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REVIEW

Comfort and function remain key factors in upper limb prosthetic abandonment: findings of a scoping review

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ABSTRACT

Purpose: Rates of prosthetic device abandonment are dramatically high; however, the reasons behind abandonment are less understood. A scoping review was conducted to explore the current state of the literature on why individuals abandon upper limb prosthetic devices and consider how these reasons have evolved historically.

Materials and methods: A systematic search of the literature identified 123 articles. After reviewing the articles using predetermined inclusion and exclusion criteria, nine relevant articles were included in the final review. The included articles covered passive, body-powered and myoelectric prosthetic devices.

Results: Across time, reasons for abandonment could be broadly categorized into comfort and function. Weight, temperature and perspiration were among the most common and persistent comfort-related reasons for abandonment. Regarding function, studies-reported abandonment was attributed to key concerns about control and sensory feedback, whereby participants may feel more functional without their device.

Conclusions: In agreement with the previous literature, lack of comfort and function remain persistent reasons for upper limb prosthesis abandonment. Up-to-date research on reasons for abandonment of upper limb prosthetic devices is lacking, and recent prosthesis advancements have not been included in studies of device use, adoption and abandonment. Therefore, future work should explore reasons for abandonment in contemporary upper limb prosthetic devices. By understanding the reasons for prosthetic device abandonment, clinicians, therapists and researchers can use this information to proactively mitigate future upper limb prosthetic device abandonment. Findings from this review can be used to guide future prosthetic device development to improve these areas of concern and satisfy user needs.

➤ IMPLICATIONS FOR REHABILITATION

- By understanding the reasons for prosthetic device abandonment, clinicians, therapists and researchers can use this information to proactively mitigate future upper limb prosthetic device abandonment.
- The findings from this review can be used to guide future prosthetic device development to improve areas of concern and satisfy user needs.

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Prosthesis; upper limb; abandonment; rejection; comfort; function

Introduction

Upper limb prosthetic devices act as direct extensions of their users' arm [1] and are thus incredibly important to their functionality and independence [2,3]. There is a large amount of variability in the population of upper limb prosthetic users due to their varying anatomy (i.e., residual limb), lifestyle and goals: as such, a variety of upper limb prosthetic devices are available to attempt to satisfy the highly variable needs of this population. Currently, there are four main types of upper limb prosthetic devices available for individuals living with upper limb loss: passive, body-powered, myoelectric and hybrid.

Passive upper limb prostheses tend to be simpler and lightweight: they can restore very limited functionality to their users [4]. Body-powered upper limb prosthetic devices use a cable and harness system to control the device. These devices tend to be a popular choice for upper limb prosthesis users and are often selected for their functional value, ruggedness and durability [5]. Myoelectric devices are externally powered prostheses that rely on electromyographic signals generated from muscles to control and operate the limb. Myoelectric devices are some of the most state-of-the-art prosthetics technology available; however, they still remain difficult to use [6–9] and tend to be heavy and costly for users to acquire [10]. Hybrid prostheses combine body-powered and electrical components into a single prosthesis. For example, body-powered elbow components and myoelectric-controlled hand components are often combined into a single hybrid device. Which device type an individual acquires depends on a variety of factors.

Although there are three main general categories of devices, and advancements in upper limb prosthetics technology continue to evolve, the rates of abandonment for these devices remain dramatically high. Reported rates of abandonment for each device type are highly variable, ranging from 6% to 100% for passive prostheses, 80% to 87% for body-powered prostheses and 0% to 75% for myoelectric prostheses [6]. This high amount of variation

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could in part be due to methodological differences in acquiring these estimates, but it also shows how inherently variable this population is [6].

Purpose

The high amount of variability in these abandonment rates, and in the population of upper limb prosthesis users itself, makes it challenging to get a holistic understanding of *why* individuals choose to abandon their prosthetic devices. Therefore, the purpose of this scoping review is to explore the current state of the literature to understand the reasons why individuals choose to abandon their upper limb prosthetic device. Prosthesis technology is continually evolving, and as such, we are also seeking to understand how the reasons for abandonment have evolved over time. This will allow us to better understand how prosthesis technology has progressed to suit the needs of its users. We aim to provide clinicians, therapists, and researchers with clear data on the main reasons for current prosthetic device abandonment, as well as comment on the interplay between prosthesis design and abandonment over the years. We anticipate that these findings will:

1. Provide a foundation for future research in prosthetic design and development
2. Identify critical targets for both quantitative and qualitative enquiries to enrich our understanding of prosthetic abandonment.
3. Inform clinical strategies for prevention of abandonment.

Materials and methods

A scoping review was conducted to allow us to compile and develop a thematic summary from the relevant literature on upper limb prosthesis abandonment. The framework outlined by Arksey and O'Malley [11], and refined by Levac et al. [12], was selected to guide all aspects of this scoping review. This framework contains six stages:

1. Identifying the research question
2. Identifying relevant studies
3. Study selection
4. Charting the data
5. Collating, summarizing and reporting results
6. Consultation.

We also employed a reporting checklist specifically developed for scoping reviews to inform our reporting [13]. Each stage will be outlined below.

Identifying the research question

The overarching research question for this scoping review was, "What factors have been identified in the literature as influencing an individual's decision to abandon or reject their upper limb prosthesis?" We were interested in the current state of upper limb prosthesis abandonment, but also how the reasons for abandonment have evolved through time, as well as understanding the nature of the available evidence.

Identifying relevant studies

The key search terms were developed and selected to capture literature related to upper limb prosthesis abandonment/rejection and satisfaction. Experienced occupational therapy researchers were consulted to develop the search strategy, refine key terms and identify relevant databases. The keywords chosen for this scoping review were prosthesis, upper extremity, and reject or satisfaction. Relevant word variants for each term were utilized, and the appropriate Medical Subject Headings were included for each database' preferences to gain broad coverage of the literature. Boolean search terms were applied to appropriately combine the keywords to refine our search. We included publications that were written in English and explicitly stated reasons for upper limb prosthetic device abandonment; there were no restrictions on the type of publication. Given that our review was interested in how the reasons for abandonment have evolved over time, time period limits were not included in the search. Articles that focussed on lower limb prosthetic devices, or that did not clearly differentiate reasons for abandonment between upper and lower limb devices, were excluded. The initial search was conducted in Spring 2018 and was updated in Summer 2019. Two authors (C. N. and C. W.) searched Clinical Key, National Guideline Clearinghouse and the National Institute for Health Care and Excellence (NICE) for relevant clinical guidelines. In addition, the Cochrane Library was searched for systematic reviews on this topic. None of these searches found any relevant articles, guidelines or systematic reviews on this topic. Finally, OVID Medline, AMED, CINAHL, Embase, PsychINFO, OT Seeker and RehabDATA were searched to identify relevant studies for this scoping review. See Figure 1 for an overview of the specific search strategy applied to each database, as well as the number of sources found from each database.

Study selection

Our search strategy yielded a total of 151 articles. After removing duplicates across the databases, 123 articles remained. Two reviewers (C. N. and C. W.) independently screened the remaining 123 articles based on title. Titles were then screened simultaneously by both reviewers with direct consultation for uncertainty. The articles were then split amongst the two reviewers to separately review the abstracts with discussion for uncertainty. Following the abstract review, 36 articles moved forward to the full-text review stage. The full text-review stage was completed collaboratively and in tandem between the two reviewers. Ultimately, nine articles met the inclusion/exclusion criteria and were included in this scoping review.

A large number of articles were excluded during the review process. Many articles discussed prosthetic device usage or participant satisfaction. The authors could not assume reasons opposite those resulting in satisfaction would cause abandonment; therefore, these articles were not included in this scoping review. The entire screening process is outlined in Figure 1.

Charting the data

A table to chart the data was developed by the reviewers (L.S., C.N. and C.W.) and was used to extract pertinent data from each included article. Each study's objectives, population, country of origin, design type, outcome measures used and reasons for prosthetic device abandonment were documented in the table. Charting was completed by reviewers collaboratively in tandem to achieve consensus.

Collating, summarizing and reporting

The reasons for prosthetic device abandonment identified during charting were used to synthesize key themes. The data were

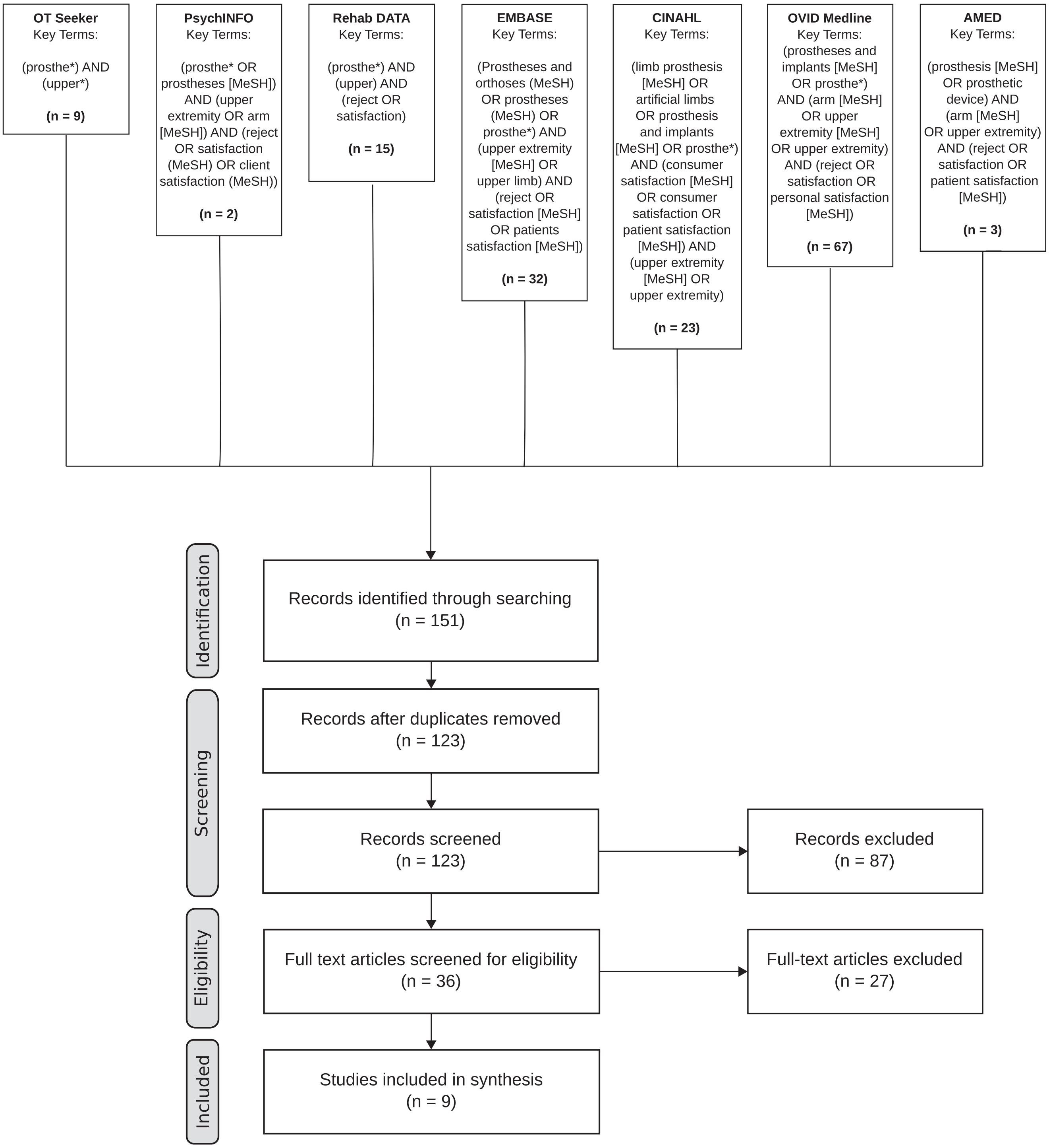

Figure 1. PRISMA diagram.

summarized into overarching themes by the three reviewers (L.S., C. N. and C. W.) individually, and then through discussion and congruence amongst the reviewers. These themes are outlined in the results section of this review. After reviewing the nine included articles, a hand search of grey literature was conducted through the first 100 articles of Google Scholar and Web of Science, and through the websites of Amputee Coalition and Veterans Affairs Canada to compare findings and triangulate our themes from the scoping review. Two sources from the grey literature were found and used to provide context, but were not added to the review [14,15].

Consultation

We consulted with stakeholders in the field to provide feedback regarding the overarching themes identified in this scoping review. Six experts were contacted for consultation, and two replied with feedback regarding the results of this scoping review.

Both experts were practicing prosthetists in Canada and were asked to comment on whether the identified themes were indicative of what is seen in practice. The consultation results helped to frame the discussion of this scoping review.

Results

Of the nine documents included in this scoping review, five articles stratified results based on prosthetic device type, and four articles identified general reasons for prosthetic device abandonment.

Descriptive review

The majority of the included studies were set in North America, specifically Canada and the United States. All but one of the included papers were cross-sectional survey designs, and the remaining included article was a literature review. Each of the cross-sectional studies utilized a self-made questionnaire or survey to record reasons for abandonment. Three articles were published this decade (i.e., 2010, 2012 and 2019). In general, the device types in each of the included articles were generally evenly distributed across each of the three decades included in the current review: the earliest papers on abandonment of upper limb prosthetics were published in 1993 [4,16]. Of the articles included from the 1990s, Kejlaa [4] investigated passive, body-powered and myoelectric devices, while Silcox et al. [16] targeted myoelectric devices. Finally, Wright et al. [17] conducted a general investigation in device abandonment, irrespective of device type. The articles included from the 2000s were also split amongst device types, with Biddiss et al. [18] investigating passive, body-powered and myoelectric abandonment, and Biddiss and Chau [6,19] conducting general investigations into upper limb prosthetic device abandonment. Three articles were included from 2010 and onwards and focussed on conventional prosthetic device types. The included study from McFarland et al. [20] investigated reasons for abandonment across each of the three types of devices, while Østlie et al. [21] conducted a general investigation irrespective of device type. Finally, Resnik et al. [22] investigated the function, needs and satisfaction of Veterans with major upper limb amputations, and stratified reasons for abandonment based on body-powered, myoelectric and hybrid device types.

The three main prosthetic device types presented in the current review are inherently different [23], and as such, reasons for abandonment have been separated according to device type to aid with interpretation and discussion. Specific reasons or subthemes for each of the device types could be separated into general themes of comfort and function. A third "Other" category was created to organize the few reasons that fell outside of the themes of comfort and function for passive devices, and from studies where device type was not specified. Given that only a single article reported on hybrid devices, a separate column for hybrid device types was created for reporting purposes but will not be discussed in depth in the discussion. For a comprehensive overview of the reasons for abandonment found in each of the included papers, see Table 1, and for an overview of the reasons grouped by device type and general theme, see Table 2.

Grey literature reports

Two grey literature reports were found and used to triangulate and provide context for the themes found in this scoping review. The first source of grey literature from Smith [15] in 2007 was found by hand searching through the Amputee Coalition and discussed an array of topics relating to prosthesis rejection and abandonment. Smith [15] reported that currently available upper limb prosthetic devices do not add functional value for their users, and also tend to be painful and heavy to use. Moreover, the lack of sensory feedback, or "connection" to the prosthesis, leaves users feeling like the limb does not belong to them, and that it is instead just a tool they are using. The second piece of grey literature from Richman [14] in 2016 also noted the issue that upper limb prostheses provide their users with limited functional value and tend to require many repairs. Richman [14] also discussed issues relating to research on upper limb prosthetics, namely the lack of studies that have investigated the needs of upper limb prosthetic users or assessed their functionality.

In general, the topics discussed in both sources of grey literature corroborate the themes of functionality and comfort found in our scoping review. Both sources stressed the user perspective that upper limb prostheses are nowhere close to being able to replicate the functionality of an upper limb, and that compared to lower limb prosthetics, upper limb prosthetic technology needs to be much more mechanically complex to replicate the upper limb.

Consultation

The consulted experts both confirmed congruence between the results of the scoping review and what is seen in practice. In particular, one expert highlighted that they routinely hear complaints surrounding prosthesis weight and temperature. They also noted that from their experience, the lack of sensory feedback from most device types is one of the largest barriers to improve functionality and successful usage. Furthermore, ensuring that individuals receive adequate training from an occupational therapist was listed as another important aspect of improving functionality and usage. Both experts noted that managing realistic expectations with regard to prosthetic device use can be challenging in practice. Prior to fitting, people with amputations may not be aware of the discomfort or lack of function that can sometimes be associated with prosthetic device use. Bilateral or dominant arm amputations were also noted to be motivators for overcoming the common reasons for prosthetic device abandonment due to the need for independence.

Discussion

Across all nine studies included in this review, both general comfort and function were consistently discussed as main reasons associated with prosthetic device abandonment. These factors were consistent across each of the included device types, and across each of the three decades of studies included in this review. This finding was verified by reports in the grey literature [14,15] and consultant input. Other reasons outside of comfort and function, such as body-powered devices lacking cosmesis [4,22], general dissatisfaction with technology, lack of established need and lack of training, were also noted as general reasons for device abandonment [6,21,24].

Overall, the reported reasons for abandonment for passive limbs were mainly due to discomfort [4,18]. A more recent study has reported lack of functionality as a reason for abandonment, along with durability; however, these findings are inconsistent with the primarily cosmetic purpose of passive limbs (e.g., McFarland et al. [20]). Reasons for abandonment of body-powered devices were once again dominated by comfort [4,18,20];

Table 1. Charted data from the included studies.

Reference	Objective	Design type	Country	Sample population	Factors associated with abandonment
Kejlaa [4]	To evaluate the consumer concerns about their prostheses and see if these contributed to prosthesis abandonment	Cross-sectional survey study	Denmark	66 individuals ($M_{age} = 45$, range 4–83 years, $N_{female} = 14$, $N_{male} = 52$) with all levels of upper deficiency/amputation	*Passive device:* • Temperature • Weight • Damaged clothing *Body-powered device:* • Temperature • Weight • Strap irritation • Damaged clothing • Not durable • Aesthetics • Difficult to use *Myoelectric device:* • Temperature • Weight • Slow response time • Difficult to control • Prosthetic device failure
Silcox et al. [16]	To examine the acceptance and usage of myoelectric and alternate prostheses by those who own both types of devices	Cross-sectional survey study	USA	44 upper limb amputees ($N_{female} = 8$, $N_{male} = 36$, $M_{age} = 38$, range 6–69 years) who have used a myoelectric prosthesis for more than 2 years	*Myoelectric devices:* • Weight • Slow to respond and use • Not durable
*Wright et al. [17]	To evaluate patterns of upper limb prosthesis use	Retrospective chart review, cross-sectional survey study	USA	135 individuals ($N_{female} = 22$, $N_{male} = 113$, $M_{age} = 36$, range 2–73 years) living with major upper extremity amputation	*Unspecified device:* • Limited functional benefit • Weight • Socket discomfort
Biddiss et al. [18]	To measure consumer satisfaction with upper limb prosthetic devices	Cross-sectional study	Canada	242 individuals ($N_{female} = 118$, $N_{male} = 124$, $M_{age} = 30$, $SD = 11$) with all levels of upper deficiency/amputation	*Passive device:* • Temperature and perspiration • Weight • Not durable *Body-powered device:* • Weight • Harness comfort • Temperature and perspiration *Myoelectric device:* • Weight • Perspiration • Lack of sensory feedback • Poor dexterity
*Biddiss and Chau [6]	To investigate the roles of predisposing characteristics, established need, and enabling resources in upper limb prosthesis use and abandonment	Cross-sectional survey study	Canada	242 individuals ($N_{female} = 118$, $N_{male} = 124$, $M_{age} = 30$, $SD = 11$) with all levels of upper deficiency/amputation over the age of 18	*Unspecified device* • Predisposing factors (i.e., gender, level of limb loss) • General discomfort • Weight • Temperature • Perspiration • Lack of sensory feedback • Dissatisfaction with technology • Lack of functional benefit
*Biddiss and Chau [19]	To review upper limb prosthesis usage and abandonment	Literature review	Canada	90 articles	*Unspecified device:* • Lack of established need given their lifestyle • Lack of information, training and follow-up appointments • Predisposing factors (i.e., level of limb loss, hand dominance, gender)
McFarland et al. [20]	To explore prosthetic use and satisfaction in wounded service members with unilateral upper limb loss	Cross-sectional survey study	USA	97 veterans/wounded service members ($M_{age} = 45$, $SD = 4$) with unilateral upper limb loss	*Passive device:* • Lack of functionality *Body-powered device:* • Weight • Pain • General discomfort • Poor fit

(*continued*)

Table 1. Continued.

Reference	Objective	Design type	Country	Sample population	Factors associated with abandonment
					Myoelectric device: • Weight • Pain • Discomfort • Not durable • Difficult to control
*Østlie et al. [21]	To estimate the rates of primary and secondary prosthesis rejection, and to describe the most frequently reported reasons for rejection, as well as influential background factors on risk of rejection	Cross-sectional survey study	Norway	224 individuals ($N_{female} = 37$, $N_{male} = 187$, $M_{age} = 53.7$) with acquired upper limb loss, major amputation (through or proximal to the radio-carpal joint)	*Unspecified device:* • Weight • Socket fit • Perspiration • Harness irritation • Functionality • Weak grip • Wrist motion • Slow response speed • Difficult to use • Lack of need • Mismatch between needs and available technology • Insufficient training and information
Resnik et al. [22]	To provide data on function, needs, preferences, and satisfaction of veterans with major upper limb amputation	Cross-sectional survey study	USA	808 Veterans ($M_{age} = 63.3$, $SD = 14.1$) with unilateral ($N_{female} = 21$, $N_{male} = 755$) and bilateral ($N_{male} = 32$) major upper limb amputation	*Body-powered, hybrid, and myoelectric devices:* • Weight • Poor fit • General discomfort • Lack of functionality • Too much fuss • Difficult to use • Not durable • Aesthetics

*Indicates results were not separated by prosthetic device type.

however, reports of body-powered devices being difficult to control [4,22], failing due to wire breakage [4,22] and with being non-functional [22] were also recorded. In contrast, the reasons for abandonment of myoelectric devices were more evenly split between comfort and function, with weight being the dominant and persistent complaint associated with comfort [4,16,18,20,22]. A wide variety of functional reasons for myoelectric abandonment were reported in the included studies, including lack of durability [16,20,22], slow response speeds [4,16], lack of sensory feedback [18] and difficulty controlling the prosthetic limb [4,20,22]. Specific reasons for myoelectric abandonment varied across the included studies, which can be attributed to not only the variability of the population, but also the non-standardized surveys used in these studies.

Based on the reported reasons for abandonment separated by device type, it appears that in general, the reasons for abandonment match with the general purpose of each device type. For example, passive prostheses are mainly for cosmetic purposes and offer minimal functional benefit [4]. Based on the findings from this scoping review, users appear to be more concerned with the comfort of a passive device, rather than its functionality. Conversely, myoelectric devices are touted as being able to restore functionality to users [25], and unsurprisingly, user expectations with regard to the functionality of myoelectric devices are higher, as our expert consultants also confirmed. These higher expectations might give users more reason to feel disappointed in the current state of the technology, as was found by Biddiss and Chau [6]. These feelings of disappointment in the current state of upper limb prosthesis technology were also echoed in both grey literature sources [14,15].

The focus on functionality

A recent literature review by Cordella et al. [26] presented the needs assessment of upper limb prosthesis users to better understand what changes must be made to improve user satisfaction and acceptance of their upper limb prosthetic devices. The main finding of the needs assessment was users-wanted improved functionality (e.g., better control, improved grasping and object manipulation, sensory feedback, improved dexterity) to be better able to interact with their environments [26]. Considering the value of functionality stressed by the target consumer population (e.g., [14,15]), it is no surprise that many researchers are focussing on improving functionality by working towards providing users with sensory feedback [27–29], increased degrees of freedom and closed-loop control systems [24,29,30]. In fact, a quick search can reveal that hundreds of research papers have been published over the past ten years concerning upper limb prosthesis functionality (e.g., [31–33]), while only a handful have been published on the topic of improving upper limb prosthesis comfort (e.g., [32,33]). Although this search was not exhaustive, the discrepancy in the number of papers is telling.

In the light of the findings from this review, we can see that although comfort is not thought of by users as being an important consideration, an uncomfortable device is one of the main reasons for abandonment across all device types and should therefore be an important area of focus for researchers, clinicians and therapists alike. Furthermore, not all individuals who currently use, or are in need of an upper limb prosthetic, want to, or are able to afford and get access to myoelectric or other more advanced devices [7,34]. Many people still use passive and body-powered devices [3,22,35–39], and therefore, we must ensure that

Table 2. Reasons for prosthetic abandonment by device type, condensed across years.

	Device type				
Theme	Passive	Body-powered	Myoelectric	Hybrid	Not Specified
Comfort	Temperature [4,18] Weight [4] Perspiration [18] Damaged clothing [4]	Temperature [4,18] Weight [4,18,20,22] Perspiration [18] Damaged clothing [4] General discomfort [20,22] Harness irritation [4] Poor fit [20,22] Pain [20]	Temperature [4] Weight [4,16,18,20,22] Pain [20] General discomfort [20,22] Poor fit (22)	Weight [22] Poor fit [22] General discomfort [22]	Temperature [6] Weight [6,17,21] Perspiration [6,21] Socket discomfort [17,21] General discomfort [6] Harness irritation [21]
Function	Lack of functional benefit [20] Not durable [18]	Difficult to control [4,22] Not durable [4,22] Lack of functionality [22]	Difficult to control [4,20,22] Slow response speed [4,16] Lack of sensory feedback [18] Poor dexterity [18] Not durable [4,16,20,22] Lack of functionality [22] Too much fuss [22]	Lack of functionality [22] Difficult to use [22] Not durable [22] Too much fuss [22]	Difficult to control [21] Slow response speed [21] Lack of sensory feedback [6] Poor dexterity [21] Limited or lack of functional benefit [6,17] Difficulty gripping objects [21]
Other		Aesthetics [4,22]	Aesthetics [22]	Aesthetics [22]	Dissatisfaction with technology [6,21] Predisposing factors (e.g., gender, level of limb loss, hand dominance) [6,24] Lack of established need [21,24] Lack of information, training and follow-up appointments [21,24]

the needs of this subset of the population are being met with regard to improved comfort and function, among other needs [18,40].

Another consideration is the need for validated assessment tools to evaluate prosthetic use and functionality [41,42]. A handful of such measures, such as the ULPOM [43] and the PUFI [44], have been created and should be used going forward. This will foster comparisons between devices and populations, and can triangulate the informal observations of clinicians and reports of the lived experience of persons after upper limb amputation.

Recent advances in upper limb prosthetic devices

While the congruence across the included studies is positive in that it suggests we have a thorough understanding of the reasons why individuals have chosen to abandon the use of their conventional upper limb prostheses, it is important to note the included studies only reported on conventional device types (i.e., passive, body-powered, myoelectric and hybrid). Given the continued focus on these device types, it is unsurprising the reasons for abandonment in the included studies still centre around comfort and function. This is troubling, as it paints an incomplete picture of the state of upper limb prosthetic technology. Major advancements in prosthetic technologies have occurred over the past five to ten years to address issues related to comfort and function. For example, the adoption of 3-D printing has resulted in more comfortable sockets and the creation of multifunctional hands at a fraction of the cost of other devices [45]. Furthermore, multi-articulated hands (e.g., the Össur i-Limb Quantum and Ottobock bebionic), multisensory e-glove technologies [46] and ultrasound-enabled digit control [47] are all examples of advances in the area of functionality over the past five years. Therefore, while there have not been many studies regarding the long-term use and abandonment of these contemporary devices, these advances appear to be already changing the adoption and usage of upper limb prosthetic devices. We cannot explicitly state whether these advances have reduced the rates of abandonment of upper limb prostheses associated with comfort and function; however, industry leaders and researchers are working towards addressing these concerns.

Future work

Since 2010, the number of publications concerning myoelectric prosthetic devices has more than doubled [48], and considerable advancements and improvements to prosthetic device functionality and comfort have been made (e.g., sensory feedback, attempts at closed-loop control) [49]. Considering the plethora of research and improvements being made to prosthetic devices, investigations into the effects of these advancements on abandonment and user satisfaction have not been conducted. This could be in part be due to most studies being conducted in laboratory settings for a few hours at a time (e.g., [50]), meaning that participants/patients are not using these devices for extended periods of time in real-world situations to allow for investigations on rejection or abandonment to be conducted. To our knowledge, two studies have investigated extended use of a neural-connected, sensory-enabled prosthetic hand and its effects on functionality, embodiment, etc. [27,28]; however, due to the experimental nature of these studies, investigations into rejection or abandonment were not included. Both of these long-term studies [27,28] suggest that the incorporation of advanced sensory feedback and control mechanisms may help reduce abandonment. While well-founded, particularly based on the findings from the current scoping review, these statements remain to be tested.

Given the considerable lack or studies on prosthesis adoption and abandonment over the past number of years, we would recommend that when possible research should be conducted to assess the rates of, and factors associated with abandonment of state-of-the-art devices. Although body-powered and passive device technology has remained relatively stable, studies should also investigate whether the factors and rates of abandonment of these devices have improved. These devices are commonly prescribed and used [3,22,35–39], and therefore, up-to-date information will be highly beneficial for clinicians, therapists and funders.

Future research should also continue to explore the psychological and social factors of prosthetic device abandonment, rather than the mainly personal factors seen in this scoping review. For example, surveys could include questions concerning an individual's readiness for prosthetic device use and its impact on abandonment or retention rates. Qualitative investigations could also be conducted to explore complex psychological and social reasons for abandonment. Perceived need was touched upon by three of the included articles [17,21,24], but further investigation into this concept would provide valuable insights into what is needed for upper limb prosthesis usage to become more worthwhile. We find this aspect crucial to investigate since it has been previously found that 98% of individuals who have rejected, and 60% of individuals who frequently use an upper limb prosthetic device, report that they are just as or more functional without it [24], and this finding is echoed across many of the included studies and grey literature sources [6,14,15,17,20].

Clinical relevance

The findings from this scoping review should be considered in amputation rehabilitation clinics in order to mitigate potential prosthetic device abandonment. The findings suggest there is a need to recognize an individual's lifestyle and find a prosthetic device that functions to best fit their needs [24]. If clinicians and therapists are purposeful in rehabilitation by targeting and compensating for these reasons for abandonment (e.g., strengthening the residual limb and improving muscle activation and coordination for myoelectric control [51]), people may be able to use their prosthetic devices to their full potential in daily activities.

Limitations

The inclusion of English-only papers likely limited the number of included papers, as well as potential insights into cultural influences on upper limb prosthesis abandonment. In addition, a great deal of the literature discussed prosthetic devices in relation to consumer satisfaction. The authors could not assume that reversing the reasons for satisfaction would yield reasons for abandonment. Similarly, the authors could not infer that reasons for disuse or infrequent use are equivalent to reasons for abandonment. This scoping review is also limited in the fact that the majority of the literature resulted from predesigned surveys, which may have limited how participants were able to respond. This topic would benefit from a qualitative, open-ended investigation to get a deep understanding of upper limb prosthetic abandonment that is not confined to solely physical/personal reasons.

To the best of our ability, all relevant studies on this topic from the databases searched have been included in the current review; however, the findings from this study are limited by the lack of papers published over the past ten years. Our search strategy also included accessing the grey literature by searching Google Scholar: however, the approach of limiting this to the first 100 hits may have missed some relevant resources. While we are not discounting the credibility or importance of the subthemes found in the current scoping review, it is possible that many of the main findings concerning comfort and functionality are not applicable to state-of-the-art upper limb prosthetic devices given the surge of research that has occurred over the last five to ten years. We acknowledge the time lag between research and publication may also contribute to the ongoing knowledge gap. We want to be careful to not make assumptions and bias readers to believe that the subthemes from older abandonment research and devices apply to current upper limb prosthetic devices available on the market, or those that are under development. As such, until future research is conducted to assess current rates and factors of abandonment, statements regarding the rates of abandonment in the state-of-the-art devices should be made with caution.

Conclusions

The reasons for prosthetic device abandonment outlined in this scoping review should be closely considered when designing and prescribing future upper limb prosthetic devices and providing training on their use. By being aware of these issues relating to comfort and function, clinicians, therapists and researchers might pre-emptively mitigate future prosthetic device abandonment. While functionality has become a focus of research over the past ten years, prosthesis comfort should not be discounted in the design and development of future upper limb prosthetic devices. Finally, up-to-date information on the factors associated with abandonment is highly relevant to the design of future upper limb prosthetic devices, and therefore, the influence of comfort and functionality and their related subthemes on abandonment should continue to be explored, especially in the state-of-the-art devices.

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Disclosure statement

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