors of high-risk residents and of measures directed to staff and residential care environment. It is thus not possible to estimate the effect of individual preventive measures. According to time and cost effectiveness it would be of major importance to be able to choose the most effective measure for each resident. Additionally, an aspect not accounted for in this thesis but potentially important is how the organisation of staff and the psychosocial working environment affect the incidence of falls.

Physiotherapy as a field of practice

This thesis shows that a fall prevention program in which physiotherapists were largely responsible for the education of staff, the administration of the fall risk screening and the tailoring of an individual program for each resident significantly reduced the number of residents falling, of falls and of femoral fractures. According to the Swedish Association of Registered Physiotherapists:

Physiotherapy as a field of practice is concerned with prevention, examination, treatment and rehabilitation of movement disorders that limit or threaten to limit the movement capacity of the individual. Interventions with the aim to prevent or rehabilitate are based on an evaluation and analysis of physical capacity and problems of the patient/client with regard to psychological and social factors including relevant environmental aspects. With the patient/client as an active partner, interventions, treatments and learning strategies aim at making the individual
aware of his/her physical resources and thereby improve the potential to cope with the demands of daily living [...].

This statement is highly applicable to the physiotherapist’s work in the present intervention study.

With a policy of an intervention program to continuously target deleterious fall risk factors through the use of individually tailored strategies and to improve safety without compromising the resident’s mobility, a close collaboration between the resident and all the occupational groups surrounding her/him is essential. As the physiotherapist has a sound knowledge of assessment and treatment of impaired mobility, s/he should offer the resident and the staff guidance on how each resident can achieve or maintain a safe transfer and locomotion both in the short and the long run.

The work of physiotherapy includes the design and frequent evaluation of challenging and meaningful training of physical function and the facilitation of learning safe motor behaviour in interaction with the environment. Both the training and guidance in learning must be individually tailored and may well be integrated with activities of daily living but could also be carried out individually or in a group. The work also includes guiding staff to increase their awareness of when psychological and physical support is needed, and improving environmental safety and providing aids. The physiotherapist should also be engaged in ongoing discussions with superintendents and staff about how safe transfer and locomotion both in general and for individual residents can be promoted by the way the work is organised.

The results of the study suggest that the physiotherapist in residential care facilities may with advantage be the co-ordinator in fall prevention. The continuous evaluation and the collaboration within the team in conjunction with frail residents’ fluctuating health status require that the physiotherapist is frequently present at the facility. In the present study the physiotherapists worked at the facility several days a week.

Research in physiotherapy

The subject of physiotherapy is “concerned with the ability of the individual to perceive, control and in a purposeful way use his/her body with regard to demands that come from the physical and social environment”, according to the Swedish Association of Registered Physiotherapists. Clearly, to gain more knowledge about the ability to walk and concurrently do something else such as talk and carry something is within physiotherapy’s sphere of interest. The initial results of this thesis revealed that the SWWT and the diffTUG were valid markers of frailty and had a potential for fall risk screening efficacy. However, the validating study showed a lower predictive accuracy. Hence, further studies remain to illuminate walking behaviour in multitask conditions with expected and unexpected events in healthy elderly people as well as
in frail people and to relate the walking behaviour to the occurrence of falls. In addition, how fear of falling affects walking behaviour and fall risk needs to be further explored. Another interesting focus is the individual’s own perception of physical ability related to observed ability, the level of physical activity, and the risk of falling. It is also of great importance to investigate how the prescription and use of walking aids affect gait safety both in the short and long run. Furthermore, the development of methods for describing and evaluating walking behaviour in multitask conditions, and the prediction of falls as well as the evaluation of interventions to increase safety while walking in multitask conditions are all important challenges to the growing field of research in physiotherapy.
GENERAL CONCLUSIONS

• The incidence of falls is high in the group of elderly people living in residential care facilities. Almost every other resident sustains a fall in six months, and many fall several times.

• Walking and interacting with a person or an object as in the SWWT and the diffTUG appear to be valid markers of frailty but establishing their predictive accuracy requires further studies.

• It is important to validate predictive models and tools in a new independent sample before results are considered reliable and put into practice.

• A combination of any two of the evaluated methods – the MIF chart, staff judgement, fall history – appears to be more accurate at identifying high risk residents than any method alone. Thus, staff who know the resident well can probably identify many of those who are at particularly high risk of falling by a global rating of future risk in combination with previous falls. In the event that this information is not obtainable, the MIF chart is of value.

• Most residents in this kind of setting have a high risk of falling. Residents classified by more than one method as being at high risk should be regarded as being at particularly high risk and thus in urgent need of preventive measures.

• A significant reduction in the number of residents falling, of falls and of femoral fractures can be achieved by a fall prevention program including a multidisciplinary approach and targeting residents’ risk factors as well as directing measures to staff and residential care.
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