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Falls in people post-Guillain-Barré syndrome in the United Kingdom: A national cross-sectional survey of community based adults

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Abstract

Guillain-Barré syndrome (GBS) has several enduring effects that can lead to further harm and/or lower quality of life. These effects include falling and body pain, neither of which have been fully explored. This study aims to examine the risk factors associated with falling and potential causes of body pain in a post-GBS population. A cross-sectional survey of 216 participants was conducted using an electronic questionnaire that included. Self-report measures for: overall health, balance, anxiety and depression levels, body pain and demographics related to GBS experience and falls. A large proportion of individuals post-GBS experience ongoing problems beyond those expected with ageing. Comparative tests indicated that people reporting falls in the previous 12 months had: poorer levels of mobility, poorer F-scores, higher levels of body pain, poorer balance, poorer anxiety and depression scores and higher levels of fatigue. Gender did not appear to contribute to falls. Injuries following falls were associated with a lack of physiotherapy postdischarge and time since GBS. In a regression analysis of the identified and expected key variables, age and body pain statistically predicted falls. In over a quarter of cases reported here, respondents did not receive community physiotherapy following hospital discharge. In the midst and aftermath of COVID-19, provision of rehabilitation needs to be recalibrated, not just for COVID patients, but the wider community with ongoing needs. Issues around well-being and quality of life in the post-GBS community also need further consideration.

KEYWORDS
balance, body pain, falls, fatigue, Guillain-Barré syndrome, physiotherapy

1 | INTRODUCTION

Guillain-Barré syndrome is a demyelinating peripheral neuropathy with an incidence of between 0.8 and 1.9/100,000 people in Europe and North America (Willison et al., 2016) affecting all age groups, with males and older aged individuals more affected (Hughes & Cornblath, 2005). Heterogeneity of severity ranges from short-lived limb paraesthesia to complete paralysis requiring prolonged mechanical ventilation (van Koningsveld et al., 2007). Although generally viewed as restorative, around 20% of people with GBS remain disabled (Hughes & Cornblath, 2005). Between 3% and 7% die in developed countries (Alshekhlee et al., 2008; van den Berg et al., 2013;

Willison et al., 2016) rising to 15% in some developing countries (Jacobs et al., 2017).

Enduring effects have been identified post-GBS (Davidson et al., 2009, 2010; Stockley et al., 2013) and include: fatigue (Merkies & Kieseier, 2016; Rekand et al., 2009; White et al., 2014), pain (Merkies & Kieseier, 2016; Rekand et al., 2009; Ruts et al., 2010; Liselotte Ruts et al., 2012), anxiety (Merkies & Kieseier, 2016), reduced physical functioning (Rudolph et al., 2008) and compromised quality of life (Darweesh et al., 2014; Demi˙r, & KöseoĞlu, 2008; Kogos et al., 2005). However, little is known about other consequences such as falls or specific detail relating to location of body pain and associated issues such as balance ability, particularly late after onset.

A survey of members and associates of the Charity: Guillain-Barré and other Inflammatory Neuropathies (GAIN) occurred between 1 and 31 October 2019. It incorporated a similar structure as a previously reported study (Davidson et al., 2009, 2010; Stockley et al., 2013) but also included sections on: Body pain; self-estimate of balance; falls (as defined by the World Health Organisation (WHO, 2021)) as 'an event which results in a person coming to rest inadvertently on the ground or floor or other lower level' over the previous year; and sleep disturbance due to pain. This present study focused on relationships between those falling in the previous year (injurious and non-injurious) and data on: fatigue, age, gender, time since diagnosis, current functional status and anxiety and depression.

1.1 | Objectives

The study aims to report on a cross-section of people previously diagnosed with GBS regarding:

1. Falls (injurious and otherwise) in the previous year.
2. Key variables associated with falls.
3. The occurrence and location of body pain.

2 | METHODS

2.1 | Design

A cross-sectional study, using self-report inventories of individuals previously diagnosed with GBS, assessing factors related to falls and fall-related injuries. Data were analysed using descriptive, associational and comparative methods.

2.2 | Electronic distribution and data collection

The questionnaire, with its embedded measures, were administered via Qualtrics (Qualtrics, 2019). This allowed respondents to complete the questionnaire on any electronic device (tablet, phone or computer). The questionnaire was 'complete' by pressing the 'submit' button although a final button allowed respondents to withdraw their data, even after completion. On completion, data were automatically entered into a preformed database, ready for data cleaning and analysis.

What is known about this topic?

- GBS is an ostensibly restorative condition
- Disability can persist post-GBS
- Community-based rehabilitation can improve function long after diagnosis

What this paper adds

- New information on the incidence of falls in a post-GBS cohort
- New information about the relationship between falls and other known sequelae such as fatigue and body pain
- New evidence for worsening body pain over time since diagnosis

2.3 | Participants

The study was recruited via the listserv and social media links of the UK Charity GAIN. GAIN sent an email, which directed potential participants to an invitation by the lead researcher which, in turn, directed interested parties to the study information sheet and the questionnaire link. Participants were encouraged to pass the study information to other potential participants in the UK.

2.3.1 | Inclusion criteria

Participants had to be: ≥ age 18; previously diagnosed with GBS and be post-nadir; able to understand the survey without translation; in the UK at the time of diagnosis and for treatment; and resident within the UK. Exclusions included: diagnosis of chronic inflammatory demyelinating polyneuropathy (CIDP) or chronic obstructive pulmonary disease (COPD).

2.4 | Measures

2.4.1 | Baseline data

Data were collected in a manner similar to previous studies (Davidson et al., 2009, 2010; Stockley et al., 2013) some differences: Anxiety was assessed using the Intolerance of uncertainty—Short Form (IUS-12) (Carleton et al., 2006) and depression using the Patient Health

Questionnaire (PHQ) (Spitzer et al., 1999) whereas the previous study utilised the HADS (Zigmond & Snaith, 1983). Additional information included: whether participants had fallen in the previous year, current existence of body pain (see outcomes below), location of body pain, sleep disturbance and balance impairment.

2.4.2 | Quality of Life: RAND Short-form health survey—version 1

(Ware & Sherbourne, 1992) Not reported in this paper as much of its content overlaps with other outcomes.

2.4.3 | Balance measure

This is a novel, 8-item, self-report inventory that asked participants to engage safely in certain balance activities and to self-report upon their outcome. Items were derived from the Berg Balance Scale (BBS) (Berg et al., 1992, 1995). However, gait was not assessed and answers to the balance questionnaire were binary: 'yes/no' rather than graded on an ordinal scale. There were 8 activities each scoring '1' if safely completed and '0' if not. The highest score was '8' 'no balance problems' and '0' was deemed as 'severe balance problems'. All other scores indicated 'partial balance problems'. Only participants with F-scores of 3 or less (able to walk 5 m with a walker or support) were asked to complete this measure. Further work on the validity and reliability of this scale is pending. A summary of the eight items is listed in Box 1.

2.4.4 | Body Pain

Participants were asked 'Do you get aches and or pains/discomfort, to a level that bothers you, in your neck or back or arms or legs (or other location) at least once per week.' Responses were dichotomous: 'Yes' or 'No'. Subsidiary questions in this section asked about the location of pain and sleep disturbance.

Fatigue Severity Scale (FSS) is a 9-item self-report measure using a 7-point Likert response where higher scores indicate greater fatigue levels. The report provides mean-average scores on individual items (Krupp et al., 1989). The FSS is a unitary scale with strong psychometric properties (Lerdal & Kottorp, 2011). Severe fatigue is defined as an FSS score of greater than 5 (Merkies et al., 1999).

Intolerance of uncertainty– Short Form (IUS-12) is a 12-item self-report measure (Carleton et al., 2006) using a five-point Likert scale to measure intolerance of uncertainty on two subscales: prospective and inhibitory anxiety. Higher scores indicated greater levels of anxiety.

Patient Health Questionnaire (PHQ-9) is a 9-item measure that assesses depressive symptoms (Kroenke et al., 2001; Spitzer et al., 1999). Higher scores indicate greater levels of depressive symptoms.

BOX 1 Items on Balance Self Report Inventory taken as modified excerpts from the Berg Balance Scale (Berg et al., 1992, 1995)

Score Yes = 1
No = 0

- Are you able to SAFELY stand up from sitting without using your hands to stabilize yourself?
- Are you able to remain unsupported in standing (e.g. with no walking aid or physical support from anyone) SAFELY, your feet shoulder width apart with your EYES OPEN for 10 s?
- Are you able to remain unsupported in standing (e.g. with no walking aid or physical support from anyone) SAFELY, your feet shoulder width apart with your EYES CLOSED for 10 s?
- Are you able stand independently (eyes open) with your feet together for 1 min SAFELY?
- From a standing position, are you able to pick up a light object such as a shoe or TV remote control SAFELY and EASILY from the floor?
- Are you able to SAFELY walk in line, with one foot in front of another (heel in contact with toe = heel—toe) independently without any support (e.g. walking aids or physical help) for 6 steps?
- Are you able to place your feet, with one foot in front of another (heel—toe) and keep your balance for 30 s independently and SAFELY?
- Are you able to stand on one leg independently and hold your free leg off the ground using only your leg muscles (not holding on with your hands) for 10 s?

Score 1 for 'Yes' and 0 for 'No'

Interpretation:
$^{8}/_{8}$ = no balance problems; Between $^{1}/_{8}$ and $^{7}/_{8}$ = Partial balance problems; $^{0}/_{8}$ = severe balance problems

F-Score. Describes a range of functional levels that can be observed in the wake of GBS (Hughes et al., 1978) (Box 2).

2.5 | Ethics

This study received approval from the Manchester Metropolitan University Ethics Committee (number 11678).

BOX 2 Physical functioning of patients with Guillain–Barré syndrome (F-score) (Hughes et al., 1978)

0 – Healthy
1 – Minor symptoms or signs, able to run
2 – Able to walk more than 5 m without assistance but unable to run
3 – Able to walk more than 5 m with assistance
4 – Bed or chair bound
5 – Requiring assisted ventilation for at least part of the day
6 – Dead

2.6 | Data analysis

Participants were asked if they had fallen in the past 12 months. Data for all participants are presented in the following categories: 'Non-fallers' and 'Fallers'. Fallers were further separated into the sub-groups: 'Fallers who sustained no injury' and 'Fallers who sustained an injury'. Analysis is of two comparator groups: 'Fallers versus Non-fallers' and 'Fallers with injuries versus Fallers without injuries'. Key demographic and clinical variables were assessed relative to participants' falls status over the previous year. Categorical data were summarised using frequency and percentage and inferential comparisons were made using chi-square tests. Continuous data (ordinal, interval and ratio) were summarised using median and range and compared by Mann–Whitney *U* tests. Selected data were analysed using odds ratios for illustration. Based on relationships identified in these analyses, a binomial logistic regression assessed associated factors related to variables for fallers/non-fallers and for fallers who were injured/uninjured (Table 5). Missing values were not used in the analysis involving such variables. As a result, some totals may not equal 216. All analyses were conducted in SPSS version 25 (IBM, 2017).

3 | RESULTS

Four hundred and seventeen individuals entered the questionnaire via a link. Of these, 201 responses were removed pre-analysis: 94 individuals provided insufficient data; 77 did not meet the inclusion criteria; 26 provided no data (opened the link/only completed the consent form); 2 withdrew consent and elimination of 2 responses from the same person providing conflicting data. Two hundred and sixteen responses were included for analysis. Tables 1 and 2 detail the sample demographic and clinical data (categorical and continuous data, respectively) for the whole sample and subgroups relating to fall status in the previous year. As this is a novel area of research in the experiences of GBS and intolerance of uncertainty was measured by two cognitive components, a Bonferroni correction was applied to the analyses in Table 2 for this variable.

One hundred and thirteen respondents (52.3%) reported falling in the last year, of which 51 (45.1% of those who had fallen) were injurious. Table 3 shows the location and nature of these injures. Of those reporting a fall in the past 12 months, 12 (11.5%) participants reported fractures with 2 participants reporting two fractures each. The total number of fractures was 14 representing 6.5% of the total cohort ($N = 216$). Injurious falls numbered 84 (39% of the total cohort).

In comparing fallers with non-fallers, there was no difference in fall occurrence in the previous 12 months for gender or for differing levels of mobility on leaving hospital. Most significant associations with falling related to the respondents' ability to walk independently (without walking aides) with the odds of a fall occurring in the previous 12 months being 4.5 times greater for those not walking independently (OR = 4.45, 95% CI [2.1, 9.4], $z = 3.91$, $p < 0.001$). Associations around balance and body pain were highly significant between fallers and non-fallers (OR = 4.45, 95% CI [2.10, 9.40], $z = 3.91$, $p = 0.001$ and OR = 3.51, 95% CI [1.88, 6.55], $z = 3.94$, $p = 0.001$, respectively). There were also significant differences between injured fallers and uninjured fallers (Table 2). The odds of being injured in a fall were higher for people with severely impaired balance but only borderline significant difference for those experiencing body pain (OR = 21.33, 95% CI [2.54, 179.22], $z = 2.82$, $p = 0.005$ and OR 2.94, 95% CI [0.99, 8.74], $z = 1.94$, $p = 0.053$, respectively). Among those who experienced body pain ($N = 152$; 70.7%) the lower limbs were more affected than anywhere else ($n = 75$, 68.2%). For sleep disturbance, for those with body pain ($N = 110$) people with lower limb pain had higher odds of disturbed sleep (always or most of the time) than those with pain anywhere else (OR = 4.98, 95% CI [1.74, 14.22], $z = 2.99$, $p = 0.003$).

For F-Scores, fallers exhibited a median score of 3 (able to walk >5 m with assistance) while non-fallers had a median F-score of 2 (able to walk >5 m without assistance but unable to run) (Table 2). However, there appeared to be no relationship between F-score at nadir and fall status.

Prospective anxiety was higher in fallers than non-fallers and there was no difference between people who fell and those that did not with regards to inhibitory anxiety (Table 2). Depression scores were significantly higher among fallers than non-fallers. Fallers had highly significant worse FFS compared to non-fallers.

Overall, 53% of participants had severe fatigue (FSS >5) and these had twice the odds of falling than those who were not severely fatigued (OR = 2.16, 95% CI [1.25, 3.74], $z = 2.75$, $p = 0.006$).

Time since diagnosis of GBS was not significant between fallers and non-fallers but was statistically significant between fallers (with injuries versus those without) with participants sustaining injury following a fall having a significantly longer period since their diagnosis (Table 2).

Participants were asked about treatment by physiotherapists as part of their recovery from GBS. Key metrics included whether or not they had physiotherapy following their discharge from hospital (after GBS), how long, on average, were their sessions, how many sessions they had per week and how many weeks

TABLE 1 Falls and falls related injuries (Categorical Data)

Demographic	All participants ($N = 216$) N (%)	Has not fallen ($N = 101$) n (%)	Fallen ($N = 113$) n (%)	Difference between non-fallers and fallers X^2 (*df*; Phi) Significance	Fallen: no injury ($N = 62$) n (%)	Fallen: sustained injury ($N = 51$) n (%)	Difference between fallers: with and without injury X^2 (DF; Phi) Significance
Gender							
Male	98 (45.4)	47 (46.5)	51 (45.1)	0.42 (1; −0.41) 0.837	32 (51.6)	19 (37.3)	2.33 (1; −0.14) 0.127
Female	118 (54.6)	54 (53.5)	62 (54.9)		30 (48.4)	32 (62.7)	
Currently Walking Independently							
Yes	130 (60.2)	79 (78.2)	50 (44.2)	25.7 (1; −0.35) **<0.001**	31 (50.0)	19 (37.3)	1.84 (1; −0.13) 0.175
No	86 (39.8)	22 (21.8)	63 (55.8)		31 (50.0)	32 (62.7)	
Balance Problems[a]							
Yes	61 (46.2)	25 (31.6)	35 (67.3)	16.07 (1; 0.35) **<0.001**	15 (48.4)	20 (95.2)	12.49 (1; 0.49) **<0.001**
No	71 (53.8)	54 (68.4)	17 (32.7)		16 (51.6)	1 (4.8)	
Body Pain[a]							
Yes	152 (70.7)	57 (57.0)	93 (82.3)	16.3 (1; 0.28) **<0.001**	47 (75.8)	46 (90.2)	3.98 (1; 0.19) **0.046**
No	63 (29.3)	43 (43.0)	20 (17.7)		15 (24.2)	5 (9.8)	
Independent Walking on Leaving Hospital[a]							
Yes	31 (14.5)	19 (18.8)	12 (10.6)	2.89 (1; −0.16) 0.089	8 (12.9)	4 (7.8)	0.755 (1; −0.08) 0.385
No	183 (85.5)	82 (81.2)	101 (89.4)		54 (87.1)	47 (92.2)	

Bold indicate significant values at $p < 0.05$.

[a]Not all participants reported on these variables; therefore, there are less than 216 responses to these items.

TABLE 2 Falls and falls injuries (Continuous Data)

Demographic	All participants (N = 216) Median (Range)	Has not fallen (N = 101) Median (Range; n)	Has fallen in past year (N = 113) Median (Range; n)	Difference between fallers and non-fallers p= (U=; Z=)	Fallen: no injury (N = 62) Median (Range, n)	Fallen: sustained injury (N = 51) Median (Range, n)	Difference between those injured and uninjured after fall p= (U=; Z=)
Age (years)	61 (22–90)	59 (23–90; 101)	62 (22–87; 111)	0.145 (4955;–1.46)	61 (23–7884; 61)	62 (22–87; 50)	0.366 (1372;0.904)
Time since GBS diagnosis (years)	7 (0–48)	8 (1–36; 100)	7 (0–48; 113)	0.322 (5206;0.991)	5 (0–48; 62)	10 (1–48; 51)	**0.024** (1190.5;2.259)
How Long on ITU (Days)[a]	15.5 (1–240)	24 (0–180; 53)	14 (0–240; 51)	0.482 (1243;0.704)	14 (1–240; 24)	16 (0–198; 27)	0.741 (306.5;0.331)
F-score at worst	5 (1–7)	5 (1–6; 101)	5 (3–7; 113)	0.986 (6599.5;0.018)	5 (3–6; 62)	5 (3–7; 51)	0.605 (1506;0.518)
F-score now	3 (1–5)	2 (1–5; 101)	3 (1–5; 113)	**<0.001**[b] (3512;–5.03)	3 (1–5; 62)	3 (1–5; 51)	0.868 (1554;0.166)
IUS–12 (Prospective anxiety)	13 (7–33)	12.5 (7–30; 100)	15 (7–33; 112)	**0.002**[c] (4251;–3.03)	15 (8–32; 62)	15 (7–33; 50)	0.628 (14,681,467.5;–0.484)
IUS–12 (Inhibitory anxiety)	11 (4–23)	10 (4–21; 100)	11 (6–23; 112)	0.046[c] (4716;–1.99)	11 (6–19; 62)	11 (6–23; 50)	0.867 (1521.5;0.167)
PHQ–9	5 (0–25)	3.5 (0–24; 100)	7 (0–25; 112)	**<0.001** (3726;–4.2)	6.5 (0–23; 62)	7.5 (1–25; 50)	0.126 (1289;1.531)
Fatigue severity score	5.22 (1–7)	4.5 (1.22–7; 100)	5.56 (1.44–7; 113)	**0.001** (4106;–3.44)	5.44 (1.44–7; 62)	5.78 (2–7; 51)	0.096 (1293.5;1.662)

Bold indicate significant values at $p < 0.05$.

[a]Time in ITU: Non-fallers n = 94 and Faller n = 105.

[b]Distribution of the F-Scores between fallers and non-fallers were not similar on visual inspection. F-Score Mean Rank for fallers = 126.92 and non-fallers = 85.77.

[c]A Bonferroni correction was applied to alter the new level of significance to p = 0.025.

TABLE 3 Location and nature of injuries

	Fractures	Non-Fracture Injuries[a]
Shoulder	0	6[b]
Elbow	1	1
Wrist and hand	2	5[c]
Hip	1	2
Knee	1	13
Foot and Ankle	8	9
Back	0	4
Ribs	0	2
Head and face	0	12[d]
Achilles	0	1
Legs (unspecified location)	1	10
Arms (Unspecified location)	0	6
Totals	14	71

[a]Lacerations Bruising, Strains, Dislocations.
[b]One respondent reported a dislocated shoulder.
[c]One respondent reported a laceration causing nerve damage requiring surgery.
[d]3 cases reported cuts over their eye.

they received physiotherapy. Table 4 shows the results from the respondents.

Eighteen participants (35.3% of those who had fallen) did not receive physiotherapy on discharge from hospital after their treatment for GBS. The odds of falling and sustaining an injury were greater for those who did not receive physiotherapy postdischarge from hospital compared with those who did (OR = 2.52, 95% CI [1.06, 6.03], $z = 2.09$, $p = 0.036$).

3.1 | Binomial logistic regression analysis

Two binomial logistic regressions were conducted. One modelled the associated factors (see Table 4) that could predict falls. The other modelled the associated factors (see Table 4) that could predict injurious falls. The results of these two regressions are reported in Table 5. These analyses were run to provide a more harmonious model of what factors are associated with falling and injurious falls.

For those who had fallen and not fallen, linearity of continuous variables with respect to the logit of the dependent variable (fall or not fallen in the past year) was assessed by the Box–Tidwell procedure (Box & Tidwell, 1962). A Bonferroni correction was applied using all 15 terms in the model resulting in a statistical significance accepted at $p < 0.0034$ (Tabachnick & Fidell, 2014). Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable. Three cases were identified as having standardised residuals of >2. Results were consistent with and without these cases and so the final analysis included all cases with complete data. Data were incomplete for 7 cases leaving 208 cases in the regression analysis. Among fallers, for those who had been injured and those who had not, the same procedure was undertaken. In this case, none of the continuous variables were statistically significant with the lowest value for alpha = 0.34. Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable. No outliers were identified in this dataset.

Table 5 shows that the variables entered explain approximately 27% of the variance between fallers and non-fallers. While these results show that the existence of body pain is an associated factor of falling, it was not associated with injurious falls. Age is also significant for fallers, but the odds ratio suggests that there is roughly an equal chance of falling regardless of age. However, of particular note, this model indicates that the younger respondents had higher odds of falls.

This finding appears to indicate that there may be other factors which moderate the effects of age. There were a number of borderline significant results. For fallers and non-fallers, these data suggest that those using walking aids had twice the odds of falling than those who walked without. Interactions between elements within the model may explain why some correlated elements were not significant in the regression model.

Considering fallers who sustained injuries versus those who did not, the model presented in Table 5 explains approximately 17.2% of the observed differences. While the model itself was significant, indicating that the variables entered in the regression play a role, their individual roles are likely moderated via interaction effects. Therefore, only borderline significance was observed. For example, there is borderline significance for people not receiving physiotherapy on discharge after treatment for GBS who had twice the odds of being injured in the event of a fall. Finally, considering injurious falls, time since diagnosis was borderline significance, but the effect was small.

4 | DISCUSSION

This study aimed to report on: the number of people, post-GBS, who experienced falls over the previous year; the variables associated with these falls; and to explore the occurrence and location of body pain. The results show that over half of respondents had fallen in the previous 12 months. Of those, just under half sustained an injury as a result. Ability to walk without an aid, body pain, balance problems, fatigue and anxiety were associated with falling. Of these variables, only body pain was a statistically significant and strong predictor of falling (Table 5). Injurious falls were associated with balance problems and body pain. Body pain occurred in most of the sample, with a majority of those reporting pain in their lower limbs. However, only borderline significant predictors of injurious falls were identified and only one of these had a large potential effect (absence of physiotherapy on discharge from hospital).

Although peripheral neuropathies have been identified as a cause of falls (Cavanagh, 1992; Richardson, 1992; Wuehr et al., 2014), to

TABLE 4 Physiotherapy related outcomes

Demographic	All participants (*N* = 214[a])	Has not fallen (*N* = 101)	Has fallen in past year (*N* = 113)	Difference between non-fallers and fallers	Fallen: no injury (*N* = 62)	Fallen: sustained injury (*N* = 51)	Different between fall with no injury and fall with injury
		n (%)	*n* (%)	X^2 (DF=; Phi=) Significance	*n* (%)	*n* (%)	X^2 (DF=; Phi=) Significance
Physiotherapy Postdischarge							
Yes	155 (72.4)	69 (69.7)	84 (74.3)	0.57 (1; 0.05) 0.45	51 (82.3)	33 (64.7)	4.52 (1; −0.2) **0.034**
No	59 (27.3)	30 (30.3)	29 (25.7)		11 (17.7)	18 (35.3)	
	Median (Range) *n*	Median (Range; *n*)	Median (Range; *n*)	*p*= (U=; Z=)	Median (Range; *n*)	Median (Range; *n*)	*p*= (U=; Z=)
Length of Physio Sessions (Minutes)	30–45 (<30–>60) 151	30–45 (<30–>60) 69	30–45 (<30–>60) 82	0.417 (2625; −0.81)	30–45 (<30–>60) 49	30–45 (<30–>60) 33	0.2 (682; 1.28)
No of Weeks of Therapy	8 (<1–>10) 152	6 (<1–>10) 69	8 (<1–>10) 83	0.25 (2562; −1.15)	8 (2–>10) 50	8 (<1–>10) 33	0.464 (749.5; −0.73)

Bold indicate significant values at $p < 0.05$.

[a]Two participants did not respond to questions around receiving physiotherapy postdischarge, therefore only 214 participants were included.

TABLE 5 Binomial Logistic Regression of associated factors for fallers/non-fallers and for those who fell who were injured/non-injured

Predictor	Falling or not falling in the previous year (N = 208)[a]				Fallers who were injured or not (N = 110)[b]			
	Odds Ratio	95% CI	B	p	Odds Ratio	95% CI	B	p
Gender	0.77	0.40–1.50	−0.25	0.46	1.42	0.60–3.43	0.35	0.44
Age	0.97	0.95–1.00	−0.03	**0.037**	0.98	0.95–1.02	−0.02	0.31
Walk independently (without the need for walking aids)	2.24	0.90–5.56	0.81	0.08	1.26	0.53–2.98	0.23	0.61
Existence of body pain	2.42	1.13–5.21	0.86	**0.024**	0.45	0.13–1.56	−0.80	0.21
Walking on leaving hospital[c]	1.10	0.45–2.70	0.01	0.83	—	—	—	—
F-Score now[c]	0.97	0.63–1.5	−0.03	0.10	—	—	—	—
IUS-12 (Prospective anxiety)[c]	0.96	0.86–1.07	−0.04	0.40	—	—	—	—
IUS-12 (Inhibitory anxiety)[c]	0.99	0.86–1.14	−0.01	0.89	—	—	—	—
PHQ-9	0.95	0.8–1.00	−0.07	0.06	0.98	0.91–1.06	−0.02	0.65
Received physiotherapy on discharge home[d]	—	—	—	—	2.30	0.10–5.90	0.84	0.08
Time since diagnosis[d]	—	—	—	—	0.96	0.92–1.00	−0.04	0.07
Fatigue score	0.90	0.71–1.14	−0.10	0.39	0.83	0.58–1.19	−0.18	0.15

Bold indicate significant values at $p < 0.05$.

[a] Model $\chi^2 = 46.51$, df:10, $p < 0.001$; Nagelkerke $R^2 = 0.27$; Hosmer-Lemeshow $\chi^2 = 5.3$, df:8, $p = 0.7$. Although 216 cases were included, 8 cases had missing data and so were not included in the analysis.

[b] Model $\chi^2 = 16.17$, df:8, $p = 0.040$; Nagelkerke $R^2 = 0.18$; Hosmer-Lemeshow $\chi^2 = 5.99$, df:8, $p = 0.65$. Although 113 cases were included, 3 cases has missing data and so were not included in the analysis. No interpolation was conducted for either analysis.

[c] Analysis only conducted for fallers versus non-fallers.

[d] Analysis only conducted on injurious falls.

our knowledge, no previous studies have considered falls in people late after GBS. These data show that fall occurrence is higher than in people aged over 65, who have a reported rate of 30% per annum (Karlsson et al., 2013). These data suggest that people post-GBS have higher falling occurrence at a younger age (median cohort age = 62 years).

The physical factors associated with falls in this present study include poor balance, being able to walk without walking aids or not, fatigue and body pain. Interdependence between some of these variables is likely. For example, poor balance and/or body pain may necessitate the need for walking aids and pain in the lower body can have a negative effect on balance (Yagci et al., 2007). However, these data suggest that body pain is not the only reason for the use of walking aids as over two-thirds of the sample reported body pain yet about 40% were able to walk without any assistance. These interactions might explain some differences in outcome between the associations and the subsequent regression analyses.

Studies investigating pain in GBS and other inflammatory neuropathies concentrate on neuropathic pain, although there is acceptance that pain in GBS could be multifaceted (Kogos et al., 2005). Dysfunction of the musculoskeletal system is one possible cause of body pain (Mullings et al., 2010), however, it is unclear what proportion of pain experienced is neuropathic and what pain is not.

Regardless of the cause, acute/subacute body pain has been reported (Artemiadis & Zis, 2018; Ruts et al., 2010; Liselotte Ruts et al., 2012) pre- and post-GBS. Just over 70% of this current post-GBS sample experienced body pain. Body pain can be a major sequela of GBS occurring with early onset and enduring for many years after (Merkies et al., 1999).

Body pain was associated with, and is a significant predictor of, increased falls occurrence, a finding also identified in older adults (Gale et al., 2016). For the post-GBS community, this finding may suggest that body pain is a phenomenon that develops, becoming more persistent over time. This assertion is supported by the observation that those who fell and those who were injured from falls had been diagnosed with GBS further in the past than those who had not fallen. As a predictor variable, this was borderline significant, but with a weak effect. The findings of this present study might suggest that there are more nuanced reasons for falling and being injured. For example, in the regression analysis, depression, as measured by the PHQ-9 is borderline significant. While not significant, taken into the broader context of these data, it is possibly an indicator of nuance because the interaction of depressive symptoms may affect falls through an interaction with body pain. Equally, individuals with body pain, due to psychical distress, possibly due to falls or other aspects of GBS, may experience augmented body pain. In addition, those with depressive symptoms may be less active therefore less likely to engage in activities (simple or complex) that may result in falls. These factors, related to depression, may increase or decrease the risk of fall and as such, this may obscure the full effects of depressive symptoms on falls within the regression model.

More broadly, a possible explanation for some findings in this present study may lie in changes to the anatomy in response to the process of recovery that creates alterations to the length and strength of anatomical structures, afferent input and consequent locomotor behaviour (Arsenault et al., 2016).

While these nuanced explanations may exist within this regression model, other factors may also be at play. For example, balance problems and body pain, exist between fallers and non-fallers. While body pain could derive from injuries sustained during falls, of those reporting body pain, a third had injurious falls suggesting other factors are involved. Balance deficiency is a well-known falls-risk (Gale et al., 2016; Karlsson et al., 2013; Yagci et al., 2007). However, the nature of injuries sustained by 'fallers' in this present study suggests saving reactions may be impaired since 14% of injuries were to the face and head (cuts and bruises) and 16.5% were fractures to other areas. This suggests that landings were heavy and lacking control, indicating that people post-GBS have continued locomotor dysfunction that includes loss of saving reactions.

Saving reactions are intended to limit bodily damage (Stack, 2017) and are stimulated in response to failure of postural control mechanisms to maintain postural stability (Baldursdottir et al., 2018). These mechanisms are controlled through complex integration of afferent input and efferent outputs, moderated through neurologically mediated feedback loops designed to maintain body stability in all postural configurations (Latash & Zatsiorsky, 2016). This finely tuned postural stability relies on the body's ability to summon and utilise strength, endurance, balance, coordination and flexibility to maintain its integrity (Skelton & Dinan, 1999). Interruption of any one or combination of these will likely result in postural insufficiency, which will predispose to falls. In GBS, this interruption is evident and in particular, fatigue may be central to this problem.

Fatigue is a common sequela of many neurological diseases (Zwarts et al., 2008) with 60%–80% of people have severe fatigue post-GBS (Garssen et al., 2006; Merkies et al., 1999). In this current study, 53% of respondents reported severe fatigue (i.e. a score >5 on the FSS (Merkies et al., 1999)) and had a significant difference in fatigue between fallers and non-fallers. While these data do not provide a definitive causative link, they do provide a theoretical foundation to examine possible causes of falls. It is possible that a convoluted mixture of central fatigue (Noakes et al., 2001; Noakes et al., 2004; 2005) and movement compensation (Jones et al., 2013; Levin et al., 2008; Paillard, 2012) might partly explain putative missing link.

This link between falls and fatigue could be explained by the assertion made through a key tenet of Central Governor Theory of Fatigue (CGTF) (Noakes et al., 2001) that motor performance is controlled directly by the brain through a dynamic and complex interaction of sensory feedback, physiological processes and biomechanics resulting in restriction of motor unit recruitment (Noakes et al., 2005). Its purpose is to maintain homeostasis and to avert catastrophe (Noakes et al., 2004).

Residual neuromuscular deficiency, observed in the continued aftermath of GBS (Davidson et al., 2009, 2010; Stockley et al., 2013), necessitates change in movement strategy placing new burdens on body biomechanics (Dimitrova et al., 2017). Alterations to biomechanics may, over time, result in musculoskeletal disorders causing specific anatomical lesions and non-specific, general pain. Biomechanical alterations may be driven by a process of compensatory movement, a natural phenomenon that allows the body to function even when faced with catastrophic events such as stroke (Felling & Song, 2015; Levin et al., 2008). Left unchecked, these compensatory movement patterns, in the absence of full recovery, can endure through afferent reinforcement, evoking abnormal efferent signals and creating learned motor response (Kleim, 2011), part of which may cause atrophic changes in the neuromuscular system resulting in learned disuse (Jones et al., 2013; Wolf, 2007). Challenges to movement dynamics through altered tendon tension angles and subsequent changes to motor unit firing sequences may require some structures take greater strain than others, creating local fatigue. Furthermore, persistence in these compromising postures becomes 'fixed' by the body's fascial network (Schleip et al., 2012) making it difficult to remedy the developing anomalies.

In normally functioning neuromuscular systems, there is deterioration in postural control during strenuous and prolonged exercise (Paillard, 2012). However, compensatory strategies in sensory, motor and cognitive domains mitigate against this deterioration (Paillard, 2012) allowing body function to continue apparently unhindered. Where the whole-body organism is under stress, as in the case of neurological disorders, the same compensatory and deteriorative adjustments are likely to occur under circumstances where the body has diminished capacity to compensate and recover. Persistent, yet necessary, efforts to re-establish locomotion may perpetuate the compensatory mechanisms which could create centrally driven fatigue through the CGTF (Noakes et al., 2005).

Once central fatigue has been established, intra-corporeal compensation is no longer possible (Paillard, 2012) making it difficult for people to sustain activities both physically and mentally due to greater perceived effort (Forsberg, 2006). Over time, the perceived discomfort of this effort progressively impedes the desire to engage in activity (Noakes et al., 2005). CGFT has led Noakes (Noakes et al., 2004, 2005) to conclude that fatigue should not be considered as a physical event but an emotional one, driven by subconscious, centrally driven processes. Emotional disturbances in humans typically manifest through feelings of anxiety and depression. These data in this present study show that people affected by falling are those, not only affected by fatigue, but also by greater anxiety and depression scores reinforcing Noakes' assertion about the relationship between fatigue and emotional wellbeing. For the survey responders, it is possible that the focus on falling, and particularly those who sustain injury, has brought into sharp relief complex, interwoven elements driving fatigue. Added to this, the observation that many who experience pain, particularly in the lower limbs, have disturbed sleep, it is little wonder that severe fatigue in post-GBS patients is an enduring feature.

These sequelae, particularly pain and fatigue can persist for years, even after recovery is ostensibly complete (Hillyer

& Nibber, 2020; Merkies et al., 1999; Ranjani et al., 2014). This persistence might signal injury (Merkies & Kieseier, 2016), an assertion supported by the findings of this present study which suggests residual injuries, insufficiencies precipitated by compensatory movements, may develop over time. This present study provides evidence for this by demonstrating the association (and borderline significant yet weak prediction) between injurious falls and a longer time since nadir. If anatomic changes persist and biomechanics change, movement becomes less efficient and more effortful, a phenomenon frequently observed in peripheral neuropathies (White et al., 2014). With greater effort comes greater energy expenditure which might drive fatigue. The finding that injurious falls are more common with increased time since nadir cannot be explained by advancing age, as age was not significant between fallers sustaining injuries whereas time since nadir showed significant association (Table 2). Furthermore, the event of falling makes future falls more likely (Lusardi et al., 2017). The increased risk is because fear of falling makes people move more cautiously (Young & Mark Williams, 2015) and the use of walking aids more likely, causing altered gait pattern (Roman de Mettelinge & Cambier, 2015) and postural control to further deteriorate (Oliveira et al., 2015).

The current study corroborates that a large percentage of people post-GBS did not receive physiotherapy on discharge (Davidson et al., 2010). Additionally, those not receiving physiotherapy on discharge had greater than double the odds of having an injurious fall compared to those receiving physiotherapy. This large effect is reinforced by the regression analysis, albeit only at a borderline significant level. The reason for this finding is unclear and deserves further investigation.

These data underline the need for continued rehabilitation post-GBS. The COVID-19 pandemic has focused attention on rehabilitation for those severely affected (CSP, 2020). Wade (2020) highlights the importance of providing rehabilitation by expert multi-disciplinary teams and not simply referral to single specialisms like physiotherapy. This present study shows that 27% of people discharge home with considerable disability do not even get physiotherapy underlining the assertion by Wade (2020) that current rehabilitation services are chaotic with paucity of provision for those who need it. Perhaps the silver lining of COVID-19's aftermath may be to refocus rehabilitation services for all who need it, not just those post-COVD-19.

The nature of cross-sectional studies means that recall can be problematic. It is clear that the potential for error remains. Although some data presented here relate to past events, most are contemporaneous. Representativeness of the respondents is also in doubt. However, this present study is as representative as previous studies (7–9) with similar proportion of men and similar median ages. The underrepresentation of males might merely reflect females' greater propensity to complete questionnaires, have more enduring problems than males or both. Nonetheless, either way, such as the rarity of this condition that the number reporting enduring problems is important.

Future research should assess the interaction of factors associated with falls and injurious falls. People post-GBS appear to have nuanced experiences that do not align with expected norms, such as a lack of gender and age difference among fallers. This assessment should aim towards developing models exploring potential interactions of key variables identified in this present study. This will assist in developing targeted treatments for individuals who may go on to fall and be injured.

5 | CONCLUSION

In summary, this study, for the first time, identifies high occurrence of falls in people long after GBS. It has exposed high levels of injurious falls and highlights possible contributing factors. Additionally, this paper indicates that post-GBS symptoms may persist, engendering chronic problems, affecting the body movement and posture via the process of compensation made to endure through neuro-plastic change and its highly adaptable supporting fascial network.

The body is an integrated, dynamic and self-sustaining mechanism. Should any internal 'system' malfunction, there is consequential impact. It is therefore unsurprising that, for many people post-GBS, neurological problems causing movement deficiency, will transform into physical change, leading to increasing body pain, lessening desire to move for fear of causing more pain, diminishing the postural control mechanism, precipitating future falls and possible harm. This, in turn, may drive anxiety about decreasing mobility, night pain, disturbed sleep and increased fall occurrence, which can lead to further retraction of activity through fear of falling thus perpetuating a downward cycle.

If fatigue is at the root and is centrally governed, and if this governor is stimulated by compensations within the system which are emotionally driven, then dealing with anxieties and musculoskeletal anomalies in combination becomes a compelling line of enquiry for people long after GBS and who have movement difficulties. However, this can only be addressed if appropriate ongoing access to a team of rehabilitation experts is available which, currently, it is patently not.

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CONFLICTS OF INTEREST

None.

DATA AVAILABILITY STATEMENT

Data are available from GAIN with author approval.

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