



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

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4 **The impact of various neurological disorders on the risk for falls in the**
5 **community dwelling elderly: a case controlled study**
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10 **Falls in the community dwelling elderly: the impact of neurological disorders**
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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 practitioners¹.

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 months² with 10% sustaining severe injuries³. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls⁴. 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 months⁵. 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 facility⁴. 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 system⁶. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs².

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly⁷. 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 elderly⁸. 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 undiagnosed⁹.

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 stroke¹⁰, Parkinson's disease¹¹ or dementia¹², 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 admission¹³. To date little is known about the risk of falling in

1 independent, community dwelling senior citizens afflicted with neurological diseases treatable in
2 outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they
3 did, the absence of neurological signs and symptoms in this cohort was not guaranteed.
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5 Because falls in community dwelling elderly patients are assumed to be both prevalent and
6 preventable, neurologists in outpatient settings need a sound base to identify patients with the
7 highest risk, to reduce not only the number of falls and the suffering they entail, but also overall
8 health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with
9 various neurological diseases that are commonly encountered in outpatient facilities. We
10 hypothesized that even in community dwelling elderly patients, the impact one or more
11 neurological diseases on top of an already increased propensity for falls is substantial; that patients
12 with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction
13 with more than one of these high risk diseases increases the risk even further.
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27 **PARTICIPANTS AND METHODS**

28 **Epidemiological and environmental bases**

29 Data were collected at the Department of Neurology of the University Hospital in Graz, Austria.
30 The Department of Neurology provides health care for about 500,000 people in Styria and southern
31 Burgenland, though mostly to inhabitants of Graz and the surrounding area. The department focuses
32 its basic and clinical research on cerebro-vascular disorders, dementia, epilepsy, movement
33 disorders and multiple sclerosis. At this teaching hospital, out of a total of 1565 beds, there are 92
34 neurological beds, including 8 in intensive care and 6 in the stroke unit. Out of approximately
35 22,600 neurological outpatient contacts recorded each year 4,600 are from the general outpatient
36 department, the rest in equal proportions from specialized outpatient clinics and the neurological
37 emergency room. Two out of five neurologists are in rotation on duty at the Neurology Outpatient
38 Clinic and they are attending to the patients on a random basis. As visits to the outpatient
39 department do not require specialist referrals, the disease spectrum largely resembles that seen by
40 community based neurologists.
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55 **Selection of participants and baseline examination**

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

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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.

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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.

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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.

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

45 46 **Frequency of falls**

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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.

54 55 **Analysis of Disability**

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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.

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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%) ($\text{Chi}^2=26,3$; $p < 0.001$). (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: $76,7 \pm 7,6$ vs. nonfallers: $72,6 \pm 7,5$; $p < 0.001$) and in healthy controls (fallers: $73,3 \pm 6,5$ vs. nonfallers: $71,0 \pm 6,9$; $p = 0.040$). In the group of neurological patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male ($\text{Chi}^2=8,675$; $p = 0.003$). 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 ($\text{Chi}^2=1,915$; $p = 0,166$).

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%).

1 The average fall frequency index in this group of patients with frequent falls ranged from 1,63
2 (peripheral neuropathy) to 1,33 (dementia) (Fig. 1.).
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9 **Risk factors for falls in neurological patients**

10 The type of neurological disease the patient was afflicted with influenced the frequency of falls in
11 that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%)
12 had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering
13 from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy
14 control (16,1%). (Fig. 2)
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20 The respective odds ratios are shown in table 2 and range from 40,1 (stroke) to 2,1 (headache) and
21 the relative risk of falling ranges between 5,5 for stroke patients and 1,8 for patients with headache.
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24 No specific combination of two or three neurological diseases characterized by substantial gait or
25 balance impairment but any accumulation of several neurological diseases regardless of their
26 influence on gait or balance was able to cause a significant raise in falls (Γ -B=0,303; $p<0.001$).
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29 Other risk factors for falls in neurological patients were female gender (Γ -B=0,195; $p=0.003$),
30 higher age (Γ -B=0,217; $p<0.001$), higher disability or disease severity as measured by the Barthel
31 Index (Γ -B=-0,232; $p<0.001$). Higher disability scores in Parkinson patients expressed by higher
32 UPDRS II (activities of daily living) scores resulted in a trend toward more frequent falls (Γ -B=-
33 0,238; $p=0.062$). Severity of depression as reflected by a higher ADS score (Γ -B=0,329; $p<0.001$)
34 and low balance confidence reflected by higher ABC scores (Γ -B=-0,384; $p<0.001$) were also
35 predictive (Fig. 3).
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48 **DISCUSSION**

49 **Incidence of falling**

50 Our study suggests that even in patients mildly to moderately affected by neurological impairments
51 the incidence of falls was three times higher than in subjects without any neurological symptoms or
52 signs. To our knowledge this is the first survey conducted on elderly neurological outpatients and
53 controls proven to be without neurological impairments, but the extent of this increased relative risk
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1 in neurological patients was unexpected, and resulted from low incidence figures in the group of
2 controls and particularly high figures in the patient group.
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5 In our group of healthy controls the 12-month incidence (16,1 %) was considerably lower than in
6 previous population based data serving as a reference for previous studies ²⁰. Literature suggests
7 that a third to one half of the community dwelling population of 60+ experience falls each year. For
8 a group of 1762 subjects 60+ years of age, Lord reported a yearly incidence rate of falls of 28% ²¹.
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10 In individuals of 65 years and older Prudham found in his survey conducted on 2793 individuals
11 that 28% experienced one or more falls in the last year ²². In O'Loughlin's group of 409 it was 29%
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13 ⁷, in Campbell's group of 533, 33% ²³, and in Blake's group of 1042, 35%. ²⁴ Luukinen's group of
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15 833 individuals aged 70+ showed a 30% annual rate of falls ³ and Tinetti's group of 336 aged 75+
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17 showed a rate of 32% ²⁵. For the very old, Campbell found in a community-based prospective study
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19 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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21 dence rate, twice or three times that of our figures, did not surprise us. Population-based data of el-
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23 derly individuals inevitably include a considerable number of patients suffering from neurological
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25 diseases or other forms of gait or balance problems. Many of these neurological disorders like
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27 stroke, Alzheimer's disease or Parkinson's disease are typical diseases of the elderly and others like
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29 epilepsy or traumatic brain injury also have a second peak in higher age ²⁷. This shows how im-
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31 portant it is, when studying groups of elderly patients, to have a truly healthy control group, as in
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33 our survey.

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35 Our study also shows that half of all ambulatory neurological patients had had at least one fall with-
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37 in the last 12 month. As to our knowledge this is the first survey of neurological outpatients, the
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39 lack of comparative data gave us no choice but to relate our findings to Stolze's data on neurologi-
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41 cal inpatients showing, much to our surprise, a falling incidence as low as 34% ¹³. One would have
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43 assumed that Stolze's patients, who required inpatient treatment for their neurological conditions,
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45 would be more severely disabled and thus more prone to falls than outpatients. It also appears con-
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47 tradictory our findings that indicators of disease severity like the Barthel index and the UPDRS cor-
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49 related positively with the incidence of falls. Several studies further support this concept by stating
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51 that the more severely affected patients are, the higher the falling risk ²⁸. However, we have reasons
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53 to believe that the correlation is not linear throughout all grades of disability but rather resembles an
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55 inverse U-shaped curve. We think that the initial propensity for falls increases with higher disability
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57 only up to a certain point. Then, as patients become more cautious and use all kind of supports, it
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59 plateaus and even decreases. When patients become so disabled that they are finally bedridden, the
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61 risk approaches zero with the lack of opportunities to fall. Our values so would be located on the
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63 inclining leg close to the peak and Stolze's further down on the declining leg. Since this concept is
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65 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 given²⁹ and 10% for community based seniors using home care services³⁰. 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 patients⁴² and another 13 out of 20 neuropathy patients (65%) had a propensity for recurrent falls for an average of 5,8 falls per year⁴⁰. 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

1 on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that
2 only accumulations of neurological deficits relating to gait and balance would influence the risk for
3 falls. Although there were no published studies on the influence of neurological diseases, it is
4 known that persons with an impaired sense of balance have an disproportionately higher risk for
5 falls when they acquire an additional new disease or condition, even if it is one that seems minor or
6 not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a
7 patient was suffering from was highly predicative of a risk to fall, better even than a mobility score.
8 She concluded that falling appears to result from an accumulated effect of multiple specific disabili-
9 ties⁴⁴. This would be in keeping with our other findings, that old age in combination with any neu-
10 rological disease increases the risk of falling above that of healthy controls, even if it is a disease
11 like headache. Also in accordance with this we found that a higher rate of depression, as reflected
12 by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be
13 that depressive thoughts are frequently combined with negative conceptions of one's own sense of
14 balance, which was found to be a prominent risk factor for falls in our and previous other studies⁴⁵.
15 That higher age would be a predictive factor for falls in neurological patients replicates previous
16 findings¹³ and is easy to explain: old age is often associated with greater frailty and eventually
17 frailty with less confidence in one's sense of balance and a higher incidence of falls⁴⁵. That females
18 are more prone to falls than males has often been stated before¹³ and has previously been explained
19 by a fear of falling and a loss of confidence – both independent risk factors for falls - being more
20 prominent in women⁶.

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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.

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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-

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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 injuries⁴⁶. 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

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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±0.4	0.078	1.44±0.9	1.24±0.4	0.14

Fall Frequency Index in neurological patients

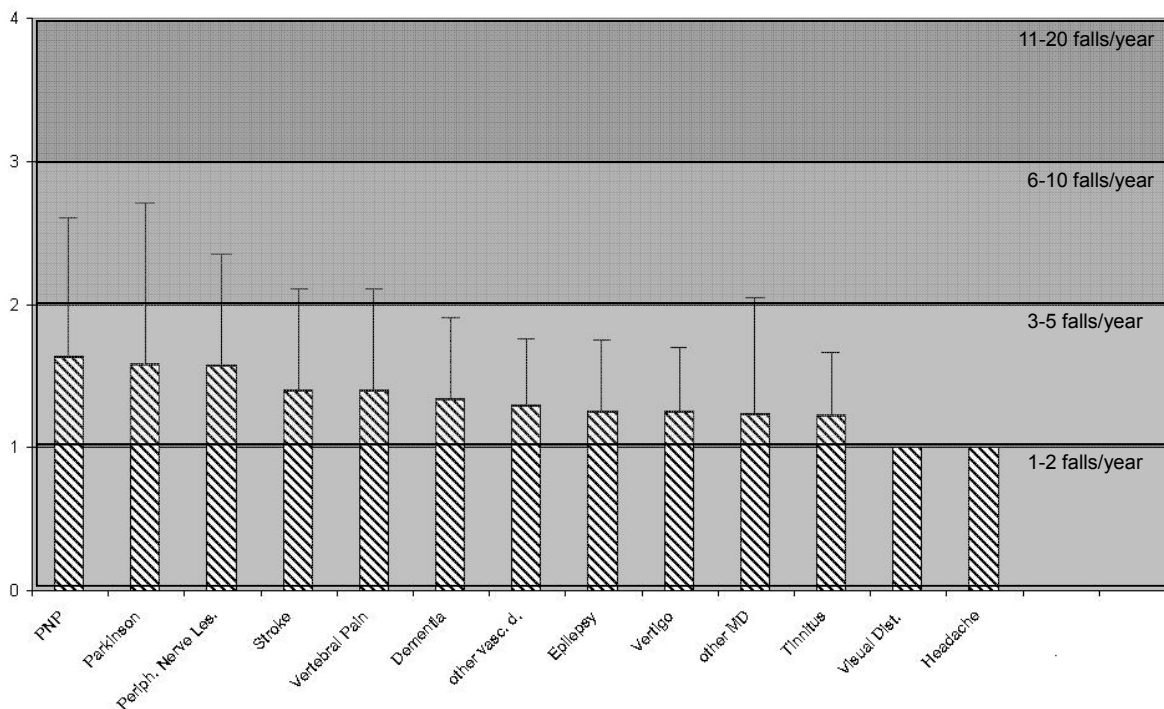


Fig.1 Frequency of falls in neurological patients according to their neurological disorder. 1=1-2 falls in the last twelve months, 2 = 3-5, 3 = 6-10, 4 = 11-20, and 5 = more than 20.

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

One year fall incidence in common neurological disorders

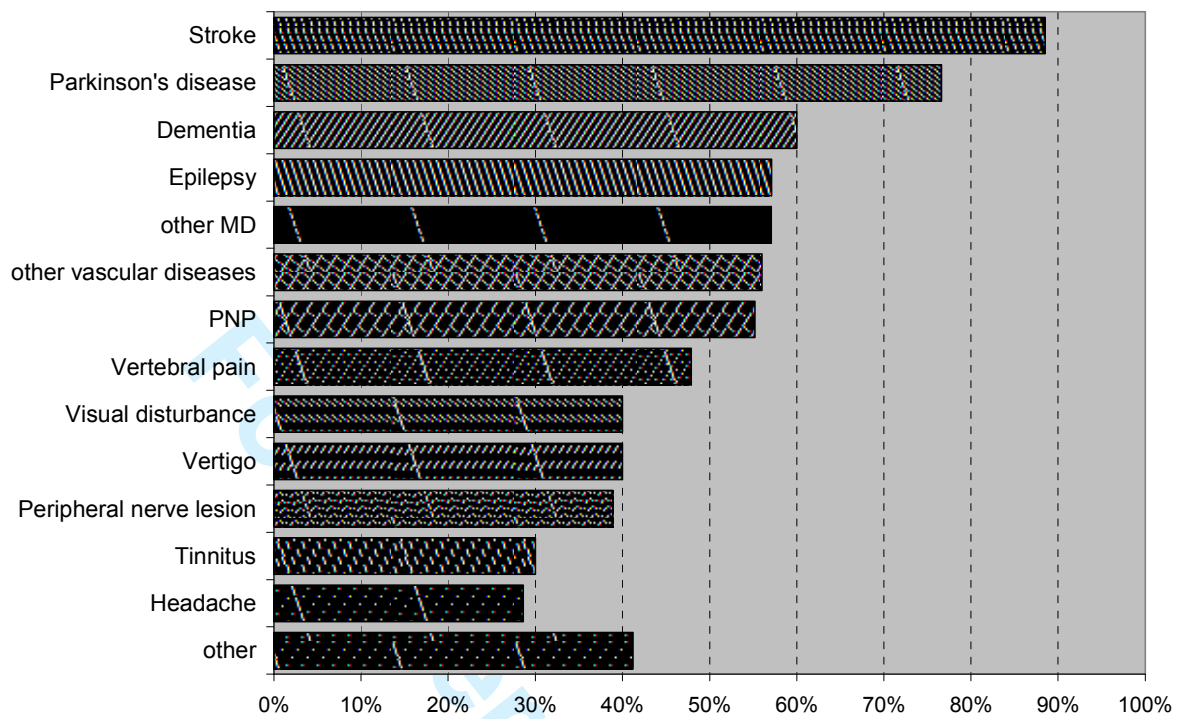


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

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

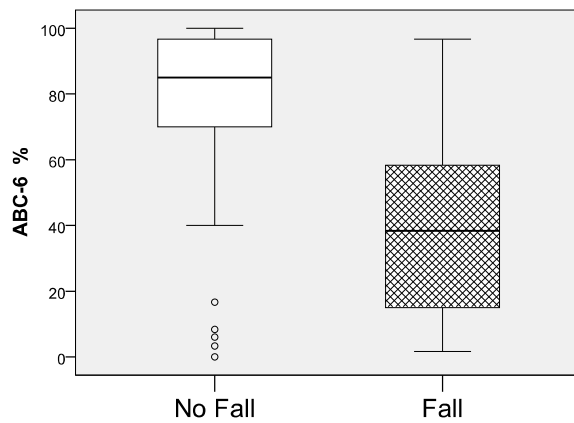
Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls (n (%))	Fall fre- quency* (in fallers)	Risk of falling		
							OR	CI	p-value
Stroke	82,7±2,3	99,76	26	23 (89%)	7 (30%)	1,39±0,72	40,1	(11,3-141,7)	0.000
Parkinson D	74,8±8,1	99,79	47	36 (77%)	11 (31%)	1,58±1,13	17,1	(7,9-37,2)	0.000
Dementia	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.

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a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

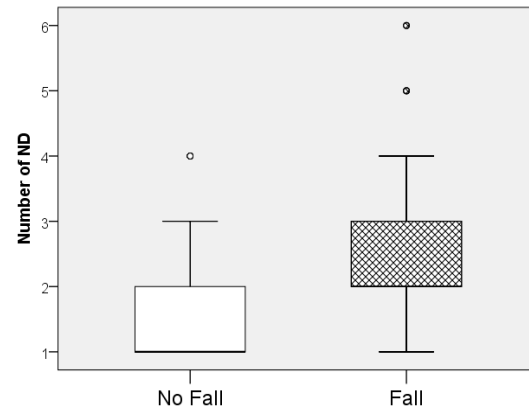


Fig.3a,b Differences in Activities-Specific Balance Confidence (ABC) scores (a) and number of neurological diseases (ND) (b) indicate that neurological patients with falls as compared to those without have lower confidence in their balance and a higher number of concomitant neurological diseases.

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) <i>Cohort study</i> ? Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> ? 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 <i>Cross sectional study</i> ? Give the eligibility criteria, and the sources and methods of selection of participants	√
		(b) <i>Cohort study</i> ? For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> ? 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) <i>Cohort study</i> ? If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> ? If applicable, explain how matching of cases and controls was addressed <i>Cross sectional study</i> ? 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) <i>Cohort study</i> ? Summarise follow-up time (eg average and total amount)	√
Outcome data	15*	<i>Cohort study</i> ? Report numbers of outcome events or summary measures over time	<i>n.a.</i>
		<i>Case-control study</i> ? Report numbers in each exposure category, or summary measures of exposure	√
		<i>Cross sectional study</i> ? Report numbers of outcome events or summary measures	<i>n.a.</i>
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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Primary Subject Heading:	Neurology
Secondary Subject Heading:	Geriatric medicine, Public health, Neurology
Keywords:	Falls, fall risk, elderly, community dwelling, neurological disorders

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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 practitioners¹.

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 months² with 10% sustaining severe injuries³. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls⁴. 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 months⁵. 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 facility⁴. 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 system⁶. 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 repeatedly⁷. 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 elderly⁸. 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 undiagnosed⁹.

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 stroke¹⁰, Parkinson's disease¹¹ or dementia¹² 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 admission¹³. To date little is known about the risk of falling in

1 independent, community dwelling senior citizens afflicted with neurological diseases treatable in
2 outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they
3 did, the absence of neurological signs and symptoms in this cohort was not guaranteed.
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5 Because falls in community dwelling elderly patients are assumed to be both prevalent and
6 preventable, neurologists in outpatient settings need a sound base to identify patients with the
7 highest risk, to reduce not only the number of falls and the suffering they entail, but also overall
8 health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with
9 various neurological diseases that are commonly encountered in outpatient facilities. We
10 hypothesized that even in community dwelling elderly patients, the impact one or more
11 neurological diseases on top of an already increased propensity for falls is substantial; that patients
12 with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction
13 with more than one of these high risk diseases increases the risk even further.
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27 **PARTICIPANTS AND METHODS**

28 **Setting**

29 Data were collected at the general outpatient department of the Department of Neurology of the
30 University Hospital in Graz, Austria. As visits to the outpatient department do not require specialist
31 referrals, the disease spectrum largely resembles that seen by community based neurologists.
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40 **Selection of participants and baseline examination**

41 Physically independent community dwelling patients treated in our general neurological outpatient
42 clinic aged 60 years and over were included in the study. Patients were all seen consecutively by
43 one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains
44 the study size. Severely disabled patients who were no longer able to walk unaided or were in poor
45 general condition, be it for reasons of neurological or other medical disease, were excluded from the
46 study. Cognitive impairment to an extent that an interview would no longer yield reliable results
47 (MMSE \leq 12), was also a cause for exclusion. All neurological patients included underwent a full
48 neurological workup with an extensive history to detect signs of past and present neurological
49 disorders. For the sake of uniformity, both the workup and history were structured and followed the
50 study protocol.
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58 As healthy controls, individuals from the general public out of the same catchment area as cases
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1 were enrolled. They were recruited among friends and acquaintances of the author and his co-
2 workers who were aged 60+ and without any history of neurological disorders or other disabling
3 medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis
4 severe enough to cause limitation of ordinary physical activity. Examination and history were as per
5 study protocol, whereby special emphasis was placed on identifying symptoms and signs of
6 Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor
7 deficits and gait or balance impairments. Controls with even subtle neurological pathologies were
8 excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known
9 diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

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

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

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

21 **Frequency of falls**

22 In the main section of the questionnaire patients and healthy controls were asked whether they had
23 had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall
24 incidence was graded according to the fall frequency index into 5 categories. Category one means
25 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

26 **Disability**

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

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

31 **Depression**

32 To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) ¹⁶, the
33 German short form of the Center of Epidemiological Studies Depression Scale (CES-D) ¹⁷ was
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1 used. It is known to be particularly well suited for the use in the elderly and in patients with certain
2 neurological disabilities¹⁸.
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5 6 7 **Balance Confidence**

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9 We also rated the patients' confidence in their own sense of balance with the Activities-Specific
10 Balance Confidence Scale (ABC -6 scale)¹⁹. Participants judged their confidence in performing
11 specific activities without loss of balance or being unsteady on a scale ranging from 0% (no
12 confidence at all) to 100% (completely confident). The total score was then computed as an average
13 of the subscores.
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18 19 **Statistical analysis**

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21 The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were
22 defined according to the WHO definition¹ as an event which results in a person coming to rest
23 inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g.
24 falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly
25 individuals and the whole sample of neurological patients. Further calculations were done for
26 subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were
27 based on the ICD-10 system for classification of diseases. The means and standard deviations were
28 calculated for numerical values like the rating scale scores. For the identification of fall related risk
29 factors, correlations (Kendall's τ -B), and for the individual neurological disorders, odds ratios were
30 computed (α -level of significance $p < 0.05$). Differences between neurological patients and healthy
31 controls were tested with the Mann-Whitney U test or the chi-square test (α -levels of significance p
32 < 0.05). To insure comparability of cohorts we formed age- and gender-matched pairs of patients
33 and control subjects. For the matching process we used alphabetical lists of names of male and
34 female neurological patients and likewise of healthy controls, sorted by age. Then working down
35 the list we searched manually to find for each neurological patient one control subject of the same
36 age. If no match was found then we looked for a control that was one year younger, then one year
37 older, then two years and finally three years younger respectively older. Only complete sets of data
38 were included in the calculations and no approximates to replace missing values were computed.
39 Calculations were performed with SPSS® statistical software PASW statistics 18. Potential bias
40 and how it was addressed will be dealt with in the section on limitations.
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58 **RESULTS**

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

11
12 Prior to recruitment, twenty patients were excluded because of inability to walk unaided and one
13 due to severe dementia. Of those that met inclusion criteria five rejected enrolment and six other
14 patients could not be enrolled due to inadequate language skills (n=1), severe aphasia (n=1), or
15 severe presbycusis (n=4).

16
17 The statistical analysis thus covered 228 neurological outpatients (aged 74.5 ± 7.8 ; 61% women)
18 and 193 healthy controls. The matching process led to 171 pairs of neurological patients and
19 healthy controls, 101 women and 70 men in each group, aged 72.0 and 72.2 years, respectively. The
20 details of these subjects are summarized in Table 1.

21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 **Incidence of falls in neurological patients and healthy controls**

36 One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen
37 at least once ($\text{Chi}^2=43.4$; $p < 0.001$) during this one-year period. Out of 126 neurological patients
38 experiencing falls, 76 (71.7%) fell once or twice, 22 (20.8%) three to five times, three (2.8%) six to
39 nine times, three (2.8%) 11-20 times and two (1.9%) more than 20 times. In the group of healthy
40 controls, out of 76 individuals with a history of falls, 24 (77.4%) fell once or twice, and seven
41 (22.6%) three to five times, but none more often than that. In the matched cohorts as well falls were
42 more frequent in neurological patients (42.1%) than in healthy controls (16.9%) ($\text{Chi}^2=26.3$;
43 $p < 0.001$). (Table 1)

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

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

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

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

24 The type of neurological disease the patient was afflicted with influenced the proportion of fallers in
25 that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%)
26 had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering
27 from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy
28 control (16.1%). (Fig. 2)
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36 The respective odds ratios are shown in table 2 and range from 40.1 (stroke) to 2.1 (headache) and
37 the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.

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

41 Other risk factors for falls in neurological patients were female gender ($\Gamma\text{-B}=0.195$; $p=0.003$),
42 higher age ($\Gamma\text{-B}=0.217$; $p<0.001$), higher disability or disease severity as measured by the Barthel
43 Index ($\Gamma\text{-B}=-0.232$; $p<0.001$). Higher disability scores in Parkinson patients expressed by higher
44 UPDRS II (activities of daily living) scores ($\Gamma\text{-B}=-0.238$; $p=0.062$) and higher Schwab & England
45 scores ($\Gamma\text{-B}=-0.235$; $p=0.070$) resulted in a trend toward more frequent falls. Severity of depression
46 as reflected by a higher ADS score ($\Gamma\text{-B}=0.329$; $p<0.001$) and low balance confidence reflected by
47 higher ABC scores ($\Gamma\text{-B}=-0.384$; $p<0.001$) were also identified as risk factors (Fig. 3).
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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 studies²⁰. 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 year²². 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 falls³ 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 year²⁶. 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 age²⁷. 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-

1 ing that the more severely affected patients are, the higher the falling risk²⁸. However, we have rea-
2 sons to believe that the correlation is not linear throughout all grades of disability but rather resem-
3 bles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher
4 disability only up to a certain point. Then, as patients become more cautious and use all kind of
5 supports, it plateaus and even decreases. When patients become so disabled that they are finally
6 bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be
7 located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since
8 this concept is not yet backed up by sound evidence, further studies directly comparing the risk of
9 falling in neurological inpatients and outpatients of various grades of disability are needed to sup-
10 port this assumption.

11 Considering recurrent falls we found that in the group of neurological patients 13.2 % fell three or
12 more times per year, compared to 3.6% in the group of healthy controls. This is in keeping with the
13 results of studies investigating recurrent falls, where figures of 8% for three or more falls in ran-
14 domly selected community dwelling elderly individuals are given²⁹ and 10% for community based
15 seniors using home care services³⁰. In Stolze's cohort of inpatients the value of 21% for recurrent
16 falls was higher and can probably be explained by methodological differences. Stolze's category of
17 recurrent falls already includes patients who had fallen twice, unlike our and other studies^{29,30} that
18 include patients only after more than three falls.

33 **Risk factors contributing to falls**

34 We found out that the type of neurological disease afflicting a patient determines the potential risk
35 factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson pa-
36 tients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with
37 previous community based studies showing a high likelihood for falls in stroke patients with a range
38 of 51-73%^{10,20,31} and in Parkinson's patients with a range of 38 – 87%³²⁻³⁸. This was followed by
39 a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consist-
40 ing of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neu-
41 ropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-
42 80%^{12,39} in Alzheimer patients and 55-65%⁴⁰⁻⁴² in patients with peripheral neuropathy. The only
43 study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents,
44 providing a 5-year fall incidence of 83%⁴³. In our sample peripheral neuropathy also proved to be a
45 risk factor for recurrent falls, but most likely significance was not reached due to the small sample
46 size (p=0.061). Confirmative data also obtained from small cohorts revealed that repetitive falls oc-
47 curred in 10 out of 25 (40%) neuropathy patients⁴² and another 13 out of 20 neuropathy patients
48 (65%) had a propensity for recurrent falls for an average of 5.8 falls per year⁴⁰. New and quite
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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 disabilities⁴⁴. 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 studies⁴⁵. That higher age would be a predictive factor for falls in neurological patients replicates previous findings¹³ 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 falls⁴⁵. That females are more prone to falls than males has often been stated before¹³ 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 women⁶.

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

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

9 Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing
10 the 3,6% that had to be excluded prior to recruitment due to inability or unwillingness to participate
11 could have lead to further underestimating the number of patients with falls. However, since these
12 patients did not obviously differ in their baseline characteristics, we assume this problem to be
13 minimal.
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15 Then, we would also like to address the issue of small sample sizes in subgroups of neurological
16 diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and
17 peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies
18 like those on peripheral neuropathy ^{40, 42}. Others, particularly the dementia group with only seven
19 patients, is, due to the exclusion of the more affected, quite small and allows only limited
20 extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels
21 of significance.
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25 CONCLUSION

26 It can be said that we managed to show, apparently for the first time, that even among
27 ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is
28 multi-factorial, but the connection between falls and disturbances of the sensorimotor
29 system frequently found in neurological diseases in elderly patients is of great importance.
30 Our findings revealed that even neurological diseases not directly connected with gait and
31 balance carry an astonishingly high risk for falls. Neurologists should therefore be aware
32 that their patients are at high risk for falls, as any neurological deficit increases this risk,
33 even more so if a combination of factors is present. Of course the risk has to be evaluated
34 individually, but patients with central diseases like stroke, Parkinson's disease, dementia and
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2 epilepsy, and for repeated falls also patients with peripheral neurological disorders, require
3 special attention. Greater disability, higher age, female gender, depression and low
4 confidence in the sense of balance are additional contributory factors that have to be taken
5 into account in this process. For patients with several of these factors, targeted prevention
6 programs should be implemented. However, although they have been shown to generally
7 reduce falls and injuries in the community dwelling elderly⁴⁸, there is but inconclusive
8 evidence for patients following stroke⁴⁹ and with PD^{50,51} and even more scanty information
9 for patients with other neurological diseases. Therefore further larger scale multicenter
10 neuro-geriatric surveys with larger sample sizes for neurological subgroups should be
11 performed not only to confirm our observations but to acquire more extensive knowledge of
12 the effectiveness of preventive measures in patient cohorts with various neurological
13 conditions and different degrees of disability. These studies should also include more
14 objective monitoring systems and include further potential risk factors like medication and
15 fear of falling.
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NOTES

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33
34 Funding and Competing interests: All authors have completed the Unified Competing Interest form
35 and declare: no support from any organisation for the submitted work; no financial relationships
36 with any organisations that might have an interest in the submitted work in the previous three years;
37 and no other relationships or activities that could appear to have influenced the submitted work.
38 Thus, neither the study nor the salary of participants was funded by any third party.
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43 Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz
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46 Patient consent: obtained
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49 Contributorship: B. H.: drafting/revising the manuscript, study concept or design, analysis or
50 interpretation of data; A. P.: analysis or interpretation of data, acquisition of data of patients and
51 controls, study concept or design; M. G.: analysis or interpretation of data, acquisition of data of
52 patients and controls, study concept or design; A.H. acquisition of data of patients and controls; T.
53 G.: acquisition of data, study concept or design, G. I.: critical revision of the manuscript for
54 important intellectual content; E. H.: statistical analysis , analysis or interpretation of data, study
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2 concept or design; G.I.: drafting/revising the manuscript, study concept or design, critical revision
3 of the manuscript for important intellectual content; F. F.: drafting/revising the manuscript, study
4 concept or design, critical revision of the manuscript for important intellectual content; C. N. H.:
5 drafting/revising the manuscript, study concept or design, acquisition of data, study supervision.
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10 **Data sharing:** An additional section of the questionnaire dealt with specific risk situations when
11 using public transport, fear of falling in these situations, and general mobility issues. These issues
12 are not directly related to the present investigation and are planned, once the analysis is completed,
13 to be included in a separate publication.
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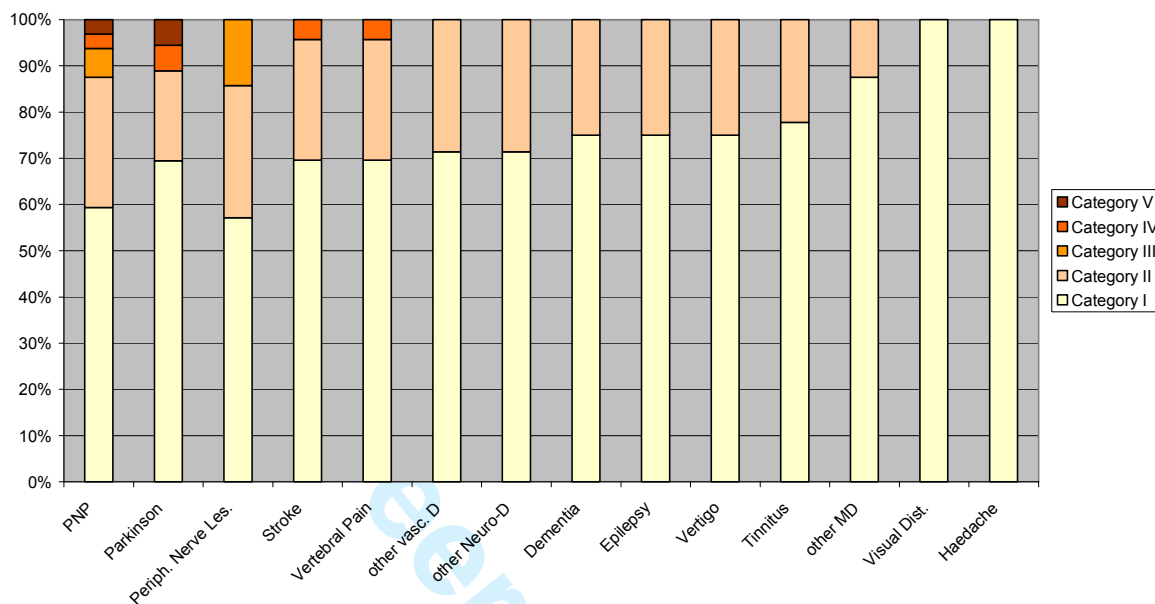
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TABLES AND FIGURES

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±0.4	0.078	1.44±0.9	1.24±0.4	0.14

Percentage of multifallers in various Neurological Diseases according to FFI categories



Cate-gories	PNP (n)	PD (n)	PNL (n)	Strok e (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, Category 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

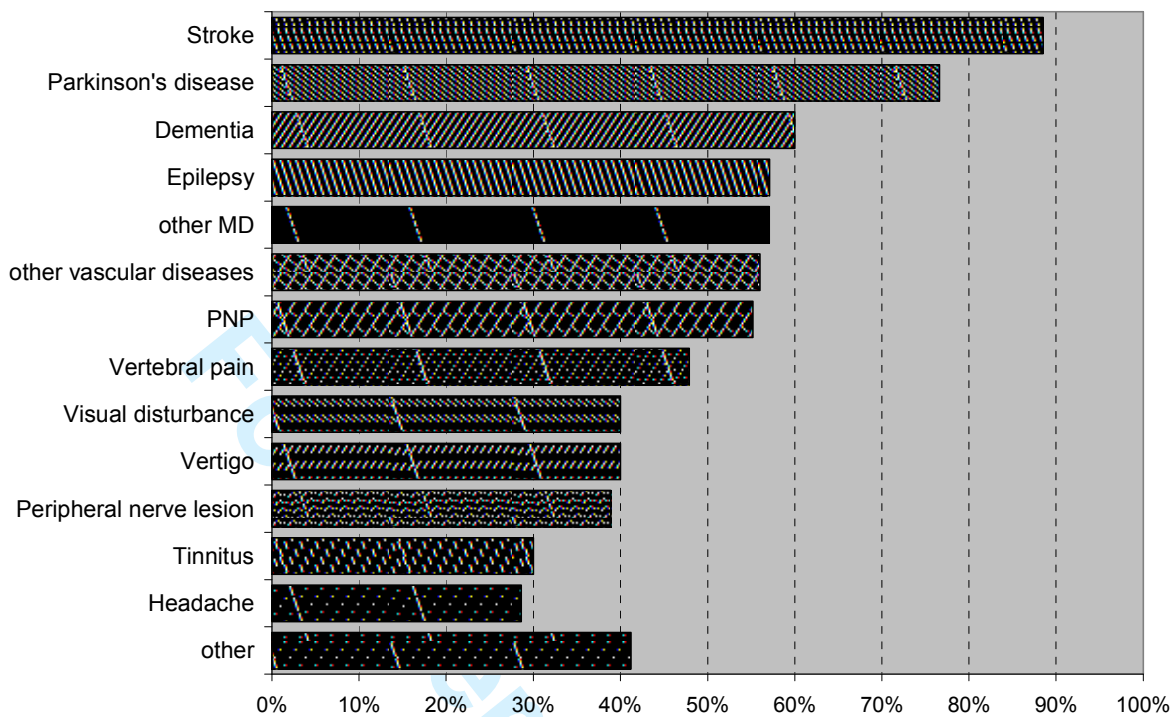


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

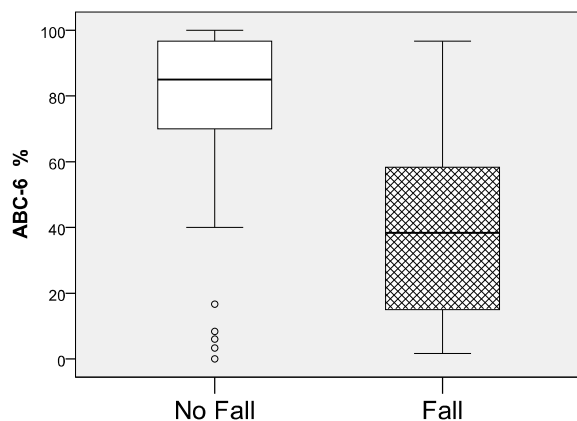
Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall fre- quency** (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

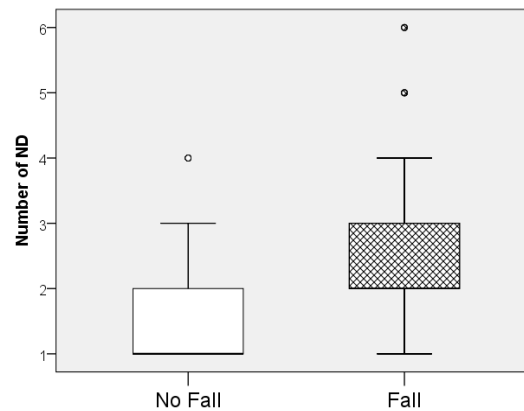


Fig.3a,b Differences in ABC-6 scores (3a) and number of neurological diseases (ND) (3b) of neurological patients with and without falls indicate that fallers as compared to non-fallers have lower confidence in their balance and a higher number of concomitant neurological diseases.

(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 (b) Provide in the abstract an informative and balanced summary of what was done and what was found	p1, p2 I12 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 I12-20
Methods			
Study design	4	Present key elements of study design early in the paper	P5 I40 – p6 I27
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5 I32-37, p5 I42-47, p6 I17-21, p6 I22-26
Participants	6	(a) <i>Cohort study</i> ? Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> ? 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 <i>Cross sectional study</i> ? Give the eligibility criteria, and the sources and methods of selection of participants	P5 I42- p6 I15
		(b) <i>Cohort study</i> ? For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> ? For matched studies, give matching criteria and the number of controls per case	P7 I4 I48
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6 I37-p7 I16
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 I37-p7 I16
Bias	9	Describe any efforts to address potential sources of bias	P13 I18-21, p7 I40-48
Study size	10	Explain how the study size was arrived at	P5 I46-47
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P7 I28-30
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	P7 I31-53
		(b) Describe any methods used to examine subgroups and interactions	P7 I37-39
		(c) Explain how missing data were addressed	P7 I48-49
		(d) <i>Cohort study</i> ? If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> ? If applicable, explain how matching of cases and controls was addressed <i>Cross sectional study</i> ? If applicable, describe analytical methods taking account of sampling strategy	P13 I15-22
		(e) Describe any sensitivity analyses	P7 I35
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 I4-29
		(b) Give reasons for non-participation at each stage	√p8 I4-29
		(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 I36-p9 I55
		(c) <i>Cohort study</i> ? Summarise follow-up time (eg average and total amount)	P8 I38
Outcome data	15*	<i>Cohort study</i> ? Report numbers of outcome events or summary measures over time	n.a.
		<i>Case-control study</i> ? Report numbers in each exposure category, or summary measures of exposure	P8 I35 – p9 I55
		<i>Cross sectional study</i> ? 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 I3-29

	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 I3-29
		(c) Consider use of a flow diagram	-
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses	P9 I23-55
Discussion			
Key results	18	Summarise key results with reference to study objectives	P3 I25-37
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 I52 – p13 I36
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P13 I43- p14 I24
Generalisability	21	Discuss the generalisability (external validity) of the study results	P3 I50-53
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 I35-41

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

Homann, Barbara¹; Plaschg, Annemarie¹; Grundner, Marion¹; Griedl, Theresa¹; Ivanic, Gerd²;
Hofer, Edith¹; Fazekas, Franz¹; Homann, Carl Nikolaus¹

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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 groups. 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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6 | ~~pairments~~ suggest that neurological impairments ~~these conditions~~ further increase the risk
7 for falls.

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9 • However, little is known on the influence of a broad range of neurological diseases and how
10 they differ among each other. ~~No data is available on independent community dwelling senior~~
11 ~~citizens.~~
12
13 • The aim of this study is to provide comparative data on the risk of falling in ambulatory el-
14 derly subjects afflicted with various common neurological diseases and to evaluate the role
15 of additional risk factors.
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18 19 *Key messages*

- 20 • The results of our study suggest that all elderly neurological patients even when still ambu-
21 latory carry a heightened risk for falls.
22
23 • The impact differs according to disease but those with impairments of the sensorimotor sys-
24 tem are particularly endangered. However our findings investigating yet unstudied popu-
25 lations, eg, such as headache revealed that even neurological disorders not directly connect-
26 ed with gait and balance carry an astonishingly unexpected high risk for falls and that there
27 is a cumulative effect of more than one neurological condition on the risk of falls.
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31 32 *Strengths and limitations of this study*

- 33 • Strengths of this study include the prospective study design, the number of standardised out-
34 come measures, the standardised assessment of neurological patients and the thorough ex-
35 amination and inclusion of healthy controls.
36
37 • The following limitations should be considered: although the design is prospective, the
38 falls history is retrospective, based on patients' recall over 12 months, therefore the infor-
39 mation on falls was self reported and underreporting of cases is possible. Small sample sizes
40 in some of the subgroups of neurological diseases. Participants were mostly of Caucasian
41 origin and there was a high drop-out rate, which may limit the generalisability of the results
42 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 practitioners¹.

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 months²⁻³ with 10% sustaining severe injuries³. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls⁴. 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 months⁵. 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 facility⁴. 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 system⁶. But there is substantial evidence that falls can be prevented when subjects at risk are identified and enrolled in targeted prevention programs⁷.

Several risk factors like sociodemographic variables, physical activity, alcohol consumption, acute and chronic health problems, dizziness, mobility, and medications have been documented repeatedly⁷. 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 elderly⁸. 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 undiagnosed⁹.

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~~ stroke¹⁰, Parkinson's disease¹¹ or dementia¹² population, but to our knowledge there is only one comparative study investigating falls in patients with of a broad range of different neurological diseases. This study by Stolze, however, was conducted on patients

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6 with neurological diseases severe enough to require hospital admission¹³. To date little is known
7 about the risk of falling in independent, community dwelling senior citizens afflicted with
8 neurological diseases treatable in outpatient facilities. Studies targeting this issue so far either did
9 not use a control group or, if they did, the absence of neurological signs and symptoms in this
10 cohort was not guaranteed.

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

31 Epidemiological and environmental basesSetting

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35 Data were collected at the general outpatient department of the Department of Neurology of the
36 University Hospital in Graz, Austria. ~~The Department of Neurology provides health care for about~~
37 ~~500,000 people in Styria and southern Burgenland, though mostly to inhabitants of Graz and the~~
38 ~~surrounding area. The department focuses its basic and clinical research on cerebrovascular~~
39 ~~disorders, dementia, epilepsy, movement disorders and multiple sclerosis. At this teaching hospital,~~
40 ~~out of a total of 1565 beds, there are 92 neurological beds, including 8 in intensive care and 6 in the~~
41 ~~stroke unit. Out of approximately 22,600 neurological outpatient contacts recorded each year 4,600~~
42 ~~are from the general outpatient department, the rest in equal proportions from specialized outpatient~~
43 ~~clinics and the neurological emergency room. Two out of five neurologists are in rotation on duty~~
44 ~~at the Neurology Outpatient Clinic and they are attending to the patients on a random basis. As~~
45 visits to the outpatient department do not require specialist referrals, the disease spectrum largely
46 resembles that seen by community based neurologists.
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53 Selection of participants and baseline examination

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

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

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

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

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

52 53 **Frequency of falls**

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

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6 had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall
7 incidence was graded according to the fall frequency index into 5 categories. Category one means
8 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

11 **Analysis of Disability**

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

14 Parkinson patients were also rated according to the ~~modified Hoehn and Yahr Scale~~, the Schwab
15 and England Scale and Part II of the Unified Parkinson's Disease Rating Scale (UPDRS) ¹⁵.

19 **Analysis of Depression**

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

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

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

38 **Statistical analysis**

39 The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were
40 defined according to the WHO definition ¹ as an event which results in a person coming to rest
41 inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g.
42 falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly
43 individuals and the whole sample of neurological patients. Further calculations were done for
44 subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were
45 based on the ICD-10 system for classification of diseases. The means and standard deviations were
46 calculated for numerical values like the rating scale scores. For the identification of fall related risk
47 factors, correlations (Kendall's τ -B), and for the individual neurological disorders, ~~risk~~ odds ratios
48 were computed (α -level of significance $p < 0.05$). Differences between neurological patients and
49 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 ($n=1045\%$) or their caregiver ($n=69\%$) requested exclusion, the telephone number on record had been disconnected ($n=2434\%$), all attempts to contact them failed ($n=1146\%$), they had become so disabled that they could no longer participate in the survey ($n=1045\%$), they had died ($n=45\%$), or for other reasons ($n=58\%$).

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 presbycusis ($n=4$).

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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 ($\text{Chi}^2=43.4$; $p < 0.001$) 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%) ($\text{Chi}^2=26.3$; $p < 0.001$). (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 ($\text{Chi}^2=8.675$; $p = 0.003$). 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 ($\text{Chi}^2=1.915$; $p = 0.166$).

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 ($\Gamma\text{-B}=0.217$; $p < 0.001$).

~~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 (peripheral 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 studies²⁰. 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 year²². 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 falls³ 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 year²⁶. 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 age²⁷. 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 risk²⁸. 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 given²⁹ and 10% for community based seniors using home care services³⁰. 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

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6 We found out that the type of neurological disease afflicting a patient determines the potential risk
7 factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson pa-
8 tients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with
9 previous community based studies showing a high likelihood for falls in stroke patients with a range
10 of 51-73%^{10, 20, 31} and in Parkinson's patients with a range of 38 – 87%³²⁻³⁸. This was followed by
11 a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consist-
12 ing of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neu-
13 ropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-
14 80%^{12, 39} in Alzheimer patients and 55-65%⁴⁰⁻⁴² in patients with peripheral neuropathy. The only
15 study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents,
16 providing a 5-year fall incidence of 83%⁴³. In our sample peripheral neuropathy also proved to be a
17 risk factor for recurrent falls, but most likely significance was not reached due to the small sample
18 size (p=0.061). Confirmative data also obtained from small cohorts revealed that repetitive falls oc-
19 curred in 10 out of 25 (40%) neuropathy patients⁴² and another 13 out of 20 neuropathy patients
20 (65%) had a propensity for recurrent falls for an average of 5.8 falls per year⁴⁰. New and quite
21 astonishing was the fact that even patients suffering from neurological diseases with no direct influ-
22 ence on gait or balance like headache (28%) had almost twice as many falls as the average healthy
23 control (16.1%). Also new is that in contrast to all the above cited data derived from studies on pa-
24 tients with only one neurological disorder, our survey provides comparative values for several neu-
25 rological diseases of elderly ambulatory neurological patients for the first time, allowing a direct
26 comparison between these disorders and a ranking according to the risk of falling.

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36 But our findings further suggest that not only the type of neurological conditions, but also the num-
37 ber of neurological diseases a patient was suffering from, no matter whether they had an influence
38 on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that
39 only accumulations of neurological deficits relating to gait and balance would influence the risk for
40 falls. Although there were no published studies on the influence of neurological diseases, it is
41 known that persons with an impaired sense of balance have an disproportionately higher risk for
42 falls when they acquire an additional new disease or condition, even if it is one that seems minor or
43 not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a
44 patient was suffering from was highly predicative of a risk to fall, better even than a mobility score.
45 She concluded that falling appears to result from an accumulated effect of multiple specific disabili-
46 ties⁴⁴. This would be in keeping with our other findings, that old age in combination with any neu-
47 rological disease increases the risk of falling above that of healthy controls, even if it is a disease
48 like headache. Also in accordance with this we found that a higher rate of depression, as reflected
49 by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be

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

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23 We also faced several limitations in our study. First and most importantly, like most other surveys
24 dealing with falls, we faced the problem that the number of falls is underreported. Elderly subjects
25 often try to downplay problems regarding their mobility for fear of having their autonomy
26 restricted. While this is in general typically found in the healthy elderly, it might be even more
27 prominent in patients with disabilities. But even remembering these events might pose a problem in
28 some of the patients with central degenerative diseases and this might have been a relevant factor in
29 our study, even though we excluded patients with severe dementia. The risk for falls in neurological
30 patients might therefore be greater than shown in any results. Future prospective studies could
31 minimize this problem by using patients diaries according to established guidelines for reporting
32 falls ⁴⁶ possibly even in combination with wearable miniaturized electronic devices apt to
33 objectively detect and monitor falls ⁴⁷.
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39 Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing
40 the 3.6% that had to be excluded prior to recruitment due to inability or unwillingness to participate
41 almost one quarter of neurological patients were lost for follow up, which could have lead to further
42 underestimating the number of patients with falls. However, since these patients did not obviously
43 differ in their baseline characteristics, we assume this problem to be minimal.
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46 ~~Thirdly, elderly subjects without even the slightest neurological symptoms are hard to find and~~
47 ~~therefore the use of a cohort of this rare group of supranormal individuals as a reference group~~
48 ~~might not be representative. The patient cohort we examined was a group of neurological patients~~
49 ~~who were mobile and affected by only mild to moderate neurological symptoms. This group of~~
50 ~~elderly patients, of the kind typically seen in neurological practice, also accounts for only a part of~~
51 ~~neurological patients and generally performs much better than the large segment of more severely~~
52 ~~affected patients placed in institutions. But to highlight the impact of even mild impairment on falls,~~
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~~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 carersNeurologists 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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6 repeated falls also patients with peripheral neurological disorders, require special attention.
7 Greater disability, higher age, female gender, depression and low confidence in the sense of
8 balance are additional contributory factors that have to be taken into account in this process.
9 For patients with several of these factors, targeted prevention programs should be
10 implemented, ~~because~~ ~~However, although~~ they have been shown to generally reduce falls
11 and injuries ~~in the community dwelling elderly~~⁴⁸, ~~there is but inconclusive evidence for~~
12 ~~patients following stroke~~⁴⁹ ~~and with PD~~^{50, 51} ~~and even more scanty information for patients~~
13 ~~with other neurological diseases.~~ ~~Therefore~~ ~~Due to the prevalence of falls and the personal~~
14 ~~and social impact they have on the lives of many, it seems important that~~ further larger scale
15 multicenter neuro-geriatric surveys with larger sample sizes for neurological subgroups
16 should be performed ~~not only to confirm our observations~~ ~~and but to~~ acquire more
17 extensive knowledge of the effectiveness of preventive measures in patient cohorts with
18 various neurological conditions and different degrees of disability. These studies should also
19 include more objective monitoring systems and include further potential risk factors like
20 medication and fear of falling.
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NOTES

33 Acknowledgements: We acknowledge the study participants for their help and participation.

34 Funding and Competing interests: All authors have completed the Unified Competing Interest form
35 and declare: no support from any organisation for the submitted work; no financial relationships
36 with any organisations that might have an interest in the submitted work in the previous three years;
37 and no other relationships or activities that could appear to have influenced the submitted work.
38 Thus, neither the study nor the salary of participants was funded by any third party.

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

40 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±0.4	0.078	1.44±0.9	1.24±0.4	0.14

	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.	

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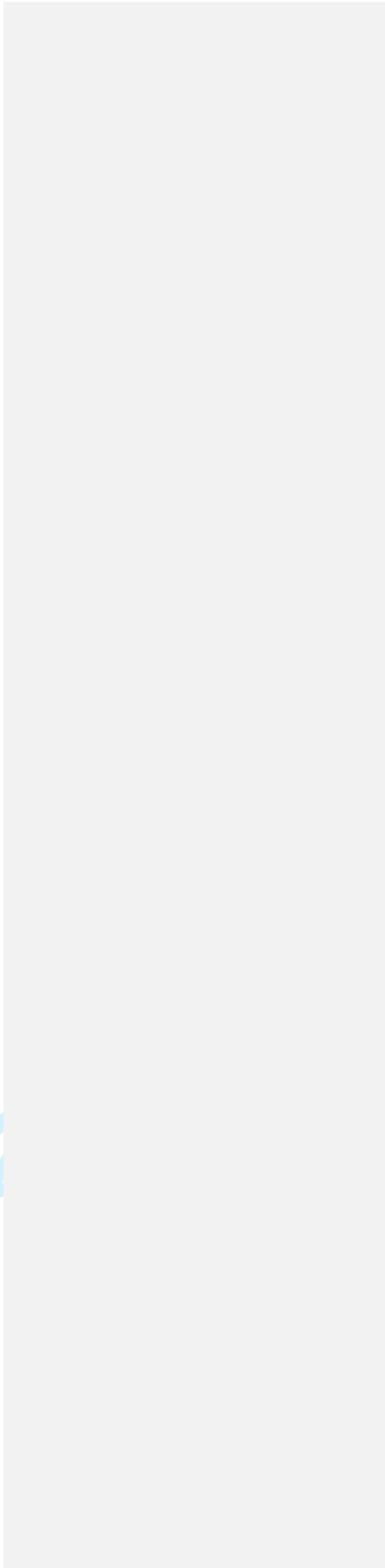
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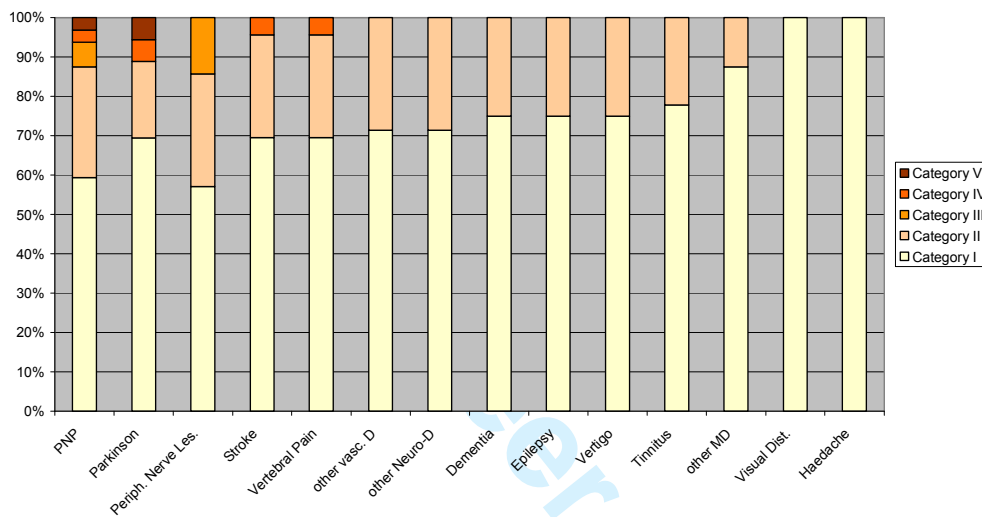
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Fallers						
Falls (n (%))	<u>46.5%</u>	<u>16.1%</u>	<u>0.000</u>	<u>42.1%</u>	<u>16.9%</u>	<u>0.000</u>
Multiple Falls (>2 falls) (n (%))	<u>28.3%</u>	<u>22.6%</u>	<u>0.528</u>	<u>26.4%</u>	<u>24.1%</u>	<u>0.815</u>
Fall frequency Index (in fallers)	<u>1.42±0.8</u>	<u>1.23±0.4</u>	<u>0.078</u>	<u>1.44±0.9</u>	<u>1.24±0.4</u>	<u>0.14</u>

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Percentage of multifallers in various Neurological Diseases according to FFI categories



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<u>Cate- gories</u>	<u>PNP (n)</u>	<u>PD (n)</u>	<u>PNL (n)</u>	<u>Strok e (n)</u>	<u>Vert P (n)</u>	<u>other vasc (n)</u>	<u>Other n. D. (n)</u>	<u>Dem (n)</u>	<u>Epi (n)</u>	<u>Vertig (n)</u>	<u>Tinni- tus (n)</u>	<u>other MD (n)</u>	<u>Visual Dist (n)</u>	<u>Haed- ache (n)</u>
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

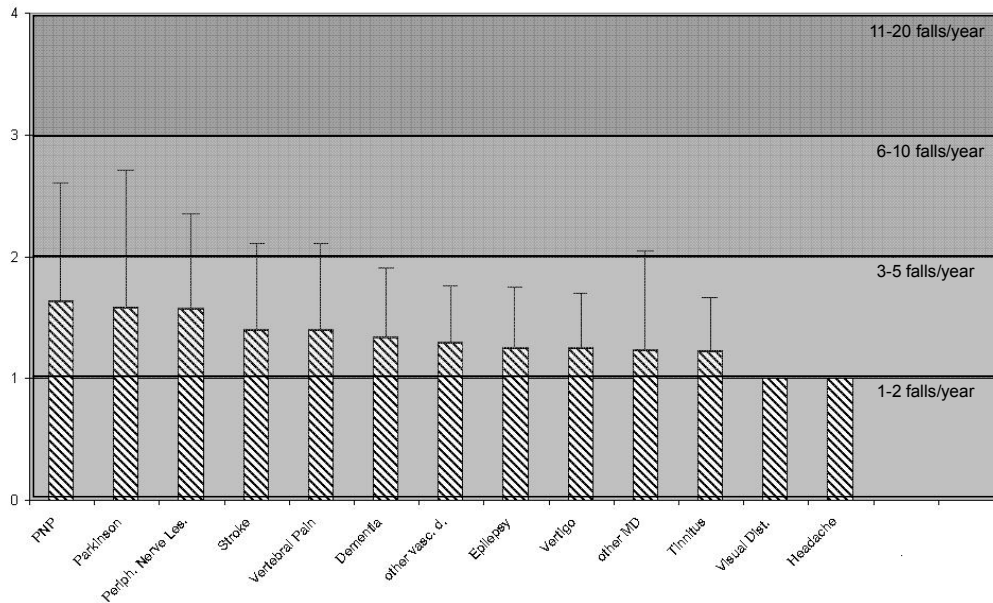


Fig.1 Frequency of falls in neurological patients according to their neurological disorder. [Fall Frequency Index \(FFI\)](#)
[Category I](#) = 1-2 falls in the last twelve months, [2-Category II](#) = 3-5, [3-Category III](#) = 6-10, [4-Category IV](#) = 11-20,
 and [5-Category V](#) = more than 20.

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

One year fall incidence in common neurological disorders

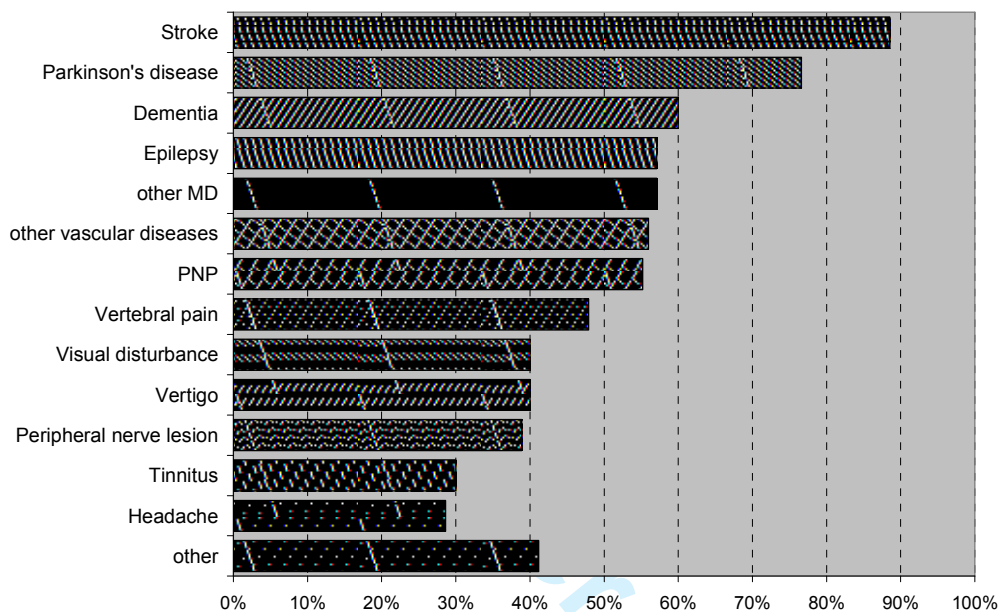


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

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

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall fre- quency** (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.

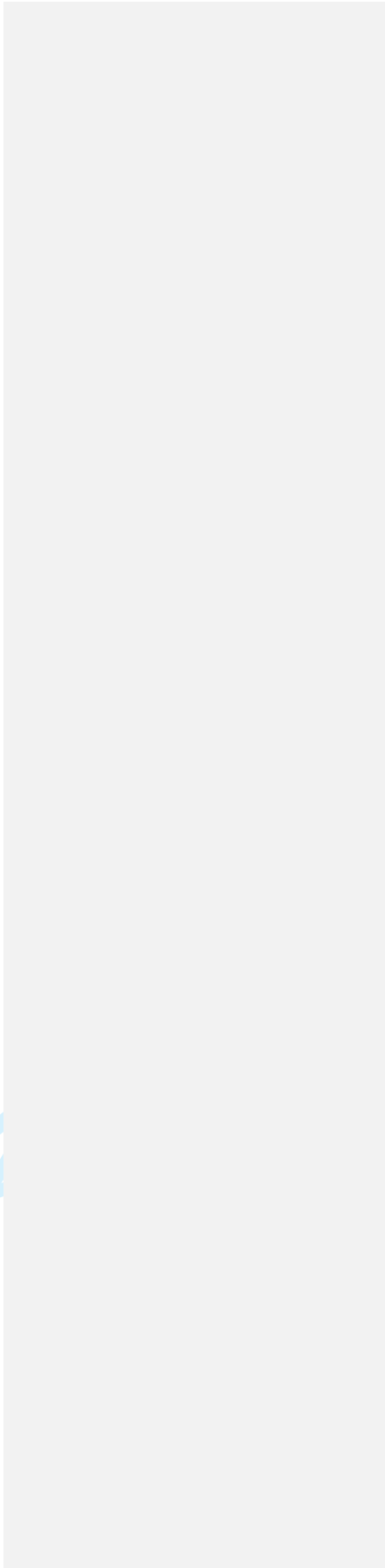
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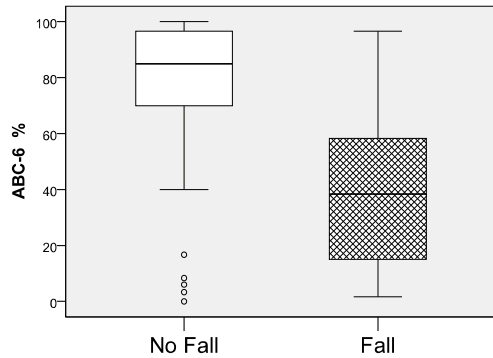
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a) Balance confidence and occurrence of falls



b) Neurological comorbidities and falls

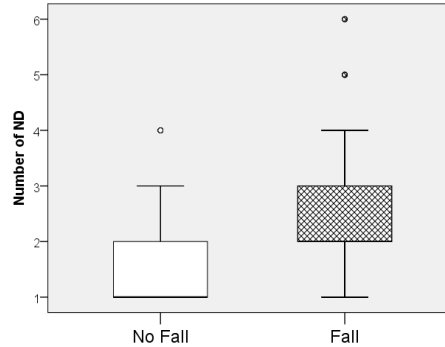


Fig.3a,b Differences in Activities-Specific Balance Confidence (ABC-6) scores (3a) and number of neurological diseases (ND) (3b) of ~~indicate that~~ neurological patients with and without falls indicate that fallers as compared to non-fallers those without have lower confidence in their balance and 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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Keywords:	Falls, fall risk, elderly, community dwelling, neurological disorders

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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 practitioners¹.

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 months² with 10% sustaining severe injuries³. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls⁴. 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 months⁵. 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 facility⁴. 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 system⁶. 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 repeatedly⁷. 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 elderly⁸. 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 undiagnosed⁹.

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 stroke¹⁰, Parkinson's disease¹¹ or dementia¹² 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 admission¹³. To date little is known about the risk of falling in

1 independent, community dwelling senior citizens afflicted with neurological diseases treatable in
2 outpatient facilities. Studies targeting this issue so far either did not use a control group or, if they
3 did, the absence of neurological signs and symptoms in this cohort was not guaranteed.
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5 Because falls in community dwelling elderly patients are assumed to be both prevalent and
6 preventable, neurologists in outpatient settings need a sound base to identify patients with the
7 highest risk, to reduce not only the number of falls and the suffering they entail, but also overall
8 health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with
9 various neurological diseases that are commonly encountered in outpatient facilities. We
10 hypothesized that even in community dwelling elderly patients, the impact one or more
11 neurological diseases on top of an already increased propensity for falls is substantial; that patients
12 with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction
13 with more than one of these high risk diseases increases the risk even further.
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27 **PARTICIPANTS AND METHODS**

28 **Setting**

29 Data were collected at the general outpatient department of the Department of Neurology of the
30 University Hospital in Graz, Austria. As visits to the outpatient department do not require specialist
31 referrals, the disease spectrum largely resembles that seen by community based neurologists.
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40 **Selection of participants and baseline examination**

41 Physically independent community dwelling patients treated in our general neurological outpatient
42 clinic aged 60 years and over were included in the study. Patients were all seen consecutively by
43 one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains
44 the study size. Severely disabled patients who were no longer able to walk unaided or were in poor
45 general condition, be it for reasons of neurological or other medical disease, were excluded from the
46 study. Cognitive impairment to an extent that an interview would no longer yield reliable results
47 (MMSE \leq 12), was also a cause for exclusion. All neurological patients included underwent a full
48 neurological workup with an extensive history to detect signs of past and present neurological
49 disorders. For the sake of uniformity, both the workup and history were structured and followed the
50 study protocol.
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58 As healthy controls, individuals from the general public out of the same catchment area as cases
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1 were enrolled. They were recruited among friends and acquaintances of the author and his co-
2 workers who were aged 60+ and without any history of neurological disorders or other disabling
3 medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis
4 severe enough to cause limitation of ordinary physical activity. Examination and history were as per
5 study protocol, whereby special emphasis was placed on identifying symptoms and signs of
6 Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor
7 deficits and gait or balance impairments. Controls with even subtle neurological pathologies were
8 excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known
9 diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

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

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

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

21 **Frequency of falls**

22 In the main section of the questionnaire patients and healthy controls were asked whether they had
23 had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall
24 incidence was graded according to the fall frequency index into 5 categories. Category one means
25 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

26 **Disability**

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

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

31 **Depression**

32 To determine the grade of depression, the Allgemeine Depressionsskala Kurzform (ADS-K) ¹⁶, the
33 German short form of the Center of Epidemiological Studies Depression Scale (CES-D) ¹⁷ was
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1 used. It is known to be particularly well suited for the use in the elderly and in patients with certain
2 neurological disabilities¹⁸.
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5 6 7 **Balance Confidence**

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9 We also rated the patients' confidence in their own sense of balance with the Activities-Specific
10 Balance Confidence Scale (ABC -6 scale)¹⁹. Participants judged their confidence in performing
11 specific activities without loss of balance or being unsteady on a scale ranging from 0% (no
12 confidence at all) to 100% (completely confident). The total score was then computed as an average
13 of the subscores.
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18 19 **Statistical analysis**

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21 The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were
22 defined according to the WHO definition¹ as an event which results in a person coming to rest
23 inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g.
24 falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly
25 individuals and the whole sample of neurological patients. Further calculations were done for
26 subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were
27 based on the ICD-10 system for classification of diseases. The means and standard deviations were
28 calculated for numerical values like the rating scale scores. For the identification of fall related risk
29 factors, correlations (Kendall's τ -B), and for the individual neurological disorders, odds ratios were
30 computed (α -level of significance $p < 0.05$). Differences between neurological patients and healthy
31 controls were tested with the Mann-Whitney U test or the chi-square test (α -levels of significance p
32 < 0.05). To insure comparability of cohorts we formed age- and gender-matched pairs of patients
33 and control subjects. For the matching process we used alphabetical lists of names of male and
34 female neurological patients and likewise of healthy controls, sorted by age. Then working down
35 the list we searched manually to find for each neurological patient one control subject of the same
36 age. If no match was found then we looked for a control that was one year younger, then one year
37 older, then two years and finally three years younger respectively older. Only complete sets of data
38 were included in the calculations and no approximates to replace missing values were computed.
39 Calculations were performed with SPSS[®] statistical software PASW statistics 18. Potential bias
40 and how it was addressed will be dealt with in the section on limitations.
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58 **RESULTS**

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

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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 presbycusis (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 ($\text{Chi}^2=43.4$; $p < 0.001$) 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%) ($\text{Chi}^2=26.3$;
 $p < 0.001$). (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 ($\text{Chi}^2=8.675$; $p = 0.003$).

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

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

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

24 The type of neurological disease the patient was afflicted with influenced the proportion of fallers in
25 that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%)
26 had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering
27 from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy
28 control (16.1%). (Fig. 2)
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36 The respective odds ratios are shown in table 2 and range from 40.1 (stroke) to 2.1 (headache) and
37 the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.

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

41 Other risk factors for falls in neurological patients were female gender ($\Gamma\text{-B}=0.195$; $p=0.003$),
42 higher age ($\Gamma\text{-B}=0.217$; $p<0.001$), higher disability or disease severity as measured by the Barthel
43 Index ($\Gamma\text{-B}=-0.232$; $p<0.001$). Higher disability scores in Parkinson patients expressed by higher
44 UPDRS II (activities of daily living) scores ($\Gamma\text{-B}=-0.238$; $p=0.062$) and higher Schwab & England
45 scores ($\Gamma\text{-B}=-0.235$; $p=0.070$) resulted in a trend toward more frequent falls. Severity of depression
46 as reflected by a higher ADS score ($\Gamma\text{-B}=0.329$; $p<0.001$) and low balance confidence reflected by
47 lower ABC scores ($\Gamma\text{-B}=-0.384$; $p<0.001$) were also identified as risk factors (Fig. 3).
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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 studies²⁰. 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 year²². 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 falls³ 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 year²⁶. 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 age²⁷. 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-

1 ing that the more severely affected patients are, the higher the falling risk²⁸. However, we have rea-
2 sons to believe that the correlation is not linear throughout all grades of disability but rather resem-
3 bles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher
4 disability only up to a certain point. Then, as patients become more cautious and use all kind of
5 supports, it plateaus and even decreases. When patients become so disabled that they are finally
6 bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be
7 located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since
8 this concept has yet only been proposed for PD²⁹ but not for other neurological conditions, further
9 studies directly comparing the risk of falling in neurological inpatients and outpatients of various
10 grades of disability are needed to support this assumption.

11 Considering recurrent falls we found that in the group of neurological patients 13.2 % fell three or
12 more times per year, compared to 3.6% in the group of healthy controls. This is in keeping with the
13 results of studies investigating recurrent falls, where figures of 8% for three or more falls in ran-
14 domly selected community dwelling elderly individuals are given³⁰ and 10% for community based
15 seniors using home care services³¹. In Stolze's cohort of inpatients the value of 21% for recurrent
16 falls was higher and can probably be explained by methodological differences. Stolze's category of
17 recurrent falls already includes patients who had fallen twice, unlike our and other studies^{30,31} that
18 include patients only after more than three falls.

32 **Risk factors contributing to falls**

33 We found out that the type of neurological disease afflicting a patient determines the potential risk
34 factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson pa-
35 tients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with
36 previous community based studies showing a high likelihood for falls in stroke patients with a range
37 of 51-73%^{10,20,32} and in Parkinson's patients with a range of 38 – 87%³³⁻³⁹. This was followed by
38 a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consist-
39 ing of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neu-
40 ropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-
41 80%^{12,40} in Alzheimer patients and 55-65%⁴¹⁻⁴³ in patients with peripheral neuropathy. The only
42 study conducted on falls in elderly patients suffering from epilepsy is one on care facility residents,
43 providing a 5-year fall incidence of 83%⁴⁴. In our sample peripheral neuropathy also proved to be a
44 risk factor for recurrent falls, but most likely significance was not reached due to the small sample
45 size (p=0.061). Confirmative data also obtained from small cohorts revealed that multiple falls oc-
46 curred in 10 out of 25 (40%) neuropathy patients⁴³ and another 13 out of 20 neuropathy patients
47 (65%) had a propensity for multiple falls for an average of 5.8 falls per year⁴¹. New and unexpected
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1 was the fact that even patients suffering from neurological diseases with no direct influence on gait
2 or balance like headache (28%) had almost twice as many falls as the average healthy control
3 (16.1%). Also new is that in contrast to all the above cited data derived from studies on patients
4 with only one neurological disorder, our survey provides comparative values for several neurologi-
5 cal diseases of elderly ambulatory neurological patients for the first time, allowing a direct compari-
6 son between these disorders and a ranking according to the risk of falling.
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8 But our findings further suggest that not only the type of neurological conditions, but also the num-
9 ber of neurological diseases a patient was suffering from, no matter whether they had an influence
10 on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that
11 only accumulations of neurological deficits relating to gait and balance would influence the risk for
12 falls. Although there were no published studies on the influence of neurological diseases, it is
13 known that persons with an impaired sense of balance have an disproportionately higher risk for
14 falls when they acquire an additional new disease or condition, even if it is one that seems minor or
15 not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a
16 patient was suffering from was highly predicative of a risk to fall, better even than a mobility score.
17 She concluded that falling appears to result from an accumulated effect of multiple specific disabili-
18 ties⁴⁵. This would be in keeping with our other findings, that old age in combination with any neu-
19 rological disease increases the risk of falling above that of healthy controls, even if it is a disease
20 like headache. Also in accordance with this we found that a higher rate of depression, as reflected
21 by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be
22 that depressive thoughts are frequently combined with negative conceptions of one's own sense of
23 balance, which was found to be a prominent risk factor for falls in our and previous other studies⁴⁶.
24 That higher age would be a predictive factor for falls in neurological patients replicates previous
25 findings¹³ and is easy to explain: old age is often associated with greater frailty and eventually
26 frailty with less confidence in one's sense of balance and a higher incidence of falls⁴⁶. That females
27 are more prone to falls than males has often been stated before¹³ and has previously been explained
28 by a fear of falling and a loss of confidence – both independent risk factors for falls - being more
29 prominent in women⁶.

50 51 52 **LIMITATIONS**

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

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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.

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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.

45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 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

1 diseases like stroke, Parkinson's disease, dementia and epilepsy, and for repeated falls also
2 patients with peripheral neurological disorders, require special attention. Greater disability,
3 higher age, female gender, depression and low confidence in the sense of balance are
4 additional contributory factors that have to be taken into account in this process. For patients
5 with several of these factors, targeted prevention programs should be implemented.
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8 However, although they have been shown to generally reduce falls and injuries in the
9 community dwelling elderly⁴⁹, there is but inconclusive evidence for patients following
10 stroke⁵⁰ and with PD^{51,52} and even more scanty information for patients with other
11 neurological diseases. Therefore further larger scale multicenter neuro-geriatric surveys
12 with larger sample sizes for neurological subgroups should be performed not only to confirm
13 our observations but to acquire more extensive knowledge of the effectiveness of preventive
14 measures in patient cohorts with various neurological conditions and different degrees of
15 disability. These studies should also include more objective monitoring systems and include
16 further potential risk factors like medication and fear of falling.
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30

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32 and declare: no support from any organisation for the submitted work; no financial relationships
33 with any organisations that might have an interest in the submitted work in the previous three years;
34 and no other relationships or activities that could appear to have influenced the submitted work.
35 Thus, neither the study nor the salary of participants was funded by any third party.
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38 Contributorship Statement: B. H.: drafting/revising the manuscript, study concept or design, analy-
39 sis or interpretation of data; A. P.: analysis or interpretation of data, acquisition of data of patients
40 and controls, study concept or design; M. G.: analysis or interpretation of data, acquisition of data
41 of patients and controls, study concept or design; A.H. acquisition of data of patients and controls;
42 T. G.: acquisition of data, study concept or design, G. I.: critical revision of the manuscript for im-
43 portant intellectual content; E. H.: statistical analysis , analysis or interpretation of data, study con-
44 cept or design; G.I.: drafting/revising the manuscript, study concept or design, critical revision of
45 the manuscript for important intellectual content; F. F.: drafting/revising the manuscript, study con-
46 cept or design, critical revision of the manuscript for important intellectual content; C. N. H.: draft-
47 ing/revising the manuscript, study concept or design, acquisition of data, study supervision.
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54 Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz
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56 Patient consent: obtained
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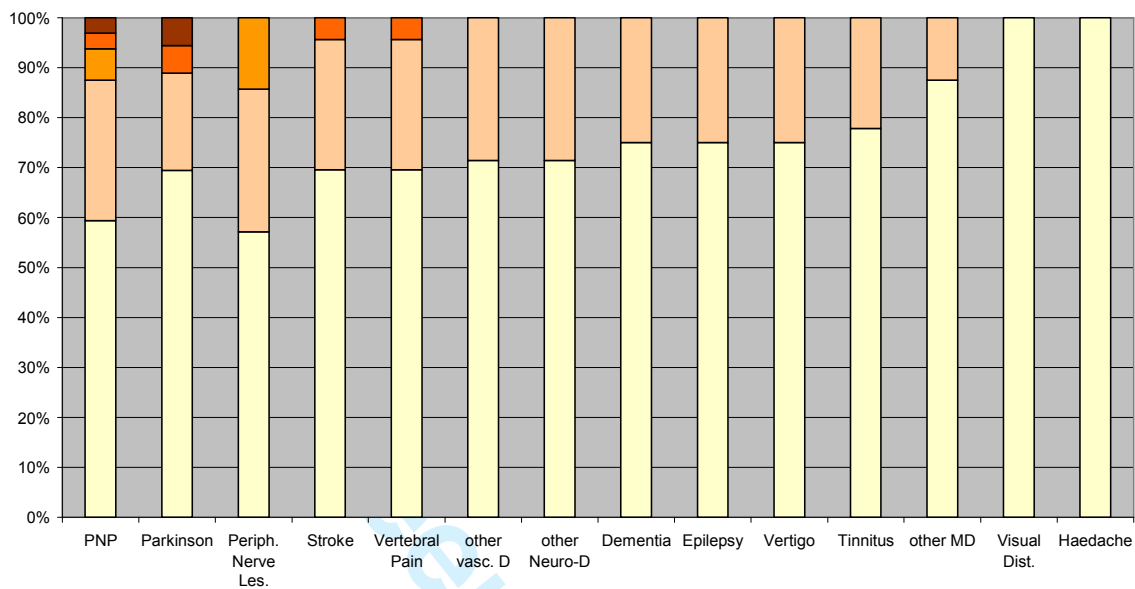
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TABLES AND FIGURES

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±0.4	0.078	1.44±0.9	1.24±0.4	0.14

Percentage of Fallers in various Neurological Diseases according to FFI Categories



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, Category 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

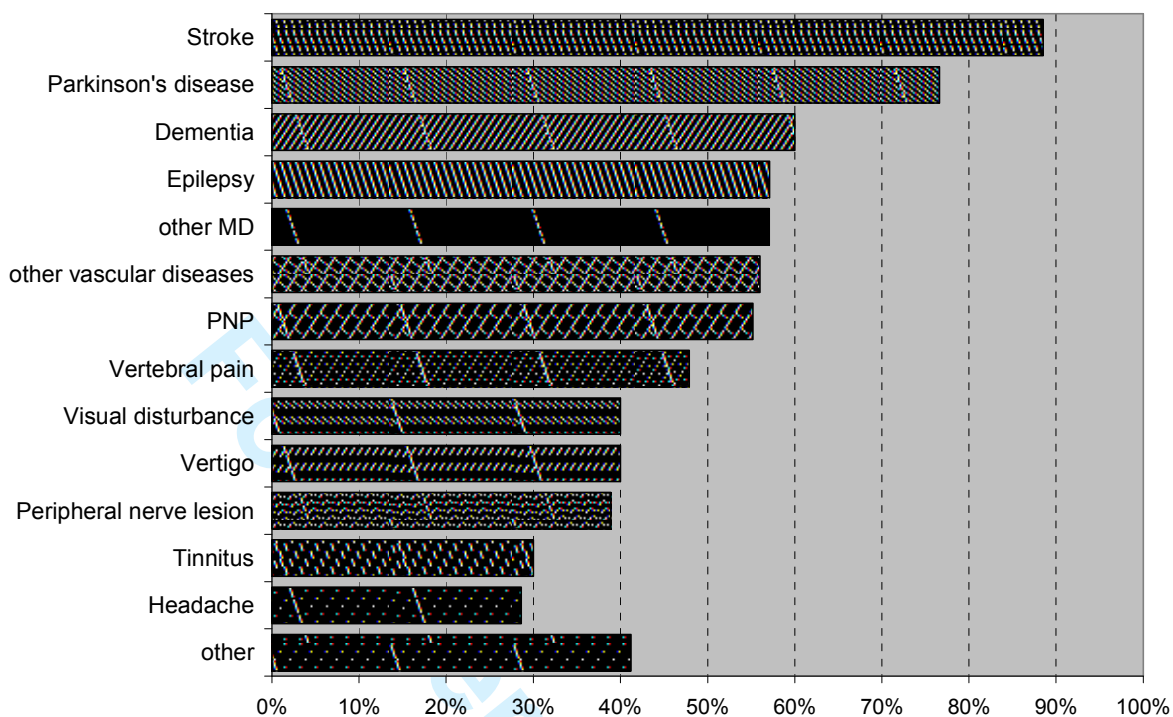


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

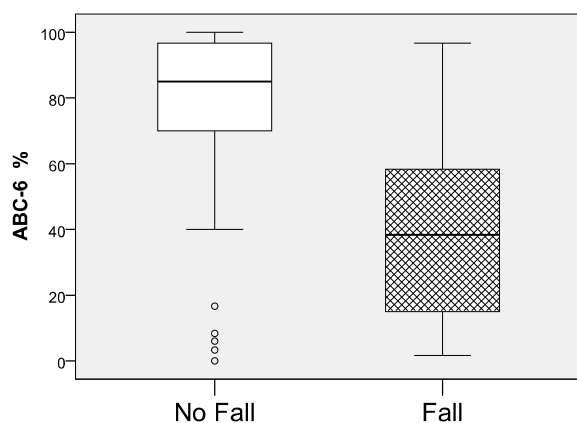
Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall fre- quency** (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

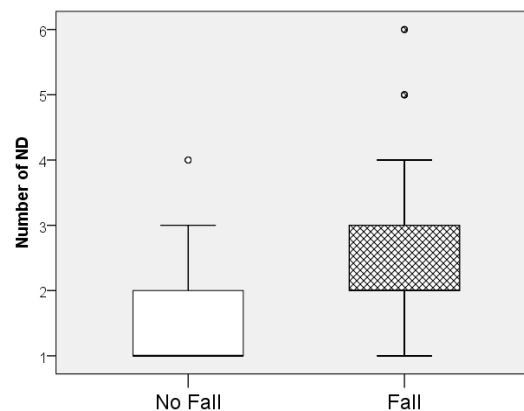


Fig.3a,b Differences in ABC-6 scores (3a) and number of neurological diseases (ND) (3b) of neurological patients with and without falls indicate that fallers as compared to non-fallers have lower confidence in their balance and a higher number of concomitant neurological diseases.

(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)

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8 **The impact of neurological disorders on the risk for falls in the community**
9 **dwelling elderly: a case controlled study**
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15 Homann, Barbara¹; Plaschg, Annemarie¹; Grundner, Marion¹; Griedl, Theresa¹; Ivanic, Gerd²;
16 Hofer, Edith¹; Fazekas, Franz¹; Homann, Carl Nikolaus¹
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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 practitioners¹.

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 months² with 10% sustaining severe injuries³. Injuries are the fifth most frequent cause of death in the elderly and up to 70% of these injuries were caused by falls⁴. 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 months⁵. 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 facility⁴. 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 system⁶. 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 repeatedly⁷. 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 elderly⁸. 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 undiagnosed⁹.

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 stroke¹⁰, Parkinson's disease¹¹ or dementia¹² 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 admission¹³. To date little is known about the risk of falling in

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

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10 Because falls in community dwelling elderly patients are assumed to be both prevalent and
11 preventable, neurologists in outpatient settings need a sound base to identify patients with the
12 highest risk, to reduce not only the number of falls and the suffering they entail, but also overall
13 health care costs. Our study thus aimed to investigate the risk of falls in elderly patients with
14 various neurological diseases that are commonly encountered in outpatient facilities. We
15 hypothesized that even in community dwelling elderly patients, the impact one or more
16 neurological diseases on top of an already increased propensity for falls is substantial; that patients
17 with certain diseases like stroke or Parkinson's disease are particularly at risk; and that affliction
18 with more than one of these high risk diseases increases the risk even further.
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24 25 26 27 **PARTICIPANTS AND METHODS**

28 29 30 31 **Setting**

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33 Data were collected at the general outpatient department of the Department of Neurology of the
34 University Hospital in Graz, Austria. As visits to the outpatient department do not require specialist
35 referrals, the disease spectrum largely resembles that seen by community based neurologists.
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38 39 **Selection of participants and baseline examination**

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41 Physically independent community dwelling patients treated in our general neurological outpatient
42 clinic aged 60 years and over were included in the study. Patients were all seen consecutively by
43 one and the same consultant (CNH) in the period from July 2007 to May 2008, what also explains
44 the study size. Severely disabled patients who were no longer able to walk unaided or were in poor
45 general condition, be it for reasons of neurological or other medical disease, were excluded from the
46 study. Cognitive impairment to an extent that an interview would no longer yield reliable results
47 (MMSE \leq 12), was also a cause for exclusion. All neurological patients included underwent a full
48 neurological workup with an extensive history to detect signs of past and present neurological
49 disorders. For the sake of uniformity, both the workup and history were structured and followed the
50 study protocol.
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53 As healthy controls, individuals from the general public out of the same catchment area as cases
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6 were enrolled. They were recruited among friends and acquaintances of the author and his
7 workers who were aged 60+ and without any history of neurological disorders or other disabling
8 medical conditions like heart failure, chronic obstructive pulmonary disease or rheumatoid arthritis
9 severe enough to cause limitation of ordinary physical activity. Examination and history were as per
10 study protocol, whereby special emphasis was placed on identifying symptoms and signs of
11 Parkinson's disease, peripheral neuropathy, stroke or epilepsy, as well as minor sensory-motor
12 deficits and gait or balance impairments. Controls with even subtle neurological pathologies were
13 excluded. Although not routinely screened for cognitive deficits, obvious signs of or a known
14 diagnosis of dementia or even of mild cognitive impairment was a reason for exclusion.

15
16 A telephone follow-up was scheduled 12 months after the baseline outpatient visit; it was carried
17 out by one of two examiners (AP, MG) following a predefined format and only subjects who had
18 given verbal informed consent at the start of the telephone contact were interviewed.

19
20 The first section of the interview questionnaire covered demographic data like age and place of
21 residence. The residence category had 5 subsections on size and traffic infrastructure, with group 1
22 being the state capital and group 5 a small town in the periphery. Next were specific questions on
23 fall frequency, physical disability, depression and confidence in one's own sense of balance. The
24 final section dealt with risk situations (like when using public transport) and general mobility
25 issues, whereby the latter are not included in this publication.

26
27 The survey, including all details concerning the selection process, was approved by the Ethics
28 Committee of the Medical University Graz.

29 30 31 32 33 34 35 36 **Frequency of falls**

37 In the main section of the questionnaire patients and healthy controls were asked whether they had
38 had a fall during the past 12 months and, if yes, how many times they had fallen. The yearly fall
39 incidence was graded according to the fall frequency index into 5 categories. Category one means
40 1-2 falls, category two 3-5, three 6-10, four 11-20, and five more than 20 falls.

41 42 43 44 **Disability**

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

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

49 50 51 52 **Depression**

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

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6 used. It is known to be particularly well suited for the use in the elderly and in patients with certain
7 neurological disabilities¹⁸.
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9 10 11 **Balance Confidence**

12 We also rated the patients' confidence in their own sense of balance with the Activities-Specific
13 Balance Confidence Scale (ABC -6 scale)¹⁹. Participants judged their confidence in performing
14 specific activities without loss of balance or being unsteady on a scale ranging from 0% (no
15 confidence at all) to 100% (completely confident). The total score was then computed as an average
16 of the subscores.
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20 21 **Statistical analysis**

22 The primary outcomes was falls, based on participant recall over the prior 12 months. Falls were
23 defined according to the WHO definition¹ as an event which results in a person coming to rest
24 inadvertently on the ground or floor or other lower level irrespective of cause, thus including e.g.
25 falls from epileptic seizures. The one-year incidence of falls was calculated for both healthy elderly
26 individuals and the whole sample of neurological patients. Further calculations were done for
27 subsamples of 13 neurological disorders with the highest prevalence ($n \geq 7$). The diagnoses were
28 based on the ICD-10 system for classification of diseases. The means and standard deviations were
29 calculated for numerical values like the rating scale scores. For the identification of fall related risk
30 factors, correlations (Kendall's τ -B), and for the individual neurological disorders, odds ratios were
31 computed (α -level of significance $p < 0.05$). Differences between neurological patients and healthy
32 controls were tested with the Mann-Whitney U test or the chi-square test (α -levels of significance p
33 < 0.05). To insure comparability of cohorts we formed age- and gender-matched pairs of patients
34 and control subjects. For the matching process we used alphabetical lists of names of male and
35 female neurological patients and likewise of healthy controls, sorted by age. Then working down
36 the list we searched manually to find for each neurological patient one control subject of the same
37 age. If no match was found then we looked for a control that was one year younger, then one year
38 older, then two years and finally three years younger respectively older. Only complete sets of data
39 were included in the calculations and no approximates to replace missing values were computed.
40 Calculations were performed with SPSS® statistical software PASW statistics 18. Potential bias
41 and how it was addressed will be dealt with in the section on limitations.
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52 53 54 **RESULTS**

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

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

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

35 One hundred and six (46.5%) neurological patients but only 31 (16.1%) healthy controls had fallen
36 at least once ($\text{Chi}^2=43.4$; $p < 0.001$) during this one-year period. Out of ~~126~~ 106 neurological
37 patients experiencing falls, 76 (71.7%) fell once or twice, 22 (20.8%) three to five times, three
38 (2.8%) six to nine times, three (2.8%) 11-20 times and two (1.9%) more than 20 times. In the group
39 of healthy controls, out of ~~76~~ 31 individuals with a history of falls, 24 (77.4%) fell once or twice,
40 and seven (22.6%) three to five times, but none more often than that. In the matched cohorts as well
41 falls were more frequent in neurological patients (42.1%) than in healthy controls (16.9%)
42 ($\text{Chi}^2=26.3$; $p < 0.001$). (Table 1)
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49 The mean age of individuals with a history of falls as compared to those without was higher both in
50 the neurologically affected (fallers: 76.7 ± 7.6 vs. nonfallers: 72.6 ± 7.5 ; $p < 0.001$) and in healthy
51 controls (fallers: 73.3 ± 6.5 vs. nonfallers: 71.0 ± 6.9 ; $p = 0.040$). In the group of neurological
52 patients, 75 of 106 fallers (71%) were female, but only 31 (29%) were male ($\text{Chi}^2=8.675$; $p = 0.003$).
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6 Similarly, in the group of healthy controls a higher percentage of fallers was female, with 23 out of
7 31 (74%), but this did not reach significance ($\text{Chi}^2=1.915$; $p=0.166$).

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

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13 Multiple falls occurred particularly in patients with peripheral neuropathy (43%), peripheral nerve
14 lesion (43%), dementia (33%), Parkinson's disease (30%), stroke (30%) and vertebral pain (30%).
15 The average fall frequency index in this group of five diseases ranged from 1.63 (peripheral
16 neuropathy) to 1.33 (dementia). The proportion of fallers in each index category is shown for all
17 these diseases in Fig. 1.
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20 21 22 23 24 **Risk factors for falls in neurological patients**

25 The type of neurological disease the patient was afflicted with influenced the proportion of fallers in
26 that patients post stroke (89%), with Parkinson's disease (77%), dementia (60%) and epilepsy (57%)
27 had the highest frequency of falls. The lowest likelihood of falls was found in patients suffering
28 from tinnitus (30%) and headache (28%), but was still higher than that of the average healthy
29 control (16.1%). (Fig. 2)
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35 The respective odds ratios are shown in table 2 and range from 40.1 (stroke) to 2.1 (headache) and
36 the relative risk of falling ranges between 5.5 for stroke patients and 1.8 for patients with headache.
37 No specific combination of two or three neurological diseases characterized by substantial gait or
38 balance impairment but any accumulation of several neurological diseases regardless of their
39 influence on gait or balance was able to cause a significant raise in falls ($\Gamma\text{-B}=0.303$; $p<0.001$).

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42 Other risk factors for falls in neurological patients were female gender ($\Gamma\text{-B}=0.195$; $p=0.003$),
43 higher age ($\Gamma\text{-B}=0.217$; $p<0.001$), higher disability or disease severity as measured by the Barthel
44 Index ($\Gamma\text{-B}=-0.232$; $p<0.001$). Higher disability scores in Parkinson patients expressed by higher
45 UPDRS II (activities of daily living) scores ($\Gamma\text{-B}=-0.238$; $p=0.062$) and higher Schwab & England
46 scores ($\Gamma\text{-B}=-0.235$; $p=0.070$) resulted in a trend toward more frequent falls. Severity of depression
47 as reflected by a higher ADS score ($\Gamma\text{-B}=0.329$; $p<0.001$) and low balance confidence reflected by
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51 higher-lower ABC scores ($\Gamma\text{-B}=-0.384$; $p<0.001$) were also identified as risk factors (Fig. 3).
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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 studies²⁰. 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 year²². 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 falls³ 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 year²⁶. 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 age²⁷. 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-

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6 ing that the more severely affected patients are, the higher the falling risk²⁸. However, we have rea-
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8 sons to believe that the correlation is not linear throughout all grades of disability but rather resem-
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10 bles an inverse U-shaped curve. We think that the initial propensity for falls increases with higher
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12 disability only up to a certain point. Then, as patients become more cautious and use all kind of
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14 supports, it plateaus and even decreases. When patients become so disabled that they are finally
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16 bedridden, the risk approaches zero with the lack of opportunities to fall. Our values so would be
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18 located on the inclining leg close to the peak and Stolze's further down on the declining leg. Since
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20 this concept ~~is not yet backed up by sound evidence~~ has yet only been proposed for PD²⁹ but not for
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22 other neurological conditions, further studies directly comparing the risk of falling in neurological
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24 inpatients and outpatients of various grades of disability are needed to support this assumption.

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26 Considering recurrent falls we found that in the group of neurological patients 13.2 % fell three or
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28 more times per year, compared to 3.6% in the group of healthy controls. This is in keeping with the
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30 results of studies investigating recurrent falls, where figures of 8% for three or more falls in ran-
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32 domly selected community dwelling elderly individuals are given³⁰ and 10% for community based
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34 seniors using home care services³¹. In Stolze's cohort of inpatients the value of 21% for recurrent
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36 falls was higher and can probably be explained by methodological differences. Stolze's category of
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38 recurrent falls already includes patients who had fallen twice, unlike our and other studies^{30,31} that
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40 include patients only after more than three falls.

41 42 43 **Risk factors contributing to falls**

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45 We found out that the type of neurological disease afflicting a patient determines the potential risk
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47 factor for falls. Here, two diseases stood out: stroke patients were 6 times (89%) and Parkinson pa-
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49 tients 5 times (71%) more likely to suffer falls than healthy controls (16%). This is in keeping with
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51 previous community based studies showing a high likelihood for falls in stroke patients with a range
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53 of 51-73%^{10, 20, 32} and in Parkinson's patients with a range of 38 – 87%³³⁻³⁹. This was followed by
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55 a group of neurological diseases with an almost 4 times higher likelihood (55-60%) of falls, consist-
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57 ing of dementia, epilepsy, other movement disorders, other vascular diseases and peripheral neu-
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59 ropathy. These diseases are also known to carry a high risk for falls, with an annual fall rate of 60-
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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 patients⁴³ and another 13 out of 20 neuropathy pa-
tients (65%) had a propensity for ~~multiple recurrent~~ falls for an average of 5.8 falls per year⁴¹. New

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6 | and quite astonishingly unexpected was the fact that even patients suffering from neurological diseases
7 with no direct influence on gait or balance like headache (28%) had almost twice as many falls as
8 the average healthy control (16.1%). Also new is that in contrast to all the above cited data derived
9 from studies on patients with only one neurological disorder, our survey provides comparative val-
10 ues for several neurological diseases of elderly ambulatory neurological patients for the first time,
11 allowing a direct comparison between these disorders and a ranking according to the risk of falling.
12 But our findings further suggest that not only the type of neurological conditions, but also the num-
13 ber of neurological diseases a patient was suffering from, no matter whether they had an influence
14 on gait or balance, correlated with the risk of falling. This came as a surprise as we assumed that
15 only accumulations of neurological deficits relating to gait and balance would influence the risk for
16 falls. Although there were no published studies on the influence of neurological diseases, it is
17 known that persons with an impaired sense of balance have an disproportionately higher risk for
18 falls when they acquire an additional new disease or condition, even if it is one that seems minor or
19 not related to falling per se. Tinetti was able to demonstrate that the number of chronic diseases a
20 patient was suffering from was highly predicative of a risk to fall, better even than a mobility score.
21 She concluded that falling appears to result from an accumulated effect of multiple specific disabili-
22 ties ⁴⁵. This would be in keeping with our other findings, that old age in combination with any neu-
23 rological disease increases the risk of falling above that of healthy controls, even if it is a disease
24 like headache. Also in accordance with this we found that a higher rate of depression, as reflected
25 by a higher ADS-score, also increased the risk for falls. An alternative explanation for this could be
26 that depressive thoughts are frequently combined with negative conceptions of one's own sense of
27 balance, which was found to be a prominent risk factor for falls in our and previous other studies ⁴⁶.
28 That higher age would be a predictive factor for falls in neurological patients replicates previous
29 findings ¹³ and is easy to explain: old age is often associated with greater frailty and eventually
30 frailty with less confidence in one's sense of balance and a higher incidence of falls ⁴⁶. That females
31 are more prone to falls than males has often been stated before ¹³ and has previously been explained
32 by a fear of falling and a loss of confidence – both independent risk factors for falls - being more
33 prominent in women ⁶.
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49 LIMITATIONS

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51 We also faced several limitations in our study. First and most importantly, like most other surveys
52 dealing with falls, we faced the problem that the number of falls are likely to be underreported.
53 Elderly subjects often try to downplay problems regarding their mobility for fear of having their
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6 autonomy restricted. While this is in general typically found in the healthy elderly, it might be even
7 more prominent in patients with disabilities. But even remembering these events might pose a
8 problem in some of the patients with central degenerative diseases and this might have been a
9 relevant factor in our study, even though we excluded patients with severe dementia. The risk for
10 falls in neurological patients might therefore be greater than shown in any results. Future
11 prospective studies could minimize this problem by using patients diaries according to established
12 guidelines for reporting falls ⁴⁷ possibly even in combination with wearable miniaturized electronic
13 devices apt to objectively detect and monitor falls ⁴⁸.

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17 Secondly, the large drop out rate of 23% from neurological assessment to interview, not containing
18 the 3,6% that had to be excluded prior to recruitment due to inability or unwillingness to participate
19 could have lead to further underestimating the number of patients with falls. However, since these
20 patients did not obviously differ in their baseline characteristics, we assume this problem to be
21 minimal.
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26 Then, we would also like to address the issue of small sample sizes in subgroups of neurological
27 diseases. Some of the groups like vascular diseases, movement disorders, vertebral pain and
28 peripheral neuropathy are adequately sized, and even outnumber subjects of single disease studies
29 like those on peripheral neuropathy ^{41, 43}. Others, particularly the dementia group with only seven
30 patients, is, due to the exclusion of the more affected, quite small and allows only limited
31 extrapolation. Nevertheless it is remarkable that even here the analysis of difference reached levels
32 of significance.
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40 CONCLUSION

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43 It can be said that we managed to show, apparently for the first time, that even among
44 ambulatory neurological outpatients, falls are alarmingly frequent. The aetiology of falls is
45 multi-factorial, but the connection between falls and disturbances of the sensorimotor
46 system frequently found in neurological diseases in elderly patients is of great importance.
47 Our findings revealed that even neurological diseases not directly connected with gait and
48 balance carry an astonishingly high risk for falls. Medical practitioners, allied health
49 professionals and carers ~~Neurologists~~ should therefore be aware that their patients are at high
50 risk for falls, as any neurological deficit increases this risk, even more so if a combination of
51 factors is present. Of course the risk has to be evaluated individually, but patients with
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6 central diseases like stroke, Parkinson's disease, dementia and epilepsy, and for repeated
7 falls also patients with peripheral neurological disorders, require special attention. Greater
8 disability, higher age, female gender, depression and low confidence in the sense of balance
9 are additional contributory factors that have to be taken into account in this process. For
10 patients with several of these factors, targeted prevention programs should be implemented.
11 However, although they have been shown to generally reduce falls and injuries in the
12 community dwelling elderly⁴⁹, there is but inconclusive evidence for patients following
13 stroke⁵⁰ and with PD^{51,52} and even more scanty information for patients with other
14 neurological diseases. Therefore further larger scale multicenter neuro-geriatric surveys
15 with larger sample sizes for neurological subgroups should be performed not only to confirm
16 our observations but to acquire more extensive knowledge of the effectiveness of preventive
17 measures in patient cohorts with various neurological conditions and different degrees of
18 disability. These studies should also include more objective monitoring systems and include
19 further potential risk factors like medication and fear of falling.
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Field Code Changed

NOTES

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35 and declare: no support from any organisation for the submitted work; no financial relationships
36 with any organisations that might have an interest in the submitted work in the previous three years;
37 and no other relationships or activities that could appear to have influenced the submitted work.
38 Thus, neither the study nor the salary of participants was funded by any third party.
39

40 Ethical approval: This study was approved by the Ethics Committee of the Medical University Graz
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43 Patient consent: obtained
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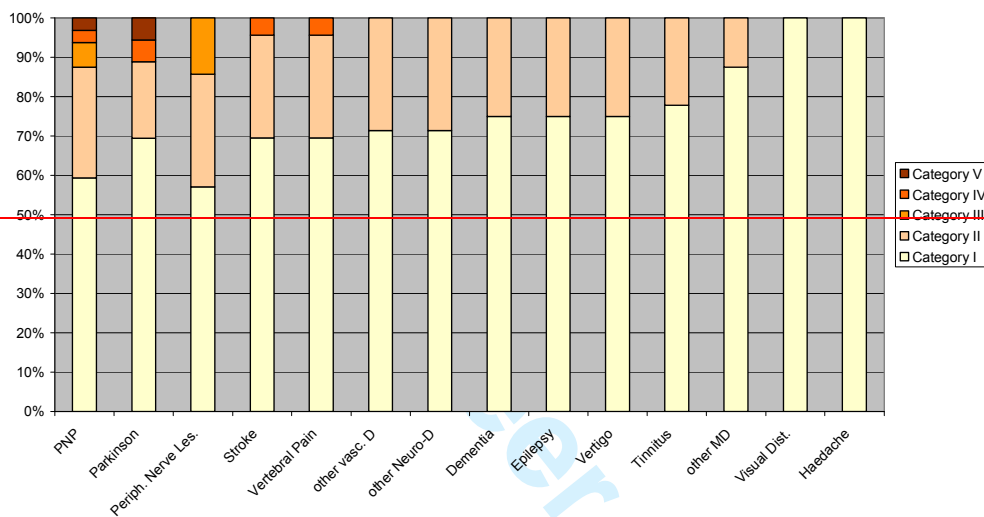
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TABLES AND FIGURES

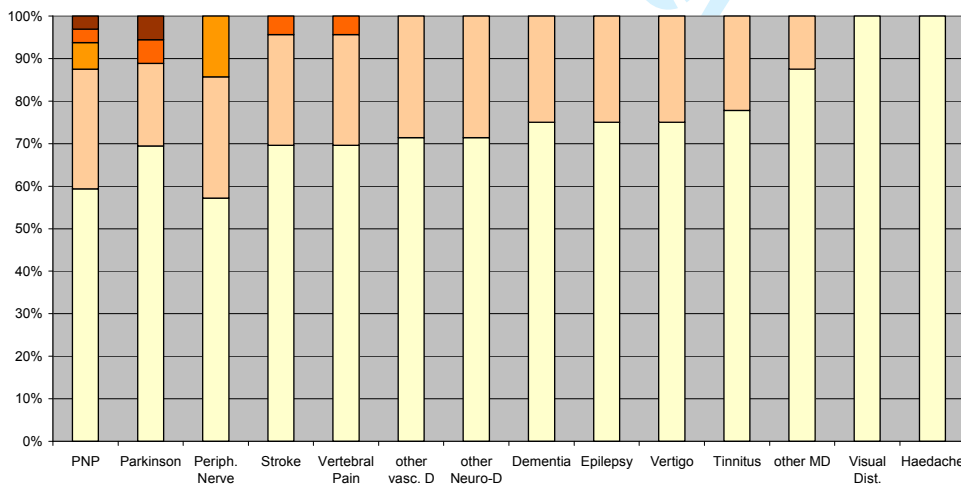
Table 1: Neurological patients and healthy controls: General demographics and fall frequency

	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±0.4	0.078	1.44±0.9	1.24±0.4	0.14

Percentage of multifallers in various Neurological Diseases according to FFI categories



Percentage of Fallers in various Neurological Diseases according to FFI Categories



Cate-gories	PNP (n)	PD (n)	PNL (n)	Strok e (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, Category 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

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One year fall incidence in common neurological disorders

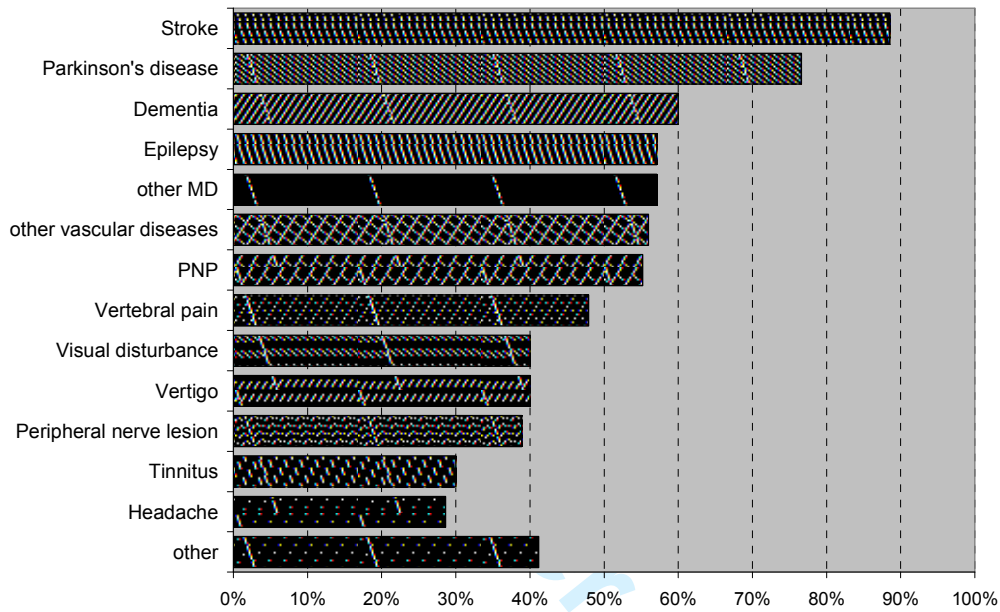


Fig.2 Difference in frequency of having at least one fall within the twelve-month period for patients suffering from the 13 most commonly encountered neurological disorders.

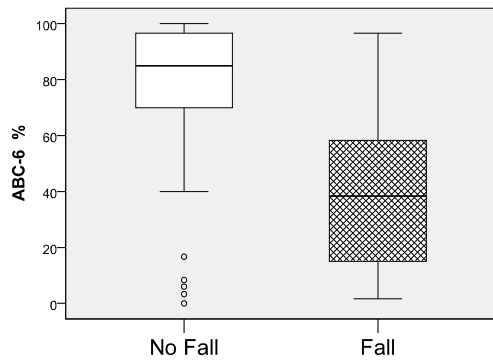
Table 2: Neurological Patient groups: General demographics and fall risk

Diagnosis	Age	Bartel	Total (n)	Falls (n (%))	Multiple Falls* (n (%))	Fall fre- quency** (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

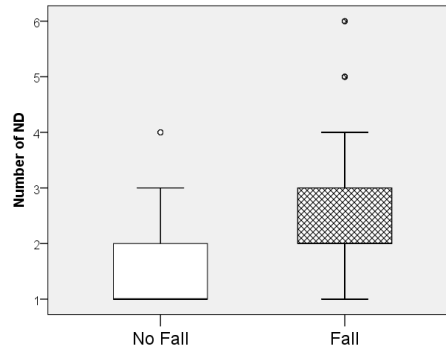


Fig.3a,b Differences in ABC-6 scores (3a) and number of neurological diseases (ND) (3b) of neurological patients with and without falls indicate that fallers as compared to non-fallers have lower confidence in their balance and a higher number of concomitant neurological diseases.

(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 (b) Provide in the abstract an informative and balanced summary of what was done and what was found	p1, p2 I12 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 I12-20
Methods			
Study design	4	Present key elements of study design early in the paper	P5 I40 – p6 I27
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5 I32-37, p5 I42-47, p6 I17-21, p6 I22-26
Participants	6	(a) <i>Cohort study</i> ? Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> ? 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 <i>Cross sectional study</i> ? Give the eligibility criteria, and the sources and methods of selection of participants	P5 I42- p6 I15
		(b) <i>Cohort study</i> ? For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> ? For matched studies, give matching criteria and the number of controls per case	P7 I4 I48
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6 I37-p7 I16
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 I37-p7 I16
Bias	9	Describe any efforts to address potential sources of bias	P13 I18-21, p7 I40-48
Study size	10	Explain how the study size was arrived at	P5 I46-47
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P7 I28-30
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	P7 I31-53
		(b) Describe any methods used to examine subgroups and interactions	P7 I37-39
		(c) Explain how missing data were addressed	P7 I48-49
		(d) <i>Cohort study</i> ? If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> ? If applicable, explain how matching of cases and controls was addressed <i>Cross sectional study</i> ? If applicable, describe analytical methods taking account of sampling strategy	P13 I15-22
		(e) Describe any sensitivity analyses	P7 I35
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 I4-29
		(b) Give reasons for non-participation at each stage	√p8 I4-29
		(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 I36-p9 I55
		(c) <i>Cohort study</i> ? Summarise follow-up time (eg average and total amount)	P8 I38
Outcome data	15*	<i>Cohort study</i> ? Report numbers of outcome events or summary measures over time	n.a.
		<i>Case-control study</i> ? Report numbers in each exposure category, or summary measures of exposure	P8 I35 – p9 I55
		<i>Cross sectional study</i> ? 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 I3-29

	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 I3-29
		(c) Consider use of a flow diagram	-
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses	P9 I23-55
Discussion			
Key results	18	Summarise key results with reference to study objectives	P3 I25-37
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 I52 – p13 I36
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P13 I43- p14 I24
Generalisability	21	Discuss the generalisability (external validity) of the study results	P3 I50-53
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 I35-41