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The relationship between physiological and perceived fall risk in people with multiple sclerosis: implications for assessment and management

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Running head: MS physiological and perceived fall risk

Title: The relationship between physiological and perceived fall risk in people with multiple sclerosis: Implications for assessment and management

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2 **Title: The relationship between physiological and perceived fall risk in people**
3 **with multiple sclerosis: implications for assessment and management**

4

5 **Abstract**

6 **Objective**

7 This study evaluated the relationship between physiological and perceived fall risk in
8 people with MS.

9 **Design**

10 Secondary analysis of data from prospective cohort studies undertaken in Australia,
11 United Kingdom and the United States.

12 **Setting**

13 Community

14 **Participants**

15 416 ambulatory people with MS (age 51.5 ±12.0 years; 73% female; 62% relapsing-
16 remitting MS; 13.7 ±9.9 years disease duration).

17 **Interventions**

18 Not applicable

19 **Outcome measures**

20 All participants completed measures of physiological (Physiological Profile
21 Assessment (PPA)) and perceived (Falls Efficacy Scale-international (FESi)) fall risk
22 and prospectively recorded falls for three months.

23 **Results**

24 155 (37%) of the participants were recurrent fallers (≥2 falls). Mean PPA and FESi
25 scores were high (PPA 2.14±1.87, FESi 34.27±11.18). The PPA and the FESi
26 independently predicted faller classification in logistic regression, which indicated

27 that the odds of being classified as a recurrent faller significantly increased with
28 increasing scores (PPA Odds Ratio 1.30 (95%CI 1.17-1.46), FESi Odds Ratio 1.05
29 (95% CI 1.03-1.07)).

30 Classification and regression tree analysis divided the sample into four groups based
31 on cut-off values for the PPA: (1) low physiological/ low perceived risk (PPA <2.83,
32 FESi <27.5), (2) low physiological/ high perceived risk (PPA <2.83, FESi >27.5), (3)
33 high physiological/ low perceived risk (PPA >2.83, FESi <35.5), and (4) high
34 physiological/ high perceived risk (PPA <2.83, FESi >35.5). Over 50% of participants
35 had a disparity between perceived and physiological fall risk; most were in group 2. It
36 is possible that physiological risk factors not detected by the PPA may also be
37 influential.

38 **Conclusion**

39 This study highlights the importance of considering *both* physiological and perceived
40 fall risk in MS, and that further research is needed to explore the complex inter-
41 relationships of perceptual and physiological risk factors in this population. This
42 study also supports the importance of developing behavioral and physical
43 interventions which can be tailored to the individual's need.

44

45 **300 words**

46 **Keywords:** Multiple sclerosis; Accidental falls; Physiological balance; Rehabilitation;
47 Cohort study

48

49 **Abbreviations:**

50 AUS: Australia; CART: Classification and Regression Tree; EDSS: Expanded
51 Disability Status Scale; MS: Multiple sclerosis; PPA: Physiological Profile

52 Assessment; SWIMS: South-West Impact of MS study; UK: United Kingdom; US:

53 United States

54

55

56 **Introduction**

57

58 Multiple sclerosis (MS) affects approximately 2.3 million people worldwide¹. People
59 with MS consistently report impaired mobility is one of their most concerning
60 problems², impacting not only access to the community but also quality of life³.

61 Impaired balance and falls are common in people MS and contribute to mobility
62 loss^{4,5}. Given the significant economic, personal, and social costs associated with
63 impaired mobility, balance and falls³, effective interventions are a high priority⁶.

64

65 Evidence from other populations suggests that individualised fall risk-factor
66 identification is important for developing targeted interventions to optimise
67 rehabilitation outcomes⁷. Identified risk factors for falls in people with MS include
68 physiological attributes such as gait disturbance, spasticity, slow reaction time, and
69 increased postural sway^{8,9} as well as psychological factors such as fear of falling¹²
70 and reduced falls self-efficacy^{13 12}. The Physiological Profile Assessment (PPA), a
71 standardised five-item test of sensorimotor and balance performance which includes
72 measures of proprioception, reaction time, visual contrast sensitivity, muscle
73 strength, and postural sway, can measure physiological contributors to fall risk¹³.

74 Although the PPA was originally developed to assess fall risk in older adults, it has
75 been validated in people with MS, where scores show moderate correlation with fall
76 risk^{8,9}. MS specific, age adjusted reference values for the PPA composite scores
77 have also been established¹⁴. The Falls Efficacy Scale-international (FESi)¹⁵, a 16
78 item questionnaire, is recommended as a measure of perceived risk of falls. The
79 FESi has established validity and reliability in people with MS^{16,17} and FESi scores

80 are associated with prospectively recorded falls in this group (Odds Ratio (OR) 1.22,
81 95% Confidence Interval (CI) 1.04-1.43)¹⁸.

82

83 In some people, physiological and perceived fall risk differ. Delbaere et al.
84 highlighted such disparities in a cohort of community dwelling older adults¹⁹. They
85 proposed categorizing individuals into four distinct groups based on their
86 physiological fall risk as measured by the PPA, and their perceived fall risk as
87 measured by the FESi. This study also identified cut-off points in the two measures
88 to identify the different groupings. These findings are relevant to practice, and may
89 inform patient management. For example, providing challenging balance exercise to
90 people with high perceived risk but relatively low physiological risk may heighten
91 their feelings of concern, and potentially reduce engagement in the program. In
92 contrast, approaches aimed at increasing self-efficacy and use of falls management
93 strategies are unlikely to be effective in people who do not perceive themselves to be
94 at high risk of falling.

95

96 Although there is increasing evidence identifying MS-specific risk factors for falling,
97 little is currently known about the relationship between perceived and physiological
98 fall risk. Our aim was to evaluate this relationship using a similar methodology to
99 Delbaere et al.¹⁹. The specific objectives were to assess whether there are
100 disparities between perceived and physiological fall risk in people with MS, and to
101 explore potential contributory factors. The findings could be used to guide
102 individualised assessment and development of tailored fall risk management
103 strategies.

104

105 **Methods**

106

107 *Data Sources*

108 This analysis used data from prospective cohort studies of falls and fall risk in people
109 with MS carried out in Australia (AUS)⁸, the United Kingdom (UK)⁹ and the United
110 States (US)²⁰. All relevant local ethical permissions were obtained for all three
111 studies (AUS: HC09253; UK: 10/H0203/66 and US: E7244W). All participants gave
112 written informed consent.

113

114 *Participants*

115 Study participants were 416 people with MS (210 AUS, 148 UK and 58 US)
116 diagnosed by standardized criteria^{21,22} and aged 18 years and older. All MS
117 subtypes were included. In the UK and the US samples, disease severity was
118 measured using the Expanded Disability Status Scale (EDSS)²³, assessed either
119 face-to-face by a trained clinician or using the self-report EDSS by telephone
120 interview²⁴. In Australia, the Disease Steps Scale²⁵ was used during a face-to-face
121 assessment and converted to EDSS by mobility criteria²⁶.

122

123 Common exclusion criteria were inability to understand and sign an informed
124 consent or being unable to follow test instructions. Additional local inclusion criteria
125 were:

- 126
- 127 • Australia: ability to stand unsupported for 30 seconds and walk 10 metres with
128 or without a mobility aid (i.e. Disease Steps 0-5).
 - UK: EDSS score between 3.5 and 6.5.

- 129 • US: EDSS score of 6.0 or less, upper age limit of 50, relapse free for 30 days
130 prior to baseline examination.

131

132 *Recruitment*

133 The Australian sample was recruited in a single out-patient MS physiotherapy clinic
134 in Sydney. The UK sample was recruited via invitation letters from their local
135 neurologist and an advertisement in the newsletter of the South West Impact of MS
136 (SWIMS) project²⁷ which is accessed by over 1500 people with MS living in the
137 South West of England. The US sample was recruited from specialty MS center
138 outpatient clinics at a Department of Veterans Affairs medical centre, a university
139 medical centre in the Northwest of the United States and the surrounding
140 community.

141 *Measures*

142 Demographic data including age, gender, years since MS diagnosis, MS subtype,
143 use of walking aids, and retrospective fall history were collected at baseline using a
144 structured questionnaire.

145

146 Physiological fall risk: Physiological Profile Assessment (PPA)

147 The PPA was developed as a low-tech, clinically feasible method to assess fall risk¹³
148 in older adults and has been shown to predict falls in people with MS^{8,9}. The five
149 components of the PPA are: (1) proprioception, measured with a lower limb
150 matching task; (2) quadriceps muscle strength, measured isometrically in the
151 dominant leg while participants are seated; (3) simple reaction time, measured with a
152 light as stimulus and a finger press response; (4) visual contrast sensitivity as
153 measured by the Melbourne edge test; and (5) postural sway, measured with a sway

154 meter recording displacements of the body at the level of the pelvis while participants
155 stand on a foam rubber mat with eyes open. The five PPA components are
156 weighted to compute a composite PPA fall-risk score expressed in standard (z-
157 score) units; with higher scores indicating worse performance.

158

159 Perceived fall risk: Falls Efficacy Scale–international (FESi)¹⁵

160 The FESi is a 16-item questionnaire that asks participants to indicate their level of
161 concern about falling for a range of activities of daily living (such as cleaning the
162 house or going out on a social event). Each activity is scored on a four-point scale (1
163 = not at all concerned to 4 = very concerned).

164

165 Falls

166 Falls were assessed retrospectively and prospectively. For retrospective assessment
167 participants were asked if they had fallen in the previous three months (yes or no).
168 For prospective assessment, participants recorded falls in the subsequent three
169 months using a daily diary²⁸. Participants received falls diary sheets, written
170 instructions and reply-paid return envelopes; in AUS and USA these were returned
171 monthly, the UK diaries were returned every two weeks. A reminder telephone call or
172 email was sent to participants whose diary returns fell behind schedule²⁸. In AUS, a
173 fall was defined as “unintentionally coming to the ground or other lower level and
174 other than as a consequence of sustaining a violent blow, loss of consciousness, or
175 sudden onset of paralysis as in stroke or epileptic seizure”²⁹. In the UK and US, a fall
176 was defined as “a slip or trip in which participants came to rest on the ground or floor
177 or lower level”¹⁵. In line with recommendations, recurrent fallers were defined as

178 those who fell twice or more in the three month retrospective and prospective
179 periods³⁰.

180

181 *Data analysis*

182 All statistical analyses were performed using SPSS V23 (IBM, Chicago, USA). Data
183 were summarized using frequencies and percentages, mean and standard deviation
184 or median and interquartile range (IQR) as appropriate. Given the low numbers of
185 missing data, missing values were imputed using the overall mean from the rest of
186 the sample³¹.

187

188 Baseline differences between the three geographical samples were assessed by
189 either univariate analyses of variance (ANOVA) or by χ^2 tests. Subsequently, logistic
190 regression was used to calculate univariate and bivariate odds ratios for the
191 associations between physiological fall risk (PPA) and perceived fall risk (FESi) with
192 fall classification.

193

194 A classification and regression tree (CART) analysis was undertaken to develop a
195 framework to classify participants into groups based on their physiological and
196 perceived fall risk. CART analysis aims to develop subsets of a data set, which are
197 as homogenous as possible with respect to the target variable, through repeated
198 analyses based on predictor variables³². Confirmation of the CART model was
199 performed using cross-validation methods³³. Subsequently, the associations
200 between the CART groupings were explored. For categorical variables, the
201 groupings were analysed using Fishers exact test. For continuous variables, the

202 differences between the CART groups were compared using ANOVA, with between
203 group comparisons analysed using a Bonferroni corrected p value.

204

205 **Results**

206

207 A total of 416 participants were included in the analyses. Of these, 10 (<3%) had
208 missing FESi data. Participants had a mean age of 52 years (range 21-84 years),
209 305 (73%) were female, and 257 (62%) were classified as having relapsing-remitting
210 MS (table 1). Approximately one third (155 participants, 37.3%) reported ≥ 2 falls in
211 the three-month follow-up periods. There were significant differences between the
212 cohorts for all characteristics except gender.

213

214 *Insert table 1 about here*

215

216 *Association between PPA/FESi and prospective falls*

217 Univariate logistic regression confirmed higher PPA and FESi scores increased the
218 odds of being classified as a recurrent faller (PPA OR 1.30 (95%CI 1.17-1.46, FESi
219 OR 1.05 (95% CI 1.03-1.07). Bivariate regression analysis demonstrated that both
220 the PPA and FESi scores were independent predictors of recurrent falls, with PPA
221 making the greater contribution to the model (standardised B, table 2). An overall
222 indication of goodness of fit of the model was obtained through the use of the
223 Hosmer and Lemeshow statistic. The non-significant result of χ^2 10.87, df 8 $p=0.21$
224 indicates there is no evidence of lack of fit based on this statistic.

225

226 *Insert table 2 about here*

227

228 *Classification and regression tree analysis*

229 The CART analysis divided the sample into four groups (figure 1).

- 230 • Group 1: low physiological risk/low perceived risk;
- 231 • Group 2: low physiological risk/high perceived risk;
- 232 • Group 3: high physiological risk/low perceived risk;
- 233 • Group 4: high physiological risk/high perceived risk

234 The model and cross-validation samples performed similarly, with an overall model
235 error rate of 0.31 (Standard error (SE) 0.02), compared with the cross-validation
236 error rate of 0.35 (SE 0.02). The PPA cut-off point for splitting the group into low and
237 high physiological risk was 2.83. This cut-off point classified most participants (69%
238 (n=288)) as having 'low' physiological fall risk. The cut-off point to distinguish low
239 and high levels of perceived fall risk using the FESi differed according to
240 physiological risk; for those with a low physiological risk the FESi cut-off point was
241 27.5, whilst for those with a high physiological risk the cut-off point was 35.5.

242 The two largest groups comprised participants with a high perceived fall risk (Groups
243 2 and 4). In Group 4 (high physiological risk/ high perceived risk), 55 (64%)
244 prospectively reported two or more falls, suggesting that these individuals were
245 insightful about their level of risk. In contrast, in Group 2 (low physiological risk/ high
246 perceived risk), 106 (63%) prospectively reported fewer than 2 falls. As with Group 4,
247 most of the participants in Group 1 (low physiological/ low perceived risk) appeared
248 to have an accurate perception of their fall risk, as 84% (n=100) had fewer than 2
249 falls in the recording period. The smallest group were those classified as having high
250 physiological risk, but low levels of perceived fall risk (Group 3, n=42). Of these, 18
251 (43%) were classified as recurrent fallers.

252

253 *Insert Figure 1 about here*

254

255

256 *Associations between CART groupings and participant characteristics (table 3)*

257 Participants in Group 1 (low physiological risk/ low perceived risk) were, on average,

258 younger (mean age 47.2 (SD 12.6)) and less disabled (group median EDSS 2.5, IQR

259 2.0-3.5) than in the other groups. In contrast, Group 2 participants (low physiological

260 risk/ high perceived risk) were more likely to report having fallen in the previous year

261 than those in Group 1 (113 (67%) fallers in Group 2 compared with 56 (47% in

262 Group 1), and had similar rates of walking aid use to Groups 3 and 4 (those

263 classified at high physiological risk of falling). Groups 3 and 4 were similar to each

264 other except that Group 4 participants were more likely to report using a walking aid.

265 The distribution of participants amongst the CART groupings varied with recruiting

266 site, with proportionally more participants from the USA in Group 1, and a greater

267 proportion of UK participants in Groups 2 and 4.

268

269 *Insert table 3 about here*

270

271 **Discussion**

272

273 To our knowledge this paper presents the first analysis of the relationship between

274 physiological and perceived fall risk and prospectively reported falls in people with

275 MS. The cohort included ambulatory people with a range of disability levels and all

276 MS subtypes.

277

278 Our cohort's mean PPA score was 2.14 (SD 1.87), mean FESi score was 34.27
279 (SD 11.18) and 37.3% of the group fell at least twice in 3 months. These values are
280 all high compared to similar aged healthy individuals¹⁴, and other groups at
281 increased risk of falling (including people following a stroke³⁴ and older adults³⁵). The
282 mean PPA and FESi values in this cohort were also higher than those reported in
283 other MS cohorts (e.g. Sosnoff et al³⁶ and Carling et al³⁷). These differences most
284 likely relate to differences in sample characteristics. Our study had a higher
285 proportion of people with SPMS than Sosnoff et al's cohort³⁶ (proportion of people
286 with SPMS 24% vs. 15%) and a lower average EDSS than Carling et al's cohort³⁷
287 (Median EDSS 4.0, IQR 2.5 vs. 6.0, IQR 3.5).

288

289 The CART analysis categorized the cohort into four groups based on physiological
290 and perceived fall risk scores and identified cut-off values for high and low risk.
291 These cut-off values are higher than those obtained in Delbaere's analysis in older
292 adults¹⁹. It is possible that this is because our MS cohort were able to develop
293 strategies to manage their physical impairments more effectively to avoid falls than
294 older people. However, the high overall values of perceived fall risk highlight that
295 falls are an 'ever present reality' for most people with MS^{38,p151}, thus the cut-off to
296 differentiate those with a 'high' or 'low' perceived fall risk is made against a
297 background of high concern across the cohort. As cut-off values to distinguish fallers
298 and non-fallers in the PPA or FESi have not previously been reported in MS, further
299 research to explore the validity of our results, particularly of the proposed cut-offs, is
300 recommended.

301

302 In our analysis, over half of the participants had disparities between physiological
303 and perceived risk (i.e. those in Groups 2 and 3). This is in contrast to Delbaere's
304 study, where over two thirds had concurrent physiological and perceived fall risk¹⁹.
305 Various factors could underlie the greater disparity in our cohort. Importantly,
306 cognitive impairment, which is common in people with MS³⁹, may have contributed to
307 the disparity between physiological and perceived risk factors. Whilst all three
308 samples collected cognitive data, variations in the measures used meant we were
309 unable to include this factor in our study. Exploration of this in future studies is
310 important as it is likely that this could influence management.

311

312 In our analysis, 63 (37%) of the participants in Group 2 (low physiological/ high
313 perceived risk) were classified as recurrent fallers, which represents 41% of
314 recurrent fallers across the whole cohort. Although these individuals were classified
315 by the PPA as having 'low' physiological risk, the cut-off point (2.83) was relatively
316 high and it is likely that for at least some of them, physiological factors in addition to
317 those assessed by the PPA contributed to fall risk. For example, impaired gait,
318 spasticity and dual task interference have all been identified as fall risk factors in
319 prospective MS cohort studies but are not captured by the PPA^{8,9,12}. It is essential
320 that the complexity of factors contributing to risk of falls is recognised during the
321 assessment process and when developing falls management interventions.

322

323 Conversely, over 60% (n=106) of Group 2 (low physiological/ high perceived risk) did
324 not report recurrent falls. Despite the moderate level of disability within this group
325 (median EDSS 4.0 (IQR 2.5-5.5)), 107 people (63%) reported using walking aids,
326 which was a similar proportion to those doing so who were classified at high

327 physiological risk of falls. Whilst the three-month reporting period may have been
328 too short to capture recurrent falls in some individuals, it could be that the high level
329 of perceived risk made people take less risk. This emphasises the importance of
330 evaluating individual's perceptions, alongside early education about fall prevention,
331 with a key aim of maintaining physical activity levels and avoiding activity
332 curtailment^{40,41}. Accurate long-term monitoring, and interventions focused on
333 increasing confidence and knowledge about effective risk management could be
334 particularly appropriate for these individuals.

335

336 While perceived risk was greater than physiological risk for most participants with a
337 disparity, 42 (10%) individuals were classified as having a high physiological risk but
338 low perceived fall risk (Group 3). Within this group, over half reported no falls,
339 suggesting their lower levels of concern were probably justified, for example they
340 may have adopted effective fall prevention strategies. However, given the high mean
341 PPA in this group, it is likely that encouraging the non-recurrent fallers to address
342 modifiable risk factors would still be warranted to prevent future falls. In contrast, 18
343 individuals in Group 3 reported recurrent falls. Identifying people who see
344 themselves as being at unduly low risk is important, since it is known that the
345 perceived relevance of a programme influences engagement⁴²⁻⁴⁴. For these
346 individuals, it may be that management could initially focus on identifying problems
347 with balance and stability before then supporting the participant to undertake
348 appropriate risk management decisions based on an accurate assessment of their
349 physical ability.

350

351 Individuals in Groups 1 and 4 were classified as having concurrent physiological and
352 perceived fall risk. Within Group 1, some participants reported falling despite being
353 classified as having both low physiological and low perceived risk of falling. These
354 participants, on average, were relatively young with a low disease severity. It is
355 postulated that an early intervention approach, which emphasizes health promotion
356 alongside preventative strategies, would be beneficial for this group to minimise the
357 long-term negative impact that falls may have on participation levels and quality of
358 life. Group 4 participants had the highest level of disability, greatest proportion of
359 individuals with progressive MS and the highest proportion of people reporting
360 having fallen in the past year. It is likely that falls management interventions for these
361 individuals would need to address multiple risk factors, carefully balancing benefit
362 and burden.

363

364 **Study Limitations**

365 This study has several limitations. Firstly, our cohort comprised participants who
366 were recruited to separate studies in three countries. It is likely that the variations in
367 recruitment criteria and baseline characteristics between the groups contributes to
368 the different proportions of participants from each country seen in the CART
369 analyses, however, other social or geographical factors cannot be discounted.

370 In addition, our sample did not include any individuals with an EDSS >6.5. It is likely
371 that the factors contributing to falls in non-ambulatory individuals are different from
372 those in ambulatory individuals⁴⁵. The findings may therefore not generalize to
373 people whose mobility is severely affected. In addition, while our analysis was able
374 to explore the relationship between physiological and perceived fall risk as indicated
375 by the PPA and the FESi, both of these measures do not capture all of the complex

376 factors contributing to fall risk in MS. Given the high rate of comorbidities⁴⁶, and the
377 prevalence of issues such as cognitive dysfunction and depression³⁹, further
378 exploration is warranted. In addition, limitations in the PPA and the FESi could result
379 in inaccurate classification for some individuals. For example, the PPA may not
380 detect subtle balance deficits that can be captured by instrumented tests⁴⁷ and, may
381 not capture MS-specific physiological risk factors (e.g. spasticity, internuclear
382 ophthalmoplegia), that may be significant. Finally, it is important to emphasize that,
383 while this analysis presents cut-off points which classify individuals into groups
384 based on physiological and perceived fall risk, the results represent an *estimate* of
385 values which could differentiate those at lower and higher risk. Our intention was to
386 provide an initial exploration of the relationship between physiological and perceived
387 fall risk in MS, and to suggest ways that assessment findings could be used to inform
388 therapists' management plans. It is likely that other factors, not included within our
389 analyses, such as cognition, disability level and physical environment, may also
390 influence falls. Additional work to evaluate the relationship between the multiple
391 factors that are likely to influence risk of falling and engagement with fall prevention
392 activities is essential.

393

394 **Conclusion**

395

396 These findings highlight the importance of considering both physiological and
397 perceived fall risk when evaluating people with MS. Whilst both the PPA and the
398 FESi independently predicted falls in this cohort, the subsequent classification and
399 regression tree analysis highlighted an interrelationship between the two factors
400 which could have important implications for management. These findings are

401 consistent with the geriatrics literature and its growing focus on targeted,
402 individualized fall prevention, addressing both factors⁴⁸. These findings also
403 underline the complexity of falls in MS and the importance of detailed description,
404 evaluation and targeting of fall prevention interventions to optimize their
405 effectiveness.

406

407 3695 words

408 **Conflict of interests**

409 Stephen Lord declares the Physiological Profile Assessment (NeuRA FallScreen) is
410 commercially available through Neuroscience Research Australia.

411

412

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1 **Figure Legends**

2

3 **Figure 1: Classification tree**

4 *: "non-fallers" in this figure are those who reported ≤1 fall in the three-month reporting period

Table 1: Sample Characteristics

| | Australia (n=210) | United Kingdom (n=148) | United States (n=58) | Total sample (n=416) |
|--|----------------------|------------------------------|----------------------------|----------------------------|
| Age in years: Mean (range) ^{*a} | 50.3 (21-73) | 58 (33-84) | 39.5 (22-50) | 51.5 (21-84) |
| Gender F:M Ratio (%) ^{ns; b} | 150:60 (71:29) | 114:34 (77:23) | 41:17 (71:29) | 305:111 (73:27) |
| Years with MS: Mean (SD) ^{*a} | 13.6 (8.9) | 16.7 (10.9) | 6.5 (5.8) | 13.7 (9.9) |
| EDSS: Median (IQR) ^{*a} | 3.5 (2.0-5.0) | 5.5 (4.0-6.0) | 3.0 (1.5-3.5) | 4.0 (2.5-5.5) |
| Subtype: n (%) ^{*b} | | | | |
| RRMS | 160 (76.2) | 42 (28.4) | 55 (94.8) | 257 (61.7) |
| SPMS | 30 (14.3) | 66 (44.6) | 3 (5.2) | 99 (23.8) |
| PPMS | 19 (9.0) | 37 (25) | 0 | 56 (13.5) |
| Unknown | 1 (0.5) | 3 (2) | 0 | 4 (0.9) |
| Mobility Aid Use: Y: N Ratio (%) ^{*b} | 100:110 (48:52) | 110:38 (74:26) | 9:49 (16:84) | 219:197 (53:47) |
| Retrospective falls history: Y:N (%) ^{*b} | 152:58 (72:28) | 85:63 (57:43) | 30:28 (52:48) | 267:149 (64:36) |
| Prospective falls history (3 months) n (%) ^{*b} | | | | |
| 0 falls | 122 (58) | 44 (30) | 24 (41) | 190 (46) |
| 1 fall | 31 (15) | 26 (18) | 14 (24) | 71 (17) |
| 2+ falls | 57 (27) | 78 (52) | 20 (35) | 155 (37) |
| PPA: Mean (SD) ^{*a} | 2.32 (1.91) | 2.45 (1.75) | 0.74 (1.37) | 2.14 (1.87) |
| FESi: Mean (SD) ^{*a} | 34.93 (11.40) | 37.06 (9.84) | 25.59 (9.27) | 34.37 (11.18) |
| F: Female; M: Male; n: Number; Y: Yes; N: No; SD: Standard Deviation; IQR: Inter-quartile range; EDSS: Expanded Disability Status Scale; RRMS: Relapsing-Remitting MS; SPMS: Secondary Progressive MS; PPMS: Primary Progressive MS; PPA: Physiological Profile Assessment; FESi: Falls Efficacy Scale (international);ns: no significant differences between the samples; *: significant differences between the samples; a: ANOVA; b: χ^2 | | | | |

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Table 2: Logistic regression analysis examining association between physiological fall risk and perceived fall risk

| | B | S.E. | Wald | df | <i>p</i> | OR (95% CI) |
|----------|--------|-------|-------|----|----------|-------------------|
| PPA | 0.196 | 0.061 | 10.51 | 1 | 0.001 | 1.217 (1.08-1.37) |
| FESi | 0.034 | 0.010 | 10.64 | 1 | 0.001 | 1.035 (1.01-1.06) |
| Constant | -2.152 | .367 | 34.47 | 1 | <0.001 | 0.116 |

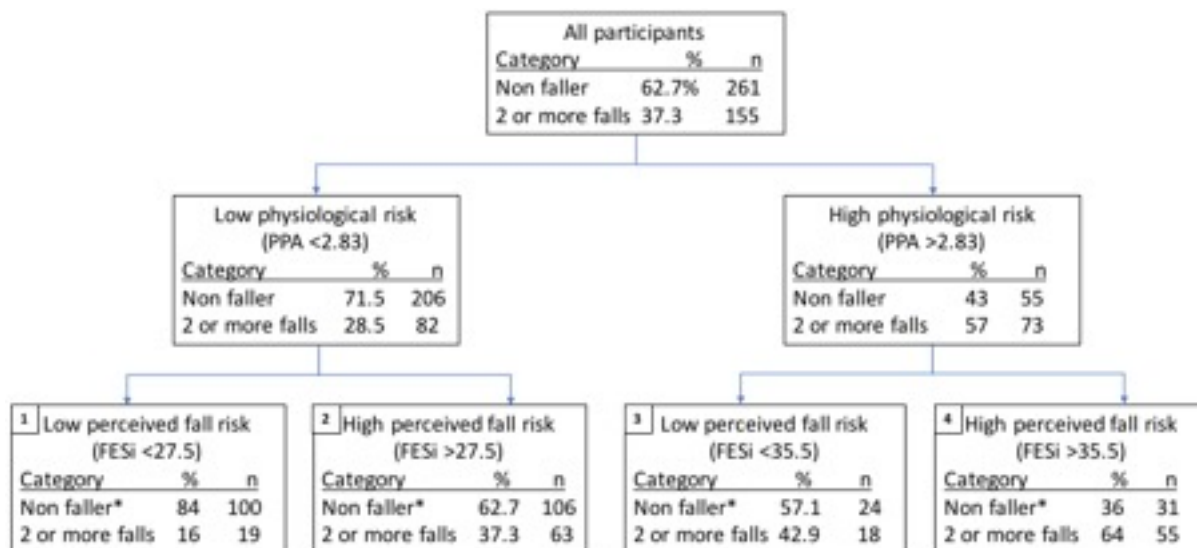
B: Standardised β coefficient; SE: Standard error; df: Degrees of freedom; OR: Odds ratio; CI: Confidence interval; PPA: Physiological Profile Assessment (physiological fall risk); FESi: Falls Efficacy Scale-international (perceived fall risk)

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Table 3: Analysis of Classification and Regression Tree (CART) groupings

| | Low physiological fall risk | | | High physiological risk | | |
|---|-----------------------------|-----------------------------|-----------------------|----------------------------|----------------------------|-----------------------|
| | Low perceived risk (n=119) | High perceived risk (n=169) | P value of difference | Low perceived risk (n= 42) | High perceived risk (n=86) | P value of difference |
| PPA (mean (SD)) | 0.77 (1.00) | 1.38 (0.90) | <0.001 ^a | 4.54 (1.41) | 4.47 (1.27) | 0.75 ^a |
| FESi (mean (SD)) | 22 (3.41) | 38.7 (7.39) | <0.001 ^a | 29 (4.71) | 47 (6.99) | <0.001 ^a |
| EDSS (median (IQR)) | 2.5 (2.0-3.5) | 4.0 (3.0-5.5) | <0.001 ^a | 4.75 (3.5-6.0) | 5.5 (4.0-6.0) | 0.01 ^a |
| Age (mean (SD)) | 47 (12.6) | 53 (11.2) | <0.001 ^a | 54 (11.21) | 55 (10.90) | 0.57 ^a |
| Type of MS (n (%)) | | | | | | |
| | PP | 6 (5) | <0.001 ^b | 6 (14) | 16 (19) | 0.31 ^b |
| | RR | 103 (87) | | 23 (55) | 34 (40) | |
| | SP | 9 (7) | | 13 (31) | 35 (41) | |
| | Unknown | 1 (1) | | - | 1 (1) | |
| Walking aid (n (%)) | | | | | | |
| | No aid | 99 (83) | <0.001 ^b | 17 (40) | 19 (22) | 0.07 ^b |
| | Any aid | 20 (17) | | 25 (60) | 67 (78) | |
| Self-report of any falls in the past year (n (%)) | | | | | | |
| | No falls | 63 (53) | 0.001 ^b | 12 (29) | 18 (21) | 0.37 ^b |
| | ≥1 fall | 56 (47) | | 30 (71) | 68 (79) | |
| Gender (n (%)) | | | | | | |
| | Male | 37 (31) | 0.35 ^b | 8 (19) | 23 (27) | 0.38 ^b |
| | Female | 82 (69) | | 34 (81) | 63 (73) | |
| Site (n (%)) of cohort in each CART group | | | | | | |
| | Australia | 59 (28) | <0.001 ^b | 25 (12) | 44 (21) | 0.32 ^b |
| | UK | 21 (14) | | 16 (11) | 39 (26) | |
| | USA | 39 (67) | | 1 (2) | 3 (5) | |

^a: analysis using ANOVA; ^b: analysis using Fisher's exact test;



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