The impact of various neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

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Complete List of Authors:	Homann, Barbara; Medical University Graz, Neurology Plaschg, Annemarie; Medical University Graz, Neurology Grundner, Marion; Medical University Graz, Neurology Haubenhofer, Alice; Medical University Graz, Neurology Griedl, Theresa; Medical University Graz, Neurology Ivanic, Gerd; Private Paracelsus Medical University Salzburg, Orthopedic Surgery Hofer, Edith; Medical University Graz, Neurology Fazekas, Franz; Medical University Graz, Neurology Homann, Carl; Medical University Graz, Neurology
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Falls in the community dwelling elderly: the impact of neurological disorders

Homann, Barbara[1;] Plaschg, Annemarie[1;] Grundner, Marion[1;] Griedl, Theresa[1;] Ivanic, Gerd[2;] Hofer, Edith[1;] Fazekas, Franz[1;] Homann, Carl Nikolaus[1]

[1)] Medical University Graz, Dept of Neurology, [2)] Paracelsus Medical University Salzburg, Dep. of Orthopaedic Surgery

ABSTRACT

Objectives: Owing to a lack of data, our aim was to evaluate and compare the impact of various common neurological diseases on the risk for falls in independent community dwelling senior citizens.

Design: Prospective case controlled study

Setting: General Hospital

Participants: Out of 298 consecutive patients and 214 controls enrolled, 228 patients (aged 74.5±7.8; 61% women) and 193 controls (aged 71.4±6.8; 63% women) were included. Exclusion criteria for patients were severe disability, disabling general condition, or severe cognitive impairment, for controls any history of neurological disorders or disabling medical conditions, and for both age below 60 years. A matching process led to 171 age- and gender-matched pairs of neurological patients and healthy controls.

Main outcome measures: One-year incidence of falls, motor and non- motor function tests to detect additional risk factors.

Results: 46% of patients and 16% of controls fell at least once a year. Patients with stroke (89%), Parkinson's disease (77%), dementia (60%) or epilepsy (57%) had particularly high fall frequencies, but even patients with the least fall-associated neurological diseases like tinnitus (30%) and headache (28%) had a higher incidence of falls than controls. Neuropathies, peripheral nerve lesions and Parkinson's disease were predisposing to recurrent falls. A higher number of neurological comorbidities ($p<0.001$), lower Barthel Index values ($p<0.001$), lower Activities-Specific Balance Confidence scores (, $p<0.001$), and higher Center of Epidemiological Studies Depression scores ($p<0.001$) as well as higher age ($p<0.001$) and female gender ($p=0.003$) proved to further increase the risk of falls.

Conclusions: Physicians should be aware that all elderly neurological patients seen in outpatient settings are potentially at high risk for falls; they should query them routinely about previous falls and fall risks and advise them on preventive strategies.

Article summary

Article focus

- Previous studies have shown that falls in the elderly are common and limited data on single neurological impairments suggest that these conditions further increase the risk for falls.

- However, little is known on the influence of a broad range of neurological diseases and how they differ among each other. No data is available on independent community dwelling senior citizens.
- The aim of this study is to provide comparative data on the risk of falling in ambulatory elderly subjects afflicted with various common neurological diseases and to evaluate the role of additional risk factors.

Key messages

- The results of our study suggest that all elderly neurological patients even when still ambulatory carry a heightened risk for falls.
- The impact differs according to disease but those with impairments of the sensorimotor system are particularly endangered. However our findings revealed that even neurological disorders not directly connected with gait and balance carry an astonishingly high risk for falls.

Strengths and limitations of this study

- Strengths of this study include the prospective study design, the number of standardised outcome measures, the standardised assessment of neurological patients and the thorough examination and inclusion of healthy controls.
- The following limitations should be considered: the information on falls was self-reported and underreporting of cases is possible. Small sample sizes in some of the subgroups of neurological diseases. Participants were mostly of Caucasian origin, which may limit the generalisability of the results to other populations.

INTRODUCTION

Due to budget cuts and austerity measures the costs of accidents and falls have come into the spotlight of health policy makers. The World Health Organisation too has recently made fall prevention in the elderly one of its top priorities. The WHO Global Report on Falls Prevention in Older Age states that due to the high percentage of elderly people worldwide the economic and societal burden of falls will increase by epidemic proportions in all parts of the world over the next few decades, unless concerted action is taken in a systematic and proactive fashion by policy makers, researchers and practitioners [1].

It is known that falls in the elderly are common and have a great impact on life and wellbeing. Studies have shown that around 30% of subjects of 65 years plus had a fall during the last 12 months [2] with 10% sustaining severe injuries [3]. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls [4]. Elderly persons surviving a fall experience significant morbidity: as many as one-third require assistance in their activities of daily living for as long as 6 months [5]. Lasting disabilities are also common as many do not reach pre-fall physical functional states, resulting in increased dependency and (in up to 50%) a transfer to a care facility [4]. Associated as they are with considerable mortality as well as psychological and physical morbidity, these falls lead to increased dependence upon social support and health care services, with high economic impact on the social and health care system [6]. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs [2].

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly [7]. Neurological impairments in the elderly are also thought to increase the risk for falls, though evidence for this is mostly derived indirectly from investigations into the causes of falls in the elderly [8]. These studies show that patients admitted to hospitals due to falls frequently also suffer from neurological disorders. Data derived from a multidisciplinary fall consultation survey suggest that in two out of three patients, potentially fall inducing neurological disorders were present, most of them (85%) previously undiagnosed [9].

There is, however, substantially less known about the risk for falls in patients afflicted with various common neurological diseases. Several studies were conducted on the risk of falls in patients with a single neurological disease like stroke [10], Parkinson's disease [11] or dementia [12], but to our knowledge only one comparative study investigated falls in patients with different neurological diseases. This study by Stolze, however, was conducted on patients with neurological diseases severe enough to require hospital admission [13]. To date little is known about the risk of falling in

independent, community dwelling senior citizens afflicted with neurological diseases treatable in outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they did, the absence of neurological signs and symptoms in this cohort was not guaranteed.

Because falls in community dwelling elderly patients are assumed to be both prevalent and preventable, neurologists in outpatient settings need a sound base to identify patients with the highest risk, to reduce not only the number of falls and the suffering they entail, but also overall health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with various neurological diseases that are commonly encountered in outpatient facilities. We hypothesized that even in community dwelling elderly patients, the impact one or more neurological diseases on top of an already increased propensity for falls is substantial; that patients with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction with more than one of these high risk diseases increases the risk even further.

PARTICIPANTS AND METHODS

Epidemiological and environmental bases

Data were collected at the Department of Neurology of the University Hospital in Graz, Austria. The Department of Neurology provides health care for about 500,000 people in Styria and southern Burgenland, though mostly to inhabitants of Graz and the surrounding area. The department focuses its basic and clinical research on cerebro-vascular disorders, dementia, epilepsy, movement disorders and multiple sclerosis. At this teaching hospital, out of a total of 1565 beds, there are 92 neurological beds, including 8 in intensive care and 6 in the stroke unit. Out of approximately 22,600 neurological outpatient contacts recorded each year 4,600 are from the general outpatient department, the rest in equal proportions from specialized outpatient clinics and the neurological emergency room. Two out of five neurologists are in rotation on duty at the Neurology Outpatient Clinic and they are attending to the patients on a random basis. As visits to the outpatient department do not require specialist referrals, the disease spectrum largely resembles that seen by community based neurologists.

Selection of participants and baseline examination

Physically independent community dwelling patients treated in our general neurological outpatient clinic aged 60 years and over were included in the study. Patients were all seen consecutively by

one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains the study size. Severely disabled patients who were no longer able to walk unaided, were in poor general condition, or cognitively impaired to an extent that an interview would no longer yield reliable results, were excluded from the study. All neurological patients included underwent a full neurological workup with an extensive history to detect signs of past and present neurological disorders. For the sake of uniformity, both the workup and history were structured and followed the study protocol.

As healthy controls, individuals from the general public out of the same catchment area as cases were enrolled. They were recruited among friends and acquaintances of the author and his co-workers who were aged 60+ and without any history of neurological disorders or other disabling medical conditions. Examination and history were as per study protocol, whereby special emphasis was placed on identifying symptoms and signs of Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor deficits and gait or balance impairments. Controls with even subtle pathologies were excluded.

A telephone follow-up was scheduled 12 months after the baseline outpatient visit; it was carried out by one of two examiners (AP, MG) following a predefined format and only subjects who had given informed consent beforehand were interviewed.

The first section of the interview questionnaire covered demographic data like age and place of residence. The residence category had 5 subsections on size and traffic infrastructure, with group 1 being the state capital and group 5 a small town in the periphery. Next were specific questions on fall frequency, physical disability, depression and confidence in one's own sense of balance. The final section dealt with risk situations (like when using public transport) and general mobility issues, whereby the latter are not included in this publication.

The survey, including all details concerning the selection process, was approved by the Ethics Committee of the Medical University Graz.

Frequency of falls

In the main section of the questionnaire patients and healthy controls were asked whether they had had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall incidence was graded according to the fall frequency index into 5 categories. Category one means 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

Analysis of Disability

The Barthel Index [14], a disability scale with scores from 0 (completely dependent) to 100 (completely independent) was used to evaluate the functional status of all neurological patients.

Parkinson patients were also rated according to the modified Hoehn and Yahr Scale, the Schwab and England Scale and the Unified Parkinson's Disease Rating Scale (UPDRS) [15].

Analysis of Depression

To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) [16], the German short form of the Center of Epidemiological Studies Depression Scale (CES-D) [17] was used. It is known to be particularly well suited for the use in the elderly and in patients with certain neurological disabilities [18].

Analysis of the Confidence in one's own Sense of Balance

We also rated the patients' confidence in their own sense of balance with the Activities-Specific Balance Confidence Scale (ABC -6 scale) [19]. Participants judged their confidence not to fall during specific activities on a scale ranging from 0% (no confidence at all) to 100% (completely confident). The total score was then computed as an average of the subscores.

Statistical analysis

The one-year incidence of falls was calculated for both healthy elderly individuals and the whole sample of neurological patients. Further calculations were done for subsamples of 13 neurological disorders with the highest prevalence. The means and standard deviations were calculated for numerical values like the rating scale scores. For the identification of fall related risk factors, correlations (Kendall's τ-B), and for the individual neurological disorders, risk odds ratios were computed (α-level of significance $p < 0.05$). Differences between neurological patients and healthy controls were tested with the Mann-Whitney U test or the chi-square test (α-levels of significance $p < 0.05$). To insure comparability of cohorts we formed age- and gender-matched pairs of patients and control subjects (allowing an age deviation of ± 3 years) according to a predefined algorithm. Only complete sets of data were included in the calculations and no approximates to replace missing values were computed. Calculations were performed with SPSS ® statistical software PASW statistics 18. Potential bias and how it was addressed will be dealt with in the section on limitations.

RESULTS

During a period of 10 months we recruited 298 mobile neurological outpatients and 214 healthy

controls aged 60 years and over. In the group of healthy controls 21 patients initially recruited could not be included in the study due to neurological symptoms and signs, or a history of a neurological disorder. In the group of neurological patients another 70 patients had to be excluded from the study because at the time of the interview they (15%) or their caregiver (9%) requested exclusion, the telephone number on record had been disconnected (34%), all attempts to contact them failed (16%), they had become so disabled that they could no longer participate in the survey (15%), they had died (5%), or for other reasons (8%).

The statistical analysis thus covered 228 neurological outpatients (aged 74.5 ± 7.8; 61% women) and 193 healthy controls. The matching process led to 171 pairs of neurological patients and healthy controls, 101 women and 70 men in each group, aged 72.0 and 72.2 years, respectively. The details of these subjects are summarized in Table 1.

Incidence of falls in neurological patients and healthy controls

One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen at least once ($p < 0.001$) during this one-year period. Out of 126 neurological patients experiencing falls, 76 (71,7%) fell once or twice, 22 (20,8%) three to five times, three (2,8%) six to nine times, three (2,8%) 11-20 times and two (1,9%) more than 20 times. In the group of healthy controls, out of 76 individuals with a history of falls, 24 (77,4%) fell once or twice, and seven (22,6%) three to five times, but none more often than that. In the matched cohorts as well falls were more frequent in neurological patients (42,1%) than in healthy controls (16,9%) ($Chi^2=26,3$; $p<0.001$). (Table 1)

The mean age of individuals with a history of falls as compared to those without was higher both in the neurologically affected (fallers: 76,7 ± 7,6 vs. nonfallers: 72,6 ± 7,5; $p<0.001$) and in healthy controls (fallers: 73,3 ± 6,5 vs. nonfallers: 71,0 ± 6,9; $p=0.040$). In the group of neurological patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male ($Chi^2=8,675$; $p=0.003$). Similarly, in the group of healthy controls a higher percentage of fallers was female, with 23 out of 31 (74%), but this did not reach significance ($Chi^2=1,915$; $p=0,166$).

The occurrence of falls in neurological patients was independent of where they lived. For healthy controls, however, their place of residence had an influence, in that subjects living in more rural environments were more prone to falls ($p<0.001$).

Repeated falls occurred particularly in patients with peripheral neuropathy (43%), peripheral nerve lesion (43%), dementia (33%), Parkinson's disease (30%), stroke (30%) and vertebral pain (30%).

The average fall frequency index in this group of patients with frequent falls ranged from 1,63 (peripheral neuropathy) to 1,33 (dementia) (Fig. 1.).

Risk factors for falls in neurological patients

The type of neurological disease the patient was afflicted with influenced the frequency of falls in that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%) had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy control (16,1%). (Fig. 2)

The respective odds ratios are shown in table 2 and range from 40,1 (stroke) to 2,1 (headache) and the relative risk of falling ranges between 5,5 for stroke patients and 1,8 for patients with headache.
No specific combination of two or three neurological diseases characterized by substantial gait or balance impairment but any accumulation of several neurological diseases regardless of their influence on gait or balance was able to cause a significant raise in falls (Γ-B=0,303; p<0.001).
Other risk factors for falls in neurological patients were female gender (Γ-B=0,195; p=0.003), higher age (Γ-B=0,217; p<0.001), higher disability or disease severity as measured by the Barthel Index (Γ-B=-0,232; p<0.001). Higher disability scores in Parkinson patients expressed by higher UPDRS II (activities of daily living) scores resulted in a trend toward more frequent falls (Γ-B=-0,238; p=0.062). Severity of depression as reflected by a higher ADS score (Γ-B=0,329; p<0.001) and low balance confidence reflected by higher ABC scores (Γ-B=-0,384; p<0.001) were also predictive (Fig. 3).

DISCUSSION

Incidence of falling

Our study suggests that even in patients mildly to moderately affected by neurological impairments the incidence of falls was three times higher than in subjects without any neurological symptoms or signs. To our knowledge this is the first survey conducted on elderly neurological outpatients and controls proven to be without neurological impairments, but the extent of this increased relative risk

in neurological patients was unexpected, and resulted from low incidence figures in the group of controls and particularly high figures in the patient group.

In our group of healthy controls the 12-month incidence (16,1 %) was considerably lower than in previous population based data serving as a reference for previous studies [20]. Literature suggests that a third to one half of the community dwelling population of 60+ experience falls each year. For a group of 1762 subjects 60+ years of age, Lord reported a yearly incidence rate of falls of 28% [21]. In individuals of 65 years and older Prudham found in his survey conducted on 2793 individuals that 28% experienced one or more falls in the last year [22]. In O'Loughlin's group of 409 it was 29% [7], in Campbell's group of 533, 33% [23], and in Blake's group of 1042, 35%. [24] Luukinen's group of 833 individuals aged 70+ showed a 30% annual rate of falls [3] and Tinetti's group of 336 aged 75+ showed a rate of 32% [25]. For the very old, Campbell found in a community-based prospective study based on 761 subjects that half of those age 80 years and over have a fall every year [26]. This incidence rate, twice or three times that of our figures, did not surprise us. Population-based data of elderly individuals inevitably include a considerable number of patients suffering from neurological diseases or other forms of gait or balance problems. Many of these neurological disorders like stroke, Alzheimer's disease or Parkinson's disease are typical diseases of the elderly and others like epilepsy or traumatic brain injury also have a second peak in higher age [27]. This shows how important it is, when studying groups of elderly patients, to have a truly healthy control group, as in our survey.

Our study also shows that half of all ambulatory neurological patients had had at least one fall within the last 12 month. As to our knowledge this is the first survey of neurological outpatients, the lack of comparative data gave us no choice but to relate our findings to Stolze's data on neurological inpatients showing, much to our surprise, a falling incidence as low as 34% [13]. One would have assumed that Stolze's patients, who required inpatient treatment for their neurological conditions, would be more severely disabled and thus more prone to falls than outpatients. It also appears contradictory our findings that indicators of disease severity like the Barthel index and the UPDRS correlated positively with the incidence of falls. Several studies further support this concept by stating that the more severely affected patients are, the higher the falling risk [28]. However, we have reasons to believe that the correlation is not linear throughout all grades of disability but rather resembles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher disability only up to a certain point. Then, as patients become more cautious and use all kind of supports, it plateaus and even decreases. When patients become so disabled that they are finally bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since this concept is not yet backed up by sound evidence, further studies directly comparing the risk of falling in neuro-

logical inpatients and outpatients of various grades of disability are needed to support this assumption.

Considering recurrent falls we found that in the group of neurological patients 13,2 % fell three or more times per year, compared to 3,6% in the group of healthy controls. This is in keeping with the results of studies investigating recurrent falls, where figures of 8% for three or more falls in randomly selected community dwelling elderly individuals are given [29] and 10% for community based seniors using home care services [30]. In Stolze's cohort of inpatients the value of 21% for recurrent falls was higher and can probably be explained by methodological differences. Stolze's category of recurrent falls already includes patients who had fallen twice, unlike our and other studies [29, 30] that include patients only after more than three falls.

Risk factors contributing to falls

We found out that the type of neurological disease afflicting a patient determines the potential risk factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson patients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with previous community based studies showing a high likelihood for falls in stroke patients with a range of 51-73% [10, 20, 31] and in Parkinson's patients with a range of 38 – 87% [11, 32-38]. This was followed by a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consisting of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neuropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-80% [12, 39] in Alzheimer patients and 55-65% [40-42] in patients with peripheral neuropathy. The only study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents, providing a 5-year fall incidence of 83% [43]. In our sample peripheral neuropathy also proved to be a risk factor for recurrent falls, but most likely significance was not reached due to the small sample size ($p=0.061$). Confirmative data also obtained from small cohorts revealed that repetitive falls occurred in 10 out of 25 (40%) neuropathy patients [42] and another 13 out of 20 neuropathy patients (65%) had a propensity for recurrent falls for an average of 5,8 falls per year [40]. New and quite astonishing was the fact that even patients suffering from neurological diseases with no direct influence on gait or balance like headache (28%) had almost twice as many falls as the average healthy control (16,1%). Also new is that in contrast to all the above cited data derived from studies on patients with only one neurological disorder, our survey provides comparative values for several neurological diseases of elderly ambulatory neurological patients for the first time, allowing a direct comparison between these disorders and a ranking according to the risk of falling.

But our findings further suggest that not only the type of neurological conditions, but also the number of neurological diseases a patient was suffering from, no matter whether they had an influence

on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that only accumulations of neurological deficits relating to gait and balance would influence the risk for falls. Although there were no published studies on the influence of neurological diseases, it is known that persons with an impaired sense of balance have an disproportionately higher risk for falls when they acquire an additional new disease or condition, even if it is one that seems minor or not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a patient was suffering from was highly predicative of a risk to fall, better even than a mobility score. She concluded that falling appears to result from an accumulated effect of multiple specific disabilities [44]. This would be in keeping with our other findings, that old age in combination with any neurological disease increases the risk of falling above that of healthy controls, even if it is a disease like headache. Also in accordance with this we found that a higher rate of depression, as reflected by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be that depressive thoughts are frequently combined with negative conceptions of one's own sense of balance, which was found to be a prominent risk factor for falls in our and previous other studies [45]. That higher age would be a predictive factor for falls in neurological patients replicates previous findings [13] and is easy to explain: old age is often associated with greater frailty and eventually frailty with less confidence in one's sense of balance and a higher incidence of falls [45]. That females are more prone to falls than males has often been stated before [13] and has previously been explained by a fear of falling and a loss of confidence – both independent risk factors for falls - being more prominent in women [6].

LIMITATIONS

We also faced several limitations in our study. First and most importantly, like most other surveys dealing with falls, we faced the problem that the number of falls is underreported. Elderly subjects often try to downplay problems regarding their mobility for fear of having their autonomy restricted. While this is in general typically found in the healthy elderly, it might be even more prominent in patients with disabilities. But even remembering these events might pose a problem in some of the patients with central degenerative diseases and this might have been a relevant factor in our study, even though we excluded patients with severe dementia. The risk for falls in neurological patients might therefore be greater than shown in any results.

Secondly, almost one quarter of neurological patients were lost for follow up, which could have lead to further underestimating the number of patients with falls. However, since these patients did not obviously differ in their baseline characteristics, we assume this problem to be minimal.

Thirdly, elderly subjects without even the slightest neurological symptoms are hard to find and therefore the use of a cohort of this rare group of supranormal individuals as a reference group might not be representative. The patient cohort we examined was a group of neurological patients who were mobile and affected by only mild to moderate neurological symptoms. This group of elderly patients, of the kind typically seen in neurological practice, also accounts for only a part of neurological patients and generally performs much better than the large segment of more severely affected patients placed in institutions. But to highlight the impact of even mild impairment on falls, we nevertheless felt that it was of importance to use controls with no impairment, regardless of how many percent of the population they might represent.

Then, we would also like to address the issue of small sample sizes in subgroups of neurological diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies like those on peripheral neuropathy [40, 42]. Others, particularly the dementia group with only seven patients, is, due to the exclusion of the more affected, quite small and allows only limited extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels of significance.

Finally, this study was performed on participants of a mid-sized central European city and surrounding countryside with patients to a large percentage of Caucasian origin which raises the question as to what extent our study results can be generalized to other geographical locations. However, almost all other studies on falls were also performed in similar settings. Given the fact that incidence figures were all in the range of previous studies conducted in other western developed countries we believe that our findings should in general well reflect falling risks in similar settings of these regions. However, due to lack of data, we cannot make any suggestions as to whether comparable results could be expected in emerging South American, Asian or African countries. There technical and cultural barriers as well as support systems probably have constituted different mobility environments for elderly people. To investigate the impact of neurological impairment on risk for falls in the elderly in these regions would be an important topic for future projects.

CONCLUSION

It can be said that we managed to show, apparently for the first time, that even among ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is multi-factorial, but the connection between falls and disturbances of the sensorimotor system frequently found in neu-

rological diseases in elderly patients is of great importance. Our findings revealed that even neurological diseases not directly connected with gait and balance carry an astonishingly high risk for falls. Neurologists should therefore be aware that their patients are at high risk for falls, as any neurological deficit increases this risk, even more so if a combination of factors is present. Of course the risk has to be evaluated individually, but patients with central diseases like stroke, Parkinson's disease, dementia and epilepsy, and for repeated falls also patients with peripheral neurological disorders, require special attention. Greater disability, higher age, female gender, depression and low confidence in the sense of balance are additional contributory factors that have to be taken into account in this process. For patients with several of these factors, targeted prevention programs should be implemented, because they have been shown to generally reduce falls and injuries [46]. Due to the prevalence of falls and the personal and social impact they have on the lives of many, it seems important that further larger scale multicenter neuro-geriatric surveys should be performed to acquire more extensive knowledge of the effectiveness of preventive measures in patient cohorts with various neurological conditions and different degrees of disability.

NOTES

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Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz

Patient consent: obtained

Contributorship: B. H.: drafting/revising the manuscript, study concept or design, analysis or interpretation of data; A. P.: analysis or interpretation of data, acquisition of data of patients and controls, study concept or design; M. G.: analysis or interpretation of data, acquisition of data of patients and controls, study concept or design; A.H. acquisition of data of patients and controls; T. G.: acquisition of data, study concept or design, G. I.: critical revision of the manuscript for important intellectual content; E. H.: statistical analysis , analysis or interpretation of data, study concept or design; G.I.: drafting/revising the manuscript, study concept or design, critical revision

of the manuscript for important intellectual content; F. F.: drafting/revising the manuscript, study concept or design, critical revision of the manuscript for important intellectual content; C. N. H.: drafting/revising the manuscript, study concept or design, acquisition of data, study supervision.

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TABLES AND FIGURES

Table 1: Neurological patients and healthy controls: General demographics and fall frequency

	Total			Matched pairs		
	Patients (n=228)	Healthy (n=193)	p-value	Patients (n=171)	Healthy (n=171)	p-value
Total						
Age	74.5±7.8	71.4±6.8	0.000	72.2±7.0	72.0±6.9	0.839
Gender (f in %)	61%	63%	0.572	59%	59%	1.000
Fallers						
Falls (n (%))	46.5%	16.1%	0.000	42.1%	16.9%	0.000
Multiple Falls (>2 falls) (n (%))	28.3%	22.6%	0.528	26.4%	24.1%	0.815
Fall frequency Index (in fallers)	1.42±0.8	1.23±04	0.078	1.44±0.9	1.24±04	0.14

Fall Frequency Index in neurological patients

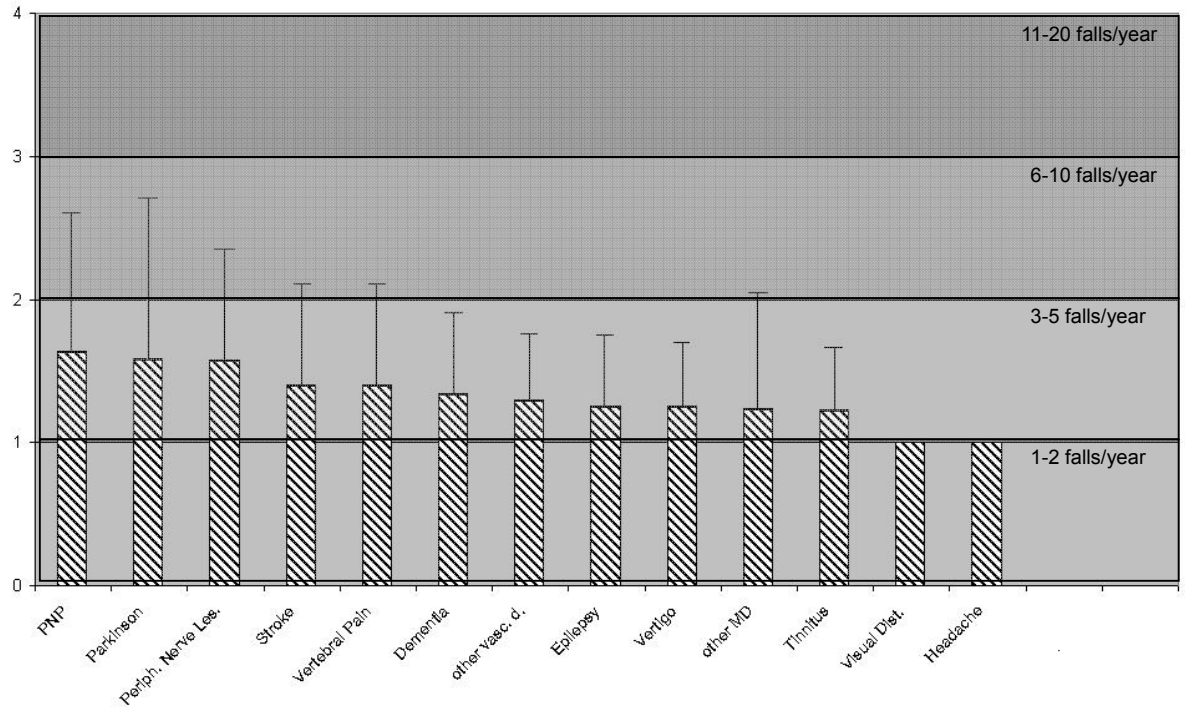


Fig.1 Frequency of falls in neurological patients according to their neurological disorder. 1=1-2 falls in the last twelve months, 2 = 3-5, 3 = 6-10, 4 = 11-20, and 5 = more than 20.

Abbreviations: PNP = peripheral neuropathy, Periph. nerve les. = peripheral nerve lesion**,** other MD = other movement disorders, other vasc. d. = other vascular disease, Visual.Dist. = visual disturbances

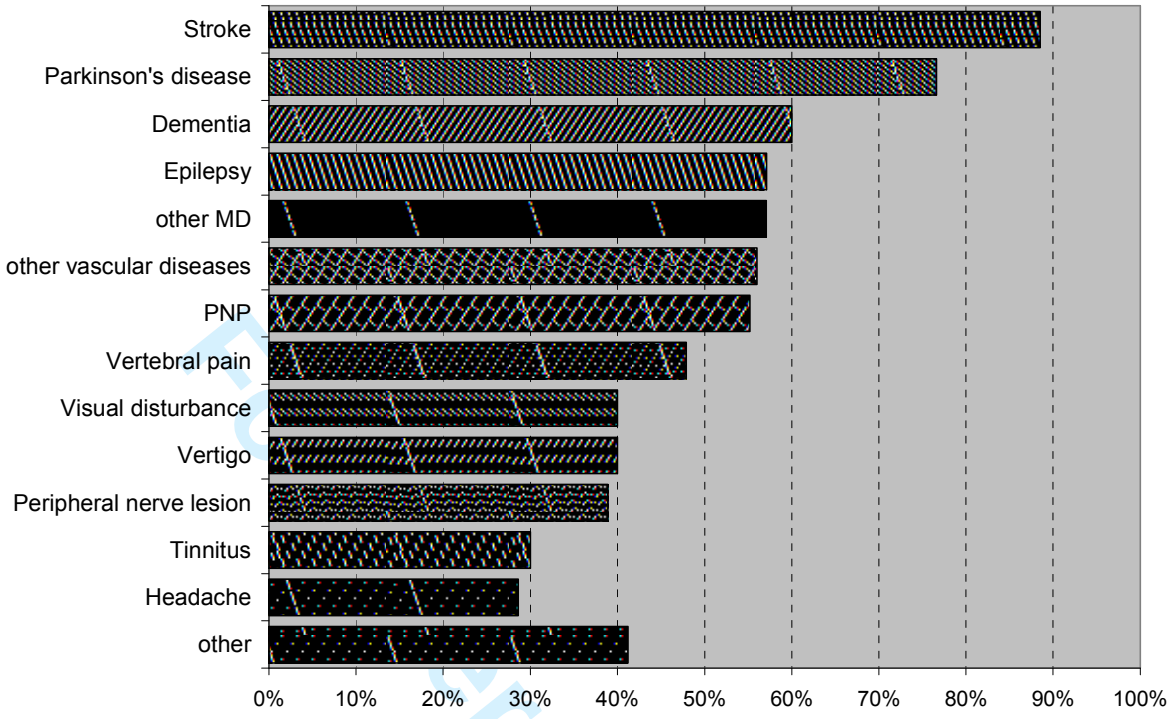


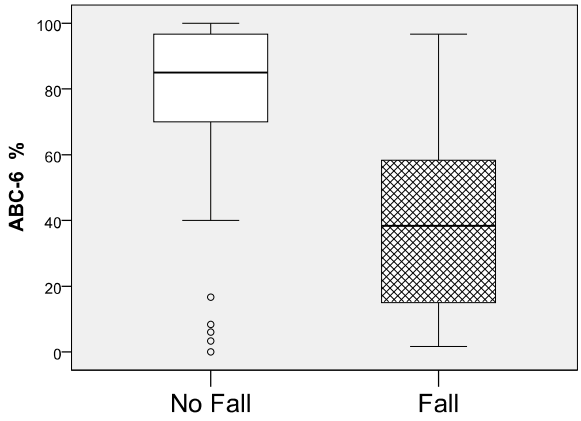
Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls (n (%))	Fall frequency* (in fallers)	Risk of falling		
							OR	CI	p-value
Stroke	82,7±2,3	99,76	26	23 (89%)	7 (30%)	1,39±0,72	40,1	(11,3-141,7)	0.000
Parkinson D	74,8±8,1	99,79	47	36 (77%)	11 (31%)	1,58±1,13	17,1	(7,9-37,2)	0.000
Dementia	77,5±9,2	99,77	7	3 (60%)	1 (33%)	1,33±0,58	7,8	(1,3-48,9)	0.01
Epilepsy	71,0±8,2	99,78	7	4 (57%)	1 (25%)	1,25±0,5	7,0	(1,5-32,7)	0.005
other MD	74,3±7,9	100	14	8 (57%)	1 (13%)	1,23±0,82	7,0	(2,3-21,5)	0.000
other vasc. D	74,8±8,1	99,79	25	14 (56%)	4 (29%)	1,29±0,47	6,7	(2,8-16,0)	0.000
PNP	71,0±8,1	99,78	58	32 (55%)	13 (43%)	1,63±0,98	6,4	(3,4-12,3)	0.000
Vertebral Pain	76,8±9,1	99,75	48	23 (48%)	7 (30%)	1,39±0,72	4,8	(2,4-9,5)	0.000
Visual Disturb.	69,5±0,7	99,77	10	4 (40%)	0 (0%)	1±0	3,5	(0,9-13,1)	0.051
Vertigo	72,0±8,1	99,75	30	12 (40%)	3 (25%)	1,25±0,45	3,5	(1,5-8,0)	0.002
P. Nerve Les.	66,0±8,1	99,79	18	7 (39%)	3 (43%)	1,57±0,79	3,3	(1,2-9,2)	0.016
Tinnitus	74,3±8,4	99,76	30	9 (30%)	2 (22%)	1,22±0,44	2,2	(0,9 - 5,3)	0.064
Headache	74,8±8,1	99,79	14	4 (29%)	0 (0%)	1,0±0.0	2,1	(0,6-7,1)	0,228
Other	79,4±7,1	99,74	34	14 (41%)	4 (29%)	1,29±0,47	3,7	(1,7 - 8,0)	0.001

*) Fall frequency index:. 1=1-2 falls in the last twelve months, 2 = 3-5 falls in the last twelve months, 3 = 6-10 falls in the last twelve months, 4 = 11-20 falls in the last twelve months, and 5 = more than 20 falls in the last twelve months.

a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

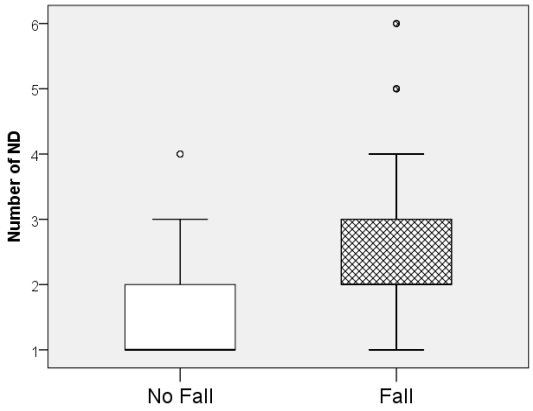


Fig.3a,b Differences in Activities-Specific Balance Confidence (ABC) scores (a) and number of neurological diseases (ND) (b) indicate that neurological patients with falls as compared to those without have lower confidence in their balance and a higher number of concomitant neurological diseases.

STROBE checklist - observational studies

	Item No	Recommendation	
Title and abstract			
	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	√
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	√
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	√
Objectives	3	State specific objectives, including any prespecified hypotheses	√
Methods			
Study design	4	Present key elements of study design early in the paper	√
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	√
Participants	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up*Case-control study*?Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls*Cross sectional study*?Give the eligibility criteria, and the sources and methods of selection of participants	√
		(*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case	√
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	√
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	√
Bias	9	Describe any efforts to address potential sources of bias	√
Study size	10	Explain how the study size was arrived at	√
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	√
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	√
		(*b*) Describe any methods used to examine subgroups and interactions	√
		(*c*) Explain how missing data were addressed	√
		(*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed*Case-control study*?If applicable, explain how matching of cases and controls was addressed*Cross sectional study*?If applicable, describe analytical methods taking account of sampling strategy	√
		(*e*) Describe any sensitivity analyses	√
Results			
Participants	13*	(*a*) Report numbers of individuals at each stage of study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	√
		(*b*) Give reasons for non-participation at each stage	√
		(*c*) Consider use of a flow diagram	-
Descriptive data	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	√
		(*b*) Indicate number of participants with missing data for each variable of interest	√

	Item No	Recommendation	
		(*c*) *Cohort study*?Summarise follow-up time (eg average and total amount)	√
Outcome data	15*	*Cohort study*?Report numbers of outcome events or summary measures over time	*n.a.*
		*Case-control study?*Report numbers in each exposure category, or summary measures of exposure	√
		*Cross sectional study?*Report numbers of outcome events or summary measures	*n.a.*
Main results	16	(*a*) Report the numbers of individuals at each stage of the study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	√
		(*b*) Give reasons for non-participation at each stage	√
		(*c*) Consider use of a flow diagram	-
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses	√
Discussion			
Key results	18	Summarise key results with reference to study objectives	√
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	√
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	√
Generalisability	21	Discuss the generalisability (external validity) of the study results	√
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	√

The impact of various neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

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Complete List of Authors:	Homann, Barbara; Medical University Graz, Neurology Plaschg, Annemarie; Medical University Graz, Neurology Grundner, Marion; Medical University Graz, Neurology Haubenhofer, Alice; Medical University Graz, Neurology Griedl, Theresa; Medical University Graz, Neurology Ivanic, Gerd; Private Paracelsus Medical University Salzburg, Orthopedic Surgery Hofer, Edith; Medical University Graz, Neurology Fazekas, Franz; Medical University Graz, Neurology Homann, Carl; Medical University Graz, Neurology
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Keywords:	Falls, fall risk, elderly, community dwelling, neurological disorders

The impact of neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

Homann, Barbara[1;] Plaschg, Annemarie[1;] Grundner, Marion[1;] Griedl, Theresa[1;] Ivanic, Gerd[2;] Hofer, Edith[1;] Fazekas, Franz[1;] Homann, Carl Nikolaus[1]

[1)] Medical University Graz, Dept of Neurology, [2)] Paracelsus Medical University Salzburg, Dep. of Orthopaedic Surgery

ABSTRACT

Objectives: Owing to a lack of data, our aim was to evaluate and compare the impact of various common neurological diseases on the risk for falls in independent community dwelling senior citizens.

Design: Prospective case controlled study

Setting: General Hospital

Participants: Out of 298 consecutive patients and 214 controls enrolled, 228 patients (aged 74.5±7.8; 61% women) and 193 controls (aged 71.4±6.8; 63% women) were included. Exclusion criteria for patients were severe disability, disabling general condition, or severe cognitive impairment, for controls any history of neurological disorders or disabling medical conditions, and for both age below 60 years. A matching process led to 171 age- and gender-matched pairs of neurological patients and healthy controls.

Main outcome measures: One-year incidence of falls based on patients' 12 month recall; motor and non- motor function tests to detect additional risk factors.

Results: 46% of patients and 16% of controls fell at least once a year. Patients with stroke (89%), Parkinson's disease (77%), dementia (60%) or epilepsy (57%) had a particularly high **proportion of fallers**, but even **subgroups of** patients with the least fall-associated neurological diseases like tinnitus (30%) and headache (28%) had a higher **proportion of fallers** than the control group. Neuropathies, peripheral nerve lesions and Parkinson's disease were predisposing to recurrent falls. A higher number of neurological comorbidities ($p<0.001$), lower Barthel Index values ($p<0.001$), lower Activities-Specific Balance Confidence scores (, $p<0.001$), and higher Center of Epidemiological Studies Depression scores ($p<0.001$) as well as higher age ($p<0.001$) and female gender ($p=0.003$) proved to further increase the risk of falls.

Conclusions: Physicians should be aware that all elderly neurological patients seen in outpatient settings are potentially at high risk for falls; they should query them routinely about previous falls and fall risks and advise them on preventive strategies.

Article summary

Article focus

- Previous studies have shown that falls in the elderly are common and substantial amount of data on single neurological conditions like stroke and Parkinson's disease suggest that neurological impairments further increase the risk for falls.
- However, little is known on the influence of a broad range of neurological diseases and how they differ among each other.
- The aim of this study is to provide comparative data on the risk of falling in ambulatory elderly subjects afflicted with various common neurological diseases and to evaluate the role of additional risk factors.

Key messages

- The results of our study suggest that all elderly neurological patients even when still ambulatory carry a heightened risk for falls.
- The impact differs according to disease but those with impairments of the sensorimotor system are particularly endangered. However our findings investigating yet unstudied populations, eg, such as headache revealed that even neurological disorders not directly connected with gait and balance carry an unexpected high risk for falls and that there is a cumulative effect of more than one neurological condition on the risk of falls.

Strengths and limitations of this study

- Strengths of this study include the prospective study design, the number of standardised outcome measures, the standardised assessment of neurological patients and the thorough examination and inclusion of healthy controls.
- The following limitations should be considered: although the design is prospective, the falls history is retrospective, based on patients'recall over 12 months, therefore underreporting of cases is possible. Small sample sizes in some of the subgroups of neurological diseases. Participants were mostly of Caucasian origin and there was a high drop-out rate, which may limit the generalisability of the results to other populations.

INTRODUCTION

Due to budget cuts and austerity measures the costs of accidents and falls have come into the spotlight of health policy makers. The World Health Organisation too has recently made fall prevention in the elderly one of its top priorities. The WHO Global Report on Falls Prevention in Older Age states that due to the high percentage of elderly people worldwide the economic and societal burden of falls will increase by epidemic proportions in all parts of the world over the next few decades, unless concerted action is taken in a systematic and proactive fashion by policy makers, researchers and practitioners [1].

It is known that falls in the elderly are common and have a great impact on life and wellbeing. Studies have shown that around 30% of subjects of 65 years plus had a fall during the last 12 months [2] with 10% sustaining severe injuries [3]. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls [4]. Elderly persons surviving a fall experience significant morbidity: as many as one-third require assistance in their activities of daily living for as long as 6 months [5]. Lasting disabilities are also common as many do not reach pre-fall physical functional states, resulting in increased dependency and (in up to 50%) a transfer to a care facility [4]. Associated as they are with considerable mortality as well as psychological and physical morbidity, these falls lead to increased dependence upon social support and health care services, with high economic impact on the social and health care system [6]. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs.

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly [7]. Neurological impairments in the elderly are also thought to increase the risk for falls, though evidence for this is mostly derived indirectly from investigations into the causes of falls in the elderly [8]. These studies show that patients admitted to hospitals due to falls frequently also suffer from neurological disorders. Data derived from a multidisciplinary fall consultation survey suggest that in two out of three patients, potentially fall inducing neurological disorders were present, most of them (85%) previously undiagnosed [9].

There is, however, substantially less known about the risk for falls in patients afflicted with various common neurological diseases. While there is already a substantial amount known about increased risk of falls in the stroke [10], Parkinson's disease [11] or dementia [12] population, to our knowledge there is only one comparative study investigating falls in patients with of a broad range of neurological diseases. This study by Stolze, however, was conducted on patients with neurological diseases severe enough to require hospital admission [13]. To date little is known about the risk of falling in

independent, community dwelling senior citizens afflicted with neurological diseases treatable in outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they did, the absence of neurological signs and symptoms in this cohort was not guaranteed.

Because falls in community dwelling elderly patients are assumed to be both prevalent and preventable, neurologists in outpatient settings need a sound base to identify patients with the highest risk, to reduce not only the number of falls and the suffering they entail, but also overall health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with various neurological diseases that are commonly encountered in outpatient facilities. We hypothesized that even in community dwelling elderly patients, the impact one or more neurological diseases on top of an already increased propensity for falls is substantial; that patients with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction with more than one of these high risk diseases increases the risk even further.

PARTICIPANTS AND METHODS

Setting

Data were collected at the general outpatient department of the Department of Neurology of the University Hospital in Graz, Austria. As visits to the outpatient department do not require specialist referrals, the disease spectrum largely resembles that seen by community based neurologists.

Selection of participants and baseline examination

Physically independent community dwelling patients treated in our general neurological outpatient clinic aged 60 years and over were included in the study. Patients were all seen consecutively by one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains the study size. Severely disabled patients who were no longer able to walk unaided or were in poor general condition, be it for reasons of neurological or other medical disease, were excluded from the study. Cognitive impairment to an extent that an interview would no longer yield reliable results (MMSE≤12), was also a cause for exclusion. All neurological patients included underwent a full neurological workup with an extensive history to detect signs of past and present neurological disorders. For the sake of uniformity, both the workup and history were structured and followed the study protocol.

As healthy controls, individuals from the general public out of the same catchment area as cases

were enrolled. They were recruited among friends and acquaintances of the author and his co-workers who were aged 60+ and without any history of neurological disorders or other disabling medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis severe enough to cause limitation of ordinary physical activity. Examination and history were as per study protocol, whereby special emphasis was placed on identifying symptoms and signs of Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor deficits and gait or balance impairments. Controls with even subtle neurological pathologies were excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

A telephone follow-up was scheduled 12 months after the baseline outpatient visit; it was carried out by one of two examiners (AP, MG) following a predefined format and only subjects who had given verbal informed consent at the start of the telephone contact were interviewed.

The first section of the interview questionnaire covered demographic data like age and place of residence. The residence category had 5 subsections on size and traffic infrastructure, with group 1 being the state capital and group 5 a small town in the periphery. Next were specific questions on fall frequency, physical disability, depression and confidence in one's own sense of balance. The final section dealt with risk situations (like when using public transport) and general mobility issues, whereby the latter are not included in this publication.

The survey, including all details concerning the selection process, was approved by the Ethics Committee of the Medical University Graz.

Frequency of falls

In the main section of the questionnaire patients and healthy controls were asked whether they had had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall incidence was graded according to the fall frequency index into 5 categories. Category one means 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

Disability

The Barthel Index [14], a disability scale with scores from 0 (completely dependent) to 100 (completely independent) was used to evaluate the functional status of all neurological patients.

Parkinson patients were also rated according to the the Schwab and England Scale and Part II of the Unified Parkinson's Disease Rating Scale (UPDRS) [15].

Depression

To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) [16], the German short form of the Center of Epidemiological Studies Depression Scale (CES-D) [17] was

used. It is known to be particularly well suited for the use in the elderly and in patients with certain neurological disabilities [18].

Balance Confidence

We also rated the patients' confidence in their own sense of balance with the Activities-Specific Balance Confidence Scale (ABC -6 scale) [19]. Participants judged their confidence in performing specific activities without loss of balance or being unsteady on a scale ranging from 0% (no confidence at all) to 100% (completely confident). The total score was then computed as an average of the subscores.

Statistical analysis

The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were defined according to the WHO definition [1] as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g. falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly individuals and the whole sample of neurological patients. Further calculations were done for subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were based on the ICD-10 system for classification of diseases. The means and standard deviations were calculated for numerical values like the rating scale scores. For the identification of fall related risk factors, correlations (Kendall's τ-B), and for the individual neurological disorders, odds ratios were computed (α-level of significance $p < 0.05$). Differences between neurological patients and healthy controls were tested with the Mann-Whitney U test or the chi-square test (α-levels of significance $p < 0.05$). To insure comparability of cohorts we formed age- and gender-matched pairs of patients and control subjects. For the matching process we used alphabetical lists of names of male and female neurological patients and likewise of healthy controls, sorted by age. Then working down the list we searched manually to find for each neurological patient one control subject of the same age. If no match was found then we looked for a control that was one year younger, then one year older, then two years and finally three years younger respectively older. Only complete sets of data were included in the calculations and no approximates to replace missing values were computed. Calculations were performed with SPSS ® statistical software PASW statistics 18. Potential bias and how it was addressed will be dealt with in the section on limitations.

RESULTS

During a period of 10 months we recruited 298 mobile neurological outpatients and 214 healthy controls aged 60 years and over. In the group of healthy controls 21 patients initially recruited could not be included in the study due to neurological symptoms and signs, or a history of a neurological disorder. In the group of neurological patients another 70 patients had to be excluded from the study because at the time of the interview they (n=10) or their caregiver (n=6) requested exclusion, the telephone number on record had been disconnected (n=24), all attempts to contact them failed (n=11), they had become so disabled that they could no longer participate in the survey (n=10), they had died (n=4), or for other reasons (n=5).

Prior to recruitment, twenty patients were excluded because of inability to walk unaided and one due to severe dementia. Of those that met inclusion criteria five rejected enrolment and six other patients could not be enrolled due to inadequate language skills (n=1), severe aphasia (n=1), or severe presbyacusis (n=4).

The statistical analysis thus covered 228 neurological outpatients (aged 74.5 ± 7.8; 61% women) and 193 healthy controls. The matching process led to 171 pairs of neurological patients and healthy controls, 101 women and 70 men in each group, aged 72.0 and 72.2 years, respectively. The details of these subjects are summarized in Table 1.

Incidence of falls in neurological patients and healthy controls

One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen at least once (Chi^2=43.4; p <0.001) during this one-year period. Out of 126 neurological patients experiencing falls, 76 (71.7%) fell once or twice, 22 (20.8%) three to five times, three (2.8%) six to nine times, three (2.8%) 11-20 times and two (1.9%) more than 20 times. In the group of healthy controls, out of 76 individuals with a history of falls, 24 (77.4%) fell once or twice, and seven (22.6%) three to five times, but none more often than that. In the matched cohorts as well falls were more frequent in neurological patients (42.1%) than in healthy controls (16.9%) (Chi^2=26.3; p<0.001). (Table 1)

The mean age of individuals with a history of falls as compared to those without was higher both in the neurologically affected (fallers: 76.7 ± 7.6 vs. nonfallers: 72.6 ± 7.5; p<0.001) and in healthy controls (fallers: 73.3 ± 6.5 vs. nonfallers: 71.0 ± 6.9; p=0.040). In the group of neurological patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male (Chi^2=8.675; p=0.003).

Similarly, in the group of healthy controls a higher percentage of fallers was female, with 23 out of 31 (74%), but this did not reach significance (Chi^2=1.915; p=0.166).

The occurrence of falls in neurological patients was independent of where they lived. For healthy controls, however, their place of residence had an influence, in that subjects living in more rural environments were more prone to falls (Γ-B=0.217; p<0.001).

Multiple falls occurred particularly in patients with peripheral neuropathy (43%), peripheral nerve lesion (43%), dementia (33%), Parkinson's disease (30%), stroke (30%) and vertebral pain (30%). The average fall frequency index in this group of five diseases ranged from 1.63 (periperal neuropathy) to 1.33 (dementia). The proportion of fallers in each index category is shown for all these diseases in Fig. 1.

Risk factors for falls in neurological patients

The type of neurological disease the patient was afflicted with influenced the proportion of fallers in that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%) had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy control (16.1%). (Fig. 2)

The respective odds ratios are shown in table 2 and range from 40.1 (stroke) to 2.1 (headache) and the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.

No specific combination of two or three neurological diseases characterized by substantial gait or balance impairment but any accumulation of several neurological diseases regardless of their influence on gait or balance was able to cause a significant raise in falls (Γ-B=0.303; p<0.001).

Other risk factors for falls in neurological patients were female gender (Γ-B=0.195; p=0.003), higher age (Γ-B=0.217; p<0.001), higher disability or disease severity as measured by the Barthel Index (Γ-B=-0.232; p<0.001). Higher disability scores in Parkinson patients expressed by higher UPDRS II (activities of daily living) scores (Γ-B=-0.238; p=0.062) and higher Schwab & England scores (Γ-B=-0.235; p=0.070) resulted in a trend toward more frequent falls. Severity of depression as reflected by a higher ADS score (Γ-B=0.329; p<0.001) and low balance confidence reflected by higher ABC scores (Γ-B=-0.384; p<0.001) were also identified as risk factors (Fig. 3).

DISCUSSION

Incidence of falling

Our study suggests that even in patients mildly to moderately affected by neurological impairments the incidence of falls was three times higher than in subjects without any neurological symptoms or signs. To our knowledge this is the first survey conducted on elderly neurological outpatients and controls proven to be without neurological impairments, but the extent of this increased relative risk in neurological patients was unexpected, and resulted from low incidence figures in the group of controls and particularly high figures in the patient group.

In our group of healthy controls the 12-month incidence (16.1 %) was considerably lower than in previous population based data serving as a reference for previous studies [20]. Literature suggests that a third to one half of the community dwelling population of 60+ experience falls each year. For a group of 1762 subjects 60+ years of age, Lord reported a yearly incidence rate of falls of 28% [21]. In individuals of 65 years and older Prudham found in his survey conducted on 2793 individuals that 28% experienced one or more falls in the last year [22]. In O'Loughlin's group of 409 it was 29% [7], in Campbell's group of 533, 33% [23], and in Blake's group of 1042, 35%. [24] Luukinen's group of 833 individuals aged 70+ showed a 30% annual rate of falls [3] and Tinetti's group of 336 aged 75+ showed a rate of 32% [25]. For the very old, Campbell found in a community-based prospective study based on 761 subjects that half of those age 80 years and over have a fall every year [26]. This incidence rate, twice or three times that of our figures, did not surprise us. Population-based data of elderly individuals inevitably include a considerable number of patients suffering from neurological diseases or other forms of gait or balance problems. Many of these neurological disorders like stroke, Alzheimer's disease or Parkinson's disease are typical diseases of the elderly and others like epilepsy or traumatic brain injury also have a second peak in higher age [27]. This shows that it can be of advantage, when studying groups of elderly patients, to have a truly healthy control group, as in our survey.

Our study also shows that half of all ambulatory neurological patients had had at least one fall within the last 12 month. As to our knowledge this is the first survey of neurological outpatients, the lack of comparative data gave us no choice but to relate our findings to Stolze's data on neurological inpatients showing, much to our surprise, a falling incidence as low as 34% [13]. One would have assumed that Stolze's patients, who required inpatient treatment for their neurological conditions, would be more severely disabled and thus more prone to falls than outpatients. It also appears contradictory our findings that indicators of disease severity like the Barthel index and the UPDRS II correlated positively with the incidence of falls. Several studies further support this concept by stat-

ing that the more severely affected patients are, the higher the falling risk [28]. However, we have reasons to believe that the correlation is not linear throughout all grades of disability but rather resembles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher disability only up to a certain point. Then, as patients become more cautious and use all kind of supports, it plateaus and even decreases. When patients become so disabled that they are finally bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since this concept is not yet backed up by sound evidence, further studies directly comparing the risk of falling in neurological inpatients and outpatients of various grades of disability are needed to support this assumption.

Considering recurrent falls we found that in the group of neurological patients 13.2 % fell three or more times per year, compared to 3.6% in the group of healthy controls. This is in keeping with the results of studies investigating recurrent falls, where figures of 8% for three or more falls in randomly selected community dwelling elderly individuals are given [29] and 10% for community based seniors using home care services [30]. In Stolze's cohort of inpatients the value of 21% for recurrent falls was higher and can probably be explained by methodological differences. Stolze's category of recurrent falls already includes patients who had fallen twice, unlike our and other studies [29, 30] that include patients only after more than three falls.

Risk factors contributing to falls

We found out that the type of neurological disease afflicting a patient determines the potential risk factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson patients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with previous community based studies showing a high likelihood for falls in stroke patients with a range of 51-73% [10, 20, 31] and in Parkinson's patients with a range of 38 – 87% [32-38]. This was followed by a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consisting of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neuropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-80% [12, 39] in Alzheimer patients and 55-65% [40-42] in patients with peripheral neuropathy. The only study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents, providing a 5-year fall incidence of 83% [43]. In our sample peripheral neuropathy also proved to be a risk factor for recurrent falls, but most likely significance was not reached due to the small sample size (p=0.061). Confirmative data also obtained from small cohorts revealed that repetitive falls occurred in 10 out of 25 (40%) neuropathy patients [42] and another 13 out of 20 neuropathy patients (65%) had a propensity for recurrent falls for an average of 5.8 falls per year [40]. New and quite

astonishing was the fact that even patients suffering from neurological diseases with no direct influence on gait or balance like headache (28%) had almost twice as many falls as the average healthy control (16.1%). Also new is that in contrast to all the above cited data derived from studies on patients with only one neurological disorder, our survey provides comparative values for several neurological diseases of elderly ambulatory neurological patients for the first time, allowing a direct comparison between these disorders and a ranking according to the risk of falling.

But our findings further suggest that not only the type of neurological conditions, but also the number of neurological diseases a patient was suffering from, no matter whether they had an influence on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that only accumulations of neurological deficits relating to gait and balance would influence the risk for falls. Although there were no published studies on the influence of neurological diseases, it is known that persons with an impaired sense of balance have an disproportionately higher risk for falls when they acquire an additional new disease or condition, even if it is one that seems minor or not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a patient was suffering from was highly predicative of a risk to fall, better even than a mobility score. She concluded that falling appears to result from an accumulated effect of multiple specific disabilities [44]. This would be in keeping with our other findings, that old age in combination with any neurological disease increases the risk of falling above that of healthy controls, even if it is a disease like headache. Also in accordance with this we found that a higher rate of depression, as reflected by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be that depressive thoughts are frequently combined with negative conceptions of one's own sense of balance, which was found to be a prominent risk factor for falls in our and previous other studies [45].

That higher age would be a predictive factor for falls in neurological patients replicates previous findings [13] and is easy to explain: old age is often associated with greater frailty and eventually frailty with less confidence in one's sense of balance and a higher incidence of falls [45]. That females are more prone to falls than males has often been stated before [13] and has previously been explained by a fear of falling and a loss of confidence – both independent risk factors for falls - being more prominent in women [6].

LIMITATIONS

We also faced several limitations in our study. First and most importantly, like most other surveys dealing with falls, we faced the problem that the number of falls is underreported. Elderly subjects often try to downplay problems regarding their mobility for fear of having their autonomy

restricted. While this is in general typically found in the healthy elderly, it might be even more prominent in patients with disabilities. But even remembering these events might pose a problem in some of the patients with central degenerative diseases and this might have been a relevant factor in our study, even though we excluded patients with severe dementia. The risk for falls in neurological patients might therefore be greater than shown in any results. Future prospective studies could minimize this problem by using patients diaries according to established guidelines for reporting falls [46] possibly even in combination with wearable miniaturized electronic devices apt to objectively detect and monitor falls [47].

Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing the 3,6% that had to be excluded prior to recruitment due to inability or unwillingness to participate could have lead to further underestimating the number of patients with falls. However, since these patients did not obviously differ in their baseline characteristics, we assume this problem to be minimal.

Then, we would also like to address the issue of small sample sizes in subgroups of neurological diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies like those on peripheral neuropathy [40, 42]. Others, particularly the dementia group with only seven patients, is, due to the exclusion of the more affected, quite small and allows only limited extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels of significance.

CONCLUSION

It can be said that we managed to show, apparently for the first time, that even among ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is multi-factorial, but the connection between falls and disturbances of the sensorimotor system frequently found in neurological diseases in elderly patients is of great importance. Our findings revealed that even neurological diseases not directly connected with gait and balance carry an astonishingly high risk for falls. Neurologists should therefore be aware that their patients are at high risk for falls, as any neurological deficit increases this risk, even more so if a combination of factors is present. Of course the risk has to be evaluated individually, but patients with central diseases like stroke, Parkinson's disease, dementia and

epilepsy, and for repeated falls also patients with peripheral neurological disorders, require special attention. Greater disability, higher age, female gender, depression and low confidence in the sense of balance are additional contributory factors that have to be taken into account in this process. For patients with several of these factors, targeted prevention programs should be implemented. However, although they have been shown to generally reduce falls and injuries in the community dwelling elderly [48], there is but inconclusive evidence for patients following stroke [49] and with PD [50, 51] and even more scanty information for patients with other neurological diseases. Therefore further larger scale multicenter neuro-geriatric surveys with larger sample sizes for neurological subgroups should be performed not only to confirm our observations but to acquire more extensive knowledge of the effectiveness of preventive measures in patient cohorts with various neurological conditions and different degrees of disability. These studies should also include more objective monitoring systems and include further potential risk factors like medication and fear of falling.

NOTES

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Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz

Patient consent: obtained

Contributorship: B. H.: drafting/revising the manuscript, study concept or design, analysis or interpretation of data; A. P.: analysis or interpretation of data, acquisition of data of patients and controls, study concept or design; M. G.: analysis or interpretation of data, acquisition of data of patients and controls, study concept or design; A.H. acquisition of data of patients and controls; T. G.: acquisition of data, study concept or design, G. I.: critical revision of the manuscript for important intellectual content; E. H.: statistical analysis , analysis or interpretation of data, study

concept or design; G.I.: drafting/revising the manuscript, study concept or design, critical revision of the manuscript for important intellectual content; F. F.: drafting/revising the manuscript, study concept or design, critical revision of the manuscript for important intellectual content; C. N. H.: drafting/revising the manuscript, study concept or design, acquisition of data, study supervision.

Data sharing: An additional section of the questionnaire dealt with specific risk situations when using public transport, fear of falling in these situations, and general mobility issues. These issues are not directly related to the present investigation and are planned, once the analysis is completed, to be included in a seperate puplication.

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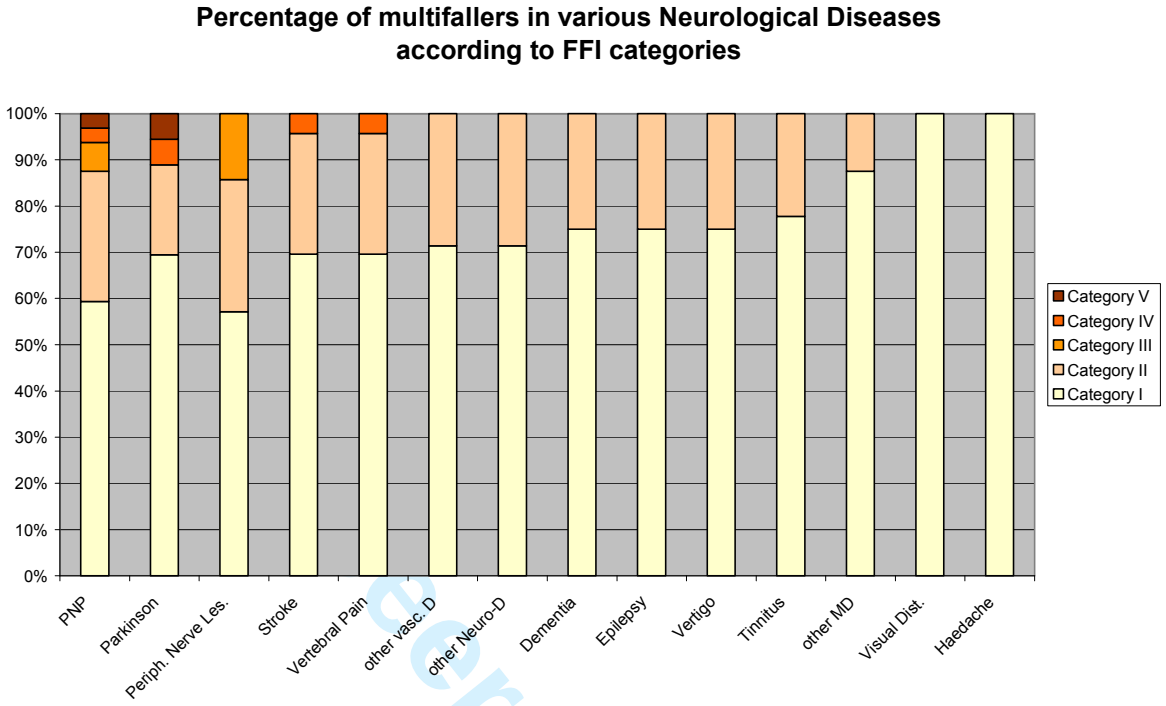
TABLES AND FIGURES

Table 1: Neurological patients and healthy controls: General demographics and fall frequency

	Total			Matched pairs		
	Patients (n=228)	Healthy (n=193)	p-value	Patients (n=171)	Healthy (n=171)	p-value
Total						
Age	74.5±7.8	71.4±6.8	0.000	72.2±7.0	72.0±6.9	0.839
Gender (f in %)	61%	63%	0.572	59%	59%	1.000
Region (Residential Index: mean)	2.53	2.21	0.021	2.66	2.22	0.004
Disability (Bartelindex: mean)	98.20	n.d.		98.24	n.d.	
Balance (ABC-score: mean)	73.19	n.d.		83.39	n.d.	
Depression (ADS-K-score: mean)	7.2	n.d.		6.9	n.d.	
Fallers						
Falls (n (%))	46.5%	16.1%	0.000	42.1%	16.9%	0.000
Multiple Falls (>2 falls) (n (%))	28.3%	22.6%	0.528	26.4%	24.1%	0.815
Fall frequency Index (in fallers)	1.42±0.8	1.23±04	0.078	1.44±0.9	1.24±04	0.14



Categories	PNP (n)	PD (n)	PNL (n)	Stroke (n)	Vert P (n)	other vasc (n)	Other n. D. (n)	Dem (n)	Epi (n)	Vertig (n)	Tinnitus (n)	other MD (n)	Visual Dist (n)	Haedache (n)
V	1	2	0	0	0	0	0	0	0	0	0	0	0	0
IV	1	2	0	1	1	0	0	0	0	0	0	0	0	0
III	2	0	1	0	0	0	0	0	0	0	0	0	0	0
II	9	7	2	6	6	4	4	1	1	3	2	1	0	0
I	19	25	4	16	16	10	10	3	3	9	7	7	4	4
0	27	11	11	3	15	11	20	3	3	18	21	6	6	10
Total	**59**	**47**	**18**	**26**	**48**	**25**	**34**	**7**	**7**	**30**	**30**	**14**	**10**	**14**

Fig.1 Frequency of falls in neurological patients according to their neurological disorder. Fall Frequency Index (FFI) Category I = 1-2 falls in the last twelve months, Cagegory II = 3-5, Category III = 6-10, Category IV = 11-20, and Category V = more than 20.

Abbreviations: PNP = peripheral neuropathy, Periph. nerve les. = peripheral nerve lesion, other MD = other movement disorders, other vasc. d. = other vascular disease, Visual.Dist. = visual disturbances

One year fall incidence in common neurological disorders

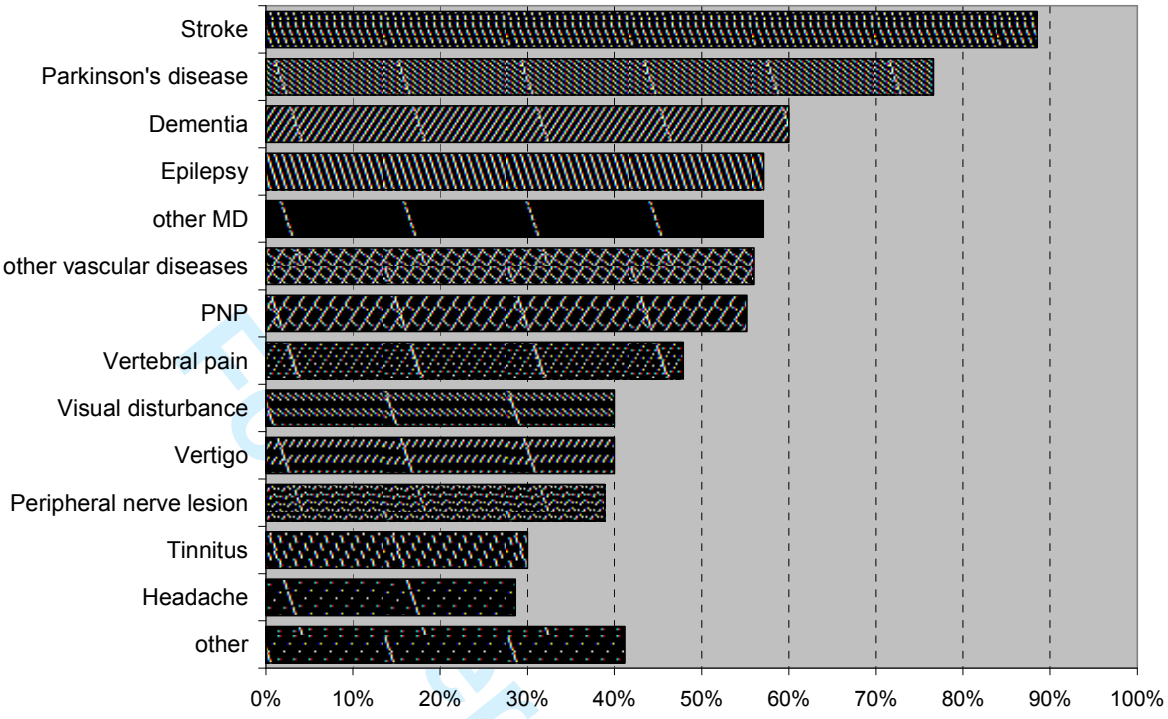


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

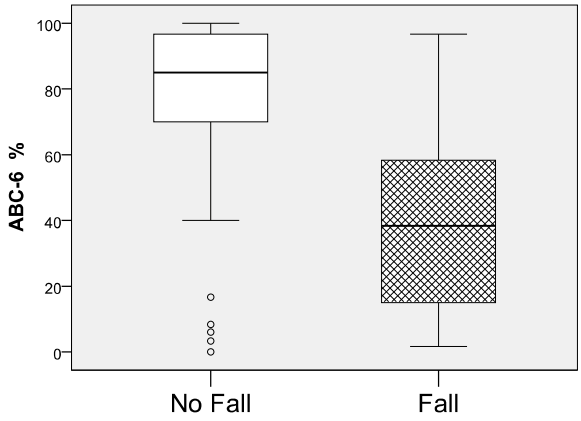
Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall frequency** (in fallers)	Risk of falling		
							OR	CI	p-value
Stroke	82,7±2,3	99,76	26	23 (89%)	7 (30%)	1,39±0,72	40,1	(11,3-141,7)	0.000
Parkinson D	74,8±8,1	99,79	47	36 (77%)	11 (31%)	1,58±1,13	17,1	(7,9-37,2)	0.000
Dementia	77,5±9,2	99,77	7	3 (60%)	1 (33%)	1,33±0,58	7,8	(1,3-48,9)	0.01
Epilepsy	71,0±8,2	99,78	7	4 (57%)	1 (25%)	1,25±0,5	7,0	(1,5-32,7)	0.005
other MD	74,3±7,9	100	14	8 (57%)	1 (13%)	1,23±0,82	7,0	(2,3-21,5)	0.000
other vasc. D	74,8±8,1	99,79	25	14 (56%)	4 (29%)	1,29±0,47	6,7	(2,8-16,0)	0.000
PNP	71,0±8,1	99,78	58	32 (55%)	13 (43%)	1,63±0,98	6,4	(3,4-12,3)	0.000
Vertebral Pain	76,8±9,1	99,75	48	23 (48%)	7 (30%)	1,39±0,72	4,8	(2,4-9,5)	0.000
Visual Disturb.	69,5±0,7	99,77	10	4 (40%)	0 (0%)	1±0	3,5	(0,9-13,1)	0.051
Vertigo	72,0±8,1	99,75	30	12 (40%)	3 (25%)	1,25±0,45	3,5	(1,5-8,0)	0.002
P. Nerve Les.	66,0±8,1	99,79	18	7 (39%)	3 (43%)	1,57±0,79	3,3	(1,2-9,2)	0.016
Tinnitus	74,3±8,4	99,76	30	9 (30%)	2 (22%)	1,22±0,44	2,2	(0,9 - 5,3)	0.064
Headache	74,8±8,1	99,79	14	4 (29%)	0 (0%)	1,0±0.0	2,1	(0,6-7,1)	0,228
Other	79,4±7,1	99,74	34	14 (41%)	4 (29%)	1,29±0,47	3,7	(1,7 - 8,0)	0.001

) Multiple falls were defined as more than two falls per year (i.e. a fall frequency index ≥2)*

**) Fall frequency index:. Category I = 1-2 falls in the last twelve months, Category II = 3-5 falls in the last twelve months, Category III = 6-10 falls in the last twelve months, Category IV = 11-20 falls in the last twelve months, and Category V = more than 20 falls in the last twelve months.

a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

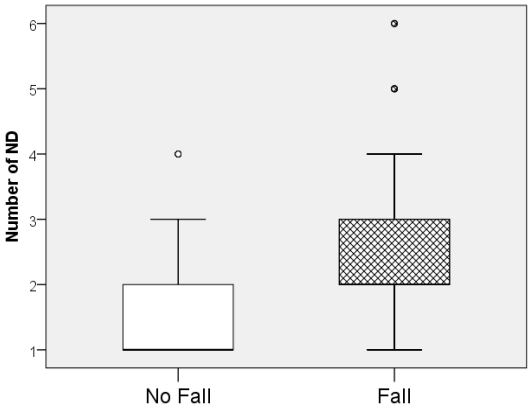


Fig.3a,b Differences in ABC-6 scores (3a) and number of neurological diseases (ND) (3b) of neurological patients with and without falls indicate that fallers as compared to non-fallers have lower confidence in their balance and a higher number of concomitant neurological diseases.

(ABC-6% meaning percentage scores of the 6-item version of the Activities-Specific Balance Confidence scale, number of ND meaning number of neurological diseases a patient is afflicted with)

STROBE checklist - observational studies

	Item No	Recommendation	
Title and abstract			
	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p1, p2 l12
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	P5 l12-20
Methods			
Study design	4	Present key elements of study design early in the paper	P5 l40 – p6 l27
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5 l32-37, p5 l42-47, p6 l17-21, p6 l22-26
Participants	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up*Case-control study*?Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls*Cross sectional study*?Give the eligibility criteria, and the sources and methods of selection of participants	P5 l42- p6 l15
		(*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case	P7 l4148
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6 l37-p7 l16
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P6 l37-p7 l16
Bias	9	Describe any efforts to address potential sources of bias	P13 l18-21, p7 l40-48
Study size	10	Explain how the study size was arrived at	P5 l46-47
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P7 l28-30
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P7 l31-53
		(*b*) Describe any methods used to examine subgroups and interactions	P7 l37-39
		(*c*) Explain how missing data were addressed	P7 l48-49
		(*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed*Case-control study*?If applicable, explain how matching of cases and controls was addressed*Cross sectional study*?If applicable, describe analytical methods taking account of sampling strategy	P13 l15-22
		(*e*) Describe any sensitivity analyses	P7 l35
Results			
Participants	13*	(*a*) Report numbers of individuals at each stage of study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P8 l4-29
		(*b*) Give reasons for non-participation at each stage	√p8 l4-29
		(*c*) Consider use of a flow diagram	-
Descriptive data	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P18
		(*b*) Indicate number of participants with missing data for each variable of interest	P8 l36-p9 l55
		(*c*) *Cohort study*?Summarise follow-up time (eg average and total amount)	P8 l38
Outcome data	15*	*Cohort study*?Report numbers of outcome events or summary measures over time	*n.a.*
		*Case-control study?*Report numbers in each exposure category, or summary measures of exposure	P8 l35 – p9 l55
		*Cross sectional study?*Report numbers of outcome events or summary measures	*n.a.*
Main results	16	(*a*) Report the numbers of individuals at each stage of the study?eg numbers	P8 l3-29

	Item No	Recommendation	
		potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(*b*) Give reasons for non-participation at each stage	P8 l3-29
		(*c*) Consider use of a flow diagram	-
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses	P9 l23-55
Discussion			
Key results	18	Summarise key results with reference to study objectives	P3 l25-37
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P12 l52 – p13 l36
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P13 l43- p14 l24
Generalisability	21	Discuss the generalisability (external validity) of the study results	P3 l50-53
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P14 l35-41

The impact of ~~various~~ neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

Homann, Barbara[1;] Plaschg, Annemarie[1;] Grundner, Marion[1;] Griedl, Theresa[1;] Ivanic, Gerd[2;] Hofer, Edith[1;] Fazekas, Franz[1;] Homann, Carl Nikolaus[1]

[1)] Medical University Graz, Dept of Neurology, [2)] Paracelsus Medical University Salzburg, Dep. of Orthopaedic Surgery

ABSTRACT

Objectives: Owing to a lack of data, our aim was to evaluate and compare the impact of various common neurological diseases on the risk for falls in independent community dwelling senior citizens.

Design: Prospective case controlled study

Setting: General Hospital

Participants: Out of 298 consecutive patients and 214 controls enrolled, 228 patients (aged 74.5±7.8; 61% women) and 193 controls (aged 71.4±6.8; 63% women) were included. Exclusion criteria for patients were severe disability, disabling general condition, or severe cognitive impairment, for controls any history of neurological disorders or disabling medical conditions, and for both age below 60 years. A matching process led to 171 age- and gender-matched pairs of neurological patients and healthy controls.

Main outcome measures: One-year incidence of falls based on patients' 12 month recall; ~~,~~ motor and non- motor function tests to detect additional risk factors.

Results: 46% of patients and 16% of controls fell at least once a year. Patients with stroke (89%), Parkinson's disease (77%), dementia (60%) or epilepsy (57%) had a particularly high **proportion of fallers**~~fall frequencies~~, but even **subgroups of** patients with the least fall-associated neurological diseases like tinnitus (30%) and headache (28%) had a higher **proportion of fallers** ~~incidence of falls~~ than the control group~~s~~. Neuropathies, peripheral nerve lesions and Parkinson's disease were predisposing to recurrent falls. A higher number of neurological comorbidities ($p<0.001$), lower Barthel Index values ($p<0.001$), lower Activities-Specific Balance Confidence scores (, $p<0.001$), and higher Center of Epidemiological Studies Depression scores ($p<0.001$) as well as higher age ($p<0.001$) and female gender ($p=0.003$) proved to further increase the risk of falls.

Conclusions: Physicians should be aware that all elderly neurological patients seen in outpatient settings are potentially at high risk for falls; they should query them routinely about previous falls and fall risks and advise them on preventive strategies.

Article summary

Article focus

- Previous studies have shown that falls in the elderly are common and **substantial amount** of ~~limited~~ data on single neurological conditions like **stroke and Parkinson's disease**~~in~~

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~~pairments~~ suggest that neurological impairments ~~these conditions~~ further increase the risk for falls.

- However, little is known on the influence of a broad range of neurological diseases and how they differ among each other. ~~No data is available on independent community dwelling senior citizens.~~
- The aim of this study is to provide comparative data on the risk of falling in ambulatory elderly subjects afflicted with various common neurological diseases and to evaluate the role of additional risk factors.

Key messages

- The results of our study suggest that all elderly neurological patients even when still ambulatory carry a heightened risk for falls.
- The impact differs according to disease but those with impairments of the sensorimotor system are particularly endangered. However our findings investigating **yet unstudied populations**, eg, such as headache revealed that even neurological disorders not directly connected with gait and balance carry an ~~astonishingly~~ unexpected high risk for falls and that there is a **cumulative effect of more than one neurological** condition on the risk of falls.

Strengths and limitations of this study

- Strengths of this study include the prospective study design, the number of standardised outcome measures, the standardised assessment of neurological patients and the thorough examination and inclusion of healthy controls.
- The following limitations should be considered: although the **design is prospective, the falls history is retrospective**, based on patients'recall over 12 months, therefore~~the information on falls was self reported and~~ underreporting of cases is possible. Small sample sizes in some of the subgroups of neurological diseases. Participants were mostly of Caucasian origin and there was a high drop-out rate, which may limit the generalisability of the results to other populations.

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INTRODUCTION

Due to budget cuts and austerity measures the costs of accidents and falls have come into the spotlight of health policy makers. The World Health Organisation too has recently made fall prevention in the elderly one of its top priorities. The WHO Global Report on Falls Prevention in Older Age states that due to the high percentage of elderly people worldwide the economic and societal burden of falls will increase by epidemic proportions in all parts of the world over the next few decades, unless concerted action is taken in a systematic and proactive fashion by policy makers, researchers and practitioners [1].

It is known that falls in the elderly are common and have a great impact on life and wellbeing. Studies have shown that around 30% of subjects of 65 years plus had a fall during the last 12 months [2 3] with 10% sustaining severe injuries [3]. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls [4]. Elderly persons surviving a fall experience significant morbidity: as many as one-third require assistance in their activities of daily living for as long as 6 months [5]. Lasting disabilities are also common as many do not reach pre-fall physical functional states, resulting in increased dependency and (in up to 50%) a transfer to a care facility [4]. Associated as they are with considerable mortality as well as psychological and physical morbidity, these falls lead to increased dependence upon social support and health care services, with high economic impact on the social and health care system [6]. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs [7].

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly [7]. Neurological impairments in the elderly are also thought to increase the risk for falls, though evidence for this is mostly derived indirectly from investigations into the causes of falls in the elderly [8]. These studies show that patients admitted to hospitals due to falls frequently also suffer from neurological disorders. Data derived from a multidisciplinary fall consultation survey suggest that in two out of three patients, potentially fall inducing neurological disorders were present, most of them (85%) previously undiagnosed [9].

There is, however, substantially less known about the risk for falls in patients afflicted with various common neurological diseases. While there is already a substantial amount known about increased risk of falls in the ~~Several studies were conducted on the risk of falls in patients with a single neurological disease like~~ stroke [10], Parkinson's disease [11] or dementia [12] population, ~~but~~ to our knowledge there is only one comparative study investigati~~nged~~ falls in patients with of a broad range of~~different~~ neurological diseases. This study by Stolze, however, was conducted on patients

with neurological diseases severe enough to require hospital admission [13]. To date little is known about the risk of falling in independent, community dwelling senior citizens afflicted with neurological diseases treatable in outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they did, the absence of neurological signs and symptoms in this cohort was not guaranteed.

Because falls in community dwelling elderly patients are assumed to be both prevalent and preventable, neurologists in outpatient settings need a sound base to identify patients with the highest risk, to reduce not only the number of falls and the suffering they entail, but also overall health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with various neurological diseases that are commonly encountered in outpatient facilities. We hypothesized that even in community dwelling elderly patients, the impact one or more neurological diseases on top of an already increased propensity for falls is substantial; that patients with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction with more than one of these high risk diseases increases the risk even further.

PARTICIPANTS AND METHODS

~~Epidemiological and environmental bases~~Setting

Data were collected at the general outpatient department of the Department of Neurology of the University Hospital in Graz, Austria. ~~The Department of Neurology provides health care for about 500,000 people in Styria and southern Burgenland, though mostly to inhabitants of Graz and the surrounding area. The department focuses its basic and clinical research on cerebro vascular disorders, dementia, epilepsy, movement disorders and multiple sclerosis. At this teaching hospital, out of a total of 1565 beds, there are 92 neurological beds, including 8 in intensive care and 6 in the stroke unit. Out of approximately 22,600 neurological outpatient contacts recorded each year 4,600 are from the general outpatient department, the rest in equal proportions from specialized outpatient clinics and the neurological emergency room. Two out of five neurologists are in rotation on duty at the Neurology Outpatient Clinic and they are attending to the patients on a random basis.~~ As visits to the outpatient department do not require specialist referrals, the disease spectrum largely resembles that seen by community based neurologists.

Selection of participants and baseline examination

Physically independent community dwelling patients treated in our general neurological outpatient clinic aged 60 years and over were included in the study. Patients were all seen consecutively by one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains the study size. Severely disabled patients who were no longer able to walk unaided~~,~~ or were in poor general condition, be it for reasons of neurological or other medical disease, were excluded from the study. ~~or~~ C~~c~~ognitive~~ly~~ impair~~e~~ment~~d~~ to an extent that an interview would no longer yield reliable results (MMSE≤12), was also a cause for exclusion. ~~were excluded from the study.~~ All neurological patients included underwent a full neurological workup with an extensive history to detect signs of past and present neurological disorders. For the sake of uniformity, both the workup and history were structured and followed the study protocol.

As healthy controls, individuals from the general public out of the same catchment area as cases were enrolled. They were recruited among friends and acquaintances of the author and his co-workers who were aged 60+ and without any history of neurological disorders or other disabling medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis severe enough to cause limitation of ordinary physical activity. Examination and history were as per study protocol, whereby special emphasis was placed on identifying symptoms and signs of Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor deficits and gait or balance impairments. Controls with even subtle neurological pathologies were excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

A telephone follow-up was scheduled 12 months after the baseline outpatient visit; it was carried out by one of two examiners (AP, MG) following a predefined format and only subjects who had given ~~oral~~verbal informed consent ~~beforehand~~ at the ~~time~~start of the telephone contact were interviewed.

The first section of the interview questionnaire covered demographic data like age and place of residence. The residence category had 5 subsections on size and traffic infrastructure, with group 1 being the state capital and group 5 a small town in the periphery. Next were specific questions on fall frequency, physical disability, depression and confidence in one's own sense of balance. The final section dealt with risk situations (like when using public transport) and general mobility issues, whereby the latter are not included in this publication.

The survey, including all details concerning the selection process, was approved by the Ethics Committee of the Medical University Graz.

Frequency of falls

In the main section of the questionnaire patients and healthy controls were asked whether they had

had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall incidence was graded according to the fall frequency index into 5 categories. Category one means 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

~~Analysis of~~ Disability

The Barthel Index [14], a disability scale with scores from 0 (completely dependent) to 100 (completely independent) was used to evaluate the functional status of all neurological patients. Parkinson patients were also rated according to the ~~modified Hoehn and Yahr Scale,~~ the Schwab and England Scale and Part II of the Unified Parkinson's Disease Rating Scale (UPDRS) [15].

~~Analysis of~~ Depression

To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) [16], the German short form of the Center of Epidemiological Studies Depression Scale (CES-D) [17] was used. It is known to be particularly well suited for the use in the elderly and in patients with certain neurological disabilities [18].

~~Analysis of the Confidence in one's own Sense of~~ Balance Confidence

We also rated the patients' confidence in their own sense of balance with the Activities-Specific Balance Confidence Scale (ABC -6 scale) [19]. Participants judged their confidence in performing specific activities without loss of balance or being unsteady~~not to fall during specific activities~~ on a scale ranging from 0% (no confidence at all) to 100% (completely confident). The total score was then computed as an average of the subscores.

Statistical analysis

The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were defined according to the WHO definition [1] as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g. falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly individuals and the whole sample of neurological patients. Further calculations were done for subsamples of 13 neurological disorders with the highest prevalence (n≥7). The diagnoses were based on the ICD-10 system for classification of diseases. The means and standard deviations were calculated for numerical values like the rating scale scores. For the identification of fall related risk factors, correlations (Kendall's τ-B), and for the individual neurological disorders, ~~risk~~ odds ratios were computed (α-level of significance $p < 0.05$). Differences between neurological patients and healthy controls were tested with the Mann-Whitney U test or the chi-square test (α-levels of

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significance p <0.05). To insure comparability of cohorts we formed age- and gender-matched pairs of patients and control subjects ~~(allowing an age deviation of ± 3 years) according to a predefined algorithm~~. For the matching process we used alphabetical lists of names of male and female neurological patients and likewise of healthy controls, sorted by age. Then working down the list we searched manually to find for each neurological patient one control subject of the same age. If no match was found then we looked for a control that was one year younger, then one year older, then two years and finally three years younger respectively older. Only complete sets of data were included in the calculations and no approximates to replace missing values were computed. Calculations were performed with SPSS ® statistical software PASW statistics 18. Potential bias and how it was addressed will be dealt with in the section on limitations.

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RESULTS

During a period of 10 months we recruited 298 mobile neurological outpatients and 214 healthy controls aged 60 years and over. In the group of healthy controls 21 patients initially recruited could not be included in the study due to neurological symptoms and signs, or a history of a neurological disorder. In the group of neurological patients another 70 patients had to be excluded from the study because at the time of the interview they (n=10~~15%~~) or their caregiver (n=6~~9%~~) requested exclusion, the telephone number on record had been disconnected (n=24~~34%~~), all attempts to contact them failed (n=11~~16%~~), they had become so disabled that they could no longer participate in the survey (n=10~~15%~~), they had died (n=4~~5%~~), or for other reasons (n=5~~8%~~).

Prior to recruitment, twenty patients were excluded because of inability to walk unaided and one due to severe dementia. Of those that met inclusion criteria five rejected enrolment and six other patients could not be enrolled due to inadequate language skills (n=1), severe aphasia (n=1), or severe presbyacusis (n=4).

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The statistical analysis thus covered 228 neurological outpatients (aged 74.5 ± 7.8; 61% women) and 193 healthy controls. The matching process led to 171 pairs of neurological patients and healthy controls, 101 women and 70 men in each group, aged 72.0 and 72.2 years, respectively. The details of these subjects are summarized in Table 1.

Incidence of falls in neurological patients and healthy controls

One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen

at least once (Chi^2=43.4; p <0.001) during this one-year period. Out of 126 neurological patients experiencing falls, 76 (71,7%) fell once or twice, 22 (20,8%) three to five times, three (2,8%) six to nine times, three (2,8%) 11-20 times and two (1,9%) more than 20 times. In the group of healthy controls, out of 76 individuals with a history of falls, 24 (77,4%) fell once or twice, and seven (22,6%) three to five times, but none more often than that. In the matched cohorts as well falls were more frequent in neurological patients (42,1%) than in healthy controls (16,9%) (Chi^2=26,3; p<0.001). (Table 1)

The mean age of individuals with a history of falls as compared to those without was higher both in the neurologically affected (fallers: 76,7 ± 7,6 vs. nonfallers: 72,6 ± 7,5; p<0.001) and in healthy controls (fallers: 73,3 ± 6,5 vs. nonfallers: 71,0 ± 6,9; p=0.040). In the group of neurological patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male (Chi^2=8,675; p=0.003). Similarly, in the group of healthy controls a higher percentage of fallers was female, with 23 out of 31 (74%), but this did not reach significance (Chi^2=1,915; p=0,166).

The occurrence of falls in neurological patients was independent of where they lived. For healthy controls, however, their place of residence had an influence, in that subjects living in more rural environments were more prone to falls (Γ-B=0.217; p<0.001).

~~Repeated~~ Multiple falls occurred particularly in patients with peripheral neuropathy (43%), peripheral nerve lesion (43%), dementia (33%), Parkinson's disease (30%), stroke (30%) and vertebral pain (30%). The average fall frequency index in this group of five diseases ~~patients with frequent falls~~ ranged from 1,63 (periperal neuropathy) to 1,33 (dementia). The proportion of fallers in each index category is shown for all these diseases in ~~(~~Fig. 1.~~)~~.

Risk factors for falls in neurological patients

The type of neurological disease the patient was afflicted with influenced the proportion of fallers ~~frequency of falls~~ in that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%) had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy control (16,1%). (Fig. 2)

The respective odds ratios are shown in table 2 and range from 40,1 (stroke) to 2,1 (headache) and

the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.

No specific combination of two or three neurological diseases characterized by substantial gait or balance impairment but any accumulation of several neurological diseases regardless of their influence on gait or balance was able to cause a significant raise in falls (Γ-B=0.303; p<0.001).

Other risk factors for falls in neurological patients were female gender (Γ-B=0.195; p=0.003), higher age (Γ-B=0.217; p<0.001), higher disability or disease severity as measured by the Barthel Index (Γ-B=-0.232; p<0.001). Higher disability scores in Parkinson patients expressed by higher UPDRS II (activities of daily living) scores (Γ-B=-0.238; p=0.062) and higher Schwab & England scores (Γ-B=-0.235; p=0.070) resulted in a trend toward more frequent falls ~~(Γ-B= 0.238; p=0.062)~~. Severity of depression as reflected by a higher ADS score (Γ-B=0.329; p<0.001) and low balance confidence reflected by higher ABC scores (Γ-B=-0.384; p<0.001) were also identified as risk factors~~predictive~~ (Fig. 3).

DISCUSSION

Incidence of falling

Our study suggests that even in patients mildly to moderately affected by neurological impairments the incidence of falls was three times higher than in subjects without any neurological symptoms or signs. To our knowledge this is the first survey conducted on elderly neurological outpatients and controls proven to be without neurological impairments, but the extent of this increased relative risk in neurological patients was unexpected, and resulted from low incidence figures in the group of controls and particularly high figures in the patient group.

In our group of healthy controls the 12-month incidence (16.1 %) was considerably lower than in previous population based data serving as a reference for previous studies [20]. Literature suggests that a third to one half of the community dwelling population of 60+ experience falls each year. For a group of 1762 subjects 60+ years of age, Lord reported a yearly incidence rate of falls of 28% [21]. In individuals of 65 years and older Prudham found in his survey conducted on 2793 individuals that 28% experienced one or more falls in the last year [22]. In O'Loughlin's group of 409 it was 29% [7], in Campbell's group of 533, 33% [23], and in Blake's group of 1042, 35%. [24] Luukinen's group of 833 individuals aged 70+ showed a 30% annual rate of falls [3] and Tinetti's group of 336 aged 75+ showed a rate of 32% [25]. For the very old, Campbell found in a community-based prospective study based on 761 subjects that half of those age 80 years and over have a fall every year [26]. This inci-

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dence rate, twice or three times that of our figures, did not surprise us. Population-based data of elderly individuals inevitably include a considerable number of patients suffering from neurological diseases or other forms of gait or balance problems. Many of these neurological disorders like stroke, Alzheimer's disease or Parkinson's disease are typical diseases of the elderly and others like epilepsy or traumatic brain injury also have a second peak in higher age [27]. This shows ~~how important it is~~that it can be of advantage, when studying groups of elderly patients, to have a truly healthy control group, as in our survey.

Our study also shows that half of all ambulatory neurological patients had had at least one fall within the last 12 month. As to our knowledge this is the first survey of neurological outpatients, the lack of comparative data gave us no choice but to relate our findings to Stolze's data on neurological inpatients showing, much to our surprise, a falling incidence as low as 34% [13]. One would have assumed that Stolze's patients, who required inpatient treatment for their neurological conditions, would be more severely disabled and thus more prone to falls than outpatients. It also appears contradictory our findings that indicators of disease severity like the Barthel index and the UPDRS II correlated positively with the incidence of falls. Several studies further support this concept by stating that the more severely affected patients are, the higher the falling risk [28]. However, we have reasons to believe that the correlation is not linear throughout all grades of disability but rather resembles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher disability only up to a certain point. Then, as patients become more cautious and use all kind of supports, it plateaus and even decreases. When patients become so disabled that they are finally bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since this concept is not yet backed up by sound evidence, further studies directly comparing the risk of falling in neurological inpatients and outpatients of various grades of disability are needed to support this assumption.

Considering recurrent falls we found that in the group of neurological patients 13,2 % fell three or more times per year, compared to 3,6% in the group of healthy controls. This is in keeping with the results of studies investigating recurrent falls, where figures of 8% for three or more falls in randomly selected community dwelling elderly individuals are given [29] and 10% for community based seniors using home care services [30]. In Stolze's cohort of inpatients the value of 21% for recurrent falls was higher and can probably be explained by methodological differences. Stolze's category of recurrent falls already includes patients who had fallen twice, unlike our and other studies [29, 30] that include patients only after more than three falls.

Risk factors contributing to falls

We found out that the type of neurological disease afflicting a patient determines the potential risk factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson patients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with previous community based studies showing a high likelihood for falls in stroke patients with a range of 51-73% [10, 20, 31] and in Parkinson's patients with a range of 38 – 87% [32-38]. This was followed by a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consisting of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neuropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-80% [12, 39] in Alzheimer patients and 55-65% [40-42] in patients with peripheral neuropathy. The only study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents, providing a 5-year fall incidence of 83% [43]. In our sample peripheral neuropathy also proved to be a risk factor for recurrent falls, but most likely significance was not reached due to the small sample size (p=0.061). Confirmative data also obtained from small cohorts revealed that repetitive falls occurred in 10 out of 25 (40%) neuropathy patients [42] and another 13 out of 20 neuropathy patients (65%) had a propensity for recurrent falls for an average of 5-8 falls per year [40]. New and quite astonishing was the fact that even patients suffering from neurological diseases with no direct influence on gait or balance like headache (28%) had almost twice as many falls as the average healthy control (16-1%). Also new is that in contrast to all the above cited data derived from studies on patients with only one neurological disorder, our survey provides comparative values for several neurological diseases of elderly ambulatory neurological patients for the first time, allowing a direct comparison between these disorders and a ranking according to the risk of falling.

But our findings further suggest that not only the type of neurological conditions, but also the number of neurological diseases a patient was suffering from, no matter whether they had an influence on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that only accumulations of neurological deficits relating to gait and balance would influence the risk for falls. Although there were no published studies on the influence of neurological diseases, it is known that persons with an impaired sense of balance have an disproportionately higher risk for falls when they acquire an additional new disease or condition, even if it is one that seems minor or not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a patient was suffering from was highly predicative of a risk to fall, better even than a mobility score. She concluded that falling appears to result from an accumulated effect of multiple specific disabilities [44]. This would be in keeping with our other findings, that old age in combination with any neurological disease increases the risk of falling above that of healthy controls, even if it is a disease like headache. Also in accordance with this we found that a higher rate of depression, as reflected by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be

that depressive thoughts are frequently combined with negative conceptions of one's own sense of balance, which was found to be a prominent risk factor for falls in our and previous other studies [45]. That higher age would be a predictive factor for falls in neurological patients replicates previous findings [13] and is easy to explain: old age is often associated with greater frailty and eventually frailty with less confidence in one's sense of balance and a higher incidence of falls [45]. That females are more prone to falls than males has often been stated before [13] and has previously been explained by a fear of falling and a loss of confidence – both independent risk factors for falls - being more prominent in women [6].

LIMITATIONS

We also faced several limitations in our study. First and most importantly, like most other surveys dealing with falls, we faced the problem that the number of falls is underreported. Elderly subjects often try to downplay problems regarding their mobility for fear of having their autonomy restricted. While this is in general typically found in the healthy elderly, it might be even more prominent in patients with disabilities. But even remembering these events might pose a problem in some of the patients with central degenerative diseases and this might have been a relevant factor in our study, even though we excluded patients with severe dementia. The risk for falls in neurological patients might therefore be greater than shown in any results. Future prospective studies could minimize this problem by using patients diaries according to **established guidelines for reporting falls** [46] possibly even in combination with wearable miniaturized electronic devices apt to objectively detect and monitor falls [47].

Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing the 3,6% that had to be excluded prior to recruitment due to inability or unwillingness to participate ~~almost one quarter of neurological patients were lost for follow up, which~~ could have lead to further underestimating the number of patients with falls. However, since these patients did not obviously differ in their baseline characteristics, we assume this problem to be minimal.

~~Thirdly, elderly subjects without even the slightest neurological symptoms are hard to find and therefore the use of a cohort of this rare group of supranormal individuals as a reference group might not be representative. The patient cohort we examined was a group of neurological patients who were mobile and affected by only mild to moderate neurological symptoms. This group of elderly patients, of the kind typically seen in neurological practice, also accounts for only a part of neurological patients and generally performs much better than the large segment of more severely affected patients placed in institutions. But to highlight the impact of even mild impairment on falls,~~

~~we nevertheless felt that it was of importance to use controls with no impairment, regardless of how many percent of the population they might represent.~~

Then, we would also like to address the issue of small sample sizes in subgroups of neurological diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies like those on peripheral neuropathy [40, 42]. Others, particularly the dementia group with only seven patients, is, due to the exclusion of the more affected, quite small and allows only limited extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels of significance.

~~Finally, this study was performed on participants of a mid-sized central European city and surrounding countryside with patients to a large percentage of Caucasian origin which raises the question as to what extent our study results can be generalized to other geographical locations. However, almost all other studies on falls were also performed in similar settings. Given the fact that incidence figures were all in the range of previous studies conducted in other western developed countries we believe that our findings should in general well reflect falling risks in similar settings of these regions. However, due to lack of data, we cannot make any suggestions as to whether comparable results could be expected in emerging South American, Asian or African countries. There technical and cultural barriers as well as support systems probably have constituted different mobility environments for elderly people. To investigate the impact of neurological impairment on risk for falls in the elderly in these regions would be an important topic for future projects.~~

CONCLUSION

It can be said that we managed to show, apparently for the first time, that even among ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is multi-factorial, but the connection between falls and disturbances of the sensorimotor system frequently found in neurological diseases in elderly patients is of great importance. Our findings revealed that even neurological diseases not directly connected with gait and balance carry an astonishingly high risk for falls. General practitioners, geriatricians, neurologists and carers~~Neurologists~~ should therefore be aware that ~~their~~ neurological patients are at high risk for falls, as any neurological deficit increases this risk, even more so if a combination of factors is present. Of course the risk has to be evaluated individually, but patients with central diseases like stroke, Parkinson's disease, dementia and epilepsy, and for

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repeated falls also patients with peripheral neurological disorders, require special attention. Greater disability, higher age, female gender, depression and low confidence in the sense of balance are additional contributory factors that have to be taken into account in this process. For patients with several of these factors, targeted prevention programs should be implemented. ~~, because~~ However, although they have been shown to generally reduce falls and injuries in the community dwelling elderly [48], there is but inconclusive evidence for patients following stroke [49] and with PD [50, 51] and even more scanty information for patients with other neurological diseases. ~~Due to the prevalence of falls and the personal and social impact they have on the lives of many, it seems important that~~ Therefore further larger scale multicenter neuro-geriatric surveys **with larger sample sizes for neurological subgroups** should be performed not only to **confirm our observations ~~and~~but to** acquire more extensive knowledge of the effectiveness of preventive measures in patient cohorts with various neurological conditions and different degrees of disability. These studies should also include more objective monitoring systems and include further potential risk factors like medication and fear of falling.

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NOTES

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Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz

Patient consent: obtained

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TABLES AND FIGURES

Table 1: Neurological patients and healthy controls: General demographics and fall frequency

	Total			Matched pairs		
-	Patients (n=228)	Healthy (n=193)	p-value	Patients (n=171)	Healthy (n=171)	p-value
Total						
Age	74.5±7.8	71.4±6.8	0.000	72.2±7.0	72.0±6.9	0.839
Gender (f in %)	61%	63%	0.572	59%	59%	1.000
Fallers						
Falls (n (%))	46.5%	16.1%	0.000	42.1%	16.9%	0.000
Multiple Falls (>2 falls) (n (%))	28.3%	22.6%	0.528	26.4%	24.1%	0.815
Fall frequency Index (in fallers)	1.42±0.8	1.23±04	0.078	1.44±0.9	1.24±04	0.14

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-	Patients (n=228)	Healthy (n=193)	p-value	Patients (n=171)	Healthy (n=171)	p-value
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Gender (f in %)	61%	63%	0.572	59%	59%	1.000
Region (Residential Index: mean)	2.53	2.21	0.021	2.66	2.22	0.004
Disability (Bartelindex: mean)	98.20	n.d.		98.24	n.d.	
Balance (ABC-score: mean)	73.19	n.d.		83.39	n.d.	
Depression (ADS-K-score: mean)	7.2	n.d.		6.9	n.d.	

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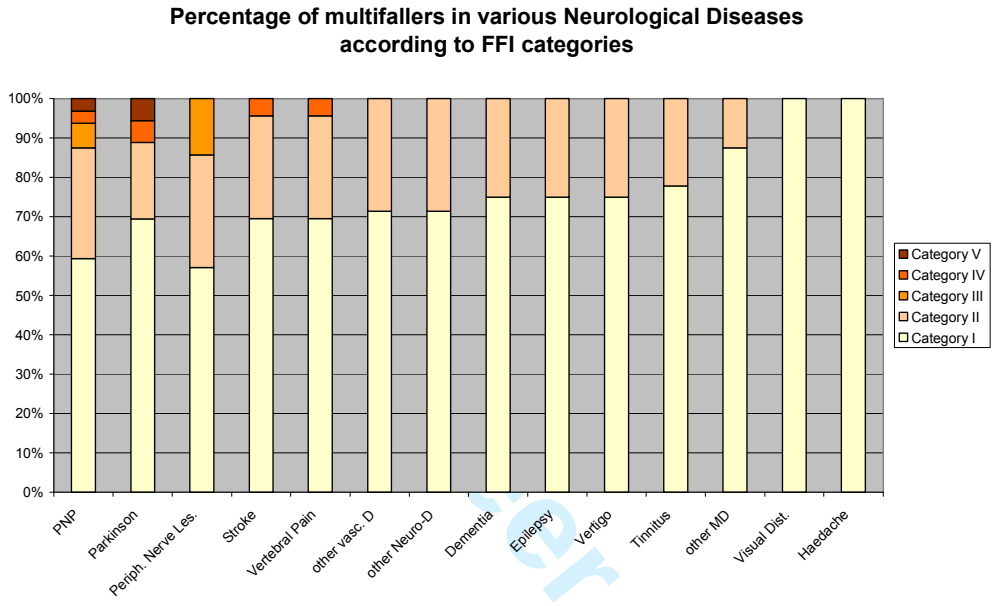

Cate-gories	PNP (n)	PD (n)	PNL (n)	Stroke (n)	Vert P (n)	other vasc (n)	Other n. D. (n)	Dem (n)	Epi (n)	Vertig (n)	Tinni-tus (n)	other MD (n)	Visual Dist (n)	Haed-ache (n)
V	1	2	0	0	0	0	0	0	0	0	0	0	0	0
IV	1	2	0	1	1	0	0	0	0	0	0	0	0	0
III	2	0	1	0	0	0	0	0	0	0	0	0	0	0
II	9	7	2	6	6	4	4	1	1	3	2	1	0	0
I	19	25	4	16	16	10	10	3	3	9	7	7	4	4
0	27	11	11	3	15	11	20	3	3	18	21	6	6	10
Total	**59**	**47**	**18**	**26**	**48**	**25**	**34**	**7**	**7**	**30**	**30**	**14**	**10**	**14**

~~**Fall Frequency Index in neurological patients**~~

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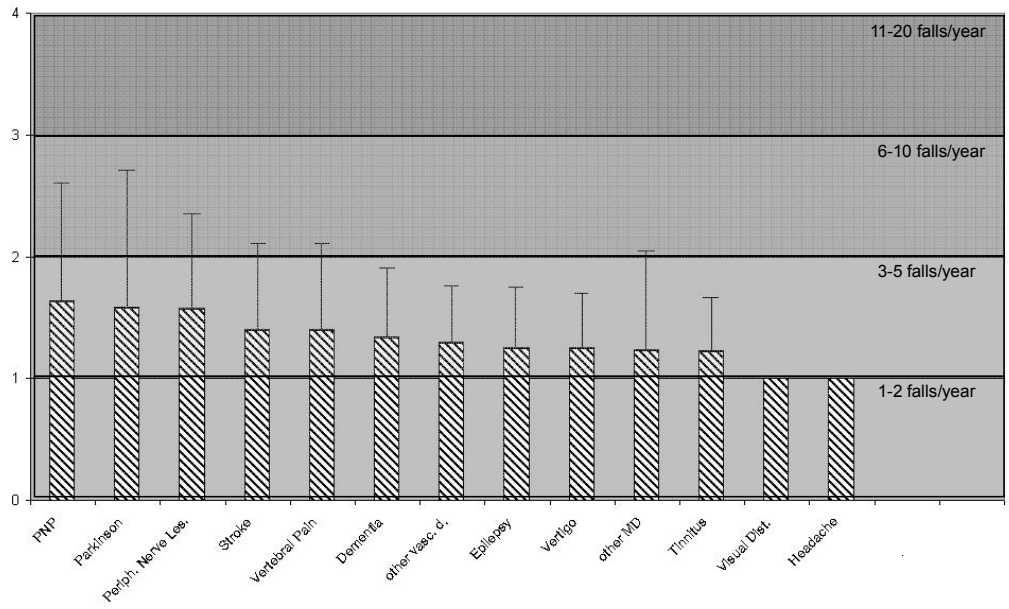

Fig.1 Frequency of falls in neurological patients according to their neurological disorder. Fall Frequency Index (FFI) Category I ~~1~~= 1-2 falls in the last twelve months, ~~2~~ Cagegory II = 3-5, ~~3~~ Category III = 6-10, ~~4~~ Category IV = 11-20, and ~~5~~ Category V = more than 20.

Abbreviations: PNP = peripheral neuropathy, Periph. nerve les. = peripheral nerve lesion**,** other MD = other movement disorders, other vasc. d. = other vascular disease, Visual.Dist. = visual disturbances

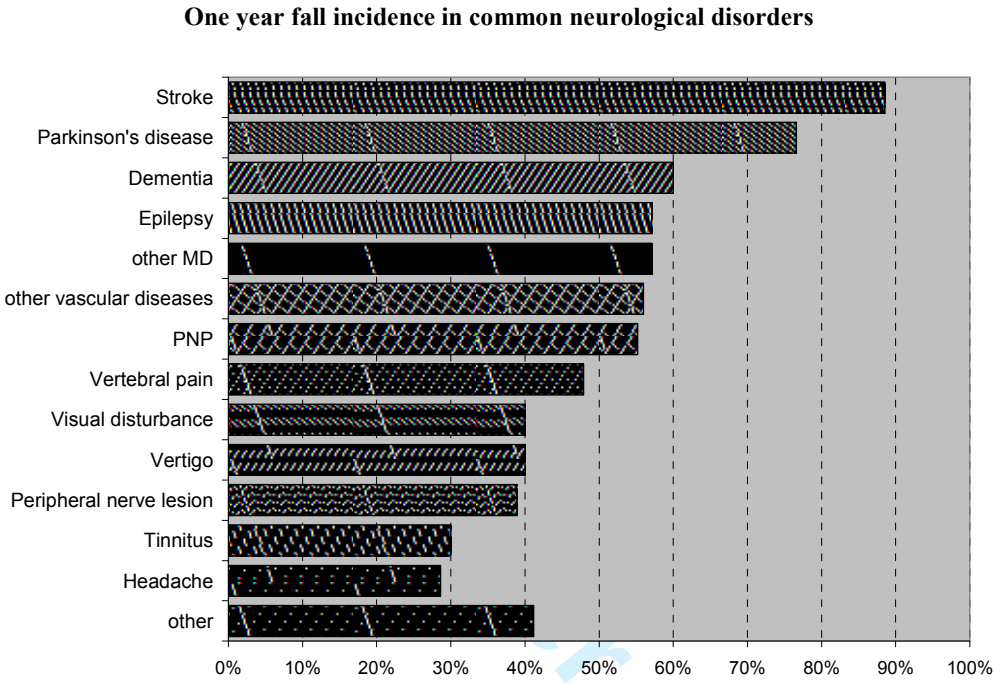

Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall frequency** (in fallers)	Risk of falling		
							OR	CI	p-value
Stroke	82,7±2,3	99,76	26	23 (89%)	7 (30%)	1,39±0,72	40,1	(11,3-141,7)	0.000
Parkinson D	74,8±8,1	99,79	47	36 (77%)	11 (31%)	1,58±1,13	17,1	(7,9-37,2)	0.000
Dementia	77,5±9,2	99,77	7	3 (60%)	1 (33%)	1,33±0,58	7,8	(1,3-48,9)	0.01
Epilepsy	71,0±8,2	99,78	7	4 (57%)	1 (25%)	1,25±0,5	7,0	(1,5-32,7)	0.005
other MD	74,3±7,9	100	14	8 (57%)	1 (13%)	1,23±0,82	7,0	(2,3-21,5)	0.000
other vasc. D	74,8±8,1	99,79	25	14 (56%)	4 (29%)	1,29±0,47	6,7	(2,8-16,0)	0.000
PNP	71,0±8,1	99,78	58	32 (55%)	13 (43%)	1,63±0,98	6,4	(3,4-12,3)	0.000
Vertebral Pain	76,8±9,1	99,75	48	23 (48%)	7 (30%)	1,39±0,72	4,8	(2,4-9,5)	0.000
Visual Disturb.	69,5±0,7	99,77	10	4 (40%)	0 (0%)	1±0	3,5	(0,9-13,1)	0.051
Vertigo	72,0±8,1	99,75	30	12 (40%)	3 (25%)	1,25±0,45	3,5	(1,5-8,0)	0.002
P. Nerve Les.	66,0±8,1	99,79	18	7 (39%)	3 (43%)	1,57±0,79	3,3	(1,2-9,2)	0.016
Tinnitus	74,3±8,4	99,76	30	9 (30%)	2 (22%)	1,22±0,44	2,2	(0,9 - 5,3)	0.064
Headache	74,8±8,1	99,79	14	4 (29%)	0 (0%)	1,0±0.0	2,1	(0,6-7,1)	0,228
Other	79,4±7,1	99,74	34	14 (41%)	4 (29%)	1,29±0,47	3,7	(1,7 - 8,0)	0.001

*) Multiple falls were defined as more thaen two falls per year (i.e. a fall frequency index >2)-

**) Fall ffrequency index:. ~~1~~Category I = 1-2 falls in the last twelve months, ~~2~~ Category II = 3-5 falls in the last twelve months, Category III~~3~~ = 6-10 falls in the last twelve months, Category IV~~4~~ = 11-20 falls in the last twelve months, and Category V~~5~~ = more than 20 falls in the last twelve months.

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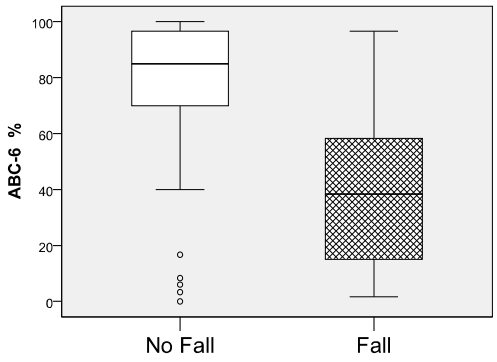
a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

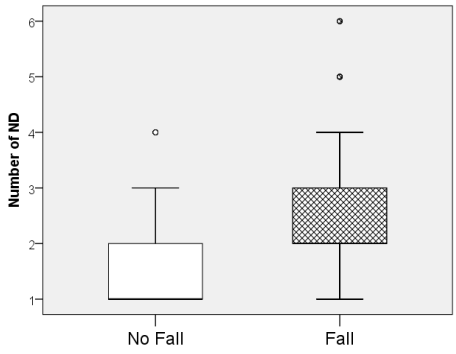


Fig.3a,b Differences in ~~Activities-Specific Balance Confidence (~~ABC-~~6)~~ scores (3a) and number of neurological diseases (ND) (3b) ~~of indicate that~~ neurological patients with and without falls indicate that fallers as compared to non-fallers ~~those without~~ have lower confidence in their balance and a higher number of concomitant neurological diseases. (ABC-6% meaning percentage scores of the 6-item version of the Activities-Specific Balance Confidence scale, number of ND meaning number of neurological diseases a patient is afflicted with)

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The impact of various neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

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Complete List of Authors:	Homann, Barbara; Medical University Graz, Neurology Plaschg, Annemarie; Medical University Graz, Neurology Grundner, Marion; Medical University Graz, Neurology Haubenhofer, Alice; Medical University Graz, Neurology Griedl, Theresa; Medical University Graz, Neurology Ivanic, Gerd; Private Paracelsus Medical University Salzburg, Orthopedic Surgery Hofer, Edith; Medical University Graz, Neurology Fazekas, Franz; Medical University Graz, Neurology Homann, Carl; Medical University Graz, Neurology
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The impact of neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

Homann, Barbara[1;] Plaschg, Annemarie[1;] Grundner, Marion[1;] Griedl, Theresa[1;] Ivanic, Gerd[2;] Hofer, Edith[1;] Fazekas, Franz[1;] Homann, Carl Nikolaus[1]

[1)] Medical University Graz, Dept of Neurology, [2)] Paracelsus Medical University Salzburg, Dep. of Orthopaedic Surgery

ABSTRACT

Objectives: Owing to a lack of data, our aim was to evaluate and compare the impact of various common neurological diseases on the risk for falls in independent community dwelling senior citizens.

Design: Prospective case controlled study

Setting: General Hospital

Participants: Out of 298 consecutive patients and 214 controls enrolled, 228 patients (aged 74.5±7.8; 61% women) and 193 controls (aged 71.4±6.8; 63% women) were included. Exclusion criteria for patients were severe disability, disabling general condition, or severe cognitive impairment, for controls any history of neurological disorders or disabling medical conditions, and for both age below 60 years. A matching process led to 171 age- and gender-matched pairs of neurological patients and healthy controls.

Main outcome measures: One-year incidence of falls based on patients' 12 month recall; motor and non- motor function tests to detect additional risk factors.

Results: 46% of patients and 16% of controls fell at least once a year. Patients with stroke (89%), Parkinson's disease (77%), dementia (60%) or epilepsy (57%) had a particularly high **proportion of fallers**, but even **subgroups of** patients with the least fall-associated neurological diseases like tinnitus (30%) and headache (28%) had a higher **proportion of fallers** than the control group. Neuropathies, peripheral nerve lesions and Parkinson's disease were predisposing to recurrent falls. A higher number of neurological comorbidities ($p<0.001$), lower Barthel Index values ($p<0.001$), lower Activities-Specific Balance Confidence scores (, $p<0.001$), and higher Center of Epidemiological Studies Depression scores ($p<0.001$) as well as higher age ($p<0.001$) and female gender ($p=0.003$) proved to further increase the risk of falls.

Conclusions: Medical practitioners, allied health professionals and carers should be aware that all elderly neurological patients seen in outpatient settings are potentially at high risk for falls; they should query them routinely about previous falls and fall risks and advise them on preventive strategies.

Article summary

Article focus

- Previous studies have shown that falls in the elderly are common and substantial amount of data on single neurological conditions like stroke and Parkinson's disease suggest that neurological impairments further increase the risk for falls.
- However, little is known on the influence of a broad range of neurological diseases and how they differ among each other.
- The aim of this study is to provide comparative data on the risk of falling in ambulatory elderly subjects afflicted with various common neurological diseases and to evaluate the role of additional risk factors.

Key messages

- The results of our study suggest that all elderly neurological patients even when still ambulatory carry a heightened risk for falls.
- The impact differs according to disease but those with impairments of the sensorimotor system are particularly endangered. However our findings investigating yet unstudied populations, eg, such as headache revealed that even neurological disorders not directly connected with gait and balance carry an unexpected high risk for falls and that there is a cumulative effect of more than one neurological condition on the risk of falls.

Strengths and limitations of this study

- Strengths of this study include the prospective study design, the number of standardised outcome measures, the standardised assessment of neurological patients and the thorough examination and inclusion of healthy controls.
- The following limitations should be considered: although the design is prospective, the falls history is retrospective, based on patients'recall over 12 months, therefore underreporting of cases is possible. Small sample sizes in some of the subgroups of neurological diseases. Participants were mostly of Caucasian origin and there was a high drop-out rate, which may limit the generalisability of the results to other populations.

INTRODUCTION

Due to budget cuts and austerity measures the costs of accidents and falls have come into the spotlight of health policy makers. The World Health Organisation too has recently made fall prevention in the elderly one of its top priorities. The WHO Global Report on Falls Prevention in Older Age states that due to the high percentage of elderly people worldwide the economic and societal burden of falls will increase by epidemic proportions in all parts of the world over the next few decades, unless concerted action is taken in a systematic and proactive fashion by policy makers, researchers and practitioners [1].

It is known that falls in the elderly are common and have a great impact on life and wellbeing. Studies have shown that around 30% of subjects of 65 years plus had a fall during the last 12 months [2] with 10% sustaining severe injuries [3]. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls [4]. Elderly persons surviving a fall experience significant morbidity: as many as one-third require assistance in their activities of daily living for as long as 6 months [5]. Lasting disabilities are also common as many do not reach pre-fall physical functional states, resulting in increased dependency and (in up to 50%) a transfer to a care facility [4]. Associated as they are with considerable mortality as well as psychological and physical morbidity, these falls lead to increased dependence upon social support and health care services, with high economic impact on the social and health care system [6]. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs.

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly [7]. Neurological impairments in the elderly are also thought to increase the risk for falls, though evidence for this is mostly derived indirectly from investigations into the causes of falls in the elderly [8]. These studies show that patients admitted to hospitals due to falls frequently also suffer from neurological disorders. Data derived from a multidisciplinary fall consultation survey suggest that in two out of three patients, potentially fall inducing neurological disorders were present, most of them (85%) previously undiagnosed [9].

There is, however, substantially less known about the risk for falls in patients afflicted with various common neurological diseases. While there is already a substantial amount known about increased risk of falls in the stroke [10], Parkinson's disease [11] or dementia [12] population, to our knowledge there is only one comparative study investigating falls in patients with of a broad range of neurological diseases. This study by Stolze, however, was conducted on patients with neurological diseases severe enough to require hospital admission [13]. To date little is known about the risk of falling in

independent, community dwelling senior citizens afflicted with neurological diseases treatable in outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they did, the absence of neurological signs and symptoms in this cohort was not guaranteed.

Because falls in community dwelling elderly patients are assumed to be both prevalent and preventable, neurologists in outpatient settings need a sound base to identify patients with the highest risk, to reduce not only the number of falls and the suffering they entail, but also overall health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with various neurological diseases that are commonly encountered in outpatient facilities. We hypothesized that even in community dwelling elderly patients, the impact one or more neurological diseases on top of an already increased propensity for falls is substantial; that patients with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction with more than one of these high risk diseases increases the risk even further.

PARTICIPANTS AND METHODS

Setting

Data were collected at the general outpatient department of the Department of Neurology of the University Hospital in Graz, Austria. As visits to the outpatient department do not require specialist referrals, the disease spectrum largely resembles that seen by community based neurologists.

Selection of participants and baseline examination

Physically independent community dwelling patients treated in our general neurological outpatient clinic aged 60 years and over were included in the study. Patients were all seen consecutively by one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains the study size. Severely disabled patients who were no longer able to walk unaided or were in poor general condition, be it for reasons of neurological or other medical disease, were excluded from the study. Cognitive impairment to an extent that an interview would no longer yield reliable results (MMSE≤12), was also a cause for exclusion. All neurological patients included underwent a full neurological workup with an extensive history to detect signs of past and present neurological disorders. For the sake of uniformity, both the workup and history were structured and followed the study protocol.

As healthy controls, individuals from the general public out of the same catchment area as cases

were enrolled. They were recruited among friends and acquaintances of the author and his co-workers who were aged 60+ and without any history of neurological disorders or other disabling medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis severe enough to cause limitation of ordinary physical activity. Examination and history were as per study protocol, whereby special emphasis was placed on identifying symptoms and signs of Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor deficits and gait or balance impairments. Controls with even subtle neurological pathologies were excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

A telephone follow-up was scheduled 12 months after the baseline outpatient visit; it was carried out by one of two examiners (AP, MG) following a predefined format and only subjects who had given verbal informed consent at the start of the telephone contact were interviewed.

The first section of the interview questionnaire covered demographic data like age and place of residence. The residence category had 5 subsections on size and traffic infrastructure, with group 1 being the state capital and group 5 a small town in the periphery. Next were specific questions on fall frequency, physical disability, depression and confidence in one's own sense of balance. The final section dealt with risk situations (like when using public transport) and general mobility issues, whereby the latter are not included in this publication.

The survey, including all details concerning the selection process, was approved by the Ethics Committee of the Medical University Graz.

Frequency of falls

In the main section of the questionnaire patients and healthy controls were asked whether they had had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall incidence was graded according to the fall frequency index into 5 categories. Category one means 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

Disability

The Barthel Index [14], a disability scale with scores from 0 (completely dependent) to 100 (completely independent) was used to evaluate the functional status of all neurological patients.

Parkinson patients were also rated according to the the Schwab and England Scale and Part II of the Unified Parkinson's Disease Rating Scale (UPDRS) [15].

Depression

To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) [16], the German short form of the Center of Epidemiological Studies Depression Scale (CES-D) [17] was

used. It is known to be particularly well suited for the use in the elderly and in patients with certain neurological disabilities [18].

Balance Confidence

We also rated the patients' confidence in their own sense of balance with the Activities-Specific Balance Confidence Scale (ABC -6 scale) [19]. Participants judged their confidence in performing specific activities without loss of balance or being unsteady on a scale ranging from 0% (no confidence at all) to 100% (completely confident). The total score was then computed as an average of the subscores.

Statistical analysis

The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were defined according to the WHO definition [1] as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g. falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly individuals and the whole sample of neurological patients. Further calculations were done for subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were based on the ICD-10 system for classification of diseases. The means and standard deviations were calculated for numerical values like the rating scale scores. For the identification of fall related risk factors, correlations (Kendall's τ-B), and for the individual neurological disorders, odds ratios were computed (α-level of significance $p < 0.05$). Differences between neurological patients and healthy controls were tested with the Mann-Whitney U test or the chi-square test (α-levels of significance $p < 0.05$). To insure comparability of cohorts we formed age- and gender-matched pairs of patients and control subjects. For the matching process we used alphabetical lists of names of male and female neurological patients and likewise of healthy controls, sorted by age. Then working down the list we searched manually to find for each neurological patient one control subject of the same age. If no match was found then we looked for a control that was one year younger, then one year older, then two years and finally three years younger respectively older. Only complete sets of data were included in the calculations and no approximates to replace missing values were computed. Calculations were performed with SPSS ® statistical software PASW statistics 18. Potential bias and how it was addressed will be dealt with in the section on limitations.

RESULTS

During a period of 10 months we recruited 298 mobile neurological outpatients and 214 healthy controls aged 60 years and over. In the group of healthy controls 21 patients initially recruited could not be included in the study due to neurological symptoms and signs, or a history of a neurological disorder. In the group of neurological patients another 70 patients had to be excluded from the study because at the time of the interview they (n=10) or their caregiver (n=6) requested exclusion, the telephone number on record had been disconnected (n=24), all attempts to contact them failed (n=11), they had become so disabled that they could no longer participate in the survey (n=10), they had died (n=4), or for other reasons (n=5).

Prior to recruitment, twenty patients were excluded because of inability to walk unaided and one due to severe dementia. Of those that met inclusion criteria five rejected enrolment and six other patients could not be enrolled due to inadequate language skills (n=1), severe aphasia (n=1), or severe presbyacusis (n=4).

The statistical analysis thus covered 228 neurological outpatients (aged 74.5 ± 7.8; 61% women) and 193 healthy controls. The matching process led to 171 pairs of neurological patients and healthy controls, 101 women and 70 men in each group, aged 72.0 and 72.2 years, respectively. The details of these subjects are summarized in Table 1.

Incidence of falls in neurological patients and healthy controls

One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen at least once (Chi^2=43.4; p <0.001) during this one-year period. Out of 106 neurological patients experiencing falls, 76 (71.7%) fell once or twice, 22 (20.8%) three to five times, three (2.8%) six to nine times, three (2.8%) 11-20 times and two (1.9%) more than 20 times. In the group of healthy controls, out of 31 individuals with a history of falls, 24 (77.4%) fell once or twice, and seven (22.6%) three to five times, but none more often than that. In the matched cohorts as well falls were more frequent in neurological patients (42.1%) than in healthy controls (16.9%) (Chi^2=26.3; p<0.001). (Table 1)

The mean age of individuals with a history of falls as compared to those without was higher both in the neurologically affected (fallers: 76.7 ± 7.6 vs. nonfallers: 72.6 ± 7.5; p<0.001) and in healthy controls (fallers: 73.3 ± 6.5 vs. nonfallers: 71.0 ± 6.9; p=0.040). In the group of neurological patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male (Chi^2=8.675; p=0.003).

Similarly, in the group of healthy controls a higher percentage of fallers was female, with 23 out of 31 (74%), but this did not reach significance (Chi^2=1.915; p=0.166).

The occurrence of falls in neurological patients was independent of where they lived. For healthy controls, however, their place of residence had an influence, in that subjects living in more rural environments were more prone to falls (Γ-B=0.217; p<0.001).

Multiple falls occurred particularly in patients with peripheral neuropathy (43%), peripheral nerve lesion (43%), dementia (33%), Parkinson's disease (30%), stroke (30%) and vertebral pain (30%). The average fall frequency index in this group of five diseases ranged from 1.63 (periperal neuropathy) to 1.33 (dementia). The proportion of fallers in each index category is shown for all these diseases in Fig. 1.

Risk factors for falls in neurological patients

The type of neurological disease the patient was afflicted with influenced the proportion of fallers in that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%) had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy control (16.1%). (Fig. 2)

The respective odds ratios are shown in table 2 and range from 40.1 (stroke) to 2.1 (headache) and the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.

No specific combination of two or three neurological diseases characterized by substantial gait or balance impairment but any accumulation of several neurological diseases regardless of their influence on gait or balance was able to cause a significant raise in falls (Γ-B=0.303; p<0.001).

Other risk factors for falls in neurological patients were female gender (Γ-B=0.195; p=0.003), higher age (Γ-B=0.217; p<0.001), higher disability or disease severity as measured by the Barthel Index (Γ-B=-0.232; p<0.001). Higher disability scores in Parkinson patients expressed by higher UPDRS II (activities of daily living) scores (Γ-B=-0.238; p=0.062) and higher Schwab & England scores (Γ-B=-0.235; p=0.070) resulted in a trend toward more frequent falls. Severity of depression as reflected by a higher ADS score (Γ-B=0.329; p<0.001) and low balance confidence reflected by lower ABC scores (Γ-B=-0.384; p<0.001) were also identified as risk factors (Fig. 3).

DISCUSSION

Incidence of falling

Our study suggests that even in patients mildly to moderately affected by neurological impairments the incidence of falls was three times higher than in subjects without any neurological symptoms or signs. To our knowledge this is the first survey conducted on elderly neurological outpatients and controls proven to be without neurological impairments, but the extent of this increased relative risk in neurological patients was unexpected, and resulted from low incidence figures in the group of controls and particularly high figures in the patient group.

In our group of healthy controls the 12-month incidence (16.1 %) was considerably lower than in previous population based data serving as a reference for previous studies [20]. Literature suggests that a third to one half of the community dwelling population of 60+ experience falls each year. For a group of 1762 subjects 60+ years of age, Lord reported a yearly incidence rate of falls of 28% [21]. In individuals of 65 years and older Prudham found in his survey conducted on 2793 individuals that 28% experienced one or more falls in the last year [22]. In O'Loughlin's group of 409 it was 29% [7], in Campbell's group of 533, 33% [23], and in Blake's group of 1042, 35%. [24] Luukinen's group of 833 individuals aged 70+ showed a 30% annual rate of falls [3] and Tinetti's group of 336 aged 75+ showed a rate of 32% [25]. For the very old, Campbell found in a community-based prospective study based on 761 subjects that half of those age 80 years and over have a fall every year [26]. This incidence rate, twice or three times that of our figures, did not surprise us. Population-based data of elderly individuals inevitably include a considerable number of patients suffering from neurological diseases or other forms of gait or balance problems. Many of these neurological disorders like stroke, Alzheimer's disease or Parkinson's disease are typical diseases of the elderly and others like epilepsy or traumatic brain injury also have a second peak in higher age [27]. This shows that it can be of advantage, when studying groups of elderly patients, to have a truly healthy control group, as in our survey.

Our study also shows that half of all ambulatory neurological patients had had at least one fall within the last 12 month. As to our knowledge this is the first survey of neurological outpatients, the lack of comparative data gave us no choice but to relate our findings to Stolze's data on neurological inpatients showing, much to our surprise, a falling incidence as low as 34% [13]. One would have assumed that Stolze's patients, who required inpatient treatment for their neurological conditions, would be more severely disabled and thus more prone to falls than outpatients. It also appears contradictory our findings that indicators of disease severity like the Barthel index and the UPDRS II correlated positively with the incidence of falls. Several studies further support this concept by stat-

ing that the more severely affected patients are, the higher the falling risk [28]. However, we have reasons to believe that the correlation is not linear throughout all grades of disability but rather resembles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher disability only up to a certain point. Then, as patients become more cautious and use all kind of supports, it plateaus and even decreases. When patients become so disabled that they are finally bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since this concept has yet only been proposed for PD[29] but not for other neurological conditions, further studies directly comparing the risk of falling in neurological inpatients and outpatients of various grades of disability are needed to support this assumption.

Considering recurrent falls we found that in the group of neurological patients 13.2 % fell three or more times per year, compared to 3.6% in the group of healthy controls. This is in keeping with the results of studies investigating recurrent falls, where figures of 8% for three or more falls in randomly selected community dwelling elderly individuals are given [30] and 10% for community based seniors using home care services [31]. In Stolze's cohort of inpatients the value of 21% for recurrent falls was higher and can probably be explained by methodological differences. Stolze's category of recurrent falls already includes patients who had fallen twice, unlike our and other studies [30, 31] that include patients only after more than three falls.

Risk factors contributing to falls

We found out that the type of neurological disease afflicting a patient determines the potential risk factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson patients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with previous community based studies showing a high likelihood for falls in stroke patients with a range of 51-73% [10, 20, 32] and in Parkinson's patients with a range of 38 – 87% [33-39]. This was followed by a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consisting of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neuropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-80% [12, 40] in Alzheimer patients and 55-65% [41-43] in patients with peripheral neuropathy. The only study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents, providing a 5-year fall incidence of 83% [44]. In our sample peripheral neuropathy also proved to be a risk factor for recurrent falls, but most likely significance was not reached due to the small sample size (p=0.061). Confirmative data also obtained from small cohorts revealed that multiple falls occurred in 10 out of 25 (40%) neuropathy patients [43] and another 13 out of 20 neuropathy patients (65%) had a propensity for multiple falls for an average of 5.8 falls per year [41]. New and unexpected

was the fact that even patients suffering from neurological diseases with no direct influence on gait or balance like headache (28%) had almost twice as many falls as the average healthy control (16.1%). Also new is that in contrast to all the above cited data derived from studies on patients with only one neurological disorder, our survey provides comparative values for several neurological diseases of elderly ambulatory neurological patients for the first time, allowing a direct comparison between these disorders and a ranking according to the risk of falling.

But our findings further suggest that not only the type of neurological conditions, but also the number of neurological diseases a patient was suffering from, no matter whether they had an influence on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that only accumulations of neurological deficits relating to gait and balance would influence the risk for falls. Although there were no published studies on the influence of neurological diseases, it is known that persons with an impaired sense of balance have an disproportionately higher risk for falls when they acquire an additional new disease or condition, even if it is one that seems minor or not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a patient was suffering from was highly predicative of a risk to fall, better even than a mobility score. She concluded that falling appears to result from an accumulated effect of multiple specific disabilities [45]. This would be in keeping with our other findings, that old age in combination with any neurological disease increases the risk of falling above that of healthy controls, even if it is a disease like headache. Also in accordance with this we found that a higher rate of depression, as reflected by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be that depressive thoughts are frequently combined with negative conceptions of one's own sense of balance, which was found to be a prominent risk factor for falls in our and previous other studies [46].

That higher age would be a predictive factor for falls in neurological patients replicates previous findings [13] and is easy to explain: old age is often associated with greater frailty and eventually frailty with less confidence in one's sense of balance and a higher incidence of falls [46]. That females are more prone to falls than males has often been stated before [13] and has previously been explained by a fear of falling and a loss of confidence – both independent risk factors for falls - being more prominent in women [6].

LIMITATIONS

We also faced several limitations in our study. First and most importantly, like most other surveys dealing with falls, we faced the problem that the number of falls are likely to be underreported. Elderly subjects often try to downplay problems regarding their mobility for fear of having their

autonomy restricted. While this is in general typically found in the healthy elderly, it might be even more prominent in patients with disabilities. But even remembering these events might pose a problem in some of the patients with central degenerative diseases and this might have been a relevant factor in our study, even though we excluded patients with severe dementia. The risk for falls in neurological patients might therefore be greater than shown in any results. Future prospective studies could minimize this problem by using patients diaries according to established guidelines for reporting falls [47] possibly even in combination with wearable miniaturized electronic devices apt to objectively detect and monitor falls [48].

Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing the 3,6% that had to be excluded prior to recruitment due to inability or unwillingness to participate could have lead to further underestimating the number of patients with falls. However, since these patients did not obviously differ in their baseline characteristics, we assume this problem to be minimal.

Then, we would also like to address the issue of small sample sizes in subgroups of neurological diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies like those on peripheral neuropathy [41, 43]. Others, particularly the dementia group with only seven patients, is, due to the exclusion of the more affected, quite small and allows only limited extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels of significance.

CONCLUSION

It can be said that we managed to show, apparently for the first time, that even among ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is multi-factorial, but the connection between falls and disturbances of the sensorimotor system frequently found in neurological diseases in elderly patients is of great importance. Our findings revealed that even neurological diseases not directly connected with gait and balance carry an astonishingly high risk for falls. Medical practitioners, allied health professionals and carers should therefore be aware that their patients are at high risk for falls, as any neurological deficit increases this risk, even more so if a combination of factors is present. Of course the risk has to be evaluated individually, but patients with central

diseases like stroke, Parkinson's disease, dementia and epilepsy, and for repeated falls also patients with peripheral neurological disorders, require special attention. Greater disability, higher age, female gender, depression and low confidence in the sense of balance are additional contributory factors that have to be taken into account in this process. For patients with several of these factors, targeted prevention programs should be implemented. However, although they have been shown to generally reduce falls and injuries in the community dwelling elderly [49], there is but inconclusive evidence for patients following stroke [50] and with PD [51, 52] and even more scanty information for patients with other neurological diseases. Therefore further larger scale multicenter neuro-geriatric surveys with larger sample sizes for neurological subgroups should be performed not only to confirm our observations but to acquire more extensive knowledge of the effectiveness of preventive measures in patient cohorts with various neurological conditions and different degrees of disability. These studies should also include more objective monitoring systems and include further potential risk factors like medication and fear of falling.

NOTES

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Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz

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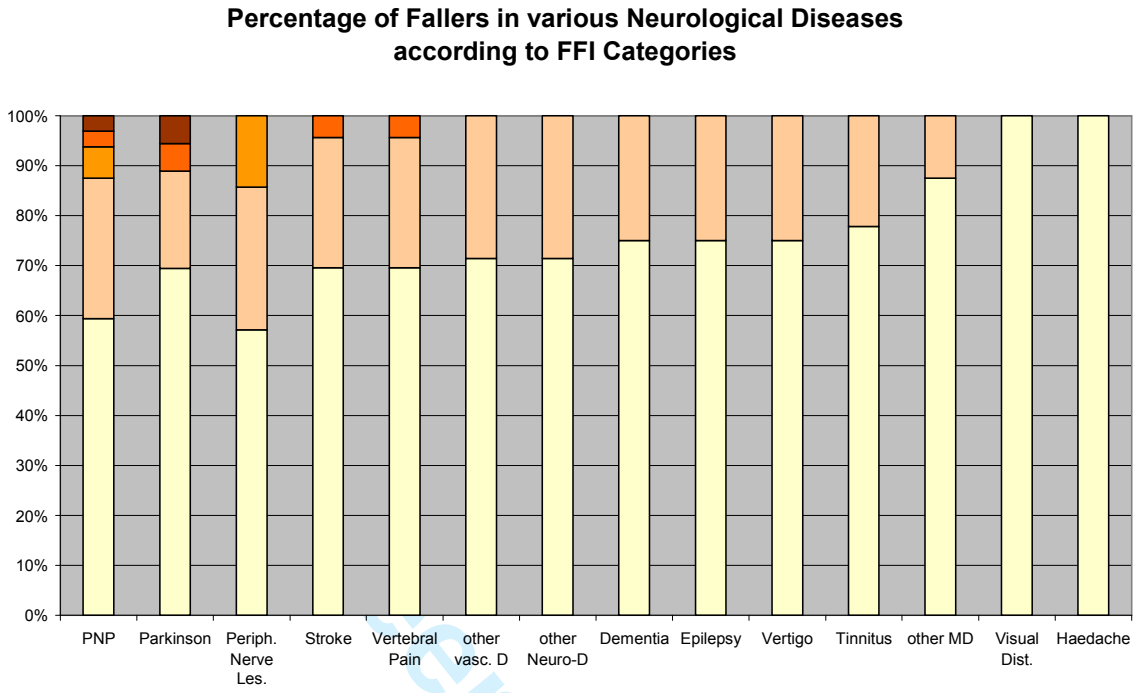
TABLES AND FIGURES

Table 1: Neurological patients and healthy controls: General demographics and fall frequency

	Total			Matched pairs		
	Patients (n=228)	Healthy (n=193)	p-value	Patients (n=171)	Healthy (n=171)	p-value
Total						
Age	74.5±7.8	71.4±6.8	0.000	72.2±7.0	72.0±6.9	0.839
Gender (f in %)	61%	63%	0.572	59%	59%	1.000
Region (Residential Index: mean)	2.53	2.21	0.021	2.66	2.22	0.004
Disability (Bartelindex: mean)	98.20	n.d.		98.24	n.d.	
Balance (ABC-score: mean)	73.19	n.d.		83.39	n.d.	
Depression (ADS-K-score: mean)	7.2	n.d.		6.9	n.d.	
Fallers						
Falls (n (%))	46.5%	16.1%	0.000	42.1%	16.9%	0.000
Multiple Falls (>2 falls) (n (%))	28.3%	22.6%	0.528	26.4%	24.1%	0.815
Fall frequency Index (in fallers)	1.42±0.8	1.23±04	0.078	1.44±0.9	1.24±04	0.14



Categories	PNP (n)	PD (n)	PNL (n)	Stroke (n)	Vert P (n)	other vasc (n)	Other n. D. (n)	Dem (n)	Epi (n)	Vertig (n)	Tinnitus (n)	other MD (n)	Visual Dist (n)	Haedache (n)
V	1	2	0	0	0	0	0	0	0	0	0	0	0	0
IV	1	2	0	1	1	0	0	0	0	0	0	0	0	0
III	2	0	1	0	0	0	0	0	0	0	0	0	0	0
II	9	7	2	6	6	4	4	1	1	3	2	1	0	0
I	19	25	4	16	16	10	10	3	3	9	7	7	4	4
0	27	11	11	3	15	11	20	3	3	18	21	6	6	10
Total	**59**	**47**	**18**	**26**	**48**	**25**	**34**	**7**	**7**	**30**	**30**	**14**	**10**	**14**

Fig.1 Frequency of falls in neurological patients according to their neurological disorder. Fall Frequency Index (FFI) Category I = 1-2 falls in the last twelve months, Cagegory II = 3-5, Category III = 6-10, Category IV = 11-20, and Category V = more than 20.

Abbreviations: PNP = peripheral neuropathy, Periph. nerve les. = peripheral nerve lesion**,** other MD = other movement disorders, other vasc. d. = other vascular disease, Visual.Dist. = visual disturbances

One year fall incidence in common neurological disorders

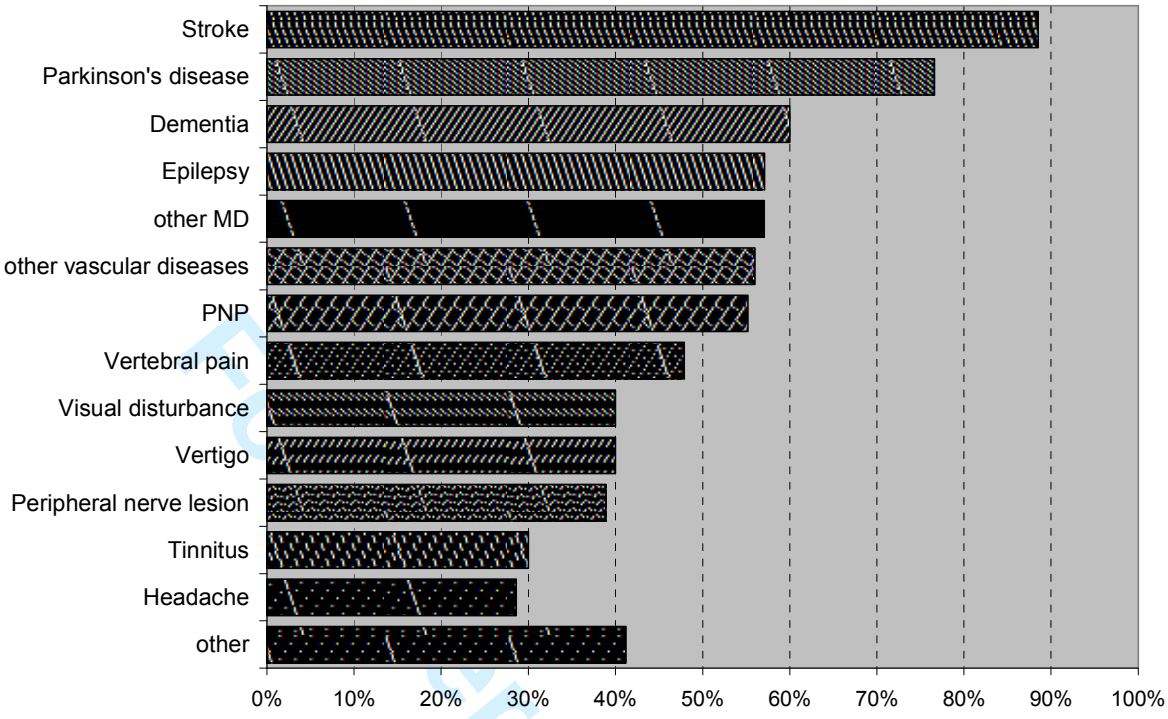


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

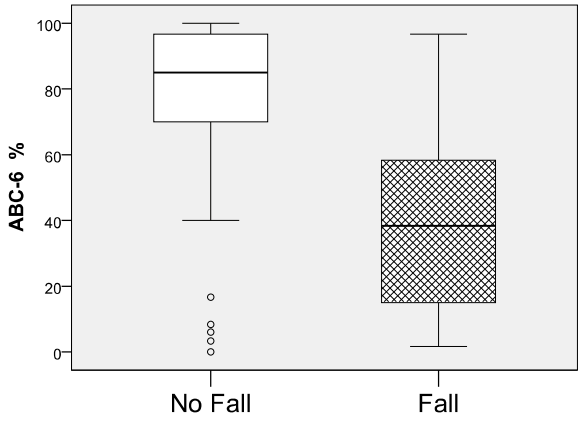
Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall frequency** (in fallers)	Risk of falling		
							OR	CI	p-value
Stroke	82,7±2,3	99,76	26	23 (89%)	7 (30%)	1,39±0,72	40,1	(11,3-141,7)	0.000
Parkinson D	74,8±8,1	99,79	47	36 (77%)	11 (31%)	1,58±1,13	17,1	(7,9-37,2)	0.000
Dementia	77,5±9,2	99,77	7	3 (60%)	1 (33%)	1,33±0,58	7,8	(1,3-48,9)	0.01
Epilepsy	71,0±8,2	99,78	7	4 (57%)	1 (25%)	1,25±0,5	7,0	(1,5-32,7)	0.005
other MD	74,3±7,9	100	14	8 (57%)	1 (13%)	1,23±0,82	7,0	(2,3-21,5)	0.000
other vasc. D	74,8±8,1	99,79	25	14 (56%)	4 (29%)	1,29±0,47	6,7	(2,8-16,0)	0.000
PNP	71,0±8,1	99,78	58	32 (55%)	13 (43%)	1,63±0,98	6,4	(3,4-12,3)	0.000
Vertebral Pain	76,8±9,1	99,75	48	23 (48%)	7 (30%)	1,39±0,72	4,8	(2,4-9,5)	0.000
Visual Disturb.	69,5±0,7	99,77	10	4 (40%)	0 (0%)	1±0	3,5	(0,9-13,1)	0.051
Vertigo	72,0±8,1	99,75	30	12 (40%)	3 (25%)	1,25±0,45	3,5	(1,5-8,0)	0.002
P. Nerve Les.	66,0±8,1	99,79	18	7 (39%)	3 (43%)	1,57±0,79	3,3	(1,2-9,2)	0.016
Tinnitus	74,3±8,4	99,76	30	9 (30%)	2 (22%)	1,22±0,44	2,2	(0,9 - 5,3)	0.064
Headache	74,8±8,1	99,79	14	4 (29%)	0 (0%)	1,0±0.0	2,1	(0,6-7,1)	0,228
Other	79,4±7,1	99,74	34	14 (41%)	4 (29%)	1,29±0,47	3,7	(1,7 - 8,0)	0.001

) Multiple falls were defined as more than two falls per year (i.e. a fall frequency index ≥2)*

**) Fall frequency index:. Category I = 1-2 falls in the last twelve months, Category II = 3-5 falls in the last twelve months, Category III = 6-10 falls in the last twelve months, Category IV = 11-20 falls in the last twelve months, and Category V = more than 20 falls in the last twelve months.

a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

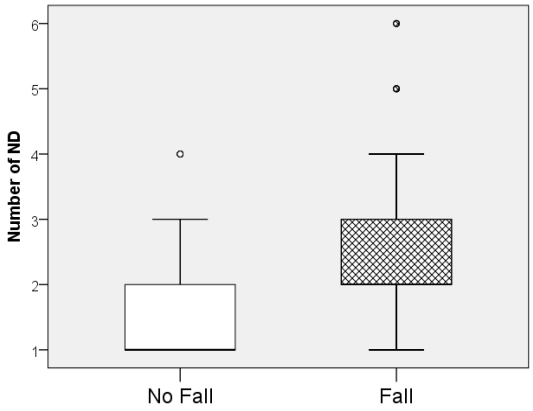


Fig.3a,b Differences in ABC-6 scores (3a) and number of neurological diseases (ND) (3b) of neurological patients with and without falls indicate that fallers as compared to non-fallers have lower confidence in their balance and a higher number of concomitant neurological diseases.

(ABC-6% meaning percentage scores of the 6-item version of the Activities-Specific Balance Confidence scale, number of ND meaning number of neurological diseases a patient is afflicted with)

The impact of neurological disorders on the risk for falls in the community dwelling elderly: a case controlled study

Homann, Barbara[1;] Plaschg, Annemarie[1;] Grundner, Marion[1;] Griedl, Theresa[1;] Ivanic, Gerd[2;] Hofer, Edith[1;] Fazekas, Franz[1;] Homann, Carl Nikolaus[1]

[1)] Medical University Graz, Dept of Neurology, [2)] Paracelsus Medical University Salzburg, Dep. of Orthopaedic Surgery

ABSTRACT

Objectives: Owing to a lack of data, our aim was to evaluate and compare the impact of various common neurological diseases on the risk for falls in independent community dwelling senior citizens.

Design: Prospective case controlled study

Setting: General Hospital

Participants: Out of 298 consecutive patients and 214 controls enrolled, 228 patients (aged 74.5±7.8; 61% women) and 193 controls (aged 71.4±6.8; 63% women) were included. Exclusion criteria for patients were severe disability, disabling general condition, or severe cognitive impairment, for controls any history of neurological disorders or disabling medical conditions, and for both age below 60 years. A matching process led to 171 age- and gender-matched pairs of neurological patients and healthy controls.

Main outcome measures: One-year incidence of falls based on patients' 12 month recall; motor and non- motor function tests to detect additional risk factors.

Results: 46% of patients and 16% of controls fell at least once a year. Patients with stroke (89%), Parkinson's disease (77%), dementia (60%) or epilepsy (57%) had a particularly high **proportion of fallers**, but even **subgroups of** patients with the least fall-associated neurological diseases like tinnitus (30%) and headache (28%) had a higher **proportion of fallers** than the control group. Neuropathies, peripheral nerve lesions and Parkinson's disease were predisposing to recurrent falls. A higher number of neurological comorbidities ($p<0.001$), lower Barthel Index values ($p<0.001$), lower Activities-Specific Balance Confidence scores (, $p<0.001$), and higher Center of Epidemiological Studies Depression scores ($p<0.001$) as well as higher age ($p<0.001$) and female gender ($p=0.003$) proved to further increase the risk of falls.

Conclusions: Medical practitioners, allied health professionals and carers~~Physicians~~ should be aware that all elderly neurological patients seen in outpatient settings are potentially at high risk for falls; they should query them routinely about previous falls and fall risks and advise them on preventive strategies.

Article summary

Article focus

- Previous studies have shown that falls in the elderly are common and substantial amount of data on single neurological conditions like stroke and Parkinson's disease suggest that neurological impairments further increase the risk for falls.
- However, little is known on the influence of a broad range of neurological diseases and how they differ among each other.
- The aim of this study is to provide comparative data on the risk of falling in ambulatory elderly subjects afflicted with various common neurological diseases and to evaluate the role of additional risk factors.

Key messages

- The results of our study suggest that all elderly neurological patients even when still ambulatory carry a heightened risk for falls.
- The impact differs according to disease but those with impairments of the sensorimotor system are particularly endangered. However our findings investigating yet unstudied populations, eg, such as headache revealed that even neurological disorders not directly connected with gait and balance carry an unexpected high risk for falls and that there is a cumulative effect of more than one neurological condition on the risk of falls.

Strengths and limitations of this study

- Strengths of this study include the prospective study design, the number of standardised outcome measures, the standardised assessment of neurological patients and the thorough examination and inclusion of healthy controls.
- The following limitations should be considered: although the design is prospective, the falls history is retrospective, based on patients'recall over 12 months, therefore underreporting of cases is possible. Small sample sizes in some of the subgroups of neurological diseases. Participants were mostly of Caucasian origin and there was a high drop-out rate, which may limit the generalisability of the results to other populations.

INTRODUCTION

Due to budget cuts and austerity measures the costs of accidents and falls have come into the spotlight of health policy makers. The World Health Organisation too has recently made fall prevention in the elderly one of its top priorities. The WHO Global Report on Falls Prevention in Older Age states that due to the high percentage of elderly people worldwide the economic and societal burden of falls will increase by epidemic proportions in all parts of the world over the next few decades, unless concerted action is taken in a systematic and proactive fashion by policy makers, researchers and practitioners [1].

It is known that falls in the elderly are common and have a great impact on life and wellbeing. Studies have shown that around 30% of subjects of 65 years plus had a fall during the last 12 months [2] with 10% sustaining severe injuries [3]. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls [4]. Elderly persons surviving a fall experience significant morbidity: as many as one-third require assistance in their activities of daily living for as long as 6 months [5]. Lasting disabilities are also common as many do not reach pre-fall physical functional states, resulting in increased dependency and (in up to 50%) a transfer to a care facility [4]. Associated as they are with considerable mortality as well as psychological and physical morbidity, these falls lead to increased dependence upon social support and health care services, with high economic impact on the social and health care system [6]. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs.

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly [7]. Neurological impairments in the elderly are also thought to increase the risk for falls, though evidence for this is mostly derived indirectly from investigations into the causes of falls in the elderly [8]. These studies show that patients admitted to hospitals due to falls frequently also suffer from neurological disorders. Data derived from a multidisciplinary fall consultation survey suggest that in two out of three patients, potentially fall inducing neurological disorders were present, most of them (85%) previously undiagnosed [9].

There is, however, substantially less known about the risk for falls in patients afflicted with various common neurological diseases. While there is already a substantial amount known about increased risk of falls in the stroke [10], Parkinson's disease [11] or dementia [12] population, to our knowledge there is only one comparative study investigating falls in patients with of a broad range of neurological diseases. This study by Stolze, however, was conducted on patients with neurological diseases severe enough to require hospital admission [13]. To date little is known about the risk of falling in

independent, community dwelling senior citizens afflicted with neurological diseases treatable in outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they did, the absence of neurological signs and symptoms in this cohort was not guaranteed.

Because falls in community dwelling elderly patients are assumed to be both prevalent and preventable, neurologists in outpatient settings need a sound base to identify patients with the highest risk, to reduce not only the number of falls and the suffering they entail, but also overall health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with various neurological diseases that are commonly encountered in outpatient facilities. We hypothesized that even in community dwelling elderly patients, the impact one or more neurological diseases on top of an already increased propensity for falls is substantial; that patients with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction with more than one of these high risk diseases increases the risk even further.

PARTICIPANTS AND METHODS

Setting

Data were collected at the general outpatient department of the Department of Neurology of the University Hospital in Graz, Austria. As visits to the outpatient department do not require specialist referrals, the disease spectrum largely resembles that seen by community based neurologists.

Selection of participants and baseline examination

Physically independent community dwelling patients treated in our general neurological outpatient clinic aged 60 years and over were included in the study. Patients were all seen consecutively by one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains the study size. Severely disabled patients who were no longer able to walk unaided or were in poor general condition, be it for reasons of neurological or other medical disease, were excluded from the study. Cognitive impairment to an extent that an interview would no longer yield reliable results (MMSE≤12), was also a cause for exclusion. All neurological patients included underwent a full neurological workup with an extensive history to detect signs of past and present neurological disorders. For the sake of uniformity, both the workup and history were structured and followed the study protocol.

As healthy controls, individuals from the general public out of the same catchment area as cases

were enrolled. They were recruited among friends and acquaintances of the author and his co-workers who were aged 60+ and without any history of neurological disorders or other disabling medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis severe enough to cause limitation of ordinary physical activity. Examination and history were as per study protocol, whereby special emphasis was placed on identifying symptoms and signs of Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor deficits and gait or balance impairments. Controls with even subtle neurological pathologies were excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

A telephone follow-up was scheduled 12 months after the baseline outpatient visit; it was carried out by one of two examiners (AP, MG) following a predefined format and only subjects who had given verbal informed consent at the start of the telephone contact were interviewed.

The first section of the interview questionnaire covered demographic data like age and place of residence. The residence category had 5 subsections on size and traffic infrastructure, with group 1 being the state capital and group 5 a small town in the periphery. Next were specific questions on fall frequency, physical disability, depression and confidence in one's own sense of balance. The final section dealt with risk situations (like when using public transport) and general mobility issues, whereby the latter are not included in this publication.

The survey, including all details concerning the selection process, was approved by the Ethics Committee of the Medical University Graz.

Frequency of falls

In the main section of the questionnaire patients and healthy controls were asked whether they had had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall incidence was graded according to the fall frequency index into 5 categories. Category one means 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

Disability

The Barthel Index [14], a disability scale with scores from 0 (completely dependent) to 100 (completely independent) was used to evaluate the functional status of all neurological patients.

Parkinson patients were also rated according to the the Schwab and England Scale and Part II of the Unified Parkinson's Disease Rating Scale (UPDRS) [15].

Depression

To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) [16], the German short form of the Center of Epidemiological Studies Depression Scale (CES-D) [17] was

used. It is known to be particularly well suited for the use in the elderly and in patients with certain neurological disabilities [18].

Balance Confidence

We also rated the patients' confidence in their own sense of balance with the Activities-Specific Balance Confidence Scale (ABC -6 scale) [19]. Participants judged their confidence in performing specific activities without loss of balance or being unsteady on a scale ranging from 0% (no confidence at all) to 100% (completely confident). The total score was then computed as an average of the subscores.

Statistical analysis

The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were defined according to the WHO definition [1] as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g. falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly individuals and the whole sample of neurological patients. Further calculations were done for subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were based on the ICD-10 system for classification of diseases. The means and standard deviations were calculated for numerical values like the rating scale scores. For the identification of fall related risk factors, correlations (Kendall's τ-B), and for the individual neurological disorders, odds ratios were computed (α-level of significance $p < 0.05$). Differences between neurological patients and healthy controls were tested with the Mann-Whitney U test or the chi-square test (α-levels of significance $p < 0.05$). To insure comparability of cohorts we formed age- and gender-matched pairs of patients and control subjects. For the matching process we used alphabetical lists of names of male and female neurological patients and likewise of healthy controls, sorted by age. Then working down the list we searched manually to find for each neurological patient one control subject of the same age. If no match was found then we looked for a control that was one year younger, then one year older, then two years and finally three years younger respectively older. Only complete sets of data were included in the calculations and no approximates to replace missing values were computed. Calculations were performed with SPSS ® statistical software PASW statistics 18. Potential bias and how it was addressed will be dealt with in the section on limitations.

RESULTS

During a period of 10 months we recruited 298 mobile neurological outpatients and 214 healthy controls aged 60 years and over. In the group of healthy controls 21 patients initially recruited could not be included in the study due to neurological symptoms and signs, or a history of a neurological disorder. In the group of neurological patients another 70 patients had to be excluded from the study because at the time of the interview they (n=10) or their caregiver (n=6) requested exclusion, the telephone number on record had been disconnected (n=24), all attempts to contact them failed (n=11), they had become so disabled that they could no longer participate in the survey (n=10), they had died (n=4), or for other reasons (n=5).

Prior to recruitment, twenty patients were excluded because of inability to walk unaided and one due to severe dementia. Of those that met inclusion criteria five rejected enrolment and six other patients could not be enrolled due to inadequate language skills (n=1), severe aphasia (n=1), or severe presbyacusis (n=4).

The statistical analysis thus covered 228 neurological outpatients (aged 74.5 ± 7.8; 61% women) and 193 healthy controls. The matching process led to 171 pairs of neurological patients and healthy controls, 101 women and 70 men in each group, aged 72.0 and 72.2 years, respectively. The details of these subjects are summarized in Table 1.

Incidence of falls in neurological patients and healthy controls

One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen at least once (Chi^2=43.4; p <0.001) during this one-year period. Out of ~~126~~ 106 neurological patients experiencing falls, 76 (71.7%) fell once or twice, 22 (20.8%) three to five times, three (2.8%) six to nine times, three (2.8%) 11-20 times and two (1.9%) more than 20 times. In the group of healthy controls, out of ~~76~~ 31 individuals with a history of falls, 24 (77.4%) fell once or twice, and seven (22.6%) three to five times, but none more often than that. In the matched cohorts as well falls were more frequent in neurological patients (42.1%) than in healthy controls (16.9%) (Chi^2=26.3; p<0.001). (Table 1)

The mean age of individuals with a history of falls as compared to those without was higher both in the neurologically affected (fallers: 76.7 ± 7.6 vs. nonfallers: 72.6 ± 7.5; p<0.001) and in healthy controls (fallers: 73.3 ± 6.5 vs. nonfallers: 71.0 ± 6.9; p=0.040). In the group of neurological patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male (Chi^2=8.675; p=0.003).

Similarly, in the group of healthy controls a higher percentage of fallers was female, with 23 out of 31 (74%), but this did not reach significance (Chi^2=1.915; p=0.166).

The occurrence of falls in neurological patients was independent of where they lived. For healthy controls, however, their place of residence had an influence, in that subjects living in more rural environments were more prone to falls (Γ-B=0.217; p<0.001).

Multiple falls occurred particularly in patients with peripheral neuropathy (43%), peripheral nerve lesion (43%), dementia (33%), Parkinson's disease (30%), stroke (30%) and vertebral pain (30%). The average fall frequency index in this group of five diseases ranged from 1.63 (periperal neuropathy) to 1.33 (dementia). The proportion of fallers in each index category is shown for all these diseases in Fig. 1.

Risk factors for falls in neurological patients

The type of neurological disease the patient was afflicted with influenced the proportion of fallers in that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%) had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy control (16.1%). (Fig. 2)

The respective odds ratios are shown in table 2 and range from 40.1 (stroke) to 2.1 (headache) and the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.

No specific combination of two or three neurological diseases characterized by substantial gait or balance impairment but any accumulation of several neurological diseases regardless of their influence on gait or balance was able to cause a significant raise in falls (Γ-B=0.303; p<0.001).

Other risk factors for falls in neurological patients were female gender (Γ-B=0.195; p=0.003), higher age (Γ-B=0.217; p<0.001), higher disability or disease severity as measured by the Barthel Index (Γ-B=-0.232; p<0.001). Higher disability scores in Parkinson patients expressed by higher UPDRS II (activities of daily living) scores (Γ-B=-0.238; p=0.062) and higher Schwab & England scores (Γ-B=-0.235; p=0.070) resulted in a trend toward more frequent falls. Severity of depression as reflected by a higher ADS score (Γ-B=0.329; p<0.001) and low balance confidence reflected by ~~higher~~ lower ABC scores (Γ-B=-0.384; p<0.001) were also identified as risk factors (Fig. 3).

DISCUSSION

Incidence of falling

Our study suggests that even in patients mildly to moderately affected by neurological impairments the incidence of falls was three times higher than in subjects without any neurological symptoms or signs. To our knowledge this is the first survey conducted on elderly neurological outpatients and controls proven to be without neurological impairments, but the extent of this increased relative risk in neurological patients was unexpected, and resulted from low incidence figures in the group of controls and particularly high figures in the patient group.

In our group of healthy controls the 12-month incidence (16.1 %) was considerably lower than in previous population based data serving as a reference for previous studies [20]. Literature suggests that a third to one half of the community dwelling population of 60+ experience falls each year. For a group of 1762 subjects 60+ years of age, Lord reported a yearly incidence rate of falls of 28% [21]. In individuals of 65 years and older Prudham found in his survey conducted on 2793 individuals that 28% experienced one or more falls in the last year [22]. In O'Loughlin's group of 409 it was 29% [7], in Campbell's group of 533, 33% [23], and in Blake's group of 1042, 35%. [24] Luukinen's group of 833 individuals aged 70+ showed a 30% annual rate of falls [3] and Tinetti's group of 336 aged 75+ showed a rate of 32% [25]. For the very old, Campbell found in a community-based prospective study based on 761 subjects that half of those age 80 years and over have a fall every year [26]. This incidence rate, twice or three times that of our figures, did not surprise us. Population-based data of elderly individuals inevitably include a considerable number of patients suffering from neurological diseases or other forms of gait or balance problems. Many of these neurological disorders like stroke, Alzheimer's disease or Parkinson's disease are typical diseases of the elderly and others like epilepsy or traumatic brain injury also have a second peak in higher age [27]. This shows that it can be of advantage, when studying groups of elderly patients, to have a truly healthy control group, as in our survey.

Our study also shows that half of all ambulatory neurological patients had had at least one fall within the last 12 month. As to our knowledge this is the first survey of neurological outpatients, the lack of comparative data gave us no choice but to relate our findings to Stolze's data on neurological inpatients showing, much to our surprise, a falling incidence as low as 34% [13]. One would have assumed that Stolze's patients, who required inpatient treatment for their neurological conditions, would be more severely disabled and thus more prone to falls than outpatients. It also appears contradictory our findings that indicators of disease severity like the Barthel index and the UPDRS II correlated positively with the incidence of falls. Several studies further support this concept by stat-

ing that the more severely affected patients are, the higher the falling risk [28]. However, we have reasons to believe that the correlation is not linear throughout all grades of disability but rather resembles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher disability only up to a certain point. Then, as patients become more cautious and use all kind of supports, it plateaus and even decreases. When patients become so disabled that they are finally bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since this concept ~~is not yet backed up by sound evidence~~has yet only been proposed for PD[29] but not for other neurological conditions, further studies directly comparing the risk of falling in neurological inpatients and outpatients of various grades of disability are needed to support this assumption.

Considering recurrent falls we found that in the group of neurological patients 13.2 % fell three or more times per year, compared to 3.6% in the group of healthy controls. This is in keeping with the results of studies investigating recurrent falls, where figures of 8% for three or more falls in randomly selected community dwelling elderly individuals are given [30] and 10% for community based seniors using home care services [31]. In Stolze's cohort of inpatients the value of 21% for recurrent falls was higher and can probably be explained by methodological differences. Stolze's category of recurrent falls already includes patients who had fallen twice, unlike our and other studies [30, 31] that include patients only after more than three falls.

Risk factors contributing to falls

We found out that the type of neurological disease afflicting a patient determines the potential risk factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson patients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with previous community based studies showing a high likelihood for falls in stroke patients with a range of 51-73% [10, 20, 32] and in Parkinson's patients with a range of 38 – 87% [33-39]. This was followed by a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consisting of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neuropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-80% [12, 40] in Alzheimer patients and 55-65% [41-43] in patients with peripheral neuropathy. The only study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents, providing a 5-year fall incidence of 83% [44]. In our sample peripheral neuropathy also proved to be a risk factor for recurrent falls, but most likely significance was not reached due to the small sample size (p=0.061). Confirmative data also obtained from small cohorts revealed that ~~repetitive~~ multiple falls occurred in 10 out of 25 (40%) neuropathy patients [43] and another 13 out of 20 neuropathy patients (65%) had a propensity for multiple~~recurrent~~ falls for an average of 5.8 falls per year [41]. New

and ~~quite astonishing~~unexpected was the fact that even patients suffering from neurological diseases with no direct influence on gait or balance like headache (28%) had almost twice as many falls as the average healthy control (16.1%). Also new is that in contrast to all the above cited data derived from studies on patients with only one neurological disorder, our survey provides comparative values for several neurological diseases of elderly ambulatory neurological patients for the first time, allowing a direct comparison between these disorders and a ranking according to the risk of falling.

But our findings further suggest that not only the type of neurological conditions, but also the number of neurological diseases a patient was suffering from, no matter whether they had an influence on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that only accumulations of neurological deficits relating to gait and balance would influence the risk for falls. Although there were no published studies on the influence of neurological diseases, it is known that persons with an impaired sense of balance have an disproportionately higher risk for falls when they acquire an additional new disease or condition, even if it is one that seems minor or not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a patient was suffering from was highly predicative of a risk to fall, better even than a mobility score. She concluded that falling appears to result from an accumulated effect of multiple specific disabilities [45]. This would be in keeping with our other findings, that old age in combination with any neurological disease increases the risk of falling above that of healthy controls, even if it is a disease like headache. Also in accordance with this we found that a higher rate of depression, as reflected by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be that depressive thoughts are frequently combined with negative conceptions of one's own sense of balance, which was found to be a prominent risk factor for falls in our and previous other studies [46].

That higher age would be a predictive factor for falls in neurological patients replicates previous findings [13] and is easy to explain: old age is often associated with greater frailty and eventually frailty with less confidence in one's sense of balance and a higher incidence of falls [46]. That females are more prone to falls than males has often been stated before [13] and has previously been explained by a fear of falling and a loss of confidence – both independent risk factors for falls - being more prominent in women [6].

LIMITATIONS

We also faced several limitations in our study. First and most importantly, like most other surveys dealing with falls, we faced the problem that the number of falls are likely to be~~is~~ underreported. Elderly subjects often try to downplay problems regarding their mobility for fear of having their

autonomy restricted. While this is in general typically found in the healthy elderly, it might be even more prominent in patients with disabilities. But even remembering these events might pose a problem in some of the patients with central degenerative diseases and this might have been a relevant factor in our study, even though we excluded patients with severe dementia. The risk for falls in neurological patients might therefore be greater than shown in any results. Future prospective studies could minimize this problem by using patients diaries according to established guidelines for reporting falls [47] possibly even in combination with wearable miniaturized electronic devices apt to objectively detect and monitor falls [48].

Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing the 3,6% that had to be excluded prior to recruitment due to inability or unwillingness to participate could have lead to further underestimating the number of patients with falls. However, since these patients did not obviously differ in their baseline characteristics, we assume this problem to be minimal.

Then, we would also like to address the issue of small sample sizes in subgroups of neurological diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies like those on peripheral neuropathy [41, 43]. Others, particularly the dementia group with only seven patients, is, due to the exclusion of the more affected, quite small and allows only limited extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels of significance.

CONCLUSION

It can be said that we managed to show, apparently for the first time, that even among ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is multi-factorial, but the connection between falls and disturbances of the sensorimotor system frequently found in neurological diseases in elderly patients is of great importance. Our findings revealed that even neurological diseases not directly connected with gait and balance carry an astonishingly high risk for falls. Medical practitioners, allied health professionals and carers~~Neurologists~~ should therefore be aware that their patients are at high risk for falls, as any neurological deficit increases this risk, even more so if a combination of factors is present. Of course the risk has to be evaluated individually, but patients with

central diseases like stroke, Parkinson's disease, dementia and epilepsy, and for repeated falls also patients with peripheral neurological disorders, require special attention. Greater disability, higher age, female gender, depression and low confidence in the sense of balance are additional contributory factors that have to be taken into account in this process. For patients with several of these factors, targeted prevention programs should be implemented. However, although they have been shown to generally reduce falls and injuries in the community dwelling elderly [49], there is but inconclusive evidence for patients following stroke [50] and with PD [51, 52] and even more scanty information for patients with other neurological diseases. Therefore further larger scale multicenter neuro-geriatric surveys with larger sample sizes for neurological subgroups should be performed not only to confirm our observations but to acquire more extensive knowledge of the effectiveness of preventive measures in patient cohorts with various neurological conditions and different degrees of disability. These studies should also include more objective monitoring systems and include further potential risk factors like medication and fear of falling.

Field Code Changed

NOTES

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Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz

Patient consent: obtained

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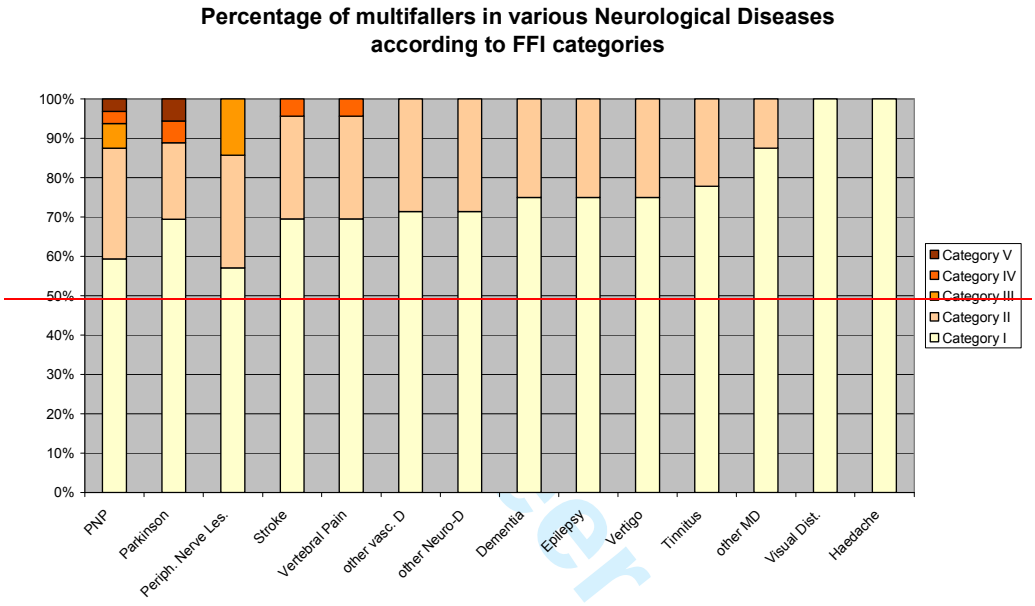
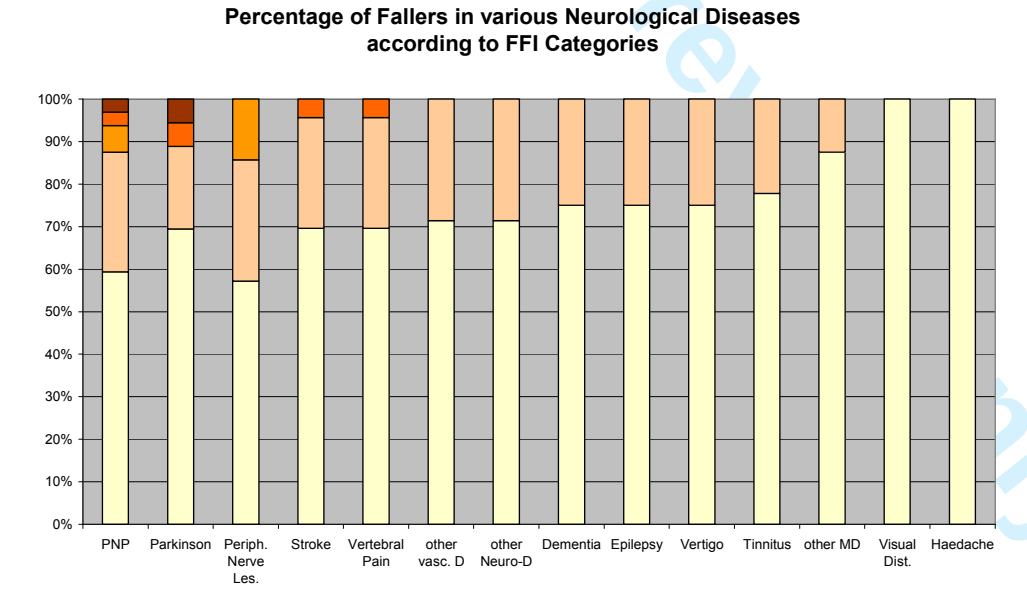
TABLES AND FIGURES

Table 1: Neurological patients and healthy controls: General demographics and fall frequency

	Total			Matched pairs		
	Patients (n=228)	Healthy (n=193)	p-value	Patients (n=171)	Healthy (n=171)	p-value
Total						
Age	74.5±7.8	71.4±6.8	0.000	72.2±7.0	72.0±6.9	0.839
Gender (f in %)	61%	63%	0.572	59%	59%	1.000
Region (Residential Index: mean)	2.53	2.21	0.021	2.66	2.22	0.004
Disability (Bartelindex: mean)	98.20	n.d.		98.24	n.d.	
Balance (ABC-score: mean)	73.19	n.d.		83.39	n.d.	
Depression (ADS-K-score: mean)	7.2	n.d.		6.9	n.d.	
Fallers						
Falls (n (%))	46.5%	16.1%	0.000	42.1%	16.9%	0.000
Multiple Falls (>2 falls) (n (%))	28.3%	22.6%	0.528	26.4%	24.1%	0.815
Fall frequency Index (in fallers)	1.42±0.8	1.23±04	0.078	1.44±0.9	1.24±04	0.14





Cate-gories	PNP (n)	PD (n)	PNL (n)	Stroke (n)	Vert P (n)	other vasc (n)	Other n. D. (n)	Dem (n)	Epi (n)	Vertig (n)	Tinni-tus (n)	other MD (n)	Visual Dist (n)	Haed-ache (n)
V	1	2	0	0	0	0	0	0	0	0	0	0	0	0
IV	1	2	0	1	1	0	0	0	0	0	0	0	0	0
III	2	0	1	0	0	0	0	0	0	0	0	0	0	0
II	9	7	2	6	6	4	4	1	1	3	2	1	0	0
I	19	25	4	16	16	10	10	3	3	9	7	7	4	4

0	27	11	11	3	15	11	20	3	3	18	21	6	6	10
Total	**59**	**47**	**18**	**26**	**48**	**25**	**34**	**7**	**7**	**30**	**30**	**14**	**10**	**14**

Fig.1 Frequency of falls in neurological patients according to their neurological disorder. Fall Frequency Index (FFI) Category I = 1-2 falls in the last twelve months, Cagegory II = 3-5, Category III = 6-10, Category IV = 11-20, and Category V = more than 20.

Abbreviations: PNP = peripheral neuropathy, Periph. nerve les. = peripheral nerve lesion**,** other MD = other movement disorders, other vasc. d. = other vascular disease, Visual.Dist. = visual disturbances

One year fall incidence in common neurological disorders

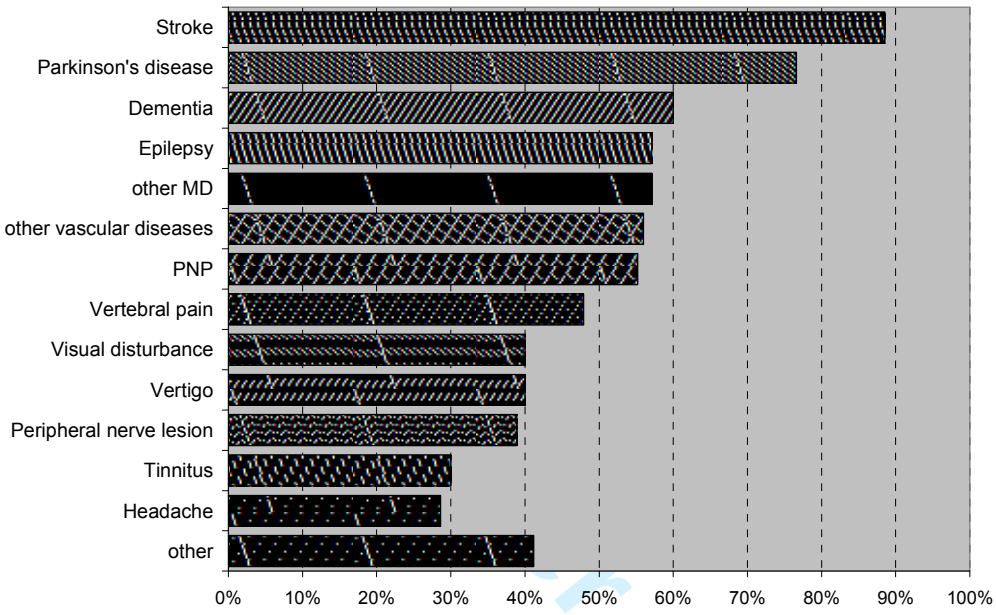


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

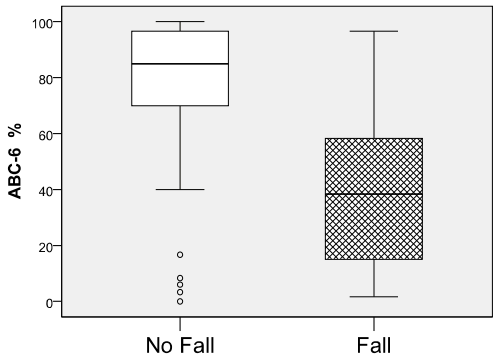
Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall frequency** (in fallers)	Risk of falling		
							OR	CI	p-value
Stroke	82,7±2,3	99,76	26	23 (89%)	7 (30%)	1,39±0,72	40,1	(11,3-141,7)	0.000
Parkinson D	74,8±8,1	99,79	47	36 (77%)	11 (31%)	1,58±1,13	17,1	(7,9-37,2)	0.000
Dementia	77,5±9,2	99,77	7	3 (60%)	1 (33%)	1,33±0,58	7,8	(1,3-48,9)	0.01
Epilepsy	71,0±8,2	99,78	7	4 (57%)	1 (25%)	1,25±0,5	7,0	(1,5-32,7)	0.005
other MD	74,3±7,9	100	14	8 (57%)	1 (13%)	1,23±0,82	7,0	(2,3-21,5)	0.000
other vasc. D	74,8±8,1	99,79	25	14 (56%)	4 (29%)	1,29±0,47	6,7	(2,8-16,0)	0.000
PNP	71,0±8,1	99,78	58	32 (55%)	13 (43%)	1,63±0,98	6,4	(3,4-12,3)	0.000
Vertebral Pain	76,8±9,1	99,75	48	23 (48%)	7 (30%)	1,39±0,72	4,8	(2,4-9,5)	0.000
Visual Disturb.	69,5±0,7	99,77	10	4 (40%)	0 (0%)	1±0	3,5	(0,9-13,1)	0.051
Vertigo	72,0±8,1	99,75	30	12 (40%)	3 (25%)	1,25±0,45	3,5	(1,5-8,0)	0.002
P. Nerve Les.	66,0±8,1	99,79	18	7 (39%)	3 (43%)	1,57±0,79	3,3	(1,2-9,2)	0.016
Tinnitus	74,3±8,4	99,76	30	9 (30%)	2 (22%)	1,22±0,44	2,2	(0,9 - 5,3)	0.064
Headache	74,8±8,1	99,79	14	4 (29%)	0 (0%)	1,0±0.0	2,1	(0,6-7,1)	0,228
Other	79,4±7,1	99,74	34	14 (41%)	4 (29%)	1,29±0,47	3,7	(1,7 - 8,0)	0.001

) Multiple falls were defined as more than two falls per year (i.e. a fall frequency index ≥2)*

**) Fall frequency index:. Category I = 1-2 falls in the last twelve months, Category II = 3-5 falls in the last twelve months, Category III = 6-10 falls in the last twelve months, Category IV = 11-20 falls in the last twelve months, and Category V = more than 20 falls in the last twelve months.

a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

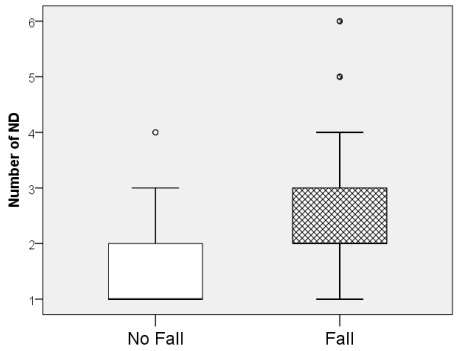


Fig.3a,b Differences in ABC-6 scores (3a) and number of neurological diseases (ND) (3b) of neurological patients with and without falls indicate that fallers as compared to non-fallers have lower confidence in their balance and a higher number of concomitant neurological diseases.

(ABC-6% meaning percentage scores of the 6-item version of the Activities-Specific Balance Confidence scale, number of ND meaning number of neurological diseases a patient is afflicted with)

STROBE checklist - observational studies

	Item No	Recommendation	
Title and abstract			
	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p1, p2 l12
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	P5 l12-20
Methods			
Study design	4	Present key elements of study design early in the paper	P5 l40 – p6 l27
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5 l32-37, p5 l42-47, p6 l17-21, p6 l22-26
Participants	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up*Case-control study*?Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls*Cross sectional study*?Give the eligibility criteria, and the sources and methods of selection of participants	P5 l42- p6 l15
		(*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case	P7 l4148
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6 l37-p7 l16
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P6 l37-p7 l16
Bias	9	Describe any efforts to address potential sources of bias	P13 l18-21, p7 l40-48
Study size	10	Explain how the study size was arrived at	P5 l46-47
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P7 l28-30
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P7 l31-53
		(*b*) Describe any methods used to examine subgroups and interactions	P7 l37-39
		(*c*) Explain how missing data were addressed	P7 l48-49
		(*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed*Case-control study*?If applicable, explain how matching of cases and controls was addressed*Cross sectional study*?If applicable, describe analytical methods taking account of sampling strategy	P13 l15-22
		(*e*) Describe any sensitivity analyses	P7 l35
Results			
Participants	13*	(*a*) Report numbers of individuals at each stage of study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P8 l4-29
		(*b*) Give reasons for non-participation at each stage	√p8 l4-29
		(*c*) Consider use of a flow diagram	-
Descriptive data	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P18
		(*b*) Indicate number of participants with missing data for each variable of interest	P8 l36-p9 l55
		(*c*) *Cohort study*?Summarise follow-up time (eg average and total amount)	P8 l38
Outcome data	15*	*Cohort study*?Report numbers of outcome events or summary measures over time	*n.a.*
		*Case-control study?*Report numbers in each exposure category, or summary measures of exposure	P8 l35 – p9 l55
		*Cross sectional study?*Report numbers of outcome events or summary measures	*n.a.*
Main results	16	(*a*) Report the numbers of individuals at each stage of the study?eg numbers	P8 l3-29

	Item No	Recommendation	
		potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(*b*) Give reasons for non-participation at each stage	P8 l3-29
		(*c*) Consider use of a flow diagram	-
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses	P9 l23-55
Discussion			
Key results	18	Summarise key results with reference to study objectives	P3 l25-37
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P12 l52 – p13 l36
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P13 l43- p14 l24
Generalisability	21	Discuss the generalisability (external validity) of the study results	P3 l50-53
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P14 l35-41