

Fall Prevention for People with Multiple Sclerosis in Germany: A Nationwide Survey

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Abstract

Purpose: Falls are common in people with Multiple Sclerosis (MS), yet it seems that there is a limited awareness for this in Germany. The lack of knowledge about falls in people with MS in Germany suggested an exploring survey that helps to describe the current state of this situation.

Methods: A nationwide web-based survey was conducted and a total of 315 people with MS with a history of falls or who were concerned about their falling risk completed the survey.

Results: Seventy-five percent of the participants reported injurious falls, and 20% of these falls lead to severe injuries such as fractures. Only half of the people talked to their doctors about their falls, although 95% were concerned about their fall risk. Participants were satisfied with the coverage of physiotherapy, yet very few fall prevention interventions were applied. Almost 80% of the participants would like to take part in a fall prevention program, but only 3.5% reported to know of a program that is offered.

Conclusion: Fall prevention in people with MS requires more awareness in Germany from researchers and health care workers that treat people with MS. The current situation is unsatisfactory for people with MS.

Keywords: Multiple sclerosis, Accidental falls, Accident prevention, Physical therapy modalities, Surveys and questionnaires, Germany

Introduction

Sensory, motor, visual and balance impairments are the most common presenting symptoms in people living with MS [1]. Balance impairments are especially associated with an increase in fall risk [2]. An analysis pooling data from four cohort studies of prospectively collected data over 3 months from 537 participants who were recruited to participate in a falls study on risk factors, reported that 56% of participants had fallen once and 37% fall regularly (twice or more) [3]. There is also evidence that among people with MS being older than 45 years of age or having a fall history, the prevalence of fear of falling is common and associated with activity curtailment [4,5]. Moreover, fear of falling is associated with a higher risk of future recurrent falls [6]. Thus, it can be hypothesized that falls and fear of falling trigger a vicious cycle which lead to reduced physical activity, further deconditioning and more falls. Consequently, it seems essential to develop interventions that reduce falls and fear of falling to prevent activity curtailment and its negative consequences for people with MS.

The high relevance of this topic has received increasing attention as researchers and health care professionals aim to identify the risk

factors, context, and consequences and to use these data to develop theory-based interventions [7]. Yet, despite the work of several individual research teams around the world, scientific knowledge about effective interventions to reduce the number, severity, and consequences of falls is in its infancy [8]. Research in this field was also repeatedly highlighted as lacking consistency and having major methodological limitations [9]. In Germany little information is available about falls in the general or aging population and fall prevention programs as well as guidelines are largely missing [10,11]. And, to the best of our knowledge, no substantial data concerning prevalence of falls and fall prevention programs for people with MS is available.

To fill this gap, an explorative, qualitative and quantitative study was set up. The qualitative study with 11 people with MS was published in 2019 and identified valuable insights on the views, opinions, preferences and reluctance regarding falls prevention interventions and organizational details of programs [12]. To gain a broader view and to complement our previous qualitative study, we conducted a nationwide survey.

Methods

Research design

The study was designed as a cross-sectional study with retrospective data using a web-based questionnaire. It was conducted between March 21, 2018 and July 31, 2018.

Recruitment

All participants were recruited via an advertisement of the study on the German MS Society's website and via emails from the German MS Society to regional groups. In both cases a link to the online survey was attached. The study information and consent form appeared on the start page of the web-based survey. After reading the information, participants provided informed consent by checking the appropriate box. Time for survey completion was approximately 20 minutes. Participant could withdraw at any time by closing their browser.

The inclusion criteria for the study were:

- Diagnosis of MS (self-reported),
- A minimal age limit of 18 years (self-reported),
- A history of falls, near falls or being concerned about balance or falling risk.

The exclusion criterion for the study was the inability to understand and sign an informed consent or fill in the survey for linguistic, cognitive or other reasons.

Data collection

Inspired by previous survey questions of other similar studies, the survey questions were developed by the first author. The survey was pilot tested by five researchers of the research team and improved with respect to language and content according to their feedback. The tool was then pilot tested by five people with MS and again improved with respect to language and content according to their feedback, before it was made public for study participants.

For each survey question, participants were given a choice of answer options. If the matching answer was not listed as an option, there was always the possibility to enter an answer in an open text field.

Demographics

Demographic information included age, gender, zip code, year of diagnosis, MS subtype and date of last stay in a rehabilitation clinic. The zip code was collected to assign participants to three groups: small town/rural (less than 20,000 inhabitants), medium-sized town (20,000-100,000) and large town/urban (more than 100,000 inhabitants). The MS subtypes were classified as relapsing remitting (RRMS), secondary progressive (SPMS), primary progressive (PPMS) and unknown upon patient report.

Disease severity

The Patient Determined Disease Steps (PDDS) was used to determine the level of disability of the participants [13]. The PDDS has a strong correlation with the Expanded Disability Status Scale (EDSS) and is a valid patient-reported outcome of disability in MS [14]. The PDDS has nine ordinal levels that mostly evaluate the walking ability of the patient ranging between 0 (normal) and 8 (bedridden).

Medications

Firstly, participants were asked how many medications they take in total. In the second step the participants specified against which symptom or disorder each medication is taken. In addition, we collected detailed information on MS disease-modifying therapies (DMTs).

Walking aid

Participants had to answer whether they used a walking aid indoors and/or outdoors and if affirmed, they ought to specify which aid they exactly used indoors and outdoors.

Near falls and falls

The near falls and falls were collected retrospectively by self-reported counts. Participants stated the number of falls they had in the last 6 months. Falls were defined as "a slip or trip in which you lost your balance and landed on the floor or ground or lower level," and near falls as "an occasion where you felt you were about to fall but did not actually fall." [15]. We also differentiated between infrequent fallers and frequent fallers for further statistical analyses. We defined frequent fallers as those who had ≥ 3 falls in the last 6 months.

Injurious falls and type of injury

The participants were asked whether any of the falls in the last six months caused an injury and how many falls caused an injury. In the next step the participants ought to specify the type of injury for the latest injurious fall and their worst injurious fall.

Physicians' responses to falls

We asked about the response of physicians on three occasions. The participants were asked whether they were treated for their last injurious fall and whether the treating physician talked to them about their falls. The same question was asked for the worst injurious fall. Finally, the participants were asked if they ever talked to their general practitioner or neurologist about their falls. When those questions were affirmed, we asked each time whether recommendations were received and what those recommendations were.

Fall prevention interventions in physiotherapy sessions

The participants were asked whether they currently receive physiotherapy. When this question was affirmed, the frequency and duration of the therapy was requested. Lastly, it was asked whether and which fall prevention interventions the physiotherapy included. As laymen/laywomen could have trouble specifying this question, a list of different fall prevention interventions was given for choice.

Fall prevention programs

First, participants were asked whether they know any programs that are offered in their district and if they ever participated in one. If the question was answered in the affirmative, the participants' satisfaction with the program and suggestions for improvement were collected. When the prior question was negated, the participants were asked if they would

participate in a program if one was offered. In the final step, questions were asked concerning program leader, location, duration of program, frequency and duration of sessions.

Data Analysis

The study is exploratory and thus the data was only analysed descriptively. P-value are only given as descriptive summary measures and cannot be interpreted as results of confirmatory analyses. Categorical data are summarized as total number and percentages. Numerical data is summarized with mean, standard deviation, and range. For comparing two categorical variables odds-ratios and the corresponding 95% confidence intervals together with a chi-square test without continuity correction were calculated. For comparing two numerical variables Pearson correlation coefficient was calculated.

Ethical Approval

The study received ethical approval from the Hamburg Chamber of Physician's ethics committee (reference number: PV5609).

Results

Demographics and sample characteristics

In total 361 participants started the survey. Since 46 participants did not complete the survey, the data of 315 participants were used for analysis. Table 1 summarizes the characteristics of these participants. Participants were an average of 49 years, had an average disease duration of 13 years and 74% were woman (Table 1).

Medications

Of the 315 survey respondents 24 (7.6%) did not take any medication whereas 248 (78.8%) took one to five medications and 43 (13.7%) took six or more medications. Of the 291 respondents who took medication, 219 (75.3%) did not take any MS DMTs. Figure 1 summarizes for which symptoms and/or disorders the medications were taken.

Near falls and falls

Of the 315 respondents, 301 (95.6%) reported a near fall in the last 6 months and 257 (81.6%) actually fell in the last six months. Overall, our sample consisted of 58 (18.4%) non-fallers, 128 (41.0%) infrequent fallers and 129 (40.6%) frequent fallers.

Non-fallers vs. fallers

Demographic factors of non-fallers compared to fallers are summarized in table 2. Fallers had a higher mean PDDS score (3.8 ± 1.6) and a longer mean disease duration (14.0 ± 9.5) than non-fallers (3.0 ± 1.7 and 9.4 ± 8.3). Rate of fallers was highest for people with SPMS ($n=75$, 88.2%), followed by people with PPMS ($n=29$, 80.6%).

Taking MS DMTs (OR=0.42, 95% CI=0.18-0.97) or psychopharmaceuticals (OR=0.59, 95% CI=0.28-1.23) decreased the odds of being a faller. Medication against spasticity (OR=2.23, 95% CI=1-4.99), against pain (OR=2.99, 95% CI=1.22-7.32), and against cardiovascular disorder (OR=1.57, 95% CI=0.7-3.53) were associated with being a faller. Other medications were not analyzed as the group sizes were too small (less than 30 respondents).

Using a walking aid indoors or outdoors increased the odds of being a faller (OR=2.69, 95% CI=1.26-5.73 and OR=2.07, 95% CI=1.16-3.69). Fallers were more likely to talk to a physician about their falls (OR=2.83, 95% CI=1.5-5.32, $p<0.001$). Receiving physiotherapy increased the odds of being a faller (OR=1.38, 95% CI=0.74-2.57). The group with a higher physiotherapy frequency had a higher PDDS score (4.4 ± 1.3) compared to the group with a lower frequency (3.7 ± 1.5) (Table 2a, 2b, 2c, 2d).

Infrequent fallers vs. frequent fallers

Demographic factors of non-fallers compared to fallers are summarized in table 3. Frequent fallers had a higher mean PDDS score (4.1 ± 1.6) than infrequent fallers (3.6 ± 1.6). The rate of frequent fallers was similar among people with SPMS ($n=45$, 60.0%) and PPMS ($n=18$, 62.1%) and lower for people with RRMS ($n=51$, 39.8%).

Table 1: Demographic and sample characteristics.

| Characteristics | Values |
|---|-------------|
| Age (y) | |
| Mean ± SD | 48.5 ± 10.8 |
| Range | 18-83 |
| Females (n (%)) | 233 (74.0) |
| Disease duration (y) | |
| Mean ± SD | 13.2 ± 9.5 |
| Range | Jan-48 |
| MS subtype (n (%)) | |
| Relapsing-remitting | 166 (52.7) |
| Secondary progressive | 85 (27) |
| Primary progressive | 36 (11.4) |
| Unknown | 28 (8.9) |
| PDDS rating for entire cohort | |
| Mean ± SD | 3.7 (1.6) |
| Range | 0-7 |
| PDDS rating by category (n (%)) | |
| 0 Normal | 12 (3.8) |
| 1 Mild Disability | 20 (6.3) |
| 2 Moderate Disability | 30 (9.5) |
| 3 Gait Disability | 87 (27.6) |
| 4 Early Cane | 73 (23.2) |
| 5 Late Cane | 49 (15.5) |
| 6 Bilateral Support | 30 (9.5) |
| 7 Wheelchair / Scooter | 14 (4.4) |
| 8 Bedridden | 0 (0) |
| Last rehabilitation stay (n (%)) | |
| Never | 107 (34.0) |
| Within the last 11 months | 49 (15.6) |
| 1 to 9 years ago | 135 (42.9) |
| 10 years ago or more | 24 (7.6) |
| Walking aid indoors (n (%)) | |
| None | 221 (72.1) |
| Cane | 30 (9.5) |
| Crutches | 10 (3.2) |
| Walkers | 46 (14.6) |
| Another aid (furniture, orthosis) | 26 (6.3) |
| Walking aid outdoors (n (%)) | |
| None | 133 (49.2) |
| Cane | 73 (23.2) |
| Crutches | 25 (7.9) |
| Walkers | 64 (20.3) |
| Another aid (Nordic walking sticks, orthosis) | 85 (20) |
| Is concerned about balance (n (%)) | 275 (87.3) |
| Is concerned about fall risk (n (%)) | 299 (94.9) |
| Size of the place of residence (n (%)) | |
| Small town | 105 (33.3) |
| Medium-sized town | 98 (31.1) |
| Large town | 108 (34.3) |

Medication against spasticity (OR=2.59, 95% CI=1.45-4.66) and psychopharmaceuticals (OR=1.93, 95% CI=0.93-4.03) were associated with being a frequent faller. There was only an exceedingly small or rather negligible correlation between number of drugs and number of falls ($r=0.1$, $p=0.077$).

Using a walking aid indoors or outdoors increased the odds of being a frequent faller (OR=1.68, 95% CI=0.99-2.85 and OR=1.61, 95% CI=0.97-2.66). All walking aids (cane, crutches, walker) increased the odds of being a faller at a similar rate. Frequent fallers were more likely to talk to a physician about their falls (OR=2.24, 95% CI=1.36-3.7).

Receiving physiotherapy was associated with being a frequent faller (OR=1.68, 95% CI=0.97-2.93). Interestingly, 22.5% of the frequent fallers did not have physiotherapy, 25.6% never had a rehabilitation stay and

36.4% never talked to a physician about their falls (**Table 3a, 3b, 3c, 3d**).

Injurious falls and type of injury

Nearly 75% (n=191) of all fallers (n=257) reported an injury caused by a near fall or fall in the last six months. Figure 2 shows the injury type for the latest and worst injurious fall in the last six months. Mild injuries such as bruises and scratches were the most common injuries (n=119, 62.3% for latest and n=109, 57.1% for worst injurious fall). Severe injuries such as fractures were common (n=32, 16.8% for latest and 20.6% for worst injurious fall) whereas concussions were seldom (n=8, 4.2% for latest and 5.6% for worst injurious fall). When we asked about what body part was affected by the injury, knee (42.4% and 37.3%), hand (36.6% and 30.9%), foot (30.4% and 26.9%) and head (19.9% and 23%) were the most common injurious for the latest and worst injury (**Figure 2, 3**).

Figure 1. For which symptom / disorder the medications are taken.

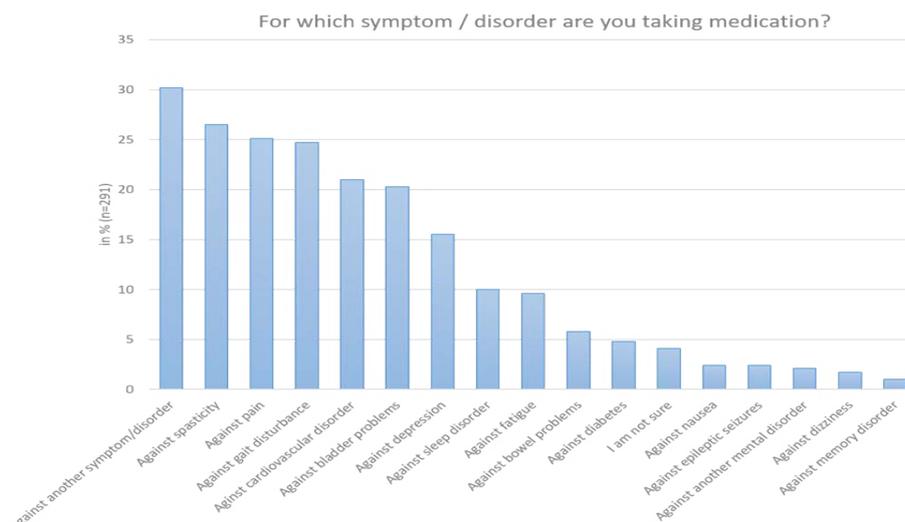


Table 2a: Non-faller vs. fallers – demographic data and disease severity.

| | Non-fallers (n=58) | Fallers (n=257) | Total (n=315) | p value |
|-------------------------------------|--------------------|-----------------|---------------|---------|
| Age in years | | | | |
| Mean (SD) | 47.0 (11.7) | 48.9 (10.5) | 48.5 (10.8) | 0.223 |
| Gender | | | | |
| female | 49 (21.0%) | 184 (79.0%) | 233 (100.0%) | 0.043 |
| male | 9 (11.0%) | 73 (89.0%) | 82 (100.0%) | |
| PDDS (numeric) | | | | |
| Mean (SD) | 3.0 (1.7) | 3.8 (1.6) | 3.7 (1.6) | < 0.001 |
| Duration of MS in years | | | | |
| Mean (SD) | 9.4 (8.3) | 14.0 (9.5) | 13.2 (9.5) | < 0.001 |
| MS Types in n (%) | | | | |
| RRMS | 38 (22.9%) | 128 (77.1%) | 166 (100.0%) | 0.119 |
| SPMS | 10 (11.8%) | 75 (88.2%) | 85 (100.0%) | |
| PPMS | 7 (19.4%) | 29 (80.6%) | 36 (100.0%) | |
| Unknown | 3 (10.7%) | 25 (89.3%) | 28 (100.0%) | |
| Rehabilitation stay in n (%) | | | | |
| Never | 28 (26.2%) | 79 (73.8%) | 107 (100.0%) | 0.011 |
| Yes | 30 (14.4%) | 178 (85.6%) | 208 (100.0%) | |

Table 2b: Non-faller vs. fallers – walking aids.

| | Non-fallers (n=58) | Fallers (n=257) | Total (n=315) | p value |
|----------------------------------|--------------------|-----------------|---------------|---------|
| Walking aid indoors | | | | |
| Yes | 9 (9.6%) | 85 (90.4%) | 94 (100.0%) | 0.008 |
| No | 49 (22.2%) | 172 (77.8%) | 221 (100.0%) | |
| Walking stick indoors | | | | |
| No | 56 (19.6%) | 229 (80.4%) | 285 (100.0%) | 0.081 |
| Yes | 2 (6.7%) | 28 (93.3%) | 30 (100.0%) | |
| Underarm support indoors | | | | |
| No | 57 (18.7%) | 248 (81.3%) | 305 (100.0%) | 0.485 |
| Yes | 1 (10.0%) | 9 (90.0%) | 10 (100.0%) | |
| Rollator indoors 0.066 | | | | |
| No | 54 (20.1%) | 215 (79.9%) | 269 (100.0%) | |
| Yes | 4 (8.7%) | 42 (91.3%) | 46 (100.0%) | |
| Walking aid outdoors | | | | |
| Yes | 25 (13.7%) | 157 (86.3%) | 182 (100.0%) | 0.012 |
| No | 33 (24.8%) | 100 (75.2%) | 133 (100.0%) | |
| Walking stick outdoors | | | | |
| No | 49 (20.2%) | 193 (79.8%) | 242 (100.0%) | 0.126 |
| Yes | 9 (12.3%) | 64 (87.7%) | 73 (100.0%) | |
| Underarm support outdoors | | | | |
| No | 54 (18.6%) | 236 (81.4%) | 290 (100.0%) | 0.746 |
| Yes | 4 (16.0%) | 21 (84.0%) | 25 (100.0%) | |
| Rollator outdoors | | | | |
| No | 52 (20.7%) | 199 (79.3%) | 251 (100.0%) | 0.037 |
| Yes | 6 (9.4%) | 58 (90.6%) | 64 (100.0%) | |

Table 2c: Non-faller vs. fallers – contact to doctor and physiotherapy.

| | Non-fallers (n=58) | Fallers (n=257) | Total (n=315) | p value |
|---|--------------------|-----------------|---------------|---------|
| Talked to doctor? Recommendation given? | | | | 0.004 |
| N-Miss | 3 | 0 | 3 | |
| Not talked | 39 (24.7%) | 119 (75.3%) | 158 (100.0%) | |
| Talked | 16 (10.4%) | 138 (89.6%) | 154 (100.0%) | |
| Talked & no recommendation | 10 (10.4%) | 86 (89.6%) | 96 (100.0%) | |
| Talked & recommendation | 6 (10.3%) | 52 (89.7%) | 58 (100.0%) | |
| Receiving physiotherapy | | | | 0.304 |
| N-Miss | 3 | 0 | 3 | |
| Yes | 36 (16.2%) | 186 (83.8%) | 222 (100.0%) | |
| No | 19 (21.1%) | 71 (78.9%) | 90 (100.0%) | |
| Frequency of physiotherapy | | | | 0.053 |
| Once a week or less | 22 (21.4%) | 81 (78.6%) | 103 (100.0%) | |
| More than once a week | 14 (11.8%) | 105 (88.2%) | 119 (100.0%) | |
| Duration of physiotherapy | | | | 0.668 |
| Short (30 min or less) | 24 (17.0%) | 117 (83.0%) | 141 (100.0%) | |
| Long (more than 30 min) | 12 (14.8%) | 69 (85.2%) | 81 (100.0%) | |

Table 2d: Non-faller vs. fallers – medication intake.

| Medication intake in n (%) | Non-fallers (n=52) | Fallers (n=239) | Total (n=291) | p value |
|---------------------------------|--------------------|-----------------|---------------|---------|
| Only MS DMTs | | | | 0.094 |
| No | 40 (16.3%) | 206 (83.7%) | 246 (100.0%) | |
| Yes | 12 (26.7%) | 33 (73.3%) | 45 (100.0%) | |
| MS DMTs | | | | 0.038 |
| No | 7 (9.7%) | 65 (90.3%) | 72 (100.0%) | |
| Yes | 45 (20.5%) | 174 (79.5%) | 219 (100.0%) | |
| Against spasticity | | | | 0.046 |
| No | 44 (20.6%) | 170 (79.4%) | 214 (100.0%) | |
| Yes | 8 (10.4%) | 69 (89.6%) | 77 (100.0%) | |
| Against pain | | | | 0.013 |
| No | 46 (21.1%) | 172 (78.9%) | 218 (100.0%) | |
| Yes | 6 (8.2%) | 67 (91.8%) | 73 (100.0%) | |
| Against cardiovascular disorder | | | | 0.276 |
| No | 44 (19.1%) | 186 (80.9%) | 230 (100.0%) | |
| Yes | 8 (13.1%) | 53 (86.9%) | 61 (100.0%) | |
| Against gait disturbance | | | | 0.508 |
| No | 41 (18.7%) | 178 (81.3%) | 219 (100.0%) | |
| Yes | 11 (15.3%) | 61 (84.7%) | 72 (100.0%) | |
| Against bladder problems | | | | 0.836 |
| No | 42 (18.1%) | 190 (81.9%) | 232 (100.0%) | |
| Yes | 10 (16.9%) | 49 (83.1%) | 59 (100.0%) | |
| Psychopharmaceuticals | | | | 0.158 |
| No | 40 (16.5%) | 203 (83.5%) | 243 (100.0%) | |
| Yes | 12 (25.0%) | 36 (75.0%) | 48 (100.0%) | |

Table 3a: Infrequent fallers vs. frequent fallers – demographic data and disease severity.

| | Infrequent fallers (n=128) | Frequent fallers (n=129) | Total (n=257) | p value |
|------------------------------|----------------------------|--------------------------|---------------|---------|
| Age in years | | | | 0.256 |
| Mean (SD) | 48.1 (10.1) | 49.6 (10.9) | 48.9 (10.5) | |
| Gender | | | | 0.514 |
| female | 94 (51.1%) | 90 (48.9%) | 184 (100.0%) | |
| male | 34 (46.6%) | 39 (53.4%) | 73 (100.0%) | |
| PDDS (numeric) | | | | 0.006 |
| Mean (SD) | 3.6 (1.6) | 4.1 (1.6) | 3.8 (1.6) | |
| Duration of MS in years | | | | 0.553 |
| Mean (SD) | 13.7 (9.5) | 14.4 (9.6) | 14.1 (9.5) | |
| MS Types in n (%) | | | | 0.012 |
| RRMS | 77 (60.2%) | 51 (39.8%) | 128 (100.0%) | |
| SPMS | 30 (40.0%) | 45 (60.0%) | 75 (100.0%) | |
| PPMS | 11 (37.9%) | 18 (62.1%) | 29 (100.0%) | |
| Unknown | 10 (40.0%) | 15 (60.0%) | 25 (100.0%) | |
| Rehabilitation stay in n (%) | | | | 0.072 |
| Never | 46 (58.2%) | 33 (41.8%) | 79 (100.0%) | |
| Yes | 82 (46.1%) | 96 (53.9%) | 178 (100.0%) | |

Table 3b: Infrequent fallers vs. frequent fallers – walking aids.

| | Infrequent fallers (n=128) | Frequent fallers (n=129) | Total (n=257) | p value |
|---------------------------|----------------------------|--------------------------|---------------|---------|
| Walking aid indoors | | | | 0.052 |
| Yes | 35 (41.2%) | 50 (58.8%) | 85 (100.0%) | |
| No | 93 (54.1%) | 79 (45.9%) | 172 (100.0%) | |
| Walking stick indoors | | | | 0.436 |
| No | 116 (50.7%) | 113 (49.3%) | 229 (100.0%) | |
| Yes | 12 (42.9%) | 16 (57.1%) | 28 (100.0%) | |
| Underarm support indoors | | | | 0.743 |
| No | 124 (50.0%) | 124 (50.0%) | 248 (100.0%) | |
| Yes | 4 (44.4%) | 5 (55.6%) | 9 (100.0%) | |
| Rollator indoors | | | | 0.517 |
| No | 109 (50.7%) | 106 (49.3%) | 215 (100.0%) | |
| Yes | 19 (45.2%) | 23 (54.8%) | 42 (100.0%) | |
| Walking aid outdoors | | | | 0.066 |
| Yes | 71 (45.2%) | 86 (54.8%) | 157 (100.0%) | |
| No | 57 (57.0%) | 43 (43.0%) | 100 (100.0%) | |
| Walking stick outdoors | | | | 0.160 |
| No | 101 (52.3%) | 92 (47.7%) | 193 (100.0%) | |
| Yes | 27 (42.2%) | 37 (57.8%) | 64 (100.0%) | |
| Underarm support outdoors | | | | 0.834 |
| No | 118 (50.0%) | 118 (50.0%) | 236 (100.0%) | |
| Yes | 10 (47.6%) | 11 (52.4%) | 21 (100.0%) | |
| Rollator outdoors | | | | 0.246 |
| No | 103 (51.8%) | 96 (48.2%) | 199 (100.0%) | |
| Yes | 25 (43.1%) | 33 (56.9%) | 58 (100.0%) | |

Table 3c: Infrequent fallers vs. frequent fallers – contact to doctor and physiotherapy.

| | Infrequent fallers (n=128) | Frequent fallers (n=129) | Total (n=257) | p value |
|---|----------------------------|--------------------------|---------------|---------|
| Talked to doctor? Recommendation given? | | | | 0.001 |
| Not talked | 72 (60.5%) | 47 (39.5%) | 119 (100.0%) | |
| Talked | 56 (40.6%) | 82 (59.4%) | 138 (100.0%) | |
| Talked & no recommendation | 32 (37.2%) | 54 (62.8%) | 86 (100.0%) | |
| Talked & recommendation | 24 (46.2%) | 28 (53.8%) | 52 (100.0%) | |
| Receiving physiotherapy | | | | 0.064 |
| Yes | 86 (46.2%) | 100 (53.8%) | 186 (100.0%) | |
| No | 42 (59.2%) | 29 (40.8%) | 71 (100.0%) | |
| Frequency of physiotherapy | | | | 0.450 |
| Once a week or less | 40 (49.4%) | 41 (50.6%) | 81 (100.0%) | |
| More than once a week | 46 (43.8%) | 59 (56.2%) | 105 (100.0%) | |
| Duration of physiotherapy | | | | 0.377 |
| Short (30 min or less) | 57 (48.7%) | 60 (51.3%) | 117 (100.0%) | |
| Long (more than 30 min) | 29 (42.0%) | 40 (58%) | 69 (100.0%) | |

Physicians’ responses to falls

Of the 191 respondents who reported their latest injurious fall, 95 (49.2%) had to be treated for their injury by a physician. Of those only 13 (13.7%) reported of having been recommended preventive measures to avoid further falls. Nearly half of all survey participants (n=161, 51.1%) never talked with their general practitioner or neurologist about falls, although they were concerned about their balance or fall risk. Of those who talked to either their general practitioner or neurologist (n=154, 48.9%), 58 (37.7%) were recommended preventive measures to avoid further falls. The most common recommended preventive measures were the prescription of physiotherapy (82.8%), the prescription of a walking

aid (72.4%) and the recommendation to be more attentive and careful (50%). Figure 4 lists all recommended preventive measures (Figure 4).

Fall prevention interventions in physiotherapy sessions

70.5% of all participants (n=222) received physiotherapy. The frequency and duration of the physiotherapy sessions is summarized in table 4. The most received fall prevention measures were the assessment and treatment of the spasticity / sensory disturbance in the lower extremity (33.3%) and physical tests to assess the risk of falling (32.4%). Almost one-third (32.0%) checked the box “none of the listed interventions were executed”. Figure 5 shows all fall prevention interventions that were applied in physiotherapy sessions. To the question “Are you satisfied

Table 3d: Infrequent fallers vs. frequent fallers – medication intake.

| Medication intake in n (%) | Non-fallers (n=119) | Fallers (n=120) | Total (n=239) | p value |
|---------------------------------|---------------------|-----------------|---------------|---------|
| Only MS DMTs | | | | 0.087 |
| No | 98 (47.6%) | 108 (52.4%) | 206 (100.0%) | |
| Yes | 21 (63.6%) | 12 (36.4%) | 33 (100.0%) | |
| MS DMTs | | | | 0.328 |
| No | 29 (44.6%) | 36 (55.4%) | 65 (100.0%) | |
| Yes | 90 (51.7%) | 84 (48.3%) | 174 (100.0%) | |
| Against spasticity | | | | 0.001 |
| No | 96 (56.5%) | 74 (43.5%) | 170 (100.0%) | |
| Yes | 23 (33.3%) | 46 (66.7%) | 69 (100.0%) | |
| Against pain 0.695 | | | | |
| No | 87 (50.6%) | 85 (49.4%) | 172 (100.0%) | |
| Yes | 32 (47.8%) | 35 (52.2%) | 67 (100.0%) | |
| Against cardiovascular disorder | | | | 0.261 |
| No | 89 (47.8%) | 97 (52.2%) | 186 (100.0%) | |
| Yes | 30 (56.6%) | 23 (43.4%) | 53 (100.0%) | |
| Against gait disturbance | | | | 0.852 |
| No | 88 (49.4%) | 90 (50.6%) | 178 (100.0%) | |
| Yes | 31 (50.8%) | 30 (49.2%) | 61 (100.0%) | |
| Against bladder problems | | | | 0.654 |
| No | 96 (50.5%) | 94 (49.5%) | 190 (100.0%) | |
| Yes | 23 (46.9%) | 26 (53.1%) | 49 (100.0%) | |
| Psychopharmaceuticals | | | | 0.075 |
| No | 106 (52.2%) | 97 (47.8%) | 203 (100.0%) | |
| Yes | 13 (36.1%) | 23 (63.9%) | 36 (100.0%) | |

Figure 2. Type of injury for the latest and worst injurious fall.

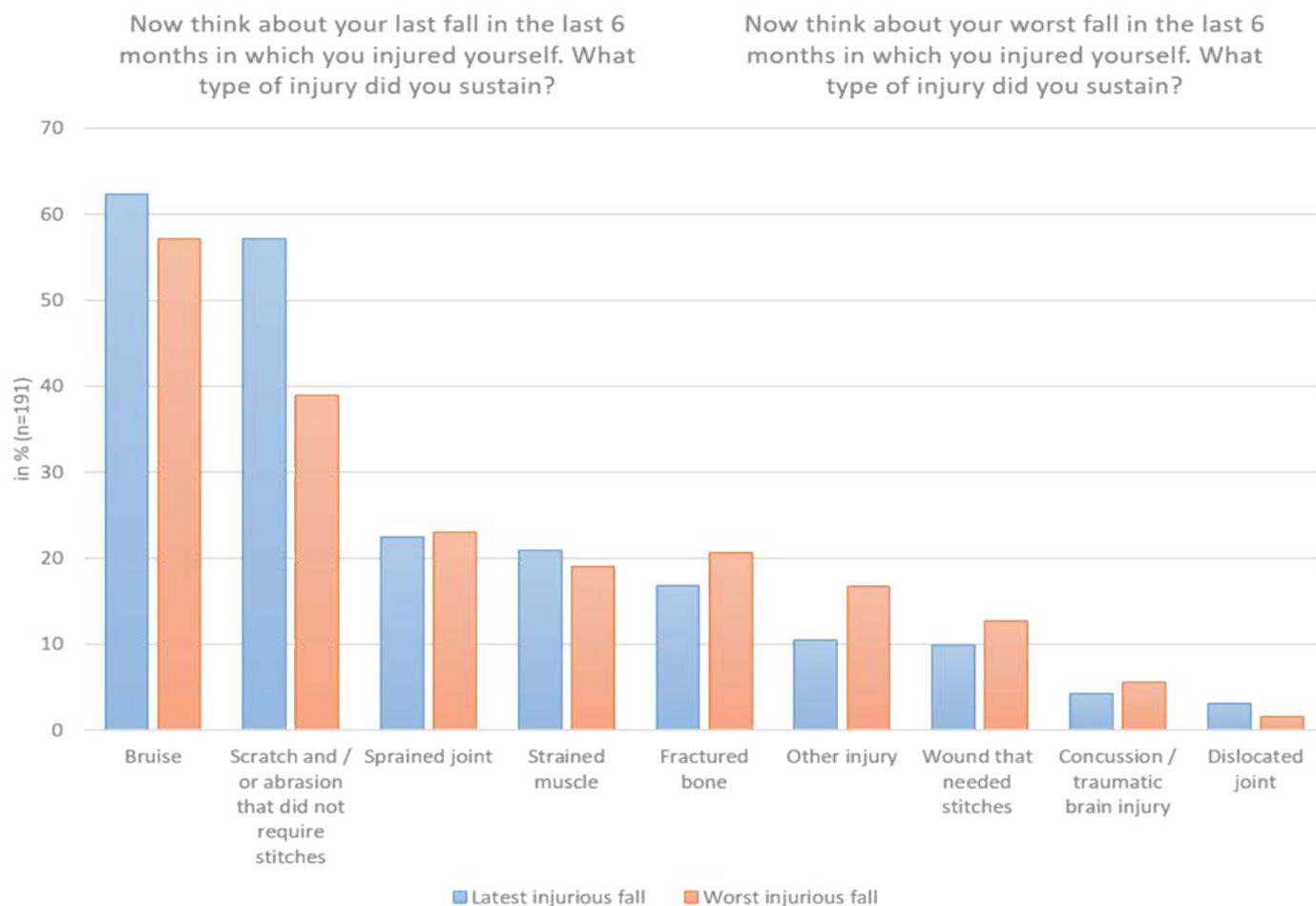


Figure 3. Injured body part for the latest and worst injurious fall.

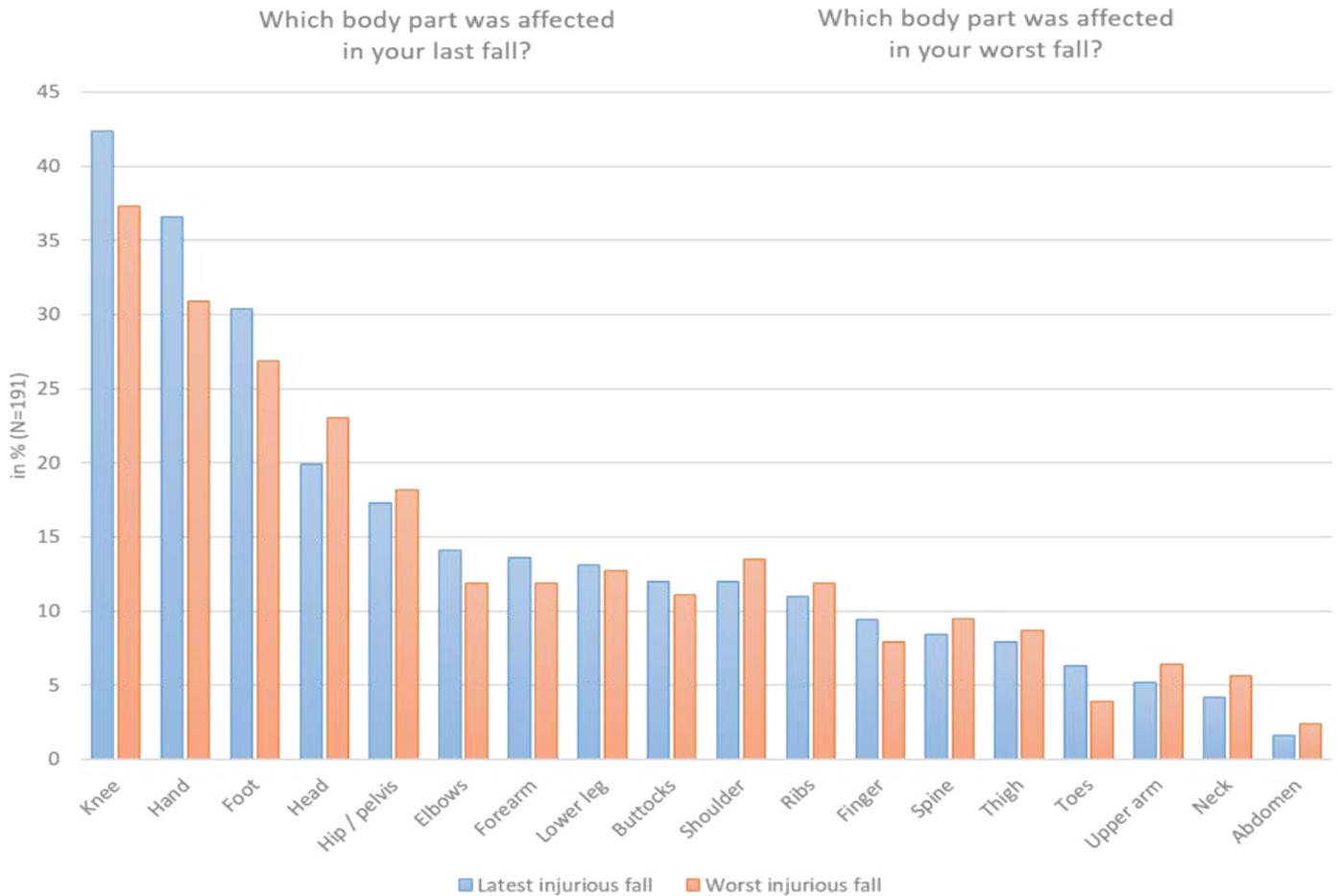


Figure 4. Recommended preventive measures of physicians

Which preventive measure was recommended by your general practitioner or neurologist?

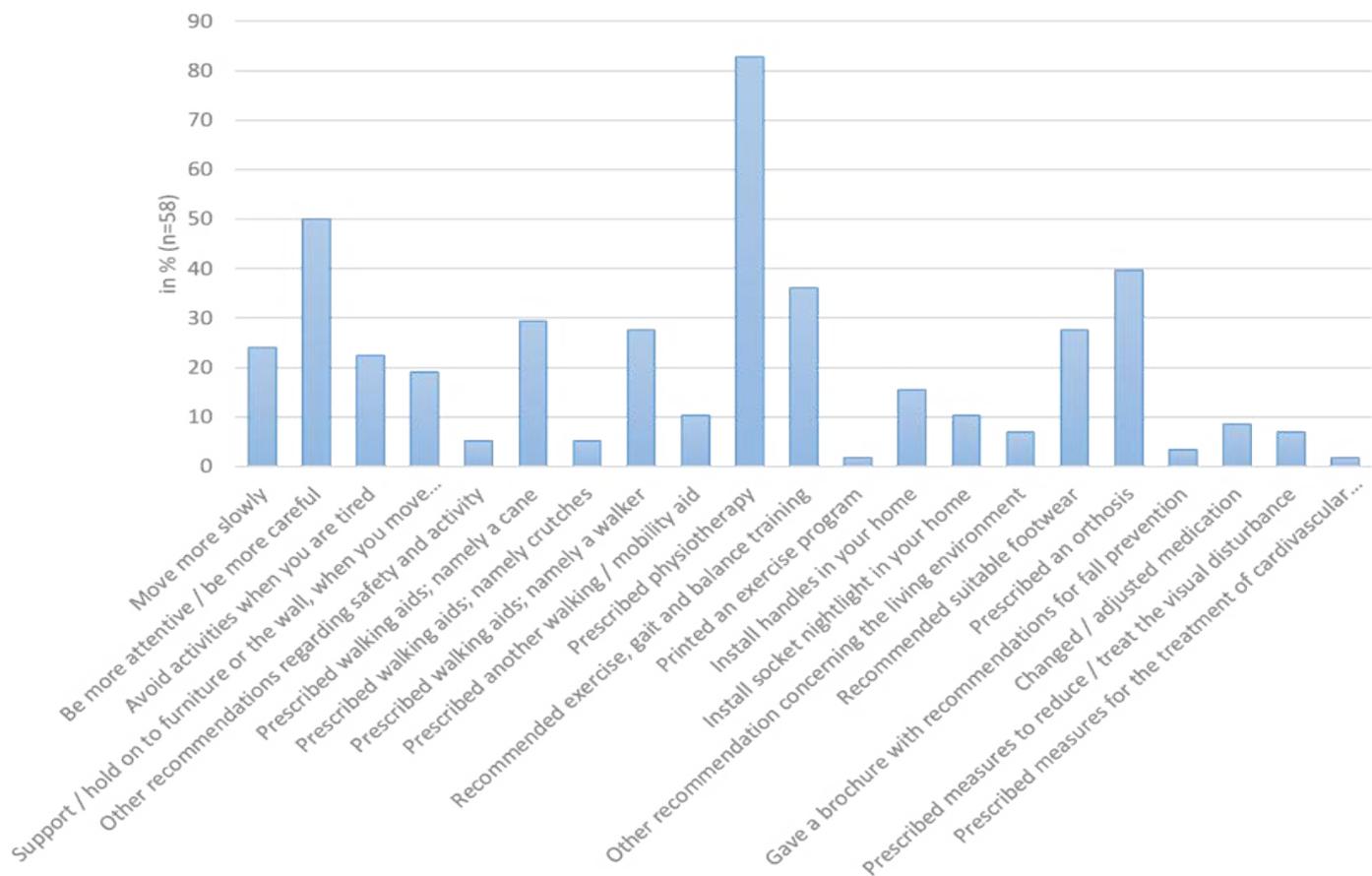


Figure 5. Fall prevention interventions that were applied in physiotherapy sessions.

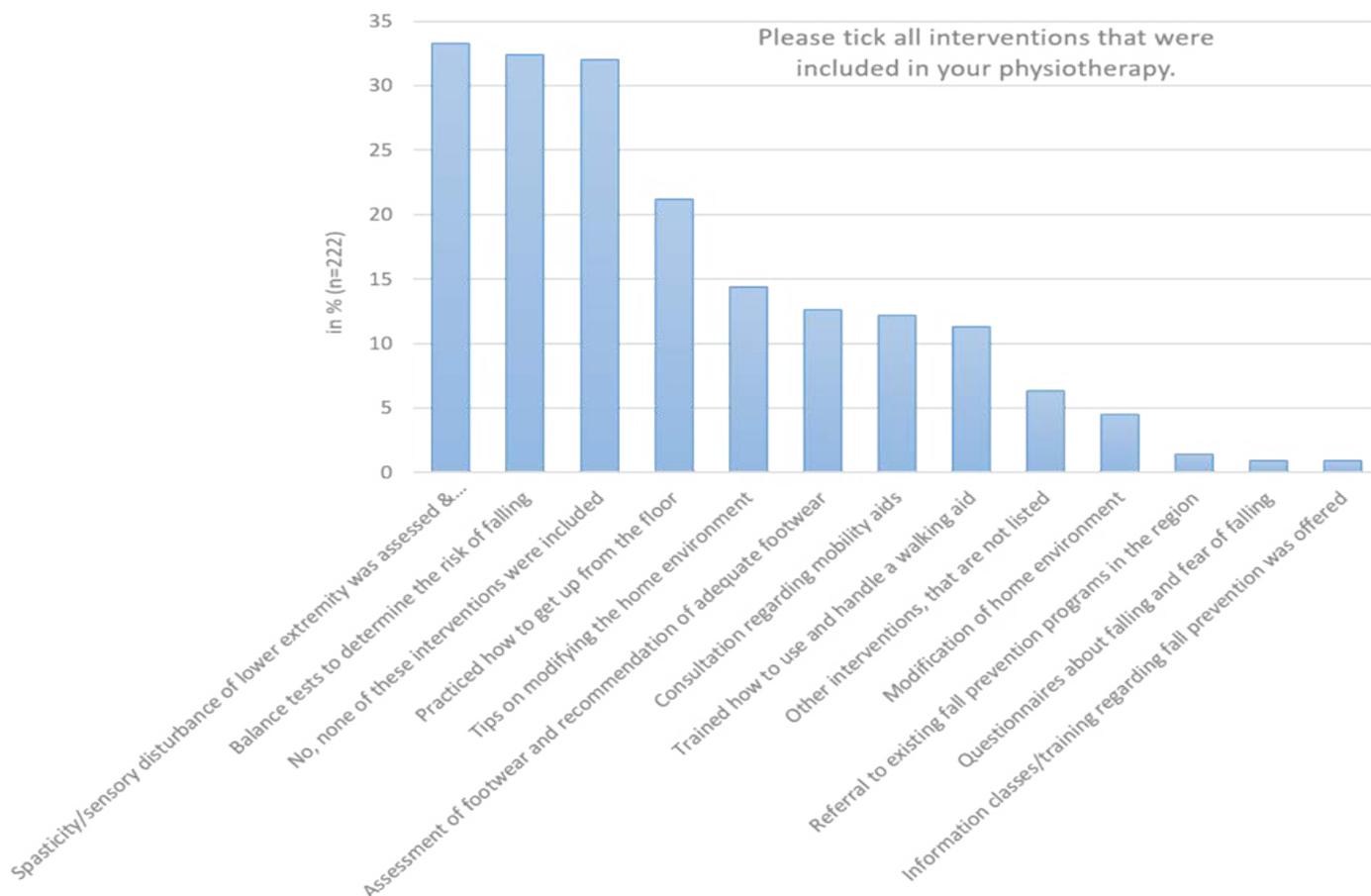


Table 4: Frequency and duration of physiotherapy.

| Frequency n (%) | |
|----------------------|-------------|
| Once a week | 97 (43.7%) |
| Twice a week | 106 (47.7%) |
| Other frequencies | 19 (8.8%) |
| Duration n (%) | |
| 20-minute session | 52 (23.4%) |
| 30-minute session | 89 (40.1%) |
| 40-minute session | 34 (15.3%) |
| 60-minute session | 38 (17.1%) |
| More than 60 minutes | 9 (4.1%) |

Table 5: Preferred features of a potential fall prevention program.

| Program type in n (%) | |
|--|-------------|
| Individual therapy | 100 (41.0%) |
| Group therapy | 28 (11.5%) |
| No preference | 116 (47.5%) |
| Location (multiple answers allowed) in % | |
| Physiotherapy practice | 62.7% |
| Web-based program | 34.8% |
| Home therapy | 21.7% |
| MS clinic | 16.8% |
| Local gym | 15.6% |
| Rehabilitation clinic | 14.3% |
| Leader in n (%) | |
| Expert (physiotherapist or gym teacher) | 118 (48.4%) |
| Expert-layperson-duo | 82 (33.6%) |
| Layperson with training | 3 (1.2%) |
| No preference | 41 (16.8%) |
| Duration of program in n (%) | |
| 4 weeks | 66 (27.0%) |
| 6 weeks | 23 (9.4%) |

| Frequency of meetings in n (%) | |
|--------------------------------|-------------|
| 8 weeks | 33 (13.5%) |
| 10, 12, 14 or 16 weeks | 26 (10.7%) |
| No preference | 96 (39.3%) |
| Duration of session | |
| Once a week | 141 (57.8%) |
| Twice a week | 32 (13.1%) |
| Every other week | 22 (9.0%) |
| Once a month | 16 (6.6%) |
| No preference | 33 (13.5%) |
| 30 minutes | 52 (21.3%) |
| 45 minutes | 58 (23.8%) |
| 60 minutes | 63 (25.8%) |
| 90 or 120 minutes | 7 (2.8%) |
| No preference | 64 (26.2%) |

with the contents of your physiotherapy regarding fall prevention?", 135 (60.8%) responded with "yes" (Figure 5) (Table 4).

Fall prevention programs

Of all participants 229 (73.4%) were not sure, if a fall prevention programme is available in their district. About a quarter (23.1%) said that there was no fall prevention program in their district and only 3.5% of the participants knew that there is such a program available in their region. Only 13 (4.1%) participants of our cohort ever took part in a fall prevention program and about a half of them were satisfied with the program. Of the 299 participants that never took part in a fall prevention program, 244 (81.6%) would like to take part in such a program.

The preferred features of these 244 participants regarding program type (individual or group therapy), location, leader, duration of program, frequency of meetings and duration of sessions are summarized in (Table 5).

Preferences of program details and sample characteristics

Of the people that lived in a small town only 25.9% aimed for a web-based program, but for the people living in a medium size and large city the percentage was higher (39% and 38.6%). People that preferred a program at home had a higher mean PDDS score (4.5 ± 1.4) than people that declined a program at home (3.6 ± 1.6).

Also, people that preferred individual therapy had a higher mean PDDS score (4.2 ± 1.6) compared to people that preferred group therapy (3.3 ± 1.5). A higher percentage of men preferred individual therapy compared to women (50.8% vs. 37.8%).

If not mentioned explicitly, the specific program preferences above did not differ significantly in age, gender, disease duration, disease severity or among rural and urban people.

Discussion

Sample characteristics and falls

A higher disease severity and as a surrogate for this, a rehabilitation stay in the past and a higher physiotherapy frequency were associated with having more falls. It was reported before that fall risk increases with increased gait disability and decrease again with decreased gait ability (wheelchair or bedridden) [3]. Also, the percentage of being a frequent faller was significantly higher for people with SPMS and PPMS compared to people with RRMS. It was hypothesized before that the difficulty of adapting to a constantly, sometimes rapidly, progressing disability level, might be the reason for an association between falls and progressive MS types [3]. Consequently, this survey confirms prior studies that found fall risk to be higher for people with MS that have a higher disease severity and/ or a dynamic, rapid progression of disease. Fall prevention seems to be more relevant to these people.

Medications and falls

Of our cohort 92.5% reported to take medications. As almost none of the studies on fall risks reported the number of medications use of their

cohort, we cannot say whether such a large proportion of people taking medication is representative for people with MS or rather for people with MS that have a history of falls. To our knowledge, there was previously only one study (involving 248 ambulatory adults with MS) that specifically analysed the effect of medication intake on fall risk. This study reported that the odds for falls increased by 13% for each medication [16].

We did not see this trend in our cohort. More medications did not lead to a relevant increase in falls in our study. While the study by Cameron et al. [16] analysed the data of participants with similar characteristics (regarding age, disease severity and concern about imbalance and falls) and documented medication use also by self-report, their study counted falls prospectively and presumably more accurately.

In our study, participants that only took MS DMTs were less likely to be a faller. The explanation for this could be that this group did not have any other symptoms and disorders that added an extra risk factor for falling. The mean PDDS score of these 45 respondents was also considerably lower than the rest of the cohort (2.6 ± 1.7 vs. 3.7 ± 1.6). Yet, our results showed that use of MS DMTs - even with other medications - was associated with 68% decreased odds of falling. This finding confirms the finding of a previous study [16]. We compared 72 participants that did not use MS DMTs with 219 people that did take MS DMTs.

Further, we observed that medication against spasticity, pain and cardiovascular disorders were associated with falls, when non-fallers were compared to fallers. When infrequent fallers were compared to frequent fallers medication against spasticity and psychopharmaceuticals were associated with more falls. With such associations, it is always questionable whether the medications or the symptom itself increased the odds for more falls. Spasticity has been reported earlier to be a risk factor for falls in people with MS [17]. It was also reported before that leg pain was associated with falls [18]. To our knowledge, neither cardiovascular disease nor medication against cardiovascular disease were reported before as a risk factor for falls in people with MS.

Although use of more nervous system medications (particularly antidepressants) were shown to be associated with a significantly increased risk of falling [16], our findings were inconsistent. In our study, psychopharmaceuticals decreased odds of falling when non-fallers were compared to fallers but increased the odds of falling when infrequent fallers were compared to frequent fallers. Cameron et al. [16] categorized psychopharmaceuticals into eight subcategories and evaluated a larger dataset. This more detailed investigation could explain the different results.

About 25% of our participants took medication to improve gait disturbance (fampridine). But interestingly, these medications did not decrease the odds of falling significantly when we compared non-fallers to fallers or infrequent fallers to frequent fallers. Previous studies report that fampridine improves walking ability [19]. So, one might expect that it also has an effect on falls as improvements in dynamic balance are associated with reduction in falls [20].

Walking aids and falls

Using a walking aid indoors or outdoors increased the odds of being a faller, when we compared non-fallers with fallers and when we compared infrequent fallers with frequent fallers. The use of a walking aid was reported to be a risk factor for falls in people with MS in two systematic reviews [21,22]. Yet, again it is unclear whether this association was caused by the walking aid itself or by the higher disease severity as people that used a walking aid, rather have a higher disease severity.

In our study, the prescription of physiotherapy (82.8%) and of a walking aid (72.4%) were the most common preventive measures chosen by physicians. Yet only 25 of the 222 respondents that currently received physiotherapy reported that they were taught how to use and handle a mobility aid. In our previous qualitative study, the participants expressed their dissatisfaction with the deficient or non-existent consultation regarding mobility aids by physiotherapists [12]. Thus, teaching how to use mobility aids should be better integrated in the physiotherapy treatment.

Injurious falls and type of injury

Nearly 75% of the fallers in our cohort (n=191) reported injurious falls. Nearly one-fifth had a serious injury (fractured bone or concussion). These findings underline once more how essential research and intervention in the field of falls prevention is for people with MS that have a history of falls. Our study showed that the knee, hand, foot, head and hip were the most affected body parts. To our knowledge, it has not been investigated before which body parts were most injured in injurious falls in people with MS.

Biomechanical studies show that the initial contact with the floor and thus impact location after a fall is mostly the hand, knee and hip [23,24] which would explain the frequency of injuries to these body parts. A high prevalence of fall-related head injuries was also reported in other high-risk populations [25]. Thus, it seems plausible to teach falling techniques in physiotherapy that minimize injury to those body parts and especially the head. Such interventions - also called fall arrest strategy training - can be integrated into fall prevention programs and are effective in reducing the risk of injuries during falls [26,27]. The aforementioned studies may explain injuries to the hand, knee, hip and head, but not injuries to the foot. Thus, it may be a relevant question which effect foot orthoses, reported reduced ankle range of motion [28] and impaired ankle control [29] has on the fall rate in people with MS.

Physicians' responses to falls

Only 13.7% of the 95 respondents with an injurious fall, were recommended preventive measures to avoid further falls. This raises the question which role first contact physicians and emergency physicians can play in fall prevention.

Of all our participants only about half talked to a physician about their falls, although almost all respondents (95%) were concerned about their fall risk. This rate matches with a previously reported rate from the USA [30]. In our qualitative study, we observed that participants believed that healthcare professionals considered falls to be an inevitable part of MS and are normal for MS [12]. When we consider that 22.5% of the frequent fallers did not have physiotherapy, 25.6% never had a rehabilitation stay and 36.4% never talked to a physician about falls, this belief is strengthened. Such a belief of affected people might explain the hesitation to address this issue in dialogs with physicians. Thus, we strongly recommend including questions about falls in medical checkup questionnaires to identify fallers early in treatment and initiate a dialog.

In addition, only 37.7% of the participants that talked to a physician about their falls received recommendations to prevent further falls. Reasons need to be elucidated.

Fall prevention interventions in physiotherapy sessions

In our study, a distinct majority (70.5%) received physiotherapy. More than 90 percent had once or twice a week physiotherapy. Around 70% had a therapy duration of 30 to 60 minutes.

Our list with fall prevention interventions (summarized in **Figure 5**) excluded balance and gait training, as we consider appropriate fall prevention to be more than mere balance and gait exercises. An attempt was made to collect the 'additional' fall prevention interventions such as home modification, assessment of footwear, training on how to use a mobility aid, etc. One-third of participants did not receive any of the listed interventions and many other interventions were just offered to a low percentage of people. Compared to the substantial coverage of physiotherapy in our cohort, falls prevention interventions seems to be insufficiently covered by the physiotherapists. Forty percent of the participants were also not satisfied with the contents of their physiotherapy regarding fall prevention. Therefore, it seems that German physiotherapists that treat people with MS require more specific training in falls prevention.

Fall prevention programs and preferences of program details

About 75% of our participants were not sure whether there was a fall prevention program in their district and only 3.5% reported to know of a program that is offered. This unfortunately confirms our introductory hypothesis that there is a limited awareness and implementation of fall prevention programs in Germany [10,11]. Yet, there seems to be a high demand for it as 81.6% of our participants would like to take part in a fall prevention program. Despite this high demand, the neglect of this therapeutic resource is unfortunate, especially since such programs report a reduction in falls and /or proportion of fallers following treatment [31,32].

To our knowledge, this study is one of the first that tries to investigate the preferences of people with MS regarding fall prevention program details. As previous programs report low adherence rates and high dropout rates [32,33], the knowledge about the preference of people with MS seems indispensable.

Interesting findings were that participants with a higher mean PDDS score rather preferred individual therapy than group training. A possible hypothesis could be that people with higher PDDS scores might think that they have more individual problems or need closer supervision (to prevent falls), which would be missing in a group session. It is important to consider this fact when fall prevention programs are developed, because – as it was mentioned before – people with a higher disease severity are probably the main target group of such programs.

Physiotherapy practices as the preferred program location and experts (e.g., physiotherapist) as the preferred program leaders were chosen by the majority of respondents. This preference could be out of convenience, since many of the participants went already frequently to the physiotherapy and traveling may be difficult for people with MS [12,33].

As web-based interventions are becoming more popular, the popularity among people with MS was an interesting question. A web-based program was the second most preferred program option in our survey. Web-based programs were more popular among people that lived in a medium sized or bigger city and less popular among people that lived in rural areas. Interestingly, the participants of our previously published qualitative study were reluctant towards web-based interventions [12]. The focus group of this study consisted of people living in a bigger city with more providers and a better public transportation. Thus, we expected that web-based programs were more popular in rural areas where traveling is more difficult for people with MS. It could be hypothesized that rural people may not use the internet as often and may not prefer web-based services because the broadband coverage in European rural areas is still insufficient [34].

Lastly, our data shows that most participants prefer short-term program with a weekly meeting frequency. In summary, these findings show that intervention programs should consider which target group they want to reach, so their intervention meets the preferences of the target group and is acceptable to them. This will hopefully lead to a higher acceptance among the potential participants, which in turn, could increase adherence and decrease dropout rates.

Study limitations

As the inclusion criteria only allowed people with MS that had a history of falls or were concerned about their balance or falling risk, to participate in this study, our sample is only representative for this group of people. If the prevalence of people with MS in Germany is considered and if the high prevalence of falls in people with MS is considered, our sample of 315 participants is small. All collected data in this study were self-reported and retrospective for the last 6 months. MS may cause cognitive or memory problems that could affect the recall accuracy. Further, the data of this study may be affected by typical bias of web surveys which include under-coverage and self-selection [35]. Nevertheless, this is the most comprehensive survey about falls in people with MS in Germany and this survey clarifies the status quo of a (so far) largely unexplored field of research for people with MS in Germany.

Conclusion

About 75% of our participants reported injurious falls and approximately 20% of them were severe injuries such as fractures. Consequently, fall prevention in people with MS requires more awareness from researchers and health care workers that treat people with MS. The current situation shows many deficits and is unsatisfactory for people with MS that have a history of falls. Only about 15% of the people who were treated by a doctor for their injury (caused by a fall) received recommendations on how to prevent future falls. Only the half of the people talked to their doctors about their falls, although 95% were concerned about their fall risk. The coverage of physiotherapy for people with MS was satisfying for our survey cohort, yet very few fall prevention interventions were applied in the physiotherapy sessions. Nearly 80% of our participants would like to participate in a fall prevention program, but only 3.5% reported knowing of a program being offered.

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References

- Multiple Sclerosis International Federation. Atlas of MS 2013: Mapping multiple sclerosis around the world. Report, MS International Federation, London, UK, 2013.
- Gunn, H., et al. "Identification of risk factors for falls in multiple sclerosis: a systematic review and meta-analysis." *Phys Ther* 93(2013): 504-513.
- Nilsagard, Y., et al. "Falls in people with MS—an individual data meta-analysis from studies from Australia, Sweden, United Kingdom and the United States." *Mult Scler* 21(2015): 92-100.
- Peterson, E. W., et al. "Fear of falling and associated activity curtailment among middle aged and older adults with multiple sclerosis." *Mult Scler* 13(2007): 1168-1175.
- Comber, L., et al. "An exploration of fall-related, psychosocial variables in people with multiple sclerosis who have fallen." *Br J Occup Ther* 80(2017): 587-595.
- Mazumder, R., et al. "Fear of falling is associated with recurrent falls in people with multiple sclerosis: A Longitudinal Cohort Study." *Int J MS Care* 17(2015): 164-170.
- Coote, S., et al. "Falls in People with Multiple Sclerosis: Risk Identification, Intervention, and Future Directions." *Int J MS Care* 22(2020): 247-255.
- Sosnoff, JJ., et al. "International MS Falls Prevention Research Network: Report from the Front Lines." *Int J MS Care* 16(2014): 161-162.
- O'Malley, N., et al. "Fall definitions, faller classifications and outcomes used in falls research among people with multiple sclerosis: a systematic review." *Disabil Rehabil* (2020): 1-8.
- Klein, D., et al. "A population-based intervention for the prevention of falls and fractures in home dwelling people 65 years and older in South Germany: protocol." *JMIR Res Protoc* 3(2014): e19.
- Rapp, K., et al. "Fall incidence in Germany: results of two population-based studies, and comparison of retrospective and prospective falls data collection methods." *BMC Geriatr* 14(2014): 105.
- Kesgin, F., et al. "Developing a fall prevention program: what are the views and opinions of people with multiple sclerosis?" *Disabil Rehabil* (2019): 1-9.
- Hohol, M. J., et al. "Disease steps in multiple sclerosis: a longitudinal study comparing disease steps and EDSS to evaluate disease progression." *Mult Scler* 5(1999): 349-354.
- Learmonth, Y. C., et al. "Validation of patient determined disease steps (PDDS) scale scores in persons with multiple sclerosis." *BMC Neurol* 13(2013): 37.
- Gunn, H., et al. "Frequency, characteristics, and consequences of falls in multiple sclerosis: findings from a cohort study." *Arch Phys Med Rehabil* 95(2014): 538-545.
- Cameron, M. H., et al. "Medications are associated with falls in people with multiple Sclerosis: A prospective cohort study." *Int J MS Care* 17(2015): 207-214.
- Gunn, H., et al. "Risk factors for falls in multiple sclerosis: an observational study." *Mult Scler* 19(2013): 1913-1922.
- Hoang, P. D., et al. "Neuropsychological, balance, and mobility risk factors for falls in people with multiple sclerosis: a prospective cohort study." *Arch Phys Med Rehabil* 95(2014): 480-486.
- Albrecht, P., et al. "Prolonged-release fampridine in multiple sclerosis: clinical data and real-world experience. Report of an expert meeting." *Ther Adv Neurol Disord* 11(2018): 1-8.
- Cattaneo, D., et al. "Targeting Dynamic Balance in Falls-Prevention Interventions in Multiple Sclerosis: Recommendations from the International MS Falls Prevention Research Network." *Int J MS Care* 16(2014): 198-202.
- Gianni, C., et al. "A systematic review of factors associated with accidental falls in people with multiple sclerosis: a meta-analytic approach." *Clin Rehabil* 28(2014): 704-716.
- Gunn, H., et al. "Identification of risk factors for falls in multiple sclerosis: a systematic review and meta-analysis." *Phys Ther* 93(2013): 504-513.
- Hsiao, E. T., et al. "Common protective movements govern unexpected falls from standing height." *J Biomech* 31(1998): 1-9.
- Smeesters, C., et al. "Disturbance type and gait speed affect fall direction and impact location." *J Biomech* 34(2001): 309-317.
- Saari, P., et al. "Fall-related injuries among initially 75- and 80-year old people during a 10-year follow-up." *Arch Gerontol Geriatr* 45(2007): 207-215.
- Abdolshah, S., et al. "Longitudinal Rollover Strategy as Effective Intervention to Reduce Wrist Injuries During Forward Fall." *EEE Robot Autom Lett* 3(2018): 4187-4192.

27. Arnold, C. M., et al. "Does Fall Arrest Strategy Training Added to a Fall Prevention Programme Improve Balance, Strength, and Agility in Older Women? A Pilot Study." *Physiother Can* 69(2017): 323-332.
28. Massot, C., et al. "Ankle dysfunction in multiple sclerosis and the effects on walking." *Disabil Rehabil* (2019): 1-10.
29. Filli, L., et al. "Profiling walking dysfunction in multiple sclerosis: characterisation, classification and progression over time." *Sci Rep* 8(2018): 4984.
30. Matsuda, P. N., et al. "Falls in multiple sclerosis." *PM R* 3(2011): 624-632.
31. Sosnoff, J. J., et al. "Reducing falls and improving mobility in multiple sclerosis." *Expert Rev Neurother* 15(2015): 655-666.
32. Gunn, H., et al. "Systematic Review: The Effectiveness of Interventions to Reduce Falls and Improve Balance in Adults With Multiple Sclerosis." *Arch Phys Med Rehabil* 96(2015): 1898-1912.
33. Nilsagard, Y., et al. "Balance exercise program reduced falls in people with multiple sclerosis: a single-group, pretest-posttest trial." *Arch Phys Med Rehabil* 95(2014): 2428-2434.
34. European Court of auditors. Broadband in the EU Member States: despite progress, not all the Europe 2020 targets will be met. Report, European Union, Luxembourg, 2018.
35. Bethlehem, J., "Selection Bias in Web Surveys." *Int Stat Rev* 78(2010): 161-188.