Reporting of Rehabilitation Outcomes in the Traumatic Lower Limb Amputation Literature: A Systematic Review

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Abstract

Objective: To synthesize the outcomes reported in the rehabilitation and community literature for adults with traumatic lower limb amputation (LLA).

Data Sources: The search strategy was conducted in 3 databases (Medline, EMBASE, and CINAHL) from inception to April 2022.

Study Selection: To be eligible, articles could be of any design but were required to have at least 50% adult individuals with traumatic LLA and had to report on interventions and outcomes in either a rehabilitation or community setting.

Data Extraction: The extracted outcomes were classified using Dodd’s framework, which is designed for organizing research outcomes. Heterogeneity was observed in the outcome measures (OMs) used for evaluation. Two reviewers independently conducted the data extraction, which was verified by a third reviewer.

Data Synthesis: Of the 7,834 articles screened, 47 articles reporting data on 692 individuals with traumatic LLA, met our inclusion criteria. Four core areas encompassing 355 OMs/indicators were identified: life effect (63.4%), physiological/clinical (30.1%), resource use (5.1%), and adverse events (1.4%). Physical functioning (eg, gait, mobility) was the most frequently reported outcome domain across studies, followed by nervous system outcomes (eg, pain) and psychiatric outcomes (eg, depression, anxiety). Domains such as global quality of life and role/emotional functioning were seldomly reported.
Lower limb amputation (LLA) is a life-changing event which significantly affects physical functioning, health, quality of life, and psychosocial well-being. An estimated 28.9 million people worldwide are believed to have undergone unilateral traumatic LLA, and another 6.4 million bilateral traumatic LLA. The lifetime prosthetic costs projected for service members with traumatic LLA have been estimated to be between $1.4 and $1.8 million USD.

Between 2006 and 2012, 6% of amputations across Canada occurred because of trauma. Although this accounts for a relatively small proportion of LLAs, traumatic LLAs pose distinct occupational and psychosocial challenges compared with amputations resulting from other causes, warranting further exploration. For example, traumatic LLAs typically occur among younger individuals compared with the dysvascular population, who may have difficulty meeting the societal expectations of being actively employed and occupationally productive in light of limb amputation. In addition to the burden of such expectations, individuals with traumatic LLAs experience limited mobility, pain, poor physical component score of quality of life, high rates of post-traumatic stress disorder, and disruptions to overall psychological well-being due to the distressing and unexpected nature of how they sustained their injuries. Systematic review evidence suggests that traumatic LLAs most commonly stem from war injuries, motor vehicle collisions, and workplace injuries. The occupational and psychosocial factors unique to traumatic LLA can affect treatment trajectories, functioning, and future health conditions; highlighting the need to focus specifically on this population to better understand their needs and improve outcome reporting.

After traumatic amputation, patients may undergo rehabilitation interventions provided by various health care professionals (eg, physicians, surgeons, physiotherapists, occupational therapists, prosthetists) to help the individual recover and regain skills, restore confidence, improve their physical functioning and quality of life, and participate in their community. Although there are data on the effectiveness of rehabilitation in improving different outcomes related to physical, mental, and social functioning and quality of life, knowledge about the most appropriate outcomes to measure during the rehabilitation of patients with LLA is still lacking.

Indeed, multidimensional rehabilitation assessments using outcome measures (OMs) have become essential in clinical practice, and their use is viewed as necessary to ensure that holistic needs are being met. However, in the Canadian context, 70% of amputee rehabilitation centers reported not using any standardized OMs to determine patient outcomes; with most using informal “homemade” indicators. The term “outcome measures” in this context refers to the tools or instruments used to evaluate the effects of an intervention or program over a specific period. OM can encompass a range of assessments, examinations, surveys, or observations that furnish either quantitative or qualitative information regarding the effects of the intervention. Conversely, “outcome indicators” are variables or attributes that can help summarize, represent, or emphasize the clinical parameters being assessed. Indicators are often used to provide a quantitative measure of desirable or undesirable outcome resulting from a specific process. Many OMs are currently being used in the rehabilitation for individuals with LLA, such as the Amputee Mobility Predictor, the Amputation Related Body Image Scale, and the Trinity Amputation and Prosthesis Experiences Scales. This heterogeneity of OMs used in clinical research makes meta-analyses difficult. Thus, the estimates of intervention effectiveness are less precise, and overall findings are less informative for clinical practice. The use of core outcome sets (COS) may address this issue because they can be used to establish consensus on the key outcomes that should be measured and reported in clinical practice or clinical trials for a specific health condition. Moreover, in terms of rehabilitation, a COS could facilitate the delivery of evidence-based care as it might help inform how to best support patients throughout their recovery process. Here, reporting homogenous COS comprising measures with strong psychometric properties can allow different rehabilitation facilities to compare their patients’ outcomes to understand patients’ needs better, assess the quality of care across sites, and inform research.

Although some recent work has identified outcomes for individuals undergoing traumatic LLA, these studies are limited in some ways. For instance, the recently published high-quality review by Tirrell et al attempted to standardize patient-centered outcomes from the perspective of advancing surgical care. This study only focused on patient-centered outcomes deducing specific COS for rehabilitation-based research, which is problematic because it lacked a global perspective. The development of COS should not only be derived from patient-reported outcomes but also by performance-related and clinician-reported outcomes since they could be valuable to help identify a COS that is meaningfully endorsed by health care practitioners as well as by adults with traumatic LLA. Likewise, a recent review report by the International Society for Prosthetics and Orthotics (ISPO) also attempted to standardize patient-reported and performance-related COS in the LLA population. However, the report included recommendations for LLA from different causes (eg, trauma, cancer, dysvascular) and, therefore, did not explicitly standardize the outcomes for adults with traumatic LLA.

To our knowledge, no study has attempted to synthesize reporting of outcomes relevant to rehabilitation for adults with traumatic LLA.
Therefore, we intended to bridge this gap in the existing literature by conducting a systematic review to describe the reporting of rehabilitation and community outcomes for adults with traumatic LLA. This review is the first step to standardize reporting of rehabilitation and community outcomes for this patient population. The findings of our study provides a list of outcome domains reported in the academic literature that will inform the first step in developing a COS specific to adults with traumatic LLA, which is a sub-population of individuals with LLA who have different demographic and clinical profiles compared with their dysvascular counterparts.

Methods

Systematic review

The systematic review was completed after the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-SR) statement. The study was registered in PROSPERO (CRD42022355410). The PRISMA-SR checklist is provided as supplemental table S1 (available online only at http://www.archives-pmr.org/).

Eligibility criteria

Articles deemed eligible for inclusion met the following characteristics: 50% of the study sample was composed of adult individuals with traumatic LLA (18 years and older), reported outcomes, took place in a rehabilitation or community setting, and were published in English or French. There was no restriction on the date of publication. Articles were deemed ineligible if their topic or focus was related to surgical procedures, congenital conditions, limb preservation, had a sample with pediatric amputation or minor amputations (ie, below the ankle), and those with non-traumatic amputation etiologies. Moreover, articles reporting on the testing, development, and validation of prosthetic interventions in commercial settings were deemed ineligible. Types of documents including conference proceedings, published abstracts, narrative reviews, commentaries, editorials, theses, non-peer reviewed articles, and articles where we could not identify outcomes specific to traumatic amputation, were also excluded.

Information sources

Three major online databases were searched: MEDLINE, EMBASE, and CINAHL, using MeSH terms (subject headings) and keywords from database inception until April 1, 2022. The search strategy (supplemental table S2, available online only at http://www.archives-pmr.org/) was developed in consultation with the research team and validated by an academic librarian. This was inspired on a study protocol for a systematic review of major LLA due to peripheral arterial disease. This search strategy was adopted because it targeted similar outcomes as this review and the domains were relevant to the traumatic LLA population.

Selection of the articles

We used Covidence, a systematic review software system, to manage the screening procedure for this systematic review. Covidence provides a prescribed workflow for reviewers to follow while closely mimicking the multiphase review process, with data extraction incorporated directly into its design. Throughout the review process, citations progress through each stage, such as title, abstract screening, and full-text screening, based on the votes received. Reviewers had the flexibility to assign voting roles, including conflict-resolution, at each stage while maintaining masking to minimize any bias. As a pilot, the first 200 titles and abstracts were independently screened by 2 reviewers (L.E., J.M.) and then compared to ensure consistent application of the inclusion criteria. After that, the remaining titles and abstracts were independently screened by the same 2 reviewers with a 91.3% agreement. All the full-text articles were independently screened by the same dyad. In cases of discrepancies in article selection, discussions were held between the 2 reviewers, and if a decision to include an article was not unanimous, a third reviewer (D.Z.) was consulted to reach a consensus.

Data extraction

The data for adults with traumatic LLA were extracted using an extraction sheet, which was developed (S.G. and D.Z.) and approved by the team. The sheet included the items: general article information (author details, publication year, country of research, description of the study population (ie, age, sex, co-morbidities), methodology/methods (study type, participant recruitment/selection/allocation), outcomes (number of total outcomes, outcome name, outcome definition, OMs, and outcome indicators). All outcomes were classified into various domains using the outcome classification framework created by Dodd et al. Dodd’s framework consists of 5 core areas (death, physiological or clinical, life effect, resource use, and adverse events) and 38 outcome domains that were further expanded into subdomains to precisely classify the OMs/indicators to their respective domains. The reason for choosing this framework in our current context was its ability to address the limitations of existing classification frameworks such as Outcome Measures in Rheumatology, Nursing Outcomes Classification, and Patient-Reported Outcomes Measurement Information System. These frameworks focus largely on patient-centered outcomes and often lack the necessary granularity and comprehensiveness when classifying disease-specific studies, which did not adequately meet the specific requirements for outcome classification in traumatic LLA.

In contrast, Dodd’s framework builds upon core areas commonly found in other outcome hierarchies and provides a more detailed classification system that is well-suited for capturing a wide range of potential outcomes relevant to traumatic LLA, particularly in the physiological, functioning, and resource use domains. Moreover, the adoption of Dodd’s framework offers several advantages. Firstly, it enables standardized outcome classification, which facilitates literature searches by providing a consistent framework. Additionally, it can assist COS developers who need to categorize outcomes.

Two researchers (L.E., J.M.) independently undertook data extraction, beginning with a pilot test whereby data from 3 randomly selected articles were extracted and discussed to ensure consensus. A third researcher (S.G.) then independently verified the extracted data and the classification of the COS.

Critical appraisal

The quality of the articles was not evaluated, and the risk of bias was not assessed as the focus of this study was to identify outcomes reported in the articles.
Results synthesis

After extracting the list of all outcomes identified in each study, the research team grouped outcomes into core areas, outcome domains, outcome sub-domains, OMs/indicators, and outcome types of assessment, that is, patient-reported outcomes, clinician-reported outcomes, or performance outcome assessment (see supplemental table S3, available online only at http://www.archives-pmr.org/) using the framework by Dodd et al.53,49

Results

Selection of the articles

The search yielded 12,517 abstracts, and after duplicates were removed, 7834 articles’ titles and abstracts were screened. A total of 337 full-text articles were screened, and 47 articles were included. See figure 1 for the PRISMA flowchart.

Characteristics of sources of evidence

Countries where studies were conducted

Twenty of the 47 articles included came from the United States,51-78 8 from Turkey,71-75 5 from the United Kingdom,79-83 4 from Japan,64-67 1 from South Korea,88 1 from Slovenia,89 1 from Netherlands,90 1 from Lebanon,91 1 from Ireland,92 1 from Iceland,93 1 from Columbia,94 1 from China,95 1 from Canada,96 and 1 from Australia.97

Study design

We identified the study designs of included articles. Eighteen were case studies,54,57,60,61,63,64,66,67,79,81,86,87,89,90,93,95-97 11 were quasi-experimental studies,58,69,73,74,75,78,82-85,89,90,91,94 8 were randomized controlled trials,51,53,55,57,71,72,76,91,94 3 were retrospective cohort studies,62,68,77 2 were prospective cohort studies,59,88 3 were case series,70,80,92 1 was a secondary analysis of an included randomized controlled trial,96 and 1 was a multiple-baseline design study.52

Sample description

The included articles reported data from 692 adults with traumatic LLA. One article56 was not included in the calculation of the overall number of individuals in this body of evidence, because it was a secondary analysis of another article.55 that had already been incorporated in our review. As well, 7 of the included articles had not reported the sex distribution in their sample, that is, a total of 298 individuals with traumatic LLA.54 Regarding the level of amputation, 4 included articles did not specify the level of amputation.74,76,94 One article specified the level of amputation for 55 individuals in their sample, but did not specify the level for the rest of the 57 individuals.51 The entire sample in this review reported a total of 298 individuals with transfemoral amputation, 255 individuals with transtibial amputation, 10 individuals with knee disarticulation, 1 with hip disarticulation amputation, and 1 with Syme’s amputation.

Rehabilitation and community setting context

Outcomes according to Dodd’s framework

Core area

In the 47 included articles, 4 out of 5 possible core areas were identified to classify 355 OMs/indicators. Life effect was the most widely reported core area (225 OMs/indicators) followed by physiological/clinical (107 OMs/indicators), resource use (18 OMs/indicators), and adverse events (5 OMs/indicators) areas. Death was not reported as a core area.

Outcome domains

Sixteen out of 38 possible outcome domains were used to classify 59 outcome sub-domains and 355 OMs/indicators in the included articles. The list of prevalent outcome domains according to specific core areas is illustrated in figure 2 and mentioned as follows.
Life effect
Physical functioning domain was most commonly reported (55.4%) outcome domain within the life effect core area, followed by global quality of life (4%), delivery of care (2.6%), cognitive functioning (0.9%), role functioning (0.3%), and emotional functioning (0.3%).

Physiological/clinical
Nervous system outcomes (15.9%) were reported most commonly in the physiological/clinical core area, followed by psychiatric outcomes (4.4%), respiratory outcomes (3.7%), cardiac outcomes (2.8%), skin/subcutaneous tissue outcomes (2.6%), endocrine outcome (0.6%), and musculoskeletal outcome (0.3%).

Resource use
Two outcome domains were classified as resource use. Here, the need for further resources (4.3%) was most reported in the resource use core area, followed by hospital outcomes (0.6%).

Adverse events/effects
Only 1 outcome domain was reported in this core area of adverse events/effects (1.4%).

Outcome sub-domains
Fifty-nine outcome sub-domains were used to classify the 355 OMs/indicators in the included articles. The list of prevalent outcome sub-domains according to specific domains are mentioned in table 1.

Outcome measures and indicators
We identified a total of 355 OMs/indicators which, upon frequency analysis, resulted in a total of 302 unique OMs/indicators. This report presents only those subdomains in which OMs/indicators were frequently reported (ie, more than 1% of the time). Further details on OMs/indicators can be found in supplemental table S4 (available online only at http://www.archives-pmr.org/).

Spatiotemporal parameters of gait during walking
A total of 43 OMs/indicators were reported in this sub-domain. Here, gait speed (2.0%) was the most widely reported measure, followed by step length (1.4%). The remaining 41 OMs/indicators (14.4%) were reported less frequently, that is, <1%.

Mobility
Of the 18 OMs/indicators reported in this sub-domain, only 1 measure, that is, timed Up and Go test (1.1%), was reported multiple times. The remaining 17 OMs/indicators (4.8%) were reported less frequently, that is, <1%.
For all the other outcome subdomains in the life effect core area, the 132 unique OMs/indicators (39.7%) were reported less frequently, that is, <1%.

Phantom limb pain
Of the 13 OMs/indicators reported in this sub-domain, only 1 measure, visual analog scale (1.7%), was reported >1%. The rest of the 12 OMs/indicators (3.7%) were reported less frequently, that is, <1%.

Cardio-respiratory fitness
A total of 9 OMs/indicators were reported in this sub-domain. Here, maximal VO₂ (1.1%) was the only measure reported >1%. The rest of 8 OMs/indicators (2.5%) were reported only once.

For all the other outcome subdomains in the physiological/clinical core area, the 66 unique OMs/indicators (21.2%) were reported for less than 1% of time. All the 16 unique OMs/indicators (5.1%) reported in the resource use core area were reported for less than 1% frequency. Similarly, for the adverse events/effects core area, the 5 unique OMs/indicators (1.4%) were too reported for less than 1% of time.

Outcome characteristics
The 355 OMs/indicators identified in the study were characterized as either performance-related outcomes (58.6%), patient-reported outcomes (36.9%), or clinician-reported outcomes (4.5%).

Heterogeneity of outcome indicators and measures
A detailed list of OMs/indicators reported, and the frequency is presented in supplemental table S4 (available online only at http://www.archives-pmr.org/). Moreover, the high number of unique OMs/indicators for each outcome subdomain presented in the table also demonstrates the heterogeneity of OMs/indicators.

Discussion
This is the first review to both identify and report on the outcomes of rehabilitation and community settings for adults who have experienced traumatic LLA. Our results categorized all retrieved outcomes into 4 major core areas, 16 outcome domains, and 59 subdomains.

Core areas and outcomes the most assessed
We observed major discrepancies in the reporting frequency of core areas, such as resource use (5.1%) as compared with life effect (63.4%) and physiological/clinical outcomes (30.1%). This difference in the reporting frequency of outcome areas is concerning. The limited reporting of outcomes concerning the use of resources can limit policymakers’ and decision makers’ ability to appropriately allocate resources for rehabilitating adults with traumatic LLA.98 For instance, in the Canadian context alone, half of the individuals undergoing LLA are readmitted to an acute care hospital within a year, accounting for annual costs exceeding 1.8 billion Canadian dollars.99,100

In terms of the most commonly reported outcome domains, we identified physical function (55.5%), nervous system (15.8%), psychiatric outcomes (4.5%), and need for further resources (4.5%). Although the present study was inspired by the review conducted by Ambler et al,42 our findings are difficult to compare because their review was focused on people who underwent an LLA from a dysvascular cause, and the authors did not differentiate the frequency of outcomes between short and medium-term time frames including the outcomes specific to a rehabilitation context. In terms of the most widely reported outcome domains, Ambler et al identified that death was the most widely reported domain (22.8%), followed by physical function (21.5%) and skin and subcutaneous outcomes (13.6%). In our study, we did not encounter articles reporting mortality outcomes. However, we did identify that the physical function domain was the most widely reported outcome domain (ie, 55.5%). In contrast, only 2.6% of
<table>
<thead>
<tr>
<th>Area</th>
<th>Outcome Domain</th>
<th>Outcome Sub-domain</th>
<th>Outcome Prevalence (%)</th>
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<tr>
<td>Life effect</td>
<td>Physical functioning</td>
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<td>Mobility</td>
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<td>Pain interference</td>
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<td>Phantom sensation</td>
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<td>Residual limb pain</td>
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the included articles reported the skin and subcutaneous outcomes. The variation in our findings might stem from variations in how we standardized outcomes within the context of adults with LLA. This could potentially relate to differences in outcomes due to comorbidities and the natural history of dysvascular conditions. Physical function is an important goal in rehabilitation, and wound healing occurs more during the acute phase or at the beginning of rehabilitation. Moreover, it is also important to acknowledge the concern of peripheral neuropathy among individuals with dysvascular amputation, which affects both wound healing and wound prevention. Although individuals with traumatic amputation may also experience diminished protective sensation depending on the injury but individuals with amputation due to dysvascular causes very frequently have diminished protective sensation and therefore, an emphasis upon skin outcomes would be expected.

We presume that lesser reporting of skin and subcutaneous outcomes in our study also makes sense because our goal was to identify outcomes only from a rehabilitation and a community care perspective compared with Ambler et al, who synthesized outcomes that also included the acute care perspective.

Our findings also resonate with the results of the recent systematic study conducted by Tirrell et al, which focused on identifying patient-reported outcome indicators after a traumatic LLA. The authors in this review reported that the most frequently reported patient-centered outcomes were physical function and mobility-related outcomes (53.2%), followed by pain (27.6%), psychosocial outcomes (24.4%), and quality of life and satisfaction outcomes (21.2%). Although classified according to Dodd’s framework, our results revealed a similar pattern in the existing literature, although with lesser prevalence. We observed that the most widely reported outcome domain was physical functioning (55.5%) which includes mobility as a sub-domain, followed by nervous system outcomes (15.8%), which contains sub-domains related to pain sensation; psychiatric outcomes (4.5%), including depression, anxiety and stress, and global quality of life outcome (3.9%) plus resource use (5.1%) and adverse events (1.4%).

Outcome domains/sub-domains that are under-investigated

With the classification of outcomes, we identified major discrepancies in the prevalence of core areas, outcome domains, and sub-domains reported by the included articles. For instance, we observed that in the life effect core area, physical functioning (55.5%) was the most widely evaluated outcome domain, whereas the other outcome domains, such as global quality of life (3.9%), delivery of care (2.5%), cognitive functioning (0.8%), and role functioning (0.5%), were reported less frequently. The existing literature has extensively reported the detrimental influence of LLA on the quality of life, role functioning, and cognitive functioning. Given the extent of the detrimental influence traumatic LLA has on aspects other than physical functioning, we report that quality of life remains a relatively poorly studied concept and warrants investigation. We further observed an even more pronounced gap in reporting outcomes for the physiological/clinical core area. Here, while the nervous system outcomes (15.8%), including pain subdomains, were reported by most articles, other outcome domains such as psychiatric (4.5%) (eg, depression and anxiety), skin and subcutaneous tissue (2.5%) (eg, stump wound healing), respiratory and mediastinal (3.7%), cardiac (2.8%), and musculoskeletal (0.3%) were reported only by a minority of articles. The difference in the reporting prevalence of certain outcomes may suggest that these outcomes may be more important than others for traumatic LLA individuals, which might not be the case. Indeed, that’s why COS development involves not only looking at the reported outcomes in the literature but also includes the views of individuals with limb loss, health care professionals, and decision makers.

LLA populations with traumatic origin have been reported to be highly predisposed to psychiatric problems compared with the individuals with LLA of other etiologies. Despite the importance of psychiatric outcomes for determining the prognostic outcome of traumatic LLA, existing literature does not adequately incorporate such an essential component while reporting outcomes for adults with traumatic LLA. Given these circumstances, achieving an adequate and balanced approach would entail granting equal weight and consideration to psychiatric outcomes in comparison with nervous system outcomes. This could ensure a comprehensive evaluation of outcomes for individuals with traumatic LLA. Moreover, it is recommended that future studies consider multiple outcome domains in their selection of outcomes to assess. It is also worth noting that there is a possibility that the outcomes that are reported less frequently may be perceived as less significant by clinicians and individuals affected by traumatic LLA.

### Table 1 (Continued)

<table>
<thead>
<tr>
<th>Area</th>
<th>Outcome Domain</th>
<th>Outcome Sub-domain</th>
<th>Outcome Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need for further resources</td>
<td>Prescription dosage of medications</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>Need for further resources</td>
<td>Non-prescription drug usage</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Need for further resources</td>
<td>Surgery</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Hospital outcome</td>
<td>Hospital re-admission</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Hospital outcome</td>
<td>Duration of hospital stay</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Adverse event</td>
<td>Adverse events/effects</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: QOL, quality of life.
Furthermore, it is equally important to consider that although pain and sensory outcomes (encompassed in the nervous system outcomes) concerning LLA are essential, it does not mean that other outcomes relating to skin, musculoskeletal, respiratory, and cardiac systems should be overlooked. For instance, the effect of traumatic LLA on the increased cardiovascular risks is well established in the existing literature.\textsuperscript{110,111} According to Naschitz and Lenger,\textsuperscript{110} several pathophysiological mechanisms, such as psychological stress, abnormal hemodynamics, heightened insulin resistance, and deviant behaviors exhibited by individuals with traumatic LLA, may serve as contributing factors to the increased likelihood of cardiovascular morbidity. Likewise, reporting additional physiological outcomes such as skin and subcutaneous tissue outcomes could be complementary in understanding the underlying cause of various sensory and nociceptive nervous system outcomes.

**Heterogeneity of OMs/indicators**

Substantial heterogeneity in the OMs used to evaluate a specific outcome subdomain was also observed (see supplementary table S4, available online only at http://www.archives-pmr.org/). For instance, the outcome subdomain of spatiotemporal parameter of gait during walking included a total of 43 unique OMs/indicators. The evaluation of gait speed alone incorporated 4 unique OMs/indicators, and 5 unique OMs/indicators evaluated step width. Likewise, we also observed heterogeneity in other outcome subdomains, such as balance. Here, 16 different OMs/indicators were reported to characterize the balance outcomes in adults with traumatic LLA. Moreover, this heterogeneous reporting of OMs/indicators was also prevalent in other domains, such as nervous system outcome, where subdomains of phantom limb pain, general pain, and phantom sensation incorporated 13, 12, and 9 different OMs/indicators, respectively.

This heterogeneous difference in using different OMs could result from clinical and methodological diversity.\textsuperscript{112} Although these heterogeneous measures allow for quantifying the changes in outcomes at an individual level, it complicates the ability to quantify the effect of interventions across the traumatic LLA population. Heterogenous reporting of OMs prevents combining results in systematic reviews or meta-analyses and brings the issue of the relevance of the reported outcomes to research users such as patients, clinicians, and decision-makers.\textsuperscript{113} Moreover, the financial effect of this non-standardized reporting of OMs has also been acknowledged in the existing literature.\textsuperscript{114,115} Employing standardized OMs can establish a shared vocabulary, enabling the quantification of intervention success and identification of interventions that align with the best clinical practices.\textsuperscript{116}

Importantly, standardization in outcome assessment and reporting could facilitate more accurate comparisons, ultimately enhancing patient care and reducing health care costs by eliminating ineffective rehabilitation interventions.\textsuperscript{115,117} This standardization can also empower clinicians to effectively direct intervention planning, allow policy- and decision-makers to determine specific areas of concern, and facilitate their ability to understand funding requests.\textsuperscript{118} Likewise, standardization of the outcome OMs can inform investment cases for developing prosthetic devices and delivering services, thereby collectively maximizing the outcomes for all individuals with LLA.\textsuperscript{38}

**Types of clinical outcome assessment used**

We also identified a disproportionate difference in reporting types of clinical outcomes assessments. Here, we determined that the included articles had primarily reported performance-related outcomes (58.6%), whereas patient-reported outcomes (36.9%) and clinician-reported outcomes (4.5%) were under examined. This finding also contrasts with the results of Tirrell et al\textsuperscript{37} and an ISPO report that included a systematic review of the quality of patient-reported and performance-related OMs that have been psychometrically tested in the LLA population.\textsuperscript{38} In the study by Tirrell et al,\textsuperscript{37} the authors reported that 60% of their included articles reported any form of patient-reported outcome. Likewise, the ISPO report found that patient-reported outcomes (66.6%) were the most widely reported, followed by performance-reported outcomes (30%).\textsuperscript{38} However, in our study, 36.9% of OMs/indicators were patient-reported, whereas 58.6% were performance-related OMs/indicators. Although performance-related outcomes are essential in quantifying the changes in a patient’s health status, it does not mean that they should prevail over the patient’s voice. Patient-reported outcomes are crucial, especially in rehabilitation, where responding to patient (and caregivers) needs and goals and optimizing the quality of life and social participation/integration in the community is paramount. Studies have suggested that combined reporting of patient-reported and performance-related outcomes completely characterizes the experience associated with the execution of tasks while simultaneously providing objective information about how the patients actually function.\textsuperscript{39}

**Future directions**

The next steps in this research would be to follow the recommendations of the COMET handbook to develop a COS for the traumatic LLA population.\textsuperscript{119} This study is the first phase of a 3-phase approach consisting of a systematic review, qualitative data collection among individuals with traumatic LLA and health care practitioners to identify the most critical outcome domains affected by LLA, and a Delphi survey to gain consensus among individuals with traumatic LLA, health care practitioners, and decision-makers about a COS.\textsuperscript{120} The findings from this systematic review will inform these subsequent phases by providing a list of the outcomes already being used in the traumatic LLA literature. Involving the traumatic LLA population and health care practitioners in the development of a COS in the subsequent phases may offer an opportunity for their input on additional key outcomes which may not have been reported in the scientific literature.

**Limitations**

Despite the novelty, the current study has some limitations. Firstly, it is possible that the systematic search may not have identified all relevant articles. Typically, individuals with traumatic LLA are often included in research aggregated with the larger population of all individuals with LLA rather than being studied in isolation and that body of research was not included in this review. Additionally, only articles published in English or French were included, and reference lists of included articles were not reviewed. Second, study quality and risk of bias were not assessed as the focus of this study was strictly to identify all reported outcomes. This limitation may have resulted in poor-quality/high-risk of bias articles being included in our review. Third, some of the articles included in our review assessed outcomes in individuals with LLA from various etiologies, not just traumatic LLA. This may have introduced bias and favored outcomes more relevant to those specific groups, potentially influencing our results. Fourth, it is worth noting that a considerable number...
of studies included were either case studies/series or quasi-experimental studies, and their poor methodological quality could affect the generalizability of the results. Fifth, this review did not determine if the frequency of outcome reporting observed in the included studies reflects the importance of these outcomes to clinicians and/or individuals with traumatic LLA. Despite these limitations, our findings highlight the importance of holistic care, as many articles focused primarily on physical functioning outcomes. Developing a COS should improve the consistency and quality of traumatic LLA rehabilitation research by optimizing outcome measurement. Outcome measurement is essential in understanding how patients respond to interventions. It can also identify treatment goals with patients and compare outcomes across rehabilitation programs in different health contexts.

Conclusion

Our study describes the reporting of rehabilitation and community outcomes for adults with traumatic LLA. We found that the OMs/indicators reported in the included studies tend to concentrate on physical functioning and overlook the psychological and social aspects of the patient’s experience. While 55.5% of articles reported at least 1 physical functioning outcome, only 4.5% reported at least 1 psychiatric outcome, and only 3.9% reported global quality of life outcomes. We also report similar differences in terms of types of outcomes. Here, outcomes related to performance (58.6%) were more frequently reported as outcomes reported by patients (36.9%) or clinicians (4.5%). The results of this review also provide evidence that the outcomes that researchers choose to assess and report on may differ by the cause of amputation. This highlights the need for the development of a homogenous COS for individuals with traumatic LLA as it could facilitate comparative effectiveness research to identify more effective care models, interventions, and clinical pathways for individuals with traumatic LLA. Next steps for this line of research will involve identifying patients’ and clinicians’ perspectives on the domains most affected by a traumatic LLA to develop a COS for individuals with traumatic LLA receiving rehabilitation services.

Keywords

Amputation; Community health; Lower extremity; Outcome assessment; Rehabilitation; Traumatic

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