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Evaluating fall event definitions relative to lower limb prosthesis users' lived experiences

Julie Ferrell-Olson[a], Brian J. Hafner[b] and Andrew Sawers[a]

[a]Department of Kinesiology and Nutrition, University of IL Chicago, Chicago, IL, USA; [b]Department of Rehabilitation Medicine, University of WA, Seattle, WA, USA

ABSTRACT

Purpose: Evaluate specific elements of previously proposed fall and near-fall definitions to determine whether they fully capture lower limb prosthesis (LLP) users' lived experiences.

Methods: Semi-structured interviews were conducted with 24 LLP users. Interview transcripts were reviewed, coded, and analyzed using deductive thematic analysis to identify shared experiences and inform revisions to previously reported definitions.

Results: Four major themes emerged: a fall can be initiated by more than just a loss of balance, loss of balance and losing balance are considered similar, falls are not limited to landing on the ground or floor, and catching yourself and recovering your balance are distinct responses to a loss of balance.

Conclusions: Two revisions were made to previous definitions to better align with LLP users' experiences and historically overlooked fall circumstances. A fall is defined as a loss of balance or sudden loss of support where your body lands on the ground, floor, or another object. A near-fall was defined as a loss of balance where you caught yourself or recovered your balance without landing on the ground, floor, or another object. Implementation of these new definitions will aid the collection of accurate, consistent, and meaningful fall data, enhancing aggregation and comparison across studies.

IMPLICATIONS FOR REHABILITATION

- Falls are a top health concern for lower limb prosthesis users.
- Understanding how lower limb prosthesis users experience falls helps build meaningful fall definitions.
- Standardized definitions allow clinicians to document fall events with greater consistency and justify fall prevention interventions.

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Introduction

Falls among lower limb prosthesis (LLP) users are common [1–5], injurious [2,3,6–8], costly [9], and socially isolating [2,10,11] events. A barrier to addressing this public health problem remains a lack of quality falls data [5,12]. Accurately documenting real-world fall events and their subsequent consequences begins with clear and meaningful definitions of fall events. In the absence of a definition that is relevant and relatable to target respondents, LLP users' interpretations of what constitutes a fall may differ [13]. The use of ambiguous definitions in falls research could lead to the collection of falls data based on different events, limiting comparisons between studies as well as individuals [5], compromising our understanding of falls by LLP users.

A number of studies [1–3,12,14] have sought to characterize the frequency, circumstances, and/or consequences of real-world falls by LLP users. While each study defined a fall, the definitions used varied between studies. Discrepancies in terms of how falls were defined, including the use of colloquial terminology (e.g., "*stumble*") [15–17], or the lack of a near-fall definition [18], highlight potential difficulties in comparing data between studies. Additionally, the definitions cited in these studies were developed without input from target respondents [19,20]. As a result, meaningful details that are pertinent to LLP users may have been overlooked and inadvertently excluded from these definitions. To address these issues, new fall and near-fall definitions based on the lived experiences and preferred terminology of a diverse group of LLP users were recently proposed [5]. Results of this qualitative study suggested that a fall could be defined as a loss of balance where your body lands on the ground or floor, while a near-fall could be defined as a loss of balance where you caught yourself or recovered your balance without landing on the ground or floor [5].

The proposed definitions are distinct from prior definitions in several notable ways. First, terms like "unexpected" or "unintentional", which are often used to characterize the accidental nature of a fall, were removed after LLP users described the inadvertent nature of falls to be implied [5]. Similarly, phrases like "come to rest" or "coming to rest", which are often used to describe the state of the body after a fall were perceived by LLP users to be confusing and unnecessary [5]. Terms such as "lower level" or "lower surface," which are often used to describe the location of the body after a fall were deemed vague by LLP users and were therefore replaced with the more specific phrase, "ground or floor." Notably, LLP users in the previous study indicated that the terms "ground" and "floor" had two distinct interpretations (i.e., outdoors and indoors, respectively) [5]. The recently proposed definitions also differentiated falls and near-falls, two events LLP users saw

CONTACT Andrew Sawers asawers@uic.edu Department of Kinesiology and Nutrition, University of Illinois Chicago, Chicago, IL, USA

as unique (i.e., did or did not land on the ground or floor) [18]. It was suggested these changes would not only provide clarity and standardize meaning of these fall events, but also increase their relevance to LLP users [5].

Upon further review of the falls literature several circumstances beyond those addressed in the fall-event definitions were identified, suggesting potential gaps in the content of the previously proposed definitions. For example, when defining a fall a number of studies in older adults expand "landing on the ground or floor" to also include "landing on an object" [21,22]. As the previously proposed definitions emphasized landing on the "ground or floor" [5], questions arose as to whether LLP users would also consider landing on something other than the ground or floor to be a fall. Several other fall-related studies in older adults have suggested that something other than a loss of balance could initiate a fall [23–25]. Specifically, "drop attacks" have been described as an alternative precursor to a fall [23,24], defined as an event that occurs suddenly, quickly, and without warning as to leave no time to prevent or to break the fall [23]. Falls that happen so quickly that the individual cannot respond have been described anecdotally by lower limb prosthesis users, but never formally reported or analyzed. If found to be part of LLP users' lived experience, the exclusion of drop attack-like events from the proposed fall definitions may have the inadvertent effect of overlooking unique fall events that could require specific assessments and/or interventions. The identification of these potential gaps would indicate that additional research is necessary to probe existing fall-event definitions and ensure they capture the full lived experience of LLP users.

The objective of this study was to evaluate specific elements of previously proposed fall and near-fall definitions [5] to determine whether LLP users' lived experiences were fully captured. We specifically sought to determine if landing on something other than the "ground or floor" would still be considered a fall; if a fall could be initiated by anything other than a "loss of balance", how "catching yourself" may differ from "recovering your balance"; and whether a "loss of balance" was perceived as distinct from "losing your balance".

Methods

Overview

Semi-structured interviews were conducted with lower limb prosthesis users from across the United States using video or telephone conferencing software (Zoom, Version 5.10.6). A semi-structured approach was adopted to maintain consistency in the questions and substance of each interview, while simultaneously promoting discussion of fall-related concepts and experiences relevant to each participant [26]. The interview guide was developed by a team of researchers and clinicians, drawing upon their prior fall-related qualitative research among LLP users [5,18,27]. The research team was composed of two researchers (PhDs, one prosthetist-orthotist, and one bioengineer) and one PhD student. A phenomenological approach was selected for interview analysis due to the emphasis placed on the lived experience of each individual, and on being open to understanding views that may differ from our previous perspectives [28]. Previous research had identified three relevant components to fall and near-fall definitions: the precursor, point of departure, and unique outcome [5]. Guiding questions were designed to ensure the interviewer asked about each of these components for both falls and near-falls during the interview [18]. Recruitment and data collection occurred between May and December 2022. The study protocol was reviewed by a University of Illinois Chicago Institutional Review Board and determined to qualify for exempt status.

Participant recruitment and screening

Purposive sampling was used to solicit a diverse set of experiences relevant to LLP users who have experienced fall events [29, 30]. Recruitment targets were set to ensure at least 20% of participants were transfemoral prosthesis users, female, greater than 50 years old, of dysvascular etiology, bilateral LLP users, and veterans or Service members [5, 12, 18]. Potential study participants were recruited from across the United States *via* invitations sent to members of a research registry maintained by the study investigators. Additionally, email and printed flyers posted by clinical collaborators were used to expand recruitment efforts. Eligibility criteria were greater than or equal to 18 years of age, a lower limb amputation at or between the ankle and hip, use of a prosthesis, one or more self-reported falls in the past 12 months, the ability to speak, read, and write in English, and agreeing to have the interview recorded and transcribed.

Data collection

Before their scheduled interview time, participants were emailed a personal link to a secure REDCap site with study information and a self-report survey that was used to collect details of participants' demographic, health, amputation, balance, and mobility-related characteristics. Survey completion was confirmed and any follow-up questions were clarified before starting the interview. Balance confidence and fall-related avoidance behaviors were measured using the Activities-specific Balance Confidence (ABC) scale [31–33] and the Fear of Falling Avoidance Behavior Questionnaire (FFABQ) [34], respectively. Participants' mobility was measured with the Prosthetic Limb Users Survey of Mobility (PLUS-M) [35].

Each interview began with the facilitator (JO) introducing the subject of the interview, discussing the applicability of fall event definitions based on the participants' experiences. Participants were then shown the previously proposed definition of a fall, "a fall is a loss of balance where your body landed on the ground or floor" [5]. Three guiding questions were used to evaluate three specific elements of the fall definition (Table 1). Notes were taken in real time by the facilitator to supplement interview transcripts.

Participants were then asked to describe if and how they would differentiate between a fall and a near-fall *(*Table 2, *guiding question #1)*. After providing their opinion and describing specific differences (or lack thereof) between a fall and a near-fall, participants were shown the previously proposed definition of a near-fall, "a near-fall is a loss of balance where you caught yourself or recovered without landing on the ground or floor" [5]. The remaining guiding questions were used to evaluate three specific elements of the near-fall definition: i) if a near-fall could be initiated by anything other than a loss of balance? ii) whether there is a difference between "catching yourself" and "recovering your balance", if so, what, and iii) are there other words to describe a near-fall? The study team met periodically to review interview transcripts and interpretations. After the first ten interviews it was

Table 1. Guiding questions to probe fall definition.

Question1: Do you think a 'loss of balance' is required to fall? Why or why not?
Clarifying question: What could cause a fall that is not due to a loss of balance?
Question 2: In your opinion, what is the difference between "a loss of balance" and "losing your balance"?
Clarifying question: Which term is better to use when defining a fall, and why?
Question 3: Do you think a fall requires "landing on the ground or floor"? Why or why not?
Clarifying question: If you lost your balance and landed on a table or chair, rather than on the ground or floor, would you still consider that to be a fall?

Table 2. Guiding questions to probe near-fall definition.

Question 1: How does a fall and near-fall differ?
Question 2: Can you experience a near-fall without a loss of balance? If so, how?
Question 3: What is the difference between "catching yourself" and "recovering your balance"?
Question 4: Are there any other terms you would use to describe a near-fall?

decided not to make any edits to the interview guide as new ideas and data were still emerging, indicating we had not met saturation [36].

Analysis

Demographics, health, amputation, and self-report measures were summarized using descriptive statistics. All interviews were audio-recorded, and transcribed verbatim (Rev.com, 2022). After each interview transcripts were reviewed, and open coding was applied to create the code list. Transcripts and code lists were reviewed and compared every five interviews to identify common ideas and responses being discussed [5]. Due to the focused nature of the interviews, data were expected to be synthesized with little difficulty, and coding was therefore performed by one researcher (JO). The research team maintained a shared spreadsheet to organize responses and pose questions that initiated discussion regarding the data and its interpretation. The study team met periodically to discuss emerging themes and determine if/when saturation was achieved. *Code saturation* was determined to have been achieved once no new codes were emerging from the data and a range of thematic issues were identified (i.e., "heard it all") [36]. *Meaning saturation* was considered to have been achieved once investigators had developed a rich understanding of the issues as described by the participants (i.e., "understood it all") [36]. Coded excerpts were then aggregated into common themes using a deductive thematic analytical approach [37].

Results

Summary

Twenty-five participants were recruited and screened; 24 completed the semi-structured interviews (Tables 3 and 4). Interviews lasted between 30 and 60 min. Twenty-two interviews were conducted over video, while two were done over the phone. Participants discussed a variety of topics related to falls. Four themes were identified from participants' fall-related lived experiences. Descriptions of these themes and how they shaped revisions to previously proposed LLP user-specific fall event definitions are presented below with supporting excerpts.

Theme 1: a fall can be initiated by more than just a loss of balance

Most participants stated that a loss of balance was the main precursor to a fall or near-fall. Several physical disturbances were described as frequent contributors to a loss of balance.

> *"Any time I've fallen… there's definitely been a loss of balance before I actually ended up on the ground. Because even the near falls where you don't fall, that's been a loss of balance too."*
>
> Female; 30 years old; unilateral transfemoral (TF) amputation; 3 years since amputation

Table 3. Participant characteristics with respect to purposive sampling criteria ($n = 24$).

	Count (%)
Gender	
female	9 (38%)
male	15 (62%)
Amputation etiology	
dysvascular or infection	10 (42%)
traumatic	14 (58%)
Amputation level	
unilateral transfemoral or knee disarticulation amputation	14 (58%)
unilateral transtibial amputation	7 (29%)
bilateral (transtibial and transfemoral) amputation	3 (13%)
Other	
greater than 50 years old	16 (67%)
military veteran or Service member	5 (21%)

Table 4. Participant demographic, health, amputation, balance, and mobility-related characteristics.

	mean (SD)	median (25th quartile, 75th quartile)	min, max
Age (years)	60 (13)	61 (49, 71)	29, 84
Number of co-morbidities	2 (2)	2 (0, 3)	0, 7
Number of daily medications	4 (4)	2 (1, 8)	0, 15
Time since first amputation (years)	20 (16)	13 (8, 33)	3, 54
Hours wearing prosthesis/day	13 (4)	14 (10, 16)	5, 18
Hours walking with prosthesis/day	6 (4)	4 (3, 7)	2, 18
ABC (/4)	2.74 (0.86)	2.81 (2.08, 3.34)	1, 4
FFABQ (/30)	9.79 (8.97)	6.50 (2.25, 15.8)	0, 30
PLUS-M (T-score)	51.6 (8.11)	50.5 (44.7, 57.3)	40.3, 71.4

ABC: activities-specific balance confidence scale; FFABQ: fear of falling avoidance behavior questionnaire; PLUS-M: prosthesis limb users survey-mobility.

> *"It doesn't really matter what caused me to fall as in my foot getting caught on something or my knee not being locked, it's always a loss of balance that causes me to go."*
>
> Male, 57 years old, unilateral transtibial (TT) amputation, 8 years since amputation

Multiple participants also shared experiences where they had fallen without a loss of balance. Participants described falls that were "*straight down*", where they had gone "*from point A to point B*" without knowing what had happened. These falls were "*too fast*", leaving them with "*no time to respond*". In each case, participants differentiated these falls from those associated with a loss of balance.

> *"Sometimes it just happens so fast. You're just down. You don't have necessarily time to… if you*
>
> *catch your toe on something and the knee doesn't work properly… I have fallen sometimes so*
>
> *quick that I didn't even realize it. I don't think it's loss of balance. "*
>
> Female, 52 years old, unilateral TF amputation, 33 years since amputation
>
> *"I am physically going through the air right now. I don't have an opportunity to catch myself. The balance isn't part of this equation because to me balance is more when I'm in an upright position and I have some control… my knee was under me before my brain can process. There's nothing I could have done."*
>
> Female, 56 years old, unilateral TT amputation, 6 years since amputation

"It's when the support comes out from underneath me …my prosthetic leg will slip right out from under me, and I always land on my natural knee."

Male, 72 years old, unilateral TF amputation, 23 years since amputation

The concept of falls happening without a loss of balance began to emerge after the first 10 participants. After discussions among the study team, the term "sudden loss of support" was suggested to summarize this experience. Previous participants were contacted, and all remaining participants who brought up the idea of falling without a loss of balance were asked whether a "sudden loss of support" captured their experience. All participants that described this unique precursor to a fall endorsed the phrase "sudden loss of support", confirming this language to be an accurate portrayal of their lived experience. The speed and resulting lack of time to respond to a "sudden loss of support" described by LLP users suggested that this precursor applied exclusively to falls.

Theme 2: a loss of balance is considered similar to losing your balance

Most participants indicated that they did not perceive any differences between the phrases "loss of balance" and "losing your balance". Participants that identified a difference between the two phrases expressed divergent views on whether loss or losing reflected the precursor to a fall or the act of falling itself.

"I would think they are pretty much the same."

Male, 41 years old, unilateral TT amputation, 8 years since amputation

"Losing your balance, I think you're in the act. You're already heading to the floor. Your loss of balance… is the precursor."

Male, 75 years old, unilateral knee disarticulation (KD) amputation, 9 years since amputation

"One is past and one is current, in the middle of it. So, losing balance, you're doing it. Loss of balance is you already did it."

Female, 52 years old, unilateral TF amputation, 33 years since amputation

Most participants expressed no preference for which of the two phrases should be included in the fall definition.

"I think they are pretty interchangeable."

Male, 41 years old, unilateral TT amputation, 8 years since amputation

"I use them interchangeably. So, for me either one."

Female, 49 years old, unilateral TF amputation, 35 years since amputation

Due to the temporal inconsistency with which "loss of balance" and "losing your balance" were described by the participants, and no strong preference for either phrase, they were considered equivalent and thus interchangeable.

Theme 3: Falls were not limited to landing on the ground or floor

Participants indicated that falls could include landing on another object, such as a table or chair, as well as landing on the ground or floor. Participants also described falls where they landed on machinery, furniture, or other objects.

"If I happen to fall against a piece of machinery, I've still fallen… I'm required to get my legs back under me and regain that loss of balance that momentarily happens."

Male, 72 years old, unilateral TF amputation, 23 years since amputation

"I can imagine a landing that would not be a catch, but where you're landing into a piece of furniture, careening across a banister…you end up hitting something in an uncontrolled fashion."

Male, 48 years old, bilateral TT amputation, 48 years since amputation

Landing on "another object", however, was not found to include walls. When asked if landing on or against a wall would be considered a fall, participants said no, provided they remained upright and on their feet.

"No, I don't consider that a fall. I consider that to help to balance you because I'd prefer to hit the wall with my body than hit the floor."

Male, 52 years old, unilateral TF amputation, 10 years since amputation

"Am I still upright? I would imagine I'm standing and I lose my balance and I fall onto the wall, but I'm still standing, I wouldn't consider that a fall."

Male, 41 years old, unilateral TT amputation, 8 years since amputation

In contrast to the previously proposed definition of a fall [5], participants in the present study indicated that a fall was not limited to landing on the ground or floor.

Theme 4: Catching yourself and recovering your balance are two distinct responses

"Catching yourself" was perceived by participants to involve reaching out to grab another object, such as a table or chair. "Recovering your balance" was viewed as a self-correcting strategy achieved by taking additional steps, hopping, or any other movements that did not involve contact with an external object.

"Catching yourself might require another object that helped you recover your balance on your own."

Female, 60 years old, unilateral TT amputation, 7 years since amputation

"Catching yourself would involve your arms reaching out and grabbing something or leaning against something… recovering would be, I'm stumbling and shifting my weight as I stumble in a way that wouldn't involve the arms, but that allowed me to regain balance without hitting the floor."

Male, 49 years old, unilateral TF amputation, 13 years since amputation

"I would say catching myself would involve potentially actually grabbing another object or somehow contacting something else, usually with the hands, but not necessarily. Whereas recovering balance could be done with a jump, a step, a postural shift, or something like that which does not require contact with anything else."

Male, 48 years old, bilateral TT amputation, 48 years since amputation

Supporting the recently proposed definitions, LLP users described "catching yourself" and "recovering your balance" as distinct responses to a loss of balance.

Discussion

The objective of this study was to evaluate specific elements of previously proposed fall and near-fall definitions to determine whether they fully capture lower limb prosthesis (LLP) users' lived experiences. Based on the analysis of 24 semi-structured interviews conducted with a diverse sample of LLP users, fall and near-fall definitions were revised in two important ways. First, in both the fall and near-fall definitions the phrase "landing on the ground or

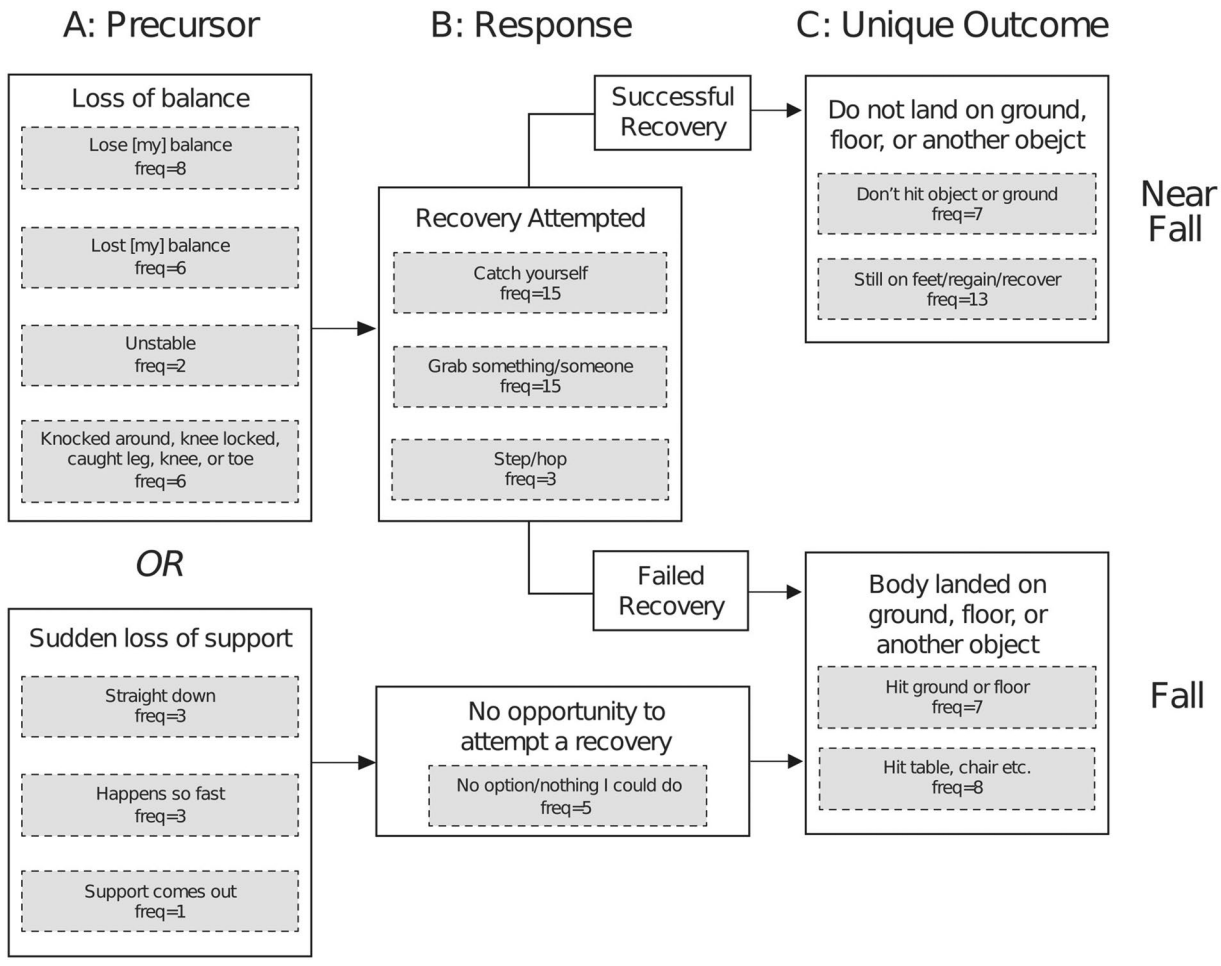

Figure 1. Formulation of the revised fall and near-fall definitions based on LLP users' shared lived experiences. Terminology and the frequency (i.e., freq) used by lower limb prosthesis users during semi-structured interviews are presented. A. Precursor: a loss of balance was a precursor common to both falls and near-falls. In contrast, a sudden loss of support was unique to falls. B. Response: the chance to attempt a recovery differed based on the precursor. LLPs users described how the speed of a sudden loss of support eliminated any opportunity to attempt a recovery. Recoveries were attempted after a loss of balance and reflected a preference for upper over lower extremity strategies. The success or failure of the attempted recovery strategy led to unique outcomes. C. Unique outcome: Falls and near-falls each had a unique outcome, landing, or not, on the ground, floor, or another object, respectively.

floor" was expanded to include "or another object." Second, in the fall definition the phrase "a loss of balance" was expanded to include "or a sudden loss of support". After incorporating each of these changes, the revised fall and near-fall definitions were (Figure 1):

> A fall is a loss of balance or sudden loss of support where your body landed on the ground, floor, or another object.
>
> A near-fall is a loss of balance where you caught yourself or recovered your balance without landing on the ground, floor, or another object.

The phrase "sudden loss of support" may reflect fall mechanics occasionally experienced by LLP users that were overlooked in previous fall definitions [5]. A "sudden loss of support" does not offer the opportunity to recover and will always lead to a fall, never a near fall. The sense of suddenly loosing support and experiencing a rapid unrecoverable descent may capture mechanical circumstances that are particularly familiar and relevant to transfemoral prosthesis users. Prosthetic knees worn by transfemoral prosthesis users often lack sufficient stance phase flexion resistance, which can on occasion leave them susceptible to buckling, and a quick downward collapse from which transfemoral prosthesis users have no opportunity to respond and/or recover [38,39]. The expansion of the fall precursor "a loss of balance" to include "sudden loss of support" may help document all falls among LLP users by adding needed detail and breadth to how a fall is defined. A "sudden loss of support" may also represent a feature of falls that is not limited to LLP users. Older adults, for example, have described experiencing "drop-attacks", where they find themselves suddenly on the ground, with no warning or time to break the fall [23,24]. While consistent with the phrasing and terminology used by LLP users in the current study to describe a "sudden loss of support", additional research is required to determine whether a "sudden loss of support" reflects a feature of falls that generalizes across clinical populations. Efforts to identify fall-related experiences shared across clinical populations may lead to the development and implementation of a universal fall definition that would allow for unbiased comparisons of fall frequency, circumstances, and consequences across clinical populations.

Previous fall definitions have incorporated the concept of landing on something other than the ground or floor, but with less specificity and relevance to LLP users [1,19]. Fall definitions used in LLP user research to date have historically referenced landing on a "lower level", "other level", or "lower surface" [1,6,16,40]. Falling onto or landing on a "level" was not a phrase used by LLP users when describing their fall-related experiences in the current study

or previous fall-related qualitative research [18]. Instead, LLP users described landing on the "floor" or "ground" depending on whether they were inside or outside, respectively. Including the phrase "landing on another object" rather than "lower level" or "other level" serves to customize fall and near-fall definitions to LLP users' preferred terminology and experiences, addressing gaps in previously proposed LLP user-specific definitions [5].

Including "landing on another object" as an element of a fall may also align better with LLP users' preference for using a reach-to-grasp strategy when attempting to recover from a loss of balance [5]. A reach-to-grasp strategy requires LLP users to reach out and grasp an object with sufficient accuracy, speed, and strength to slow or stop their descent [41].In the event such a strategy fails, LLP users would likely land on the object they were reaching for. In contrast, if a stepping or hopping strategy were used and failed, one might expect LLP users to land on the ground or floor, as it seems unlikely they would step without sufficient space to do so. While it remains to be determined if LLP users' endorsement of "landing on another object" in the present study stems from their choice of balance recovery strategies, it appears plausible that the exclusion of "another object" from the prior definition of a fall [5] could cause LLP users to overlook such events when reporting falls leading to an underestimation of their frequency and misunderstanding of their circumstances or consequences.

Using definitions for falls and near-falls based on LLP users' lived experiences will help ensure that researchers, clinicians, and participants are discussing the same events. Incorporating the same LLP user-specific fall and near-fall definitions across studies and sites will facilitate the aggregation of data and permit important sub-group analyses to determine if the frequency, circumstances, and consequences of fall events differ based on amputation level, etiology, or other relevant patient characteristics. For example, previous work identified sub-groups at risk for fall-related injuries, but the definition used may have excluded falls that involved landing on something other than the ground [7]. Use of these revised fall definitions may also help improve the quality of falls data, enabling researchers to better estimate the magnitude of the public health problem caused by falls in LLP users. Implementing standardized definitions may also help clinicians to better evaluate patients' fall experiences and justify the provision of interventions designed to mitigate falls. As previous falls are considered one of the best predictors for future falls [2], fully understanding fall history will best direct clinical practice and care for those patients at higher fall risk.

Limitations

The interpretation of study results may not generalize to newer LLP users. Despite efforts to capture a diverse range of LLP users and related experiences, newer prosthesis with less than 18 months of experience and bilateral amputees were underrepresented in the current study. New prosthesis users or users with two prosthetic limbs may have fall experiences that differ from the participants in our study, particularly as they are likely to be more prone to falls. Specifically, the mechanics of learning to walk with a prosthesis, and using two artificial limbs likely creates different experiences when attempting to maintain and/or restore balance compared to the majority of participants in the current study. Additional research involving newer and bilateral LLP users is warranted to determine if their fall-related experiences are captured by the revised definitions proposed here. The goal of this study was to test fall-event definitions within a group of LLP users that have diverse experiences. Additional research is therefore needed to determine if fall-related lived experiences of LLP users vary as a function of the cause and level of amputation, or prosthetic componentry (e.g., microprocessor versus non-microprocessor knees). Coding was completed by a single investigator, but consistently reviewed and discussed with other members of the research team. Lastly, member checking, a common practice in qualitative research [42,43] designed to enhance data accuracy, was not implemented in the current study. Based on the straightforward nature of the interview, we do not believe these limitations substantially impacted the data collected or our interpretation of those data. With a semi-structured interview design, we had the flexibility to confirm our participant's descriptions of their lived-experiences in real time, contributing to the trustworthiness of the data. All interviews were transcribed, reviewed, and compared to audio recordings to confirm they reflected participants' own words and experiences.

Conclusion

The objective of this study was to evaluate specific elements of previously-proposed fall and near-fall definitions [5] to determine whether they fully align with LLP users' lived-experiences. Based on feedback obtained from semi-structured interviews with a diverse sample of 24 LLP users, two major revisions were made to the prior definitions. First, the precursor to the fall event, which previously included just "a loss of balance," was expanded to include "a sudden loss of support". Second, the outcome for both the fall and near-fall definitions, which originally described "landing on the ground or floor" was revised to include "or another object". The addition of "or another object" may reflect a more specific version of the phrase "lower level" that is included in several previously published definitions of falls not specific to LLP users. Implementation of these revised definitions for fall events based on LLP users' lived experiences will aid in the collection of accurate, consistent, and meaningful falls data and enhance the limb loss community's ability to aggregate falls data and/or compare falls data between individuals, sites, and studies. Questions remain regarding the generalizability of these results to other clinical populations.

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Authors' contributions

Study Concept and Design: A. Sawers, B. Hafner
Acquisition of data: J. Ferrell-Olson
Analysis and interpretation of data: J Ferrell-Olson, A. Sawers, B. Hafner
Supervision: A. Sawers, B. Hafner
Drafting of manuscript: J. Ferrell-Olson
Critical revisions of manuscript of important intellectual content: A. Sawers, B. Hafner

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ORCID

Brian J. Hafner http://orcid.org/0000-0001-6175-1869

Data availability statement

All data associated with this manuscript reside with the authors.

References

[1] Kulkarni J, Wright S, Toole C, et al. Falls in patients with lower limb amputations: prevalence and contributing factors. Physiotherapy. 1996;82(2):130–136. doi: 10.1016/S0031-9406(05)66968-4.

[2] Miller WC, Speechley M, Deathe B. The prevalence and risk factors of falling and fear of falling among lower extremity amputees. Arch Phys Med Rehabil. 2001;82(8):1031–1037. doi: 10.1053/apmr.2001.24295.

[3] Wong C, Chihuri S, Li G. Risk of fall-related injury in people with lower limb amputations: a prospective cohort study. J Rehabil Med. 2016;48(1):80–85. doi: 10.2340/16501977-2042.

[4] Anderson CB, Miller MJ, Murray AM, et al. Falls after dysvascular transtibial amputation: a secondary analysis of falling characteristics and reduced physical performance. Pm R. 2021;13(1):19–29. doi: 10.1002/pmrj.12376.

[5] Sawers A, McDonald CL, Hafner BJ. A survey for characterizing details of fall events experienced by lower limb prosthesis users. PLOS One. 2022;17(7):e0272082. doi: 10.1371/journal.pone.0272082.

[6] Tobaigy M, Hafner BJ, Sawers A. The number of falls recalled in the past year and balance confidence predict the frequency of injurious falls by unilateral lower limb prosthesis users. Pm R. 2023;15(4):426–436. doi: 10.1002/pmrj.12936.

[7] Chihuri S, Wong CK. Factors associated with the likelihood of fall-related injury among people with lower limb loss. Inj Epidemiol. 2018;5(1):42. doi: 10.1186/s40621-018-0171-x.

[8] Miller TA, Paul R, Forthofer M, et al. Stability and falls evaluations in AMPutees (SAFE-AMP 2): reduced functional mobility is associated with a history of injurious falls in lower limb prosthesis users. Ann Phys Rehabil Med. 2023;66(4):101679. doi: 10.1016/j.rehab.2022.101679.

[9] Mundell B, Maradit Kremers H, Visscher S, et al. Direct medical costs of accidental falls for adults with transfemoral amputations. Prosthet Orthot Int. 2017;41(6):564–570. doi: 10.1177/0309364617704804.

[10] Hordacre B, Barr C, Crotty M. Community activity and participation are reduced in transtibial amputee fallers: a wearable technology study. BMJ Innov. 2015;1(1):10–16. doi: 10.1136/bmjinnov-2014-000014.

[11] Pezzin LE, Dillingham TR, MacKenzie EJ. Rehabilitation and the long-term outcomes of persons with trauma-related amputations. Arch Phys Med Rehabil. 2000;81(3):292–300. doi: 10.1016/s0003-9993(00)90074-1.

[12] Kim J, Major MJ, Hafner B, et al. Frequency and circumstances of falls reported by ambulatory unilateral lower limb prosthesis users: a secondary analysis. Pm R. 2019;11(4):344–353. doi: 10.1016/j.pmrj.2018.08.385.

[13] Zecevic AA, Salmoni AW, Speechley M, et al. Defining a fall and reasons for falling: comparisons among the views of seniors, health care providers, and the research literature. Gerontologist. 2006;46(3):367–376. doi: 10.1093/geront/46.3.367.

[14] Gauthier-Gagnon C, Grisé M-C, Potvin D. Enabling factors related to prosthetic use by people with transtibial and transfemoral amputation. Arch Phys Med Rehabil. 1999;80(6):706–713. doi: 10.1016/s0003-9993(99)90177-6.

[15] Kahle JT, Highsmith MJ, Hubbard SL. Comparison of nonmicroprocessor knee mechanism versus C-Leg on prosthesis evaluation questionnaire, stumbles, falls, walking tests, stair descent, and knee preference. J Rehabil Res Dev. 2008;45(1):1–14. doi: 10.1682/jrrd.2007.04.0054.

[16] Rosenblatt NJ, Bauer A, Grabiner MD. Relating minimum toe clearance to prospective, self-reported, trip-related stumbles in the community. Prosthet Orthot Int. 2017;41(4):387–392. doi: 10.1177/0309364616650085.

[17] McGrath M, Gray LA, Rek B, et al. Can microprocessor knees reduce the disparity in trips and falls risks between above and below knee prosthesis users? PLOS One. 2022;17(9):e0271315. doi: 10.1371/journal.pone.0271315.

[18] Kim J, McDonald CL, Hafner BJ, et al. Fall-related events in people who are lower limb prosthesis users: the lived experience. Disabil Rehabil. 2021;44(15):3897–3908. doi: 10.1080/09638288.2021.1891467.

[19] Lamb SE, Rstad-Stein JÃ, Hauer EC, , et al. Development of a common outcome data set for fall injury prevention trials: the prevention of falls network Europe Consensus: PROFANE COMMON OUTCOME DATA SET. J Am Geriatr Soc. 2005;53(9):1618–1622. doi: 10.1111/j.1532-5415.2005.53455.x.

[20] Kellogg International Work Group on the Prevention of Falls by the Elderly. The prevention of falls in later life. A report of the Kellogg International Work Group on the prevention of falls by the elderly. Danish Med Bull. 1987;34 Suppl 4:1–24.

[21] Crenshaw JR, Bernhardt KA, Achenbach SJ, et al. The circumstances, orientations, and impact locations of falls in community-dwelling older women. Arch Gerontol Geriatr. 2017;73:240–247. doi: 10.1016/j.archger.2017.07.011.

[22] Lach HW, Reed AT, Arfken CL, et al. Falls in the elderly: reliability of a classification system. J Am Geriatr Soc. 1991;39(2):197–202. doi: 10.1111/j.1532-5415.1991.tb01626.x.

[23] Sheldon JH. On the natural history of falls in old age. Br Med J. 1960;2(5214):1685–1690. doi: 10.1136/bmj.2.5214.1685.

[24] Manford E, Garg A, Manford M. Drop attacks: a practical guide. Pract Neurol. 2024;24(2):106–113. doi: 10.1136/pn-2023-003791.

[25] Robinovitch SN, Feldman F, Yang Y, et al. Video capture of the circumstances of falls in elderly people residing in long-term care: an observational study. *The*. Lancet. 2013;381(9860):47–54. doi: 10.1016/S0140-6736(12)61263-X.

[26] Adams WC. Conducting semi-structured interviews. In: Newcomer KE, Harry HP, Wholey JS, editors. Handbook of practical program evaluation. Hoboken (NJ): John Wiley & Sons, Inc.; 2015. P. 492–505. doi: 10.1002/9781119171386.ch19.

[27] Rosen R, Mauder K, Sawers A, et al. Fall-related outcomes in lower limb prosthesis users: a focus group study. Chicago,

IL: American Academy of Orthotists & Prosthetists; 2024., March 6).
[28] Sundler AJ, Lindberg E, Nilsson C, et al. Qualitative thematic analysis based on descriptive phenomenology. Nurs Open. 2019;6(3):733–739. doi: 10.1002/nop2.275.
[29] Etikan I. Comparison of convenience sampling and purposive sampling. AJTAS. 2016;5(1):1. doi: 10.11648/j.ajtas.20160501.11.
[30] Agan J, Koch LC, Rumrill PD. The use of focus groups in rehabilitation research. Work. 2008;31(2):259–269.
[31] Powell LE, Myers AM. The activities-specific balance confidence (ABC) scale. J Gerontol A Biol Sci Med Sci. 1995;50A(1): M28–34. doi: 10.1093/gerona/50a.1.m28.
[32] Fuller K, Omaña Moreno HA, Frengopoulos C, et al. Reliability, validity, and agreement of the short-form activities-specific balance confidence scale in people with lower extremity amputations. Prosthet Orthot Int. 2019;43(6):609–617. doi: 10.1177/0309364619875623.
[33] Hafner BJ, Gaunaurd IA, Morgan SJ, et al. Construct validity of the prosthetic limb users survey of mobility (PLUS-M) in adults with lower limb amputation. Arch Phys Med Rehabil. 2017;98(2):277–285. doi: 10.1016/j.apmr.2016.07.026.
[34] Landers M, Durand C, Powell D, et al. Development of a scale to assess avoidance behavior due to a fear of falling: the fear of falling avoidance behavior questionnaire. Phys Ther. 2011;91(8):1253–1265. doi: 10.2522/ptj.20100304.
[35] Hafner BJ, Amtmann D, Morgan SJ, et al. Development of an item bank for measuring prosthetic mobility in people with lower limb amputation: the prosthetic limb users Survey of Mobility (PLUS-M). Pm R. 2023;15(4):456–473. doi: 10.1002/pmrj.12962.
[36] Hennink MM, Kaiser BN, Marconi VC. Code saturation versus meaning saturation: how many interviews are enough? Qual Health Res. 2017;27(4):591–608. doi: 10.1177/1049732316665344.
[37] Vaismoradi M, Turunen H, Bondas T. Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. Nurs Health Sci. 2013;15(3):398–405. doi: 10.1111/nhs.12048.
[38] Crenshaw JR, Kaufman KR, Grabiner MD. Trip recoveries of people with unilateral, transfemoral or knee disarticulation amputations: initial findings. Gait Posture. 2013;38(3):534–536. doi: 10.1016/j.gaitpost.2012.12.013.
[39] Bellmann M, Schmalz T, Blumentritt S. Comparative biomechanical analysis of current microprocessor-controlled prosthetic knee joints. Arch Phys Med Rehabil. 2010;91(4):644–652. doi: 10.1016/j.apmr.2009.12.014.
[40] Major MJ, Fatone S, Roth EJ. Validity and reliability of the berg balance scale for community-dwelling persons with lower-limb amputation. Arch Phys Med Rehabil. 2013;94(11): 2194–2202. doi: 10.1016/j.apmr.2013.07.002.
[41] Maki BE, McIlroy WE, Perry SD. Influence of lateral destabilization on compensatory stepping responses. J Biomech. 1996;29(3):343–353. doi: 10.1016/0021-9290(95)00053-4.
[42] Madill A, Sullivan P. Mirrors, portraits, and member checking: managing difficult moments of knowledge exchange in the social sciences. Qual Psychol. 2018;5(3):321–339. doi: 10.1037/qup0000089.
[43] Motulsky SL, Is member checking the gold standard of quality in qualitative research? Qual Psychol. 2021;8(3):389–406. doi: 10.1037/qup0000215.