REVIEW ARTICLE

Falls after spinal cord injury: a systematic review and meta-analysis of incidence proportion and contributing factors

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Abstract

Introduction Falls are detrimental to the well-being of individuals with spinal cord injury (SCI). To establish effective fall prevention initiatives, a comprehensive understanding of falls after SCI is needed.

Objectives To report the incidence proportion of falls and summarize the factors contributing to falls in individuals with SCI.

Study design Systematic review and meta-analysis.

Methods Eight databases were searched. Abstracts/full articles were screened by two researchers independently. Data concerning study design, participant characteristics, and the incidence proportion, factors, and consequences of falls were extracted. Risk of bias was assessed using a domain-based approach that considered sampling and measurement bias. The incidence proportions of falls were pooled for ambulators and wheelchair users separately using random-effects meta-analyses, and compared descriptively for inpatients and community-dwelling individuals. Fall-related factors were organized according to the Biological, Behavioral, Social & Economic and Environmental Model of fall risk.

Results The search resulted in 1706 articles; 24 unique studies were included. The risk of sampling bias was high. All but one study focused on community-dwelling individuals; 78% (95% confidence interval 73–83%, $I^2 = 0\%$) of ambulators and 69% (95% confidence interval 60–76%, $I^2 = 59\%$) of wheelchair users fell ≥ 1 over 12 months. In contrast, only 13% of inpatients fell. Most fall-related factors were categorized as biological (e.g., muscle weakness), behavioral (e.g., inattentiveness) or environmental (e.g., uneven surfaces).

Conclusions Falls are frequent among community-dwelling individuals with SCI. A variety of biological, behavioral, and environmental factors contribute to falls, some of which are modifiable and may be addressed through SCI-specific fall prevention initiatives.

Introduction

The consequences of falls result in significant individual and societal burden. Fall-related injuries, such as fracture and head injury, cost health-care systems billions of dollars every year [1]. Not only may individuals who fall experience an injury, but they may develop a post-fall syndrome characterized by reduced mobility, depression, decreased autonomy, and reduced participation in daily activities [2]. At present, there is a strong desire among health-care administrators, rehabilitation professionals and researchers to address the “emerging public health crisis” [3] of falls and identify effective initiatives to prevent falls among vulnerable populations, such as those with spinal cord injury (SCI).

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The sensorimotor deficits characteristic of SCI, such as lower limb muscle paresis or paralysis, reduced trunk control, and decreased sensation and proprioception, contribute to impaired balance control. The inability to maintain balance is likely a key underlying cause of falls among individuals with SCI, although it is likely that other intrinsic factors (e.g., spasticity, impulsive behavior) or extrinsic factors (e.g., characteristics of the environment) contribute to falls in this population. Currently, we lack a comprehensive understanding of the frequency of falls among the SCI population and what factors contribute to falls in this group. A synthesis of the fall-related literature in SCI will inform the development of fall prevention initiatives that are tailored to the SCI population. For example, understanding which sub-group of individuals with SCI are at the greatest risk of falling, and which contributing factors are modifiable, will enable the rehabilitation team to focus fall prevention initiatives on areas likely to have the greatest impact.

Compared with other neurological populations, our knowledge of falls and how to prevent them after SCI is lacking [4–7]. Fall prevention interventions may facilitate participation in much-needed recreational, educational, and employment opportunities for the SCI population. Despite being significantly younger than individuals with other neurological conditions, the SCI population has a greater proportion with low education (20%), and with an annual household income of < \$25,000 USD (34%) [8]. Further, the demographics of SCI are changing [9–11]. The age of onset of SCI is increasing and more individuals with SCI are presenting with pre-existing health conditions [9, 10, 12]. Both increasing age and co-morbid conditions are known risk factors for falls [8]. Thus, it is reasonable to expect the frequency of falls in SCI to climb, increasing the need for effective fall prevention strategies.

In order to increase our understanding of falls after SCI, we completed a systematic review and meta-analysis that aimed to: (1) determine the incidence proportion of falls among people with SCI; and (2) identify factors associated with falls in these individuals. The findings will increase our understanding of where further research and monitoring are needed, and will assist with the development and implementation of SCI-specific fall prevention interventions.

Materials and methods

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [13]. This review had no registered protocol.

Data sources & search strategy

A literature review was completed with the help of an information specialist (MP) at the University Health Network, Toronto, Canada. Eight electronic databases were searched from inception to 24 May 2018: Medline (OVID), Cochrane Controlled Trials Register (CCTR), Cochrane Database of Systematic Reviews (COCH), Embase, PsycINFO, PubMed (excluding Medline), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Physiotherapy Evidence Database (PEDro). The search strategies utilized the PICO framework (population, intervention, comparator, and outcomes), valid subject headings as appropriate for each database, and free text terms relevant to the topical concepts. The search was kept as broad as possible by combining the Population (traumatic and non-traumatic SCI) and Outcomes (accidental falls) concepts. Minor publication types such as conference abstracts, letters, etc. were removed when possible such as from the Medline and Embase databases. The results were limited to humans. No date or language limits were applied. The full Medline search strategy is available for viewing in the Appendix.

Prior to abstract screening, the search results were de-duplicated using reference management software (EndNote, Clarivate Analytics, Philadelphia, PA, USA). The abstracts were independently reviewed by two authors (ML and NU) to select articles for full-text review. Disagreements about the inclusion of an abstract were resolved by having a third author (KEM) review the abstract and make a decision. The inclusion and exclusion criteria for abstract and full-text screening were determined a priori. The inclusion criteria were: (1) study participants had a SCI acquired after birth; (2) study participants were 18 years or older; (3) study must have reported a measure of the occurrence of falls (e.g., proportion of participants who fell, number of falls/participant), or reported factors associated with falls in the participants. The exclusion criteria included: (1) review papers with no original data presented; (2) animal studies; (3) study participants with congenital SCI (i.e., spina bifida); (4) studies involving participants with a variety of health conditions, if SCI-specific data could not be extracted; and (5) studies examining falls solely as a cause of SCI.

Data extraction

Following full-text screening, two authors (AK and CP) independently extracted data from the included articles into a data extraction table. Any discrepancies between the two authors in the extracted data were resolved by having a third reviewer (KEM) read the article and extract the data in question. The data extracted are listed in Table 1.

Table 1 Data extraction

Data extracted from included articles
• Study design
• Number of participants
• Characteristics of the participants <ul style="list-style-type: none"> ◦ Mean age ◦ Neurological level of injury ◦ American Spinal Injury Association Impairment Scale (AIS) classification ◦ Cause of SCI (trauma, non-trauma, or both)
• Inclusion and exclusion criteria of the study
• Recruitment method(s) used
• Dates during which the study was conducted
• Retrospective (i.e., asking participants about falls in the past) or prospective (i.e. tracking falls over time) data collection
• Method of data collection (e.g., survey, interview)
• Length of data collection (e.g., 6 months, 12 months)
• Study setting (i.e., inpatient/hospital or community)
• Definition of a fall
• Reported frequency of falls (or similar measure)
• Factors found to be associated with falls
• Consequences of the falls (e.g., injuries, psychosocial impact)

Data synthesis

To evaluate the risk of bias in the included articles (i.e., the likelihood the findings deviated from the truth), a domain-based approach was used [14]. This approach is a framework for evaluating the risk of bias based on aspects of the study design. The likelihood of bias for each domain is rated as low, high or unclear. Two domains were evaluated: (1) Measurement bias, which reflected the method(s) used to collect data on falls (i.e., retrospective methods, which are prone to recall bias [15], or prospective methods); and (2) Sampling bias, which considered how representative the study participants were of the larger SCI population. Sampling bias was evaluated by considering the recruitment method(s) used to enroll participants in the study. The recruitment strategy used in each study was classified according to the following four categories [16] (listed from high to low threat of bias, excluding the “Not stated” category):

- Convenience: participants were recruited from a single hospital or health center.
- Community-based: participants were recruited from more than one hospital or health center with the aim of reaching all eligible individuals in a specific geographical area (e.g., town, city).
- Population-based: participants were recruited from multiple hospitals or centers, as per community-based,

but covered a larger geographical area (e.g., state/province or country).

- Not stated: no information on the recruitment method was provided.

Whenever possible, the proportion of the study sample that experienced at least one fall during the study period was reported (i.e., incidence proportion) [17]. The incidence proportion of fallers is reported with a 95% confidence interval (CI) that was calculated using Jeffrey’s method [18]. The included articles were grouped according to the following categories in order to compare the incidence proportion and contributors to falls by: (1) stage of recovery (i.e., inpatient/hospital-dwelling participants versus community-dwelling participants); and (2) mobility status (i.e., ambulators versus wheelchair users). A random-effects meta-analysis [17] was used to pool the incidence proportion of the sub-groups when this metric was reported in two or more included articles [19]. I^2 and Q statistics assessed heterogeneity. If heterogeneity was large, a leave-one-out analysis was completed to evaluate each study’s influence on the summary proportion incidence and I^2 [20]. R v 3.5.2 (The R Foundation, Vienna, Austria) was used to complete the meta-analyses.

To summarize the findings concerning the factors contributing to falls, the identified factors were classified according to the Biological, Behavioral, Social and Economic, and Environmental (BBSE) Model of fall risk [21]. The BBSE Model was developed to illustrate the multi-factorial nature of falls and provide a means to gauge an individual’s, or a group’s, risk of falls [22]. The greater the number of risk factors identified across the four domains, the greater the risk [22]. The identified factors were grouped into biological, behavioral, social and economic, and environmental domains by three authors (AK, CP, JD) through discussion.

Results

Results of screening

The systematic search returned 2668 articles; after deduplication the total number of articles was reduced to 1706. Following abstract screening, 33 articles qualified for full-text review, and 25 of these articles were included in the review (see Fig. 1). Two studies reported data from the same data set [23, 24] and were combined for reporting and all analyses. Another two studies [25, 26] had some overlap of participants (personal communication, S. Amatachaya), but as each study included some unique participants, these two studies were kept separate for reporting and analysis. Thus, 24 unique studies were included. All articles were

Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram summarizing the identification, screening, inclusion, and exclusion of articles

published between 2003 and 2017, with 17 (68%) of the articles published in 2013 or later. All studies used quantitative research methods with the exception of the four most recently published articles, which used mixed methods [27] or qualitative methodologies [28–30] to learn about the experience of falling from study participants.

More than 3350 individuals with SCI participated in the 24 studies. The characteristics of the study participants varied across studies (see Supplementary Material 1). All but three studies [8, 27, 31] included participants with SCI only. Males made up 35–83% of the study sample, with the exception of two studies that sampled American veterans, resulting in samples comprised of 96% males [32, 33], and one qualitative study in which all seven participants were male [24]. The severity of SCI ranged from AIS A through D, with some studies focusing on ambulatory individuals and others focused on wheelchair users. Only one study looked exclusively at falls during inpatient rehabilitation [31], whereas one study included individuals participating in inpatient and outpatient rehabilitation [34]. The remaining studies examined falls in community-dwelling individuals with SCI. See Table 2 for a summary of the demographic and injury-related variables from each study.

Study quality

The risk of bias in the included studies was increased by the sampling methods used (see Supplementary Material 2). Fourteen studies (71%) used a sample of convenience to recruit participants, whereas four studies (17%) recruited from the larger community [33, 35–37]. One study (4%) recruited through national organizations for individuals with disabilities [8] and hence, adopted a population-based sampling approach. Two studies (8%) did not specify the recruitment method used [27, 34].

Eleven studies (46%) collected fall-related data retrospectively, increasing the potential for bias in the results. Retrospective methods included interviews [27, 34, 38, 39] or surveys [8, 23, 24, 35, 37, 40] about past falls history, and retrospective chart reviews [31, 32]. Twelve studies (50%) prospectively collected fall-related data from the study participants. Prospective methods included weekly or monthly phone interviews [25, 26, 33, 36, 41–44] or text messaging [43, 45] that in some studies was combined with a falls diary [25, 36, 42], and semi-structured interviews [28–30]. One study (4%) collected data on falls both retrospectively (queried falls that occurred in the past month)

Table 2 Summary of included articles

Participants	Data collection	Frequency of falls	Factors contributing to falls	Consequences of falls
<p>Amatachaya et al. [42]</p> <p><i>n</i> = 94 (66% male)</p> <p>Age: 53.5 (IQ: 42–62) yrs</p> <p>Post SCI: 3 (IQ: 1.2–5.0) yrs</p> <p>AIS: C (<i>n</i> = 15), D (<i>n</i> = 79)</p> <p>C5–C7: <i>n</i> = 26, T4–L3: <i>n</i> = 68</p> <p>Amatachaya et al. [41]</p> <p><i>n</i> = 44 (80% male)</p> <p>Age: 45.23 ± 13.78 years</p> <p>Post SCI: 51.52 ± 47.87 mos</p> <p>AIS: A (<i>n</i> = 19), B (<i>n</i> = 2), C (<i>n</i> = 10), D (<i>n</i> = 13)</p> <p>C5–C7: <i>n</i> = 18 T4–L3: <i>n</i> = 26</p> <p>Brotherton et al. [23, 24]</p> <p><i>n</i> = 119 (69% male)</p> <p>Age: 51.6 ± 13.93 yrs</p> <p>Post SCI: 13.6 ± 5.94 yrs</p> <p>AIS: not specified</p> <p>Cervical injury: 47% thoracic injury: 36% lumbar injury: 17%</p>	<p>6 months</p> <p>Prospective</p> <p>Fall diary & monthly interviews</p> <p>Community-dwelling</p> <p>6 months</p> <p>Prospective</p> <p>Monthly interviews</p> <p>Community-dwelling</p> <p>12 months</p> <p>Retrospective</p> <p>Self-report survey</p> <p>Community-dwelling</p>	<p>35% (<i>n</i> = 33) fell ≥ 1 time</p> <p>95% CI: 26–45%</p> <p>52% (<i>n</i> = 23) fell ≥ 1 time</p> <p>95% CI: 38–66%</p> <p>75% (<i>n</i> = 89) fell ≥ 1 time</p> <p>95% CI: 66–82%</p> <p>64% (<i>n</i> = 96) fell ≥ 1 time</p> <p>95% CI: 57–72%</p> <p>30% (<i>n</i> = 45) fell recurrently</p> <p>95% CI: 23–38%</p> <p>13% (<i>n</i> = 27) fell ≥ 1 time</p> <p>95% CI: 9–17%</p> <p>Not reported</p> <p>76% (<i>n</i> = 170) fell ≥ 1 time</p> <p>95% CI: 70–81%</p> <p>51% (<i>n</i> = 114) fell recurrently</p> <p>95% CI: 44–57%</p>	<p>- Fallers were younger & had poorer tactile scores in legs</p> <p>- Perceived causes: obstacles, lower limb weakness, loss of balance</p> <p>- Tasks: walking in home/workplace</p> <p>- Incomplete injury (17/23 fallers)</p> <p>- Tasks: walking & standing (motor incomplete SCI); from wheelchair (motor complete SCI)</p> <p>- Time of day: 12pm–7pm</p> <p>- Perceived contributors: ↓ strength in trunk & legs, loss of balance, environmental hazards ≥ 1 fall was associated with increased number of medical conditions, presence of arthritis, presence of dizziness, more days with poor physical health, fear of falling</p> <p>- Time of day: afternoon or evening</p> <p>- Participants with previous falls, who were working/studying, who had higher SCIM III scores were more likely to have recurrent falls</p> <p>- Sex & age did not affect likelihood of falls</p> <p>- Perceived contributors: judgment error leading to risky behavior in wheelchair, <i>n</i> = 3 (43%); error, <i>n</i> = 4 (57%); inattentiveness in not checking in with the caregiver at the time, <i>n</i> = 7 (100%); not wearing a safety belt (concern chair would fall on top), <i>n</i> = 5 (71%)</p> <p>- Recurrent falls more likely in ambulators, those who get up from ground independently, those who exercise ≥ 30 min at least 1/wk</p> <p>- Recurrent falls decreased with age</p> <p>- Wheelchair users:</p>	<p>- Wound/bruise: 54%</p> <p>- Muscle tear or pain: 8%</p> <p>- Fear of falling: 19%</p> <p>- ↓ mobility, social participation: 12%</p> <p>- Bruises: 30%</p> <p>- Muscle pain: 4%</p> <p>- Fracture: 4%</p> <p>- Bruises/cuts: 71%</p> <p>- Muscle/ligament strain: 39%</p> <p>- Joint dislocation: 7%</p> <p>- Fracture: 18%</p> <p>- Loss of consciousness: 3%</p> <p>- Required medical attention: 36%</p> <p>- ↓ ability to:</p> <p>- Be outside: 45%</p> <p>- Care for self: 29%</p> <p>- Make money: 27%</p> <p>- Interact with others: 35%</p> <p>- 34% (<i>n</i> = 50) were injured</p> <p>- Minor (e.g., bruises/scratches): 32% (<i>n</i> = 47)</p> <p>- Moderate (e.g., sprain): 11% (<i>n</i> = 16)</p> <p>- Severe (e.g., fracture, concussion): 5% (<i>n</i> = 7)</p> <p>Not specified</p> <p>Not specified</p> <p>- 100% (<i>n</i> = 7) reported fracture (study inclusion criterion)</p> <p>- 14% (<i>n</i> = 1) reported surgery and hospitalization</p> <p>- 86% (<i>n</i> = 6) experienced secondary complications due to immobilization (i.e., pressure areas, wounds, skin, and chest infections)</p> <p>- 100% (<i>n</i> = 7) required additional personal care, financial costs, deconditioning</p> <p>- Not specified</p>
<p>Forslund et al. [43]</p> <p><i>n</i> = 149 (83% male)</p> <p>Age: 47 ± 14 yrs</p> <p>Post SCI: 18.6 ± 12.8 yrs</p> <p>AIS: A (<i>n</i> = 96), B (<i>n</i> = 30)</p> <p>C (<i>n</i> = 16), D (<i>n</i> = 7)</p> <p>Cervical: <i>n</i> = 70</p> <p>T 1–6: <i>n</i> = 32</p> <p>T7–12: <i>n</i> = 39</p> <p>lumbar: <i>n</i> = 8</p> <p>Forrest et al. [31]</p> <p><i>n</i> = 216 (54.7% male)</p> <p>Age: 14–91 yrs</p> <p>Post SCI: not specified</p> <p>AIS: not specified</p> <p>Jannings [28]</p> <p><i>n</i> = 7 (100% male)</p> <p>Age: 55 ± 9.7 yrs</p> <p>Post SCI: 29.4 ± 6.9 yrs</p> <p>AIS: A (<i>n</i> = 3), B (<i>n</i> = 4)</p> <p>Cervical: <i>n</i> = 6</p> <p>Thoracic: <i>n</i> = 1</p>	<p>12 months</p> <p>Prospective</p> <p>Text messages every 2 wks, interview if fell</p> <p>Community-dwelling</p> <p>Duration of stay</p> <p>Retrospective</p> <p>Chart review</p> <p>Inpatient</p> <p>Prospective</p> <p>Qualitative, semi-structured interviews</p> <p>Community-dwelling</p> <p>12 months</p> <p>Retrospective</p> <p>Interview</p> <p>Community-dwelling</p>	<p>64% (<i>n</i> = 96) fell ≥ 1 time</p> <p>95% CI: 57–72%</p> <p>30% (<i>n</i> = 45) fell recurrently</p> <p>95% CI: 23–38%</p> <p>13% (<i>n</i> = 27) fell ≥ 1 time</p> <p>95% CI: 9–17%</p> <p>Not reported</p> <p>76% (<i>n</i> = 170) fell ≥ 1 time</p> <p>95% CI: 70–81%</p> <p>51% (<i>n</i> = 114) fell recurrently</p> <p>95% CI: 44–57%</p>	<p>- Participants with previous falls, who were working/studying, who had higher SCIM III scores were more likely to have recurrent falls</p> <p>- Sex & age did not affect likelihood of falls</p> <p>- Perceived contributors: judgment error leading to risky behavior in wheelchair, <i>n</i> = 3 (43%); error, <i>n</i> = 4 (57%); inattentiveness in not checking in with the caregiver at the time, <i>n</i> = 7 (100%); not wearing a safety belt (concern chair would fall on top), <i>n</i> = 5 (71%)</p> <p>- Recurrent falls more likely in ambulators, those who get up from ground independently, those who exercise ≥ 30 min at least 1/wk</p> <p>- Recurrent falls decreased with age</p> <p>- Wheelchair users:</p>	<p>- 34% (<i>n</i> = 50) were injured</p> <p>- Minor (e.g., bruises/scratches): 32% (<i>n</i> = 47)</p> <p>- Moderate (e.g., sprain): 11% (<i>n</i> = 16)</p> <p>- Severe (e.g., fracture, concussion): 5% (<i>n</i> = 7)</p> <p>Not specified</p> <p>Not specified</p> <p>- 100% (<i>n</i> = 7) reported fracture (study inclusion criterion)</p> <p>- 14% (<i>n</i> = 1) reported surgery and hospitalization</p> <p>- 86% (<i>n</i> = 6) experienced secondary complications due to immobilization (i.e., pressure areas, wounds, skin, and chest infections)</p> <p>- 100% (<i>n</i> = 7) required additional personal care, financial costs, deconditioning</p> <p>- Not specified</p>
<p>Jørgenson et al. [38]</p> <p><i>n</i> = 224 (77% male)</p> <p>Age: 49.6 ± 14.9 yrs</p> <p>Post SCI: 15 (IQ: 6–25) yrs AIS: A (<i>n</i> = 100), B (<i>n</i> = 31), C (<i>n</i> = 20), D (<i>n</i> = 73)</p> <p>Cervical: <i>n</i> = 114</p>	<p>12 months</p> <p>Retrospective</p> <p>Interview</p> <p>Community-dwelling</p>	<p>76% (<i>n</i> = 170) fell ≥ 1 time</p> <p>95% CI: 70–81%</p> <p>51% (<i>n</i> = 114) fell recurrently</p> <p>95% CI: 44–57%</p>	<p>- Recurrent falls more likely in ambulators, those who get up from ground independently, those who exercise ≥ 30 min at least 1/wk</p> <p>- Recurrent falls decreased with age</p> <p>- Wheelchair users:</p>	<p>- Not specified</p>

Table 2 (continued)

Participants	Data collection	Frequency of falls	Factors contributing to falls	Consequences of falls
T 1–6: $n = 33$ T7–12: $n = 59$ Lumbar: $n = 18$				
Jørgensen et al. [45] $n = 68$ (66% male) Age: 50 ± 15 yrs Post SCI: 12 yrs (1–40) AIS: A ($n = 2$), B ($n = 1$), C ($n = 3$), D ($n = 62$) Cervical: $n = 42$ Thoracic: $n = 18$ Lumbar: $n = 8$	12 months Prospective Text messages every 2 wks, interview if fell Community-dwelling	Wheelchair users ($n = 151$): 73% ($n = 110$) fell ≥ 1 time 95% CI: 65–79% 41% ($n = 62$) fell recurrently 95% CI: 33–49% ambulatory ($n = 73$): 81% ($n = 59$) fell ≥ 1 time 95% CI: 71–89% 68% ($n = 50$) fell recurrently 95% CI: 57–78% 82% ($n = 56$) fell ≥ 1 time 95% CI: 72–90% 25% ($n = 17$) fell once 95% CI: 16–36% 9% ($n = 6$) fell twice 95% CI: 4–17% 48% ($n = 33$) fell ≥ 3 times 95% CI: 37–60%	- Recurrent falls more likely in men & those with greater SCIM II mobility - Ambulators - Recurrent falls more likely in those who could get up from ground independently; less likely in those with higher scores on International SCI Quality of Life scale - Recurrent falls more likely in those with history of recurrent falls, fear of falling, increased walking speed	-65% ($n = 44$) reported ≥ 1 injurious fall -84% of injurious falls resulted in minor injury (e.g., bruises) - $n = 9$ sustained moderate injury (e.g., wounds, sprains) - $n = 3$ sustained serious injury (e.g., fractures)
Jørgensen & Roaldsen [29] $n = 15$ (67% male) Age: 47.4 ± 18.3 yrs Post SCI: 10.3 ± 10.0 yrs AIS : C ($n = 3$), D ($n = 12$) Cervical: $n = 8$ Thoracic: $n = 3$ Lumbar: $n = 4$	Prospective Qualitative, semi-structured interviews Community-dwelling	Not reported	- Impaired body functions (muscle weakness, spasticity, fatigue, reduced sensitivity) - Environmental hazards (doors, carpets, stairs, hills, uneven ground, darkness, crowds, winter climate) - Not paying attention (in home environments, multi-task situations, or when in a hurry)	- Fall-related psychological issues: fear, embarrassment, feelings of shortcoming
Kumprou et al. [39] $n = 66$ (77% male) Age: 53 ± 15 yrs Post SCI: 68.1 ± 73.3 mos AIS: C ($n = 22$), D ($n = 44$) Paraplegia: $n = 51$ (77%) Tetraplegia: $n = 15$ (23%)	6 months Retrospective Interview Community-dwelling	50% ($n = 33$) fell ≥ 1 time 95% CI: 38–62% 19.7% ($n = 13$) fell once 95% CI: 12–30% 31.8% ($n = 21$) fell ≥ 2 times 95% CI: 22–44%	- Greater walking asymmetry in participants with a history of multiple falls	- Not specified
Labuyere & van Hedel [34] $n = 28$ (57% male) Age: 51.1 ± 14.2 yrs Post SCI: 148 days (24 days–31.9 yrs) AIS: C ($n = 1$), D ($n = 27$) C3–L5	1 month 1 yr Retrospective Interview Inpatient Community-dwelling ($n = 11$)	0.3 ± 1.0 (range 0–5) falls in 1 month 1 yr .2 $\pm$ 2.2 (range 0–10) falls in 1 yr	- No correlation between choice response time and number of falls	- Not specified
Matsuda et al. [8] $n = 492$ (67% male) Age: not specified Post SCI: < 5 yrs ($n = 39$), 5–9 yrs ($n = 160$) 10–19 yrs ($n = 125$) > 20 yrs ($n = 153$) AIS: not specified 40% complete	6 months Retrospective Survey Community-dwelling	39% of SCI participants fell ≥ 1 time 95% CI: 35–44%	- Presence of co-morbid conditions, walking with gait aid & high levels of physical activity were associated with falls	- Not specified
Musselman et al. [30] $n = 8$ (75% male) Age: 48.9 ± 14.9 yrs Post SCI: 5.7 ± 5.8 yrs	Prospective Qualitative, photo-elicitation interviews	Not reported	- Factors perceived to increase fall risk: - Challenges in community (stairs, ramps, curbs, uneven surfaces, obstacles in path, transitions between surfaces,	- Impact of perceived fall risk: - Move slowly, avoid balance-provoking activities, feelings of frustration & fear

Table 2 (continued)

Participants	Data collection	Frequency of falls	Factors contributing to falls	Consequences of falls
<p> AIS: C ($n = 3$), D ($n = 5$) C2–T8 </p>			<p> high/low temperatures, negotiating public transit, heavy doors, revolving doors, long distances) - Challenges in home (stairs, obstacles, narrow spaces, transitions between surfaces, transitions between high/low lighting, slippery bathroom floors) - Physical impairments (poor balance, foot drop, pain, fatigue, decreased muscular strength & sensation in feet) - Variable fall prevention training - Choosing to take risks </p>	
<p> Nelson et al. [32] $n = 24$ (96% male) Age: 57 ± 12.25 yrs Post SCI: not specified AIS: not specified C4-L1-2 </p>	<p> Not specified Retrospective Chart review Community-dwelling </p>	Not reported	<p> - Loss of balance, equipment failure, muscle spasms, excessive speed, lack of protective straps and narcolepsy contributed to falls - Tasks: transferring, riding in vehicle, moving in bed, propelling, reaching, showering </p>	<p> - Not specified </p>
<p> Nelson et al. [33] $n = 659$ (96% male) Age: 54.8 ± 12.6 yrs Post SCI: 21.1 ± 13.1 yrs AIS: not specified 43% complete, 57% incomplete Cervical injury: 42% Thoracic injury: 51% Lumbar injury: 6.9% </p>	<p> 12 months Prospective Survey, interview, chart review Community-dwelling </p>	<p> 31% ($n = 204$) fell ≥ 1 time 95% CI: 28–35% </p>	<p> - Risk factors for falls: pain in past 2 mos, alcohol abuse, greater motor function, history of falls, shorter time since SCI, shorter wheelchair length - Risk factors for injurious falls: pain in past 2 mos, greater motor function, history of falls, inaccessible home entrance </p>	<p> - 14% ($n = 95$) were injured during fall </p>
<p> Phonthee et al. [37] $n = 77$ (70% male) Age: non-faller: 52.8 ± 12.3 yrs, Faller: 48.9 ± 11.6 yrs Post SCI: non-faller: 4.4 ± 4.7 years/ Faller: 4.4 ± 3.7 yrs AIS: C ($n = 25$), D ($n = 52$) Tetraplegia: $n = 26$ (34%) Paraplegia: $n = 51$ (66%) </p>	<p> 6 months Retrospective Survey Community-dwelling </p>	<p> 34% ($n = 26$) fell ≥ 1 time 95% CI: 24–45% 1–6 falls/individual </p>	<p> - Walking without an ambulatory device increased fall risk - Fallers achieved higher scores on the TUG and 6mWT </p>	<p> - 8% ($n = 2$) required medical attention after fall (wrist fracture, back pain) </p>
<p> Phonthee et al. [36] $n = 89$ (67% male) Age: 53.0 (43.0–60.0) yrs Post SCI: Not specified AIS: C: $n = 29$ (33%) D: $n = 60$ (67%) Tetraplegia: $n = 28$ (31%) Paraplegia: $n = 61$ (69%) </p>	<p> 6 months Prospective Fall diary & weekly phone interviews Community-dwelling </p>	<p> 39% ($n = 35$) fell ≥ 1 time 95% CI: 30–50% 1–11 falls/individual </p>	<p> - Factors $\uparrow$ fall risk: high school education or higher, AIS-C classification, fear of falling - Fallers had poorer scores on TUG and 6mWT - Perceived causes: loss of balance, lower limb weakness, environmental hazards, paying less attention during movement </p>	<p> - 18 falls (20%) caused injury: - bruise: $n = 10$ - abrasion: $n = 9$ - pain: $n = 6$ - fracture: $n = 2$ </p>
<p> Saunders et al. [40] $n = 515$ (70% male) Age: 50.2 ± 14.1 yrs Post SCI: 13.7 ± 8.7 yrs AIS: not specified C1–C4: 24% C5–C8: 31.1% Non cervical: 44.6% </p>	<p> 12 months Retrospective Questionnaire Community-dwelling </p>	Not reported	<p> - Factors associated with injurious falls: using 1 cane or crutch, walking and wheeling equally compared with wheeling only, self-reported poor balance & walking speed, engaging in less exercise than others with SCI, pain medication misuse </p>	<p> - 20.3% had a fall that resulted in an injury requiring medical attention </p>
<p> Saunders & Krause [35] $n = 759$ (72% male) Age: 54.3 ± 11.9 yrs Post SCI: 27.0 ± 10.2 yrs AIS: not specified </p>	<p> 12 months Retrospective Questionnaire Community-dwelling </p>	Not reported	<p> - Factors associated with injurious falls: walking and wheeling compared with wheeling only, prescription medication use </p>	<p> - 10.4% had a fall that resulted in an injury </p>

Table 2 (continued)

Participants	Data collection	Frequency of falls	Factors contributing to falls	Consequences of falls
Srisim et al. [44] n = 83 (67% male) Age: 50.34 ± 11.65 yrs Post SCI: non-multiple fallers: 3.9 ± 3.0 yrs Multiple fallers: 4.9 ± 5.0 yrs AIS: C (n = 21), D (n = 62) Tetraplegia: n = 29 Paraplegia: n = 54	6 months Prospective Interviews Community-dwelling	43% (n = 36) fell ≥ 1 time 95% CI: 33–54% 28% (n = 23) fell ≥ 2 times (range 2–11 falls/participant) 95% CI: 19–38%	- Perceived causes of falls: lower limb muscle weakness, tripping over obstacles - FRT showed greatest predictive ability for risk of multiple falls (those who could reaching ≥ 20 cm had ↑ risk)	- Two multiple fallers sustained fractures
Sung et al. [27] n = 23 (35% male) Age: 37.1 ± 15.5 yrs Post SCI: 22.8 ± 18.3 yrs AIS: not specified All wheelchair users	6 months Retrospective Mixed methods Community-dwelling	Median 3 falls/participant with SCI (IQR, 4)	- Surface condition (43%), muscle weakness or spasticity (24%), being distracted (43%), equipment failure (29%), cluttered environment (19%), forgetting to engage wheel locks (5%), intoxication (9%)	- Not specified
Wanapakhe et al. [25] n = 50 (74% male) Age: faller: 48.0 ± 13.2 yrs non-faller: 47.4 ± 14.4 yrs Post SCI: faller: 3.3 ± 3.4 yrs, non-faller: 2.9 ± 3.2 yrs AIS: C (n = 8), D (n = 42) Tetraplegia: n = 17 Paraplegia: n = 33	6 months Prospective Diary, interviews Community-dwelling	54% (n = 27) fell ≥ 1 time 95% CI: 40–67% 1–24 falls/individual, 83 falls in total	- Fallers had lower scores on TUG, 10mWT, 6mWT, BBS at discharge than non-fallers	- 24 falls (29%) caused injury: - Skin abrasion (27%) - Muscle pain/tear (1%) - Loss of consciousness (1%)
Wanapakhe et al. [26] n = 100 (81% male) Age: Wheelchair: 42.1 ± 12.3 yrs Ambulatory: 48.0 ± 14.0 yrs Post SCI: Wheelchair: 69.0 ± 73.6 mos Ambulatory: 38.4 ± 41.2 mos AIS: not specified Wheelchair: n = 30 Tetraplegia: n = 20 Ambulatory: n = 30 Tetraplegia: n = 20	6 months Prospective Interview & phone calls Community-dwelling	45% (n = 45) fell ≥ 1 time 95% CI: 36–55% Wheelchair Users (n = 50): 36% (n = 18) fell ≥ 1 time 95% CI: 24–50% 1–8 falls/participant Ambulators (n = 50): 54% (n = 27) fell ≥ 1 time 95% CI: 40–67% 1–24 falls/participant	- Ambulatory participants had 2.74 times greater odds of falling than wheelchair users - Factors perceived to cause falls: lower limb muscle weakness, loss of balance, hazardous environment, increased spasticity, less attention during movement	- Wheelchair users: - Bruises (n = 4, 8%) - Loss of consciousness (n = 1, 2%) - Ambulators: - Bruises & muscular pain (n = 12, 24%) - Loss of consciousness (n = 1, 2%)
Wirz et al. [46] n = 42 (79%) Age: 49.3 ± 11.5 yrs Post SCI: 5.5 ± 5.5 yrs AIS: A: n = 2 (5%) B: n = 2 (5%) C: n = 35 (83%) D: n = 3 (7%) cervical injury: n = 16 (38%) thoracic injury: n = 9 (21%) lumbar injury: n = 17 (40.5%)	5 mos (1 month retrospectively and 4 mos prospectively) Survey, assessment calendar Community-dwelling	62% (n = 26) fell ≥ 1 time 95% CI: 47–75% 270 falls total	- ↑ risk of fall in those who could walk - BBS unable to distinguish fallers from non-fallers	- 17 falls (6%) caused injury: - Abrasion: n = 8 (3%) - Joint sprain: n = 7 (3%) - Fracture: n = 2 (1%)

SCI = spinal cord injury; IQ = interquartile range; CI = confidence interval; SCIM III = Spinal Cord Independence Measure III; AIS = American Spinal Cord Association Impairment Scale; yrs = years; mos = months; wks = weeks; TUG = Timed Up and Go; 6mWT = 6-minute walk test; FRT = Functional Reach Test; 10mWT = 10-meter Walk Test; BBS = Berg Balance Scale

and prospectively (monitored falls over the subsequent four months using an “assessment calendar”) [46].

Frequency of falls

Sixteen studies (67%) provided a definition of a fall to guide their research. Similar descriptors were used to define falls across the included studies. Falls were described as unplanned and unexpected events where the individual contacted a lower support surface. Four studies (20%) from the same research group required falls to occur while standing, walking or changing postures [36, 37, 42, 44].

The single study that sampled inpatients with SCI reported that 13% (95% CI 9–17%) of the sample experienced a fall during the rehabilitation hospital stay [31]. The duration of the inpatient stay, which varied from participant to participant, was not specified [31]. Among the remaining studies that examined falls in community-dwelling individuals, the length of data collection varied from 1 to 12 months. Among the studies that monitored falls prospectively, three collected data for 12 months [33, 43, 45], five collected data for 6 months [25, 26, 36, 41, 42, 44], and one for only 1 month [46]. Among studies that monitored falls retrospectively, four collected data for 12 months [23, 24, 34, 35, 38, 40], four for 6 months [8, 27, 37, 39], and one for 4 months [46].

Figure 2 is a synthesis of the proportion of community-dwelling study participants who fell at least once during the monitoring period of each study. Data are presented

according to mobility status (ambulators and wheelchair users), length of data collection (six months and 12 months), and method of data collection (prospective and retrospective). The proportion of the study sample who fell ranged 34–82% for ambulatory participants and 31–73% for wheelchair users. The method of fall data collection did not appear to affect the reported incidence proportion of falls; however the length of data collection appeared to influence the metrics with a longer sampling period (i.e., 12 months) resulting in a larger proportion of fallers compare with a shorter sampling period (i.e., 6 months) (see Fig. 2). For this reason, meta-analyses were completed using data collected over 12 months only for ambulators and wheelchair users. The pooled incidence proportion of falls for ambulators was 78% (95% CI 73–83%) with little heterogeneity ($I^2 = 0\%$, $Q = 1.79$, $p = 0.41$). The meta-analysis for wheelchair users initially revealed high heterogeneity ($I^2 = 98\%$, $Q = 112.27$, $p < 0.001$) and a pooled incidence proportion of falls of 56% (95% CI 28–81%). When the study by Nelson et al. [33] was removed from the meta-analysis, the heterogeneity was lower and non-significant ($I^2 = 59\%$, $Q = 2.46$, $p = 0.12$). Hence the pooled incidence proportion of falls for wheelchair users was calculated without Nelson et al. [33] and was found to be 69% (95% CI 60–76%).

The incidence proportion of study participants who experienced multiple falls (i.e., > 1 fall) during the study period ranged 30–41% for wheelchair users [38, 43] and 28–68% for ambulators [38, 39, 44, 45]. Jørgensen and colleagues [38] reported that the odds of recurrent falls were

Fig. 2 Percentage of study sample that experienced one or more falls. All studies shown here involved community-dwelling individuals with SCI. WC = wheelchair. 95% Confidence intervals calculated using Jeffrey’s method [18]

29 times higher for ambulators compared with wheelchair users.

Factors contributing to falls

When the factors identified as contributing to falls in community-dwelling individuals with SCI were organized according to the BBSE Model, numerous biological, behavioral, and environmental factors were reported (see Table 3 for factors and number of articles reporting each one). In terms of biological factors, loss of balance, muscular weakness, and spasticity or muscle spasms were commonly reported as contributors to falls. Level of function or mobility, as evidenced through performance on clinical measures (e.g., Spinal Cord Injury Independence Measure (SCIM) III, Timed Up and Go (TUG)) was also associated with the risk of falling. While some studies found a higher level of function or mobility to be associated with falls [33, 37, 38, 43, 44] others found a lower level of function or mobility to be linked to an increased risk of falling [25, 36, 45]. Other biological factors reported by a few studies each included: a younger age, the presence of co-morbidities, trunk weakness, pain, fatigue, walking asymmetry, incomplete injury, male sex, narcolepsy, reduced sensation, and a shorter time since sustaining a SCI.

As for behavioral factors contributing to falls, inattention or distraction was identified most often, followed by ambulation, the presence of a fear of falling, a history of previous falls, and not using the safety features of the wheelchair or walking aid. Other behavioral factors identified by one or two studies were: risk-taking, engagement in physical activity, walking without a gait aid, walking with a gait aid, excessive speed, and alcohol consumption.

Numerous environmental factors, both within and outside of the home were identified (see Table 3). Hazards within the environment, without further detail about the specific hazards, were reported in two survey-based studies [23, 36]. In contrast, two qualitative studies provided detailed information about structures and conditions within participants' environments that were perceived to increase the risk of falling, such as stairs, ramps/hills, heavy or revolving doors, and uneven or slippery surfaces [29, 30]. A few social and economic factors were identified: a higher level of education was associated with falls [32] as was not receiving adequate fall prevention training [30] and caregiver error [28].

The identified factors were subsequently examined for wheelchair users and for ambulators separately. Risk factors specific to the use of a wheelchair for mobility included driving with excessive speed [32], not using the chair's protective straps/safety belt/wheel locks [27, 28, 32], a shorter wheelchair length [33], and an inaccessible home entrance [33]. Male sex [38] and greater motor function

Table 3 Factors contributing to falls

Biological	Behavioral
<ul style="list-style-type: none"> • Muscle weakness (8) • Impaired balance (7) • Greater function/mobility (5) • Muscle spasms/spasticity (4) • Lower function/mobility (3) • Reduced sensation (3) • Greater number of co-morbidities (2) • Younger age (2) • Pain (2) • Fatigue (2) • Trunk weakness (1) • Walking asymmetry (1) • Narcolepsy (1) • Incomplete injury (1) • Male sex (1)^a • Shorter time since SCI (1)^a 	<ul style="list-style-type: none"> • Inattention/distraction during movement (5) • Ambulating (4) • Fear of falling (3) • Previous history of falls (3) • Not using protective straps/safety belt/wheel locks (3)^a • Alcohol (2) • Taking risks (2) • Regular physical activity (2) • Walk without gait aid (1) • Walk with gait aid (1) • Excessive speed (1)^a
Social & economic	Environmental
<ul style="list-style-type: none"> • High school education or greater (1) • Variable fall prevention training (1) • Caregiver error (1) 	<ul style="list-style-type: none"> • Hazards in environment (4) • Obstacles (3) • Stairs (2) • Uneven ground (2) • Doors (2) • Low lighting (2) • Hills/ramps (2) • Equipment failure (2) • Curbs (1) • Crowds (1) • Carpet (1) • Transition between surfaces (1) • Slippery bathroom surfaces (1) • Winter climate (1) • High or low air temperature (1) • Long distances to travel (1) • Public transit (1) • Narrow spaces in home (1) • Inaccessible home entrance (1)^a • Shorter length of wheelchair (1)^a

Classification of identified contributors to falls in individuals with SCI across all included studies. BBSE Model of Fall Risk [21] is used as the framework for classification. The number of studies reporting each contributor is indicated in parentheses after each contributor

^aReported only in wheelchair users who fell

were additional factors identified in studies examining falls in wheelchair users. Specifically, higher SCIM II/III scores were associated with a greater risk of falling in wheelchair users [38, 43].

When considering the contributors to falls in ambulatory participants, contradictory findings were observed for the role of level of function and mobility. Two studies found that lower scores on the TUG and 6-minute walk test (6MWT) were associated with falls in ambulators [25, 36].

However, another study contrarily indicated that higher scores on these same tests (TUG, 6MWT) were contributors to falls [37], and Srisim and colleagues [44] reported that greater scores on the Functional Reach Test (i.e., an ability to reach ≥ 20 cm) were associated with increased risk of falling. Similarly, walking both with [40] and without [37] a gait aid were identified as contributors to falls in separate studies. In terms of factors identified for ambulators, two studies found fear of falling to be a contributor [23, 36].

The consequences of falls

The reported proportion of falls that resulted in any injury ranged from 6 to 62% among ambulators and 13 to 38% among wheelchair users. The most common fall-related injuries among participants with SCI (ambulators and wheelchair users) were bruises and abrasions/cuts/scrapes. Other reported injuries included muscle tears or pain [42] and sprains, bloody nose, and numbness [33]. One study found that ambulators have a higher rate of minor injuries sustained through falling compared with wheelchair users [26]. Based on the four studies that looked at the percentage of fallers who sustained serious injuries requiring medical attention, reports ranged from 4 to 36% of participants [23, 24, 41, 43]. The most commonly reported serious injuries included fracture and a loss of consciousness (see Table 2). In addition, one study, examining wheelchair users only, reported one death as a consequence of a fall, out of 204 fallers and 553 falls [33].

Regarding the psychosocial consequences of falls, increased fear of falling was reported by study participants [30, 42], as were feelings of embarrassment [29] and frustration [30]. Decreased participation in community activities was also reported as a consequence of falls by two studies [30, 42]. Likewise, social interaction was reported to decline as a result of falling in 12% [42] to 35% [23, 24] of fallers with incomplete SCI.

Discussion

We completed a systematic review and meta-analysis, following PRISMA guidelines, to summarize the incidence proportion of falls and factors contributing to falls in individuals with SCI. The majority of included studies used samples of convenience, thus increasing the potential for biased results. In this review we found that falling was common among community-dwelling individuals with SCI. While only one study reported on inpatient falls, we found a marked difference in the incidence proportion of falls in the hospital environment compared with the community. A variety of biological, behavioral and environmental factors

contribute to falls and the increased risk of falling after SCI. The most commonly reported consequence of falls was a minor injury; however, up to 15% of falls result in a more serious injury, such as a fracture or loss of consciousness. Psychosocial consequences of falling also exist, such as feelings of fear, embarrassment and frustration, along with a reduced participation in daily activities. Altogether, this synthesis of the literature will assist with the development of SCI-specific fall prevention initiatives.

Individuals with SCI are at a high risk of falling, even when compared with other vulnerable populations. In a 12-month period, 28–30% of able-bodied older adults [47, 48], 50% of individuals post-stroke [49] and 62–68% of individuals with Parkinson's disease [50, 51] will fall one or more times. Despite the frequent occurrence of falls among individuals with SCI, research concerning falls after SCI has only recently emerged; the majority of articles included in this review were published in the past 5 years. The increased study of falls among the SCI population, including both quantitative and qualitative methodologies, suggests increasing recognition of falls as a significant complication of SCI.

We found the reported yearly incidence proportion of falls to be similar between ambulators and wheelchair users with SCI. Prior to the recent publications by Forslund et al. [43]. and Jørgensen et al. [38]., the incidence proportion of falls among wheelchair users was reported to be lower (i.e. <40% [26, 33]) than the current estimate of 69%. Hence, evidence of high fall risk among wheelchair users is a relatively new finding.

This review identified only one study that quantified the number of falls in an inpatient hospital environment [31]; hence, the reported incidence proportion is not generalizable. This is a surprising observation given that the prevention of falls is an increasingly high priority for many hospitals, and greater emphasis has been placed on a safety culture and reducing patient harm during hospital stays [52, 53]. Our lack of knowledge concerning inpatient falls is a gap in our understanding of falls after SCI; the causes and circumstances of falls in an inpatient hospital environment may differ from those identified for community settings. The lower incidence proportion of falls among inpatients compared with community-dwelling individuals reported here may have resulted, in part, from the differing lengths of data collection. Although the length of inpatient stay was not reported in the study examining falls among inpatients [31], it is likely that the inpatient stays were shorter than the 6–12 months of monitoring in the community.

We identified ~50 factors that contribute to falls in individuals with SCI. However, this is likely not an exhaustive list as these findings are limited by the factors selected for study in the original articles. The BBSE model

provided a useful framework for organizing this data and identifying the modifiable factors that may be targeted in fall prevention programs. The two most commonly identified biological factors, muscle weakness and impaired balance control, can be impacted through physical rehabilitation. A few behavioral factors, such as inattention/distracted during movement and taking risks, could be targeted to increase awareness of these behaviors. Indeed, individuals with SCI have reported using strategies to reduce their risk of falling that involve modifying their behavior, such as increasing their awareness of their surroundings and modifying their movements to increase their stability [30]. Compared with biological and behavioral factors, environmental factors, especially those pertaining to community environments, may be more challenging to modify. It may be possible, however, to better prepare individuals with SCI to navigate challenging environments. Details concerning environmental factors related to falls were scarce until the recent publication of two qualitative studies [29, 30]. Detailed description of hazardous environments will assist clinicians in the design of appropriate simulated environments to help prepare individuals with SCI for safe mobility within their homes and communities.

The findings have led to several recommendations for future research. First, as mentioned above, there is a need to study the frequency and circumstances of falls during inpatient SCI rehabilitation as well as during the transition from hospital care to independent living in the community. Second, future research should include a combination of quantitative and qualitative methodologies to enable robust identification of fall-related trends while also targeting a detailed understanding of the nature and consequences of falls occurring among the SCI population. Third, researchers should be aware that the duration of monitoring will influence the incidence proportion of falls. As longitudinal studies lasting 12 months are not always feasible, we recommend a minimum monitoring period of 6 months, which would enable comparison of one's data with previously documented rates.

In conclusion, falls are a common event with physical and psychosocial consequences for community-dwelling individuals with SCI. The development of SCI-specific fall prevention initiatives, which aim to modify relevant biological and behavioral factors and to consider each individual's environmental risk, may result in a reduction of falls and safer mobility for the SCI population.

Data archiving

All extracted data can be found in Supplementary Material 1.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

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