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Review

The Technological and Psychological Aspects of Upper Limb Prostheses Abandonment: A Narrative Review

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Abstract

The loss of a limb is an event that significantly affects an individual's quality of life, with implications not only for autonomy in daily activities but also for their ability to interact with others. At the same time, current prostheses often fail to meet the user's needs, resulting in high drop-out rates. In this review, we investigated the primary causes of prosthesis abandonment and analyzed them by highlighting the technological and psychological aspects associated with current devices. Technological issues due to reliability, functionality and comfort, together with psychological issues related to anxiety and depression, are among the main factors contributing to prosthesis rejection. Social aspects, sport, and community activities play crucial roles in improving the sense of belonging and acceptance of prosthesis users. Although research has often prioritized functionality, prosthesis development should follow patient-centered models that address the individual needs and requirements of patients, emphasizing psychological, rehabilitative, and technological support.

Keywords: upper limb prosthesis; sensory feedback; embodiment

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1. Introduction

Limb amputation is a life-changing event with physical and psychological effects on the amputees [1]. In 2017, more than 57 million people worldwide were living with limb amputation due to traumatic causes [2], and more than 215.000 amputation surgeries are performed each year [3]. It has been estimated that in the United States, there are approximately 2 million people living with limb loss [4], and those numbers are estimated to double by 2050 due to the aging of the population and the higher incidence of vascular diseases and diabetes [4,5]. The leading causes of amputations are trauma-related and, most commonly, due to work-related accidents, traffic accidents, and falls [5–16]. According to Raspopovich et al. [17], 15,900 upper limb amputations are performed in the USA each year, while 6311 are performed in the European Union (data averaged from [17–20]). Prosthesis rejection rates remain high (30–80%) due to a lack of user needs [21–26].

Limb amputation is certainly a delicate moment that forces individuals to deal with various changes in their life [27,28], such as difficulty in continuing their work, a loss of autonomy in various daily tasks, emotional adjustment to their new condition [29,30], physical pain following the operation, and, in some cases, phantom limb pain [31]. According to Horgan and MacLachlan [32], depression and anxiety are common in the first two years after amputation, even if, as shown by Singh et al. [33], levels of anxiety and depression are not constant over the two years. Anxiety and depression levels are higher during hospitalization, followed by a drop before increasing again. Mckechnie and John [34] estimated incidences of 20.6–63% for depression and 25.45–57% for anxiety after traumatic amputation.

For upper limb loss in particular, the combined reduction in function and aesthetic appearance, along with the inability to easily hide the amputated hand or arm from view, can result in a traumatic experience. The human hand, in addition to its aesthetic value, serves a range of complex functions that enable individuals to interact with external objects through grasping and touch, as well as to communicate with others through gestures [35].

The sudden loss of such an important body part generates a multifaceted adaptation process, ranging from altered body image and lifestyle, and a change in self-concept, to altered physical functioning, prosthetic use, and pain. These stressors challenge individuals' ability to maintain emotional well-being, which can lead to maladaptive reactions and poor psychosocial adjustment [36,37]. Senra et al. [38] demonstrated how depressive symptoms, phantom limb pain, and anxiety influence self-perception and adjustments after amputation. The amputation affects the integrity of the body and, in this way, the skills and talents of the individual as well [39]. As a consequence, the individual may start perceiving themself as inferior because of the amputation, eliciting detrimental cognitions linked to catastrophizing concerning future functionality and adaptation, often leading to maladaptive behaviors [40] and negative emotional states including anger, hostility, or suicidal thoughts [41].

Added to these are any medical problems following the loss of the affected limb, recommended therapies (e.g., physical therapy, psychological counselling, etc.), the various visits with specialists, but also the possibility of prescribing the most useful prosthesis, recommended based on needs/requirements and financial availability, along with the frequency of prosthetic replacement [42].

Despite technological advancements, prosthetic abandonment remains a significant problem, with rejection rates of up to 50%, depending on the type of device and patient population [43,44]. Furthermore, failure to use the prosthetic device is not only a problem for the individual but also has repercussions on healthcare costs. In their study on lower-limb prostheses, Miller et al. showed that failure to use the prosthesis in the 12 months following amputation has an impact of over 25% on the healthcare costs associated with the individual [45]. However, the impact is also present in the upper limb, where non-use of the prosthesis leads to bodily changes that would result in additional costs for prosthetic production, further discouraging its use [46].

Henao et al. [47] highlighted that aspects such as comfort, weight reduction, and intuitive control are among the top priorities for end-users and should therefore also become key features for prosthetic design. To reduce rejection rates, prosthetic systems must be designed to meet the user's needs, fulfilling the requirements of weight, comfort, and functionality. In fact, users who perceive a significant improvement in quality of life (QoL) thanks to the use of prosthetics are less likely to abandon them [48]. Prosthetic device selection is crucial since it must be chosen to fulfil user requirements, without creating a discrepancy between prosthetic functionality and user expectations [49,50].

Physical discomfort, a lack of perceived functional benefit, and maintenance requirements, as well as psychosocial factors and external barriers such as cost and limited insurance coverage, are typically responsible for prosthetic rejection.

This review aims to identify and discuss key factors that lead to prosthetic abandonment, analyzing them by prosthesis type. It examines both technical aspects of prosthetics and psychological factors influencing device acceptance and long-term use, including motivation, cognition, and behavior. The goal is to provide a comprehensive, evidence-based perspective that can guide future upper limb prosthetic design and clinical strategies to reduce prosthetic abandonment. This narrative review includes articles found through a non-systematic search on Google Scholar, PubMed, and Scopus. An initial search of the literature was conducted using the research query "("Prostheses" or "Prosthetics") and "upper limb" and ("rejection" or "abandonment")", which was then expanded without following a systematic approach. The selection was based on relevance to the review's topics (technological and psychosocial), without applying formal inclusion/exclusion criteria or systematic screening.

2. Technological Challenges: Upper Limb Prosthetic Devices

The evolution of upper limb prostheses has led to the availability of a wide range of devices that differ in technical characteristics, functional purposes, and degree of user interaction. Upper limb prostheses are mainly divided into two categories: passive and active. Passive and cosmetic devices have purely aesthetic functions or are designed to perform straightforward tasks [51]. Active prostheses are further divided into body-powered, which utilize the motion of the residual limb, and battery-powered, which can be controlled via surface electromyography [37,52]. The use of increasingly innovative materials and technological advancements, combined with microcontroller-based boards, provides ever-improving prosthetic control [53,54]. Emerging technologies, including osseointegration and implantable electrodes, offer improved control, stability, and sensory feedback [55], while neural interfaces are being developed to achieve bidirectional communication with the nervous system [56]. While these innovations improve mechanical control and sensory feedback, prosthesis adoption also depends on psychological and perceptual aspects. One of the critical factors in user satisfaction, and thus acceptance, is the recognition of the device as an extension of one's own body [57] and this can also depend on the type of prosthesis chosen. This section presents an analysis of the main characteristics, advantages, and limitations of each kind of prosthetic typology. A graphical representation of the main prosthetic devices is shown in Figure 1.

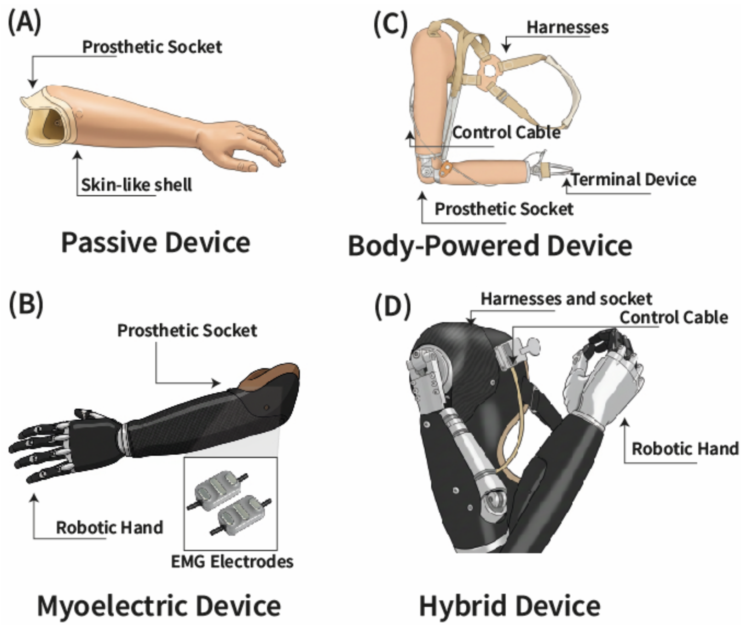

Figure 1. Main upper limb prosthetic devices. (**A**) Passive devices. (**B**) Myoelectric devices. (**C**) Body-powered devices. (**D**) Hybrid devices.

A summary of the advantages and disadvantages of each prosthetic technology is shown in Figure 2.

	Advantages	Disadvantages
Passive Prosthesis	Faithfully reproduce the appearance of the natural limb, improving body image and reducing unwanted attention, as well as providing psychological benefits and restore the ability to perform bimanual tasks for people with unilateral amputations.	Thermal discomfort during use, glove wear, excessive weight, damage to clothing, and irritation from straps. Passive prostheses range from fixed devices to systems that allow for locking in different positions or spring activation in response to contact with objects.
Body-powered Prosthesis	Reduced weight, greater robustness, resistance to adverse environmental conditions, the provision of proprioceptive feedback and a lower initial and maintenance costs in respect to their electrical counterparts and improved visibility of objects during manipulation.	Slow movement, difficult maintenance, insufficient grip strength, and the high energy expenditure required. The design of the hook, cable and harnesses can be aesthetically unappealing.
Electrically Powered Prosthesis	More powerful grip, adjustable speed proportional to muscle contraction, the ability to control two components simultaneously, and an advanced anthropomorphic appearance.	High costs, battery maintenance, greater weight, and sensitivity to environmental conditions such as dust or humidity (recently, waterproofing and more robust materials are used).
Myoelectric Prosthesis	Can perform a power grip or pinch, but also separate finger movements thanks to the several motors, resulting in a higher number of gestures. Significant advantage in term of cosmesis, grip strength, and range of motion.	Expensive, heavy, and difficult to control because of the reliability of the EMG signal. Control is not intuitive and requires extensive training. Control algorithms are sensitive to electrode placement, which reduces their reliability in daily use. Purchase is not always guaranteed by the national public service, thus making them accessible only to the wealthiest.
Hybrid Prosthesis	Simultaneous control of multiple components, lower weight than fully powered prostheses, and greater grip strength than purely mechanical ones.	The body-powered elbow still requires the use of harnesses or gravity, reducing the fluidity of movement. Requires a high level of customisation to suit the patient, thus leading to extremely high costs.

Figure 2. Summary of the advantages and disadvantages of each prosthetic technology.

2.1. Passive Prostheses

Passive prostheses are primarily designed to restore the length and appearance of the limb, allowing for stabilization or transport of objects in an ipsilateral or bilateral manner [52]. They are characterized by their simple construction, lightweight design, and minimal maintenance requirements. However, they offer limited functionality, especially in terms of active grasping [58].

These devices can be static, i.e., with no moving parts, or positional, i.e., with passive movable fingers. Because they do not generate an active grasp, the ability to manipulate objects depends entirely on the user's adaptation, with a relative advantage for positional prostheses over static ones [51,53]. Passive prostheses can be designed to faithfully reproduce the appearance of the natural limb, improving body image and reducing unwanted attention, as well as providing psychological benefits [52,54]. Among the main limitations reported by users are thermal discomfort during use, glove wear, excessive weight, damage to clothing, and irritation from straps [58,59]. Passive prostheses range from fixed devices to systems that allow for locking in different positions or spring activation in response to contact with objects [30,35]. Another functional advantage of cosmetic prostheses is that, although they may not be actively prehensile, they restore the ability to perform bimanual tasks for people with unilateral amputations [60].

In cases of wrist amputation, functional aesthetic prostheses can be used to hold objects by placing them in one hand or wedging them between the prosthesis and the wearer's torso [61]. Aesthetic restoration in the case of a trans-humeral amputation involves an elbow that can be locked at various degrees of flexion to allow people to perform a gesture such as hanging up a bag [62].

2.2. Body-Powered Prostheses

Body-powered (BP) prostheses consist of mechanical systems based on cables and straps that allow movement control through the shoulders and other residual joints [56]. Compared to alternatives, they offer several advantages—reduced weight, greater robustness, resistance to adverse environmental conditions, the provision of proprioceptive feedback and lower initial and maintenance costs—with respect to their electrical counterparts [52].

Control occurs through the movement of the shoulder, which sequentially activates the elbow, wrist, and terminal device (TD) [63]. To switch between different functions, the user must lock the joints with switches or through the movement of specific locking cables [56]. Their modularity allows for the assembly of both hands and different types of hooks. Body-powered hooks are often chosen for their lightness, functionality, and improved visibility of objects during manipulation [35].

Since the remaining limb is mechanically connected to the prosthesis, the user receives information about the prosthesis's state through the same physiological pathways used to activate it [64,65]. The resulting sensation of extended physiological proprioception in the prosthetic limb [66] may minimize the conscious attention required to control the prosthesis [67]. Despite their advantages, these prostheses present some critical issues, such as harnesses that can be restrictive and uncomfortable. Although the first information about and examples of BP prostheses can be dated to around 1812 [68], the design priorities and requirements of users still seem to have remained consistent over the past decades, with the main concerns being about harness discomfort and control [69,70].

Furthermore, the design of the hooks, cables, and harnesses can be aesthetically unappealing [52]. Rejection is typically related to slow movement, difficult maintenance, insufficient grip strength, and the high energy expenditure required. Acceptance of these devices depends heavily on the type of TD [63].

Some studies suggest that rejection of BP systems with a TD hand can reach 80–87% [10,71]. However, according to Biddis et al. [72], the rejection rate was about 50% among BP prosthesis users compared to 39% among myoelectric and hybrid system users. A similar result was found by McFarland et al. [71]. The authors reported that 40% of surveyed amputee veterans who used a body-powered system rejected the prosthesis.

2.3. Electrically Powered Prostheses

Electrically powered prosthetic devices use motors controlled by rechargeable batteries [52]. Control is mainly exerted via electromyographic (EMG) signals; however, other inputs, such as inertial measurement units (IMUs), can also be used [73]. These devices offer advantages such as a more powerful grip, adjustable speed proportional to muscle contraction, the ability to control two components simultaneously, and an advanced anthropomorphic appearance [52]. However, they have disadvantages related to high costs, battery maintenance, their greater weight, and their sensitivity to environmental conditions such as dust or humidity. Recent advances, such as waterproofing and robust materials, have mitigated some of these limitations [74].

Powered prosthetics are often considered a more modern and functional alternative to body-powered prosthetics, offering greater aesthetics, durability, and ease of use, as well as the absence of harnesses [35].

2.4. Myoelectric Prostheses

Myoelectric prostheses have been available since the late 1960s [75] and are nowadays the most common kind of active prosthesis. These devices use EMG signals generated by residual muscles to control movements [56]. Control occurs through the recording and decoding of the electrical activity of two or more separate muscles [76]. Muscle recording is typically performed using surface electrodes employing control algorithms based on different levels of muscle contractions [77] or monitoring antagonist muscles [78]. However, superficial electromyography (sEMG) is highly susceptible to motion artifacts and electromagnetic interference, which can significantly reduce control reliability [79,80]. Recent studies have highlighted the potential of implantable electrodes to enhance signal stability and improve prosthetic control [81–85]; however, no extensive clinical validation has yet been provided.

Although conventional myoelectric prostheses have a single motor that controls fingers, allowing them to perform a power grip or pinch, the most modern devices, known as multigrip prostheses, have several motors, allowing them to perform separate finger movements and resulting in a higher number of gestures [52,55,86,87].

Myoelectric prostheses offer significant advantages in terms of cosmesis, grip strength, and range of motion [88], but remain expensive, heavy, and difficult to control [58,89]. Despite advances, control interfaces still face major challenges because of the reliability of the EMG signal. Additionally, myoelectric prosthesis control is not intuitive for users and requires extensive training [90]. Control algorithms are sensitive to electrode placement and are susceptible to interference, which reduces their reliability in daily use [35]. These limitations lead to high abandonment rates, especially among unilateral amputees, who often prefer to rely on their healthy contralateral limb [35]. Moreover, their cost is still extremely high, and their purchase is not always guaranteed by the national public service, thus making them accessible only to the wealthiest [71].

2.5. Hybrid Prostheses

Hybrid prostheses combine two systems—typically a body-powered elbow and a powered hand or wrist—and this is especially true in cases of above-the-elbow amputation [52]. This approach allows for simultaneous control of multiple components, a lower weight than fully powered prostheses, and greater grip strength than purely mechanical ones [91]. However, the body-powered elbow still requires the use of harnesses or gravity, reducing the fluidity of movement [56]. The creation of a hybrid prosthesis requires a high level of customization to suit the amputee's clinical condition, thus leading to extremely high costs [92,93].

3. Prosthesis Abandonment: Main Factors

Alongside technological limitations, it must be considered that prosthetic abandonment is influenced by factors related to the individual and psychosocial sphere, with body image, self-efficacy, social support, quality of clinical communication, expectations regarding use, and perceived comfort all playing decisive roles [94].

Although upper limb prostheses are used to facilitate daily activities, for people who have undergone upper limb amputation, even the best commercially available prostheses cannot reproduce the sensation of their own arm, both in functional and sensory aspects [53,95]. What is important to make clear from the outset to anyone receiving a prosthesis is that the device itself will not restore the same abilities they had before the amputation, nor will it transform them into bionic people with extraordinary abilities [53]. The use of prostheses is notoriously challenging for activities of daily living. From cosmetic hands to body-powered hooks to externally powered devices, prosthetic design strives to meet the different needs and desires of people with upper limb loss [96].

The high variability in abandonment rates among the same population of upper limb prosthesis users makes it difficult to gain a holistic understanding of why people choose to abandon their prosthetic devices [58,96]. Below, we attempt to summarize the main reasons reported in the literature regarding prosthetic abandonment, from both technological and social perspectives.

The level and severity of the amputation strongly influence the degree of prosthetic satisfaction and abandonment [95]. Cordella et al. [97] and Brack et al. [92] deeply investigated the association between technology and level of amputation. Analyzing and collecting information from past reviews and the literature, we identified some recurring motivations, as shown in Table 1 and Figure 3.

Table 1. Table of articles from 1993 to 2025 used to evaluate the main reasons for prosthetic abandonment.

Author and Date	Country of Study	Main Aim of the Study	Data Collection	Participant Demographics	Type of Prosthetic Device	Critical Issues and Reasons for Abandonment
Kejlaa [98] (1993)	Denmark	To assess users' concerns about their prostheses and whether these have contributed to prosthesis abandonment	Cross-sectional survey study	66 Subjects (Mean age 45.1 yr. Range 4–86 yr.)	Passive Body-powered Myoelectric	-Skin irritation -Damaged clothing -Not durable -Aesthetics -Difficult to use -Slow response time -Difficult to control -Prosthetic device failure -Weight -Temperature
Silcox et al. [99] (1993)	USA	To examine the acceptance and use of prosthetics by those who own both myoelectric and other types of prosthetics	Cross-sectional survey study	44 Subjects (Mean age 38 yr. Range 6–69 yr.)	Myoelectric	-Weight -Slow to respond and use -Durability -Discomfort
Wright et al. [26] (1995)	USA	To evaluate patterns of upper limb prosthesis use	Medical record review and cross-sectional survey study	135 Subjects (Mean age 36 yr. Range 2–76 yr.)	Unspecified	-Limited functional benefit -Weight -Socket Discomfort
Atkins [100] (1996)	USA	Users' perceptions of devices in terms of cost, maintenance and improvements in body-powered and electric devices	Multiple surveys (postal)	1575 Subjects (Mean age 45 yr. 890 Adults, 685 < 18 yr.)	Body-powered Electric	-Wrist motion -Increased reliance on visual attention -Harness comfort -Durability -Reliability
Biddis et al. [72] (2007)	Canada	To measure user's satisfaction with upper limb prosthesis	Cross-sectional study	242 Subjects (Mean age 30 yr. Range 1–80 yr. from Different Countries)	Passive Body-powered Myoelectric	-Temperature -Perspiration -Durability -Harness comfort -Lack of sensory feedback -Poor dexterity -Weight -Perspiration
Biddiss and Chau [96] (2007)	Canada	To investigate the needs and resources required that lead to the use and/or abandonment of prostheses.	Cross-sectional survey study	242 Subjects (Mean age 30 yr. Range 1–80 yr. from Different Countries)	Unspecified	-Personal factors -Discomfort -Weight -Temperature -Perspiration -Lack of sensory feedback -Dissatisfaction with technology -Lack of functionality
Biddiss and Chau [25] (2007)	Canada	Review of upper limb prosthesis use and abandonment	Literature review	Literature review (1–80 yr. from Different Countries)	Unspecified	-Lack of established need given their lifestyle -Lack of information, training and follow-up -Personal factors
McFarland et al. [71] (2010)	USA	To investigate prosthetic use and satisfaction in veterans with unilateral upper limb loss	Cross-sectional survey study	97 Veterans from Vietnam and OIF/OEF conflicts (Mean age 45 yr.)	Passive Body-powered Myoelectric	-Lack of functionality -Weight -Pain -Poor fit -Durability -Difficult to control -Discomfort
Østlie et al. [101] (2012)	Norway	To estimate prosthesis rejection rates and describe the most frequent causes, as well as the contextual factors influencing prosthetic rejection.	Cross-sectional survey study	224 Subjects (Mean age 53.7 yr.)	Myoelectric Unspecified	-Weight -Socket fit -Perspiration -Skin irritation -Functionality -Weak grip -Wrist motion -Slow response speed -Difficult to use -Mismatch between needs and available technology -Insufficient training and information

Table 1. *Cont.*

Author and Date	Country of Study	Main Aim of the Study	Data Collection	Participant Demographics	Type of Prosthetic Device	Critical Issues and Reasons for Abandonment
Carey at al. [35] (2017)	USA	Review to determine the differences between myoelectric and body-powered prostheses, to inform clinical practice in user training.	Literature review	Adults, Mean age 43.3 yr. Different Countries and population	Body-powered Myoelectric	-Slower movement -Poor grasp force -Increased mass and energy expense for operation -Temperature, -Durability -Reliability -Increased reliance on visual attention -Lack of functionality -Weight -Discomfort
Resnik et al. [16] (2019)	USA	To provide data on the function, needs, preferences, and satisfaction of veterans with upper limb amputations	Cross-sectional survey study	808 War Veterans (Mean age 63.3 yr.)	Body-powered Hybrid Myoelectric	-Weight -General discomfort -Poor fit -Lack of functionality -Difficult to use -Durability -Aesthetics
Al-Owaidi et al. [102] (2024)	Spain	To highlight control issues related to myoelectric prosthetic hands.	Cross-sectional survey study	Literature review Age Not Specified	Myoelectric	-Dissatisfaction with technology -Socket discomfort and skin irritation -Cost -Lack of information, training and follow-up -Lack of psychological support
Resnik et al. [103] (2024)	USA	Compare rates of out-of-pocket prosthesis-related payments and evaluate the impact of affordability on prosthesis non-use.	Telephone survey	727 Subjects; 76% Veterans and 24% non-Veterans	Unspecified	-Excessive cost of the device and its maintenance
Henao et al. [47] (2025)	USA	To define the design requirements of prosthetics from the perspective of healthcare professionals, end-users and close relatives	Semi structured interviews	11 healthcare providers 10 users with unilateral upper limb amputation 10 close relatives (Adults > 20 yr.)	Unspecified	-Dissatisfaction with technology -Lack of information, training and follow-up

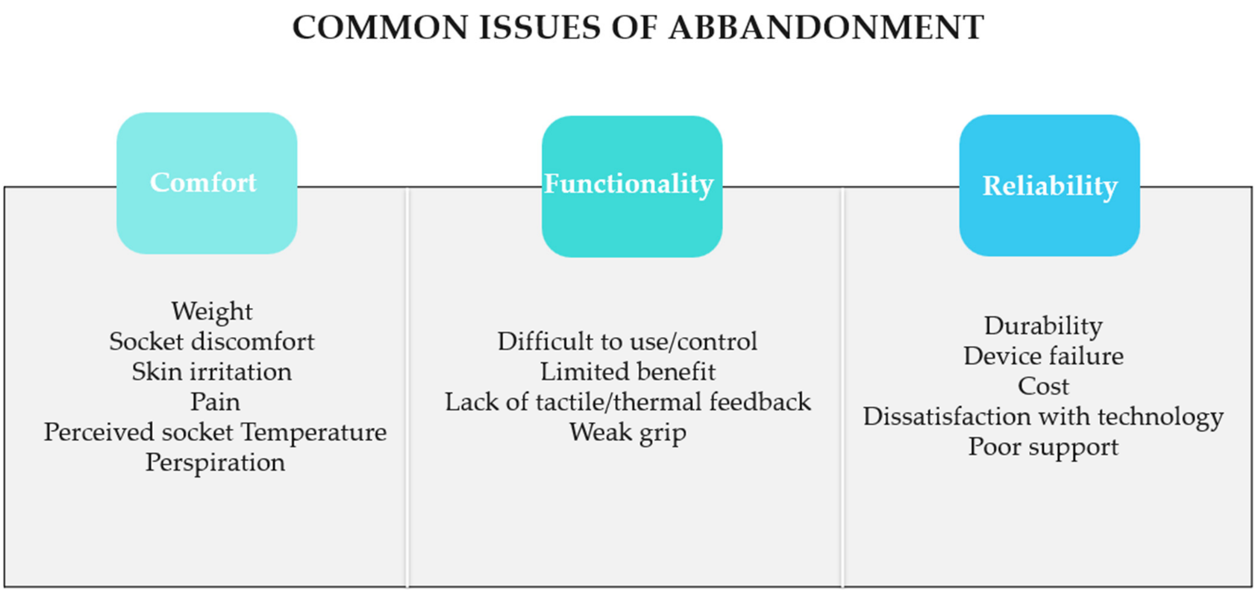

Figure 3. Most common critical factors related to comfort, functionality, and reliability that cause prosthetic abandonment.

Since the initial study on prosthetic abandonment by Atkins et al. in 1996 [100], comfort and functionality were identified as major causes. Although numerous technological advances have occurred in the meantime, prosthetic abandonment rates appear to have remained unchanged over the past 20 years, suggesting that these reasons remain valid and relevant today [8,44,102]. Similarly, the case study approached by Schaffalitzky et al. [104], which included two upper limb amputees, found that both used body-powered devices and both preferred function over cosmetics.

Several studies identified the discrepancy between user needs and device performance as a major reason for dissatisfaction and abandonment [95,105–107]. Even if some studies highlighted the importance of aesthetics [92,98,108–111], comfort, functionality, and reliability are the most important features required by the user [112], especially for BP and myoelectric devices [26,60,72,96,98,99,101,113,114]. Figure 3 summarizes the main abandonment reasons divided into the categories of comfort, functionality and reliability. These three categories represent not only critical factors but also lead to prosthetic rejection and abandonment.

Prosthetic comfort is a priority for users. Amputees' feedback regarding comfort mainly focuses on the characteristics of the prosthetic socket and the weight of the prosthesis [96,98,114]. Users have often complained about prosthetic sockets that are not soft enough and not sufficiently customized to the residual limb [115], as well as prostheses that are excessively heavy [35].

Lack of functionality remains a cross-generational issue, and it has been reported in numerous studies on prosthetic abandonment and rejection since 1996 [100]. Commercial prosthetic devices still do not adequately represent the complexity of hand gestures, and limitations in wrist and elbow control are among the main shortcomings that users note. Additionally, there are critical concerns about prosthesis reliability [89]. There are also other critical aspects relating to the reliability of the prosthesis. BP prosthesis users often report that mechanical parts like belts have limited durability and tend to wear out [16,98]. Meanwhile, myoelectric prostheses frequently fail to operate correctly throughout the day due to battery life issues [16,47,99,102,114] and deterioration of the muscle–electrode interface, which impacts control quality. If electrodes are not properly interfaced with the residual limb, users may experience increased uncertainty in controlling the prosthesis [89], and unintended activations further diminish their sense of control [67]. Users of body-powered prostheses tend to experience less uncertainty because of the direct mechanical connection between the harness and the terminal device [67]. It is essential to highlight that operating these devices is often not straightforward [16,98,114], and users need to go through extensive training and rehabilitation sessions to reach a reasonable level of proficiency with the prosthesis [90,116,117]. A lack of proper support from rehabilitation specialists or poor user participation in rehabilitation can pose major challenges, leading to dissatisfaction and the abandonment of the prosthesis [25,96,101]. Cain et al. [118] identified critical boundaries in the individual journey after limb loss, revealing inequities, including inadequate assistance, delays in prosthetic delivery (over 10 months), and financial barriers. Resnik et al. [103] conducted a study involving 727 upper limb amputees, showing that 20% of those who ever used a prosthesis paid out-of-pocket costs, while up to 25% of individuals who never used a prosthesis or abandoned it reported being unable to repair or afford the prosthetic device. Even in countries with national coverage systems, there is no guarantee that the national health system will cover the costs of the most modern and sophisticated devices [119]. In medical insurance-based states such as the USA, access to prosthetic devices depends on the rules of the health insurance company, which often do not cover all types of prosthetic terminals, including microprocessor-based prostheses [118], thus limiting the opportunity of amputees to try several types of sockets, harnesses, prostheses, and terminal devices before choosing their permanent device, as should ideally happen [120].

If an individual's prosthetic rehabilitation plan is designed to facilitate realistic goals and a prosthesis enables them to achieve those goals, rejection should only occur when their goals have changed. Failure to state those goals or define them correctly is therefore a direct path to rejection of the prosthesis. Furthermore, the role of occupational therapy cannot be overstated when it comes to upper limb prosthetic rehabilitation [53].

Prosthetic acceptance and satisfaction are strictly related to user expectations. With respect to other technologies, myoelectric devices are advertized as being able to restore users' functionality, and, obviously, expectations regarding functionality are higher. These higher expectations may give users an additional reason to feel disappointed with the current state of technology [58]. From a technological perspective, it is essential to meet the needs related to control and communication with the prosthesis. Adopting a prosthesis represents an attempt to restore these functions; however, approximately 21% of adults with upper limb amputations abandon their use, believing the available devices are insufficient to meet their needs [72]. One of the main critical issues is the lack of sensory feedback, which is recognized as a determining factor in abandoning their use [25].

Recent advances in science and technology have led to promising methods for accessing neural information for communication or control [56,121,122]. Researchers have explored invasive [47,83,115–117,123–126] and non-invasive methods [114,127–133] of connecting with muscles, nerves, or the brain to provide greater functionality to patients suffering from diseases or injuries [134], including amputation [135]. These techniques offer hope for more natural and intuitive prosthetic control, and thus a better quality of life [56,135].

According to Engdahl et al. [136,137] and Zheng, J.Y et al. [138], amputees are mostly interested in improving the dexterity and durability of prosthetic options.

To achieve these goals, they are willing to consider using invasive and non-invasive neural interfaces; however, they show some reluctance toward brain implants. Advanced neural interfaces capable of enabling bidirectional communication between prostheses and subjects using sensory feedback have been shown to improve agency, embodiment and dexterity [134,139]. Embodiment refers to the way our physical bodies, including our senses and perceptions, understand and interact with the world, while agency, on the other hand, is the capacity of an individual to act and exert control over their actions and environment [140–143]. Sensory feedback contributes directly to the modulation of both these dimensions, closing the sensorimotor circuit and allowing alignment between motor intention, execution, and perception [144]. In addition to improving motor control, sensory feedback promotes greater embodiment, or the perception of the prosthesis as an integral part of one's body, with positive effects on phantom limb pain (PLP) [145].

Conventional prostheses offer mobility and mechanical functionality; however, they do not restore the natural sensory experience of the hand. The absence of such feedback forces users of myoelectric prostheses to rely primarily on visual and auditory input, resulting in deficits in grip force control and object property discrimination [146].

The lack of physiological feedback from the remaining limb prevents the prosthesis from being properly integrated into body perception [17]. This leads to low prosthesis embodiment [147] and increases cognitive effort during device use [148], which affects acceptability and ultimately reduces user confidence in the prosthesis [149]. In users of myoelectric prostheses, when they have difficulty perceiving control over their prosthesis, it is possible that they are not receiving adequate sensory feedback to compare with the expected result of their movement [67].

It has also been shown that sensory feedback restoration has an impact on the duration of prosthesis use in everyday life [150]. The lack of proper sensory feedback in prosthetic devices is therefore responsible for an increase in the abandonment rate of these devices, preventing the full reintegration of prosthesis users into society [17].

Another interesting aspect to observe is shown in Figure 4. Some causes of prosthetic abandonment have remained almost unchanged over time, such as the weight of prosthetics, while others have changed with the advancement of technology. In the past, more attention was paid to factors such as aesthetics and the difficulty of using prosthetics, whereas today there is greater dissatisfaction linked to the high expectations people have of technology.

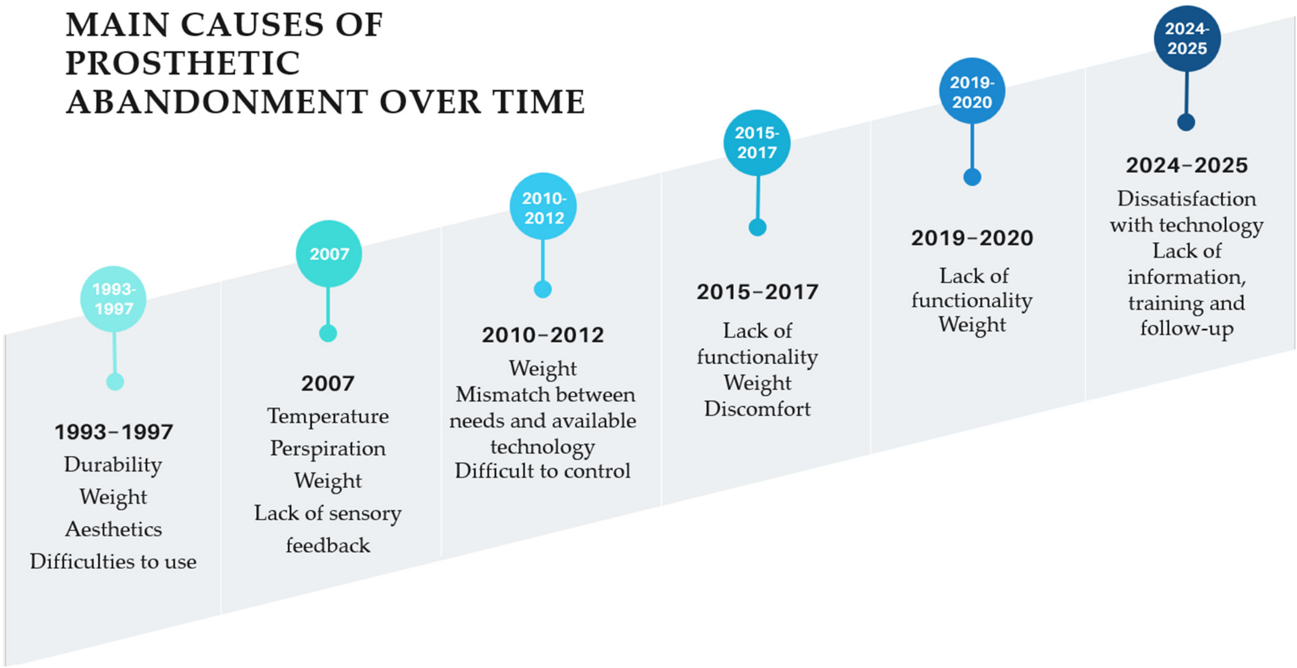

Figure 4. The figure shows the main reasons for prosthetic abandonment and how they have changed over the last thirty-two years. From 1993 to today, users' needs have changed: back in the day, even if aesthetics played an important role in prosthetic acceptance, people prioritized comfort and functionality.

Psychological and Social Implications of Wearing a Prosthesis

Losing a limb involves coping with significant physical change, which can sometimes be painful. This change is not limited to adapting to the use of a prosthesis, but also involves psychosocial upheaval, including alterations in body image and lifestyle, as well as self-concept [36].

The loss of a limb greatly impacts a person's independence and ability to perform daily activities, both at work and in social situations. The loss of a hand in particular means losing a vital tool for perceiving and interacting with the environment, as well as a key means of physical and social connection with others. The hand is fundamental in social interactions, establishing the boundaries between what belongs to oneself and the surrounding environment. Its loss can be perceived as devastating, as it affects one's level of autonomy, limiting one's ability to perform work, social, and daily life activities [97].

These factors represent a source of stress that tests individuals' ability to maintain emotional well-being and, over time, can lead to poor psychosocial adjustment [151]. Often, cases of depression have been observed in people suffering from limb loss, with a statistical incidence more than three times that of the general population [29,36,152–154].

However, there are considerable differences between individuals in the literature: some manage to adapt easily to their new condition, while others experience clinically significant psychological or social problems [155–158].

Numerous factors can contribute to psychosocial adaptation to the new physical condition [159,160]. Emotional responses after amputation vary significantly from patient to patient, influenced by a range of factors, including the reason for the amputation, personal life circumstances, social and historical context, the severity of the disease, and how the patient interprets their symptoms [161–163]. Patients who have amputations due to painful vascular disorders may feel relieved, as do those who undergo amputation to treat bone cancer. On the other hand, patients who experience trauma react differently and struggle with uncertainty about their future. The sooner a prosthesis is fitted, the less severe the associated psychological issues tend to be [39,164]. A fundamental role is attributed to the coping strategies that individuals adopt to manage the experience of severe stress associated with amputation [162,165]. Coping mechanisms and strategies influence body image and self-concept, as well as contributing to the nature and timing of the process of adjustment to loss and disability [166,167]. Therefore, the potential to promote favorable coping strategies represents a key pathway to preventing adjustment problems.

Active/task-oriented strategies, such as problem solving and perception of control over disability, promote positive psychosocial adjustment [162,168], while negative emotions and thoughts, such as cognitive disengagement and catastrophizing, have been associated with poor outcomes [162,169]. Greater problem-solving ability leads to faster adaptation and acceptance of disability. Contrary to this, coping focused on negative emotions is associated with depression, hostility, and a lack of acceptance of disability [36,162].

The complexity and diversity of the functions performed by the upper limbs and their importance in communication and self-presentation pose significant and distinct challenges for rehabilitation and prosthetic restoration [36]. No upper limb prosthesis will ever fully replace the myriad functions of the arm and hand. People who have recently undergone amputation often feel uncomfortable in social situations because they struggle to incorporate their new physical appearance into their self-image. The experience and perceptions of wearing an upper limb prosthesis, therefore, focus on the image that the subject has of themselves and on the use of the device in social contexts, considering its aesthetic and functional aspects. Prosthesis wearers must learn to modify their body posture, learning to "carry" the limb to facilitate a normal appearance [62]. The use of prostheses helps many individuals conceal what they consider to be differences, as wearing the device makes them feel more "normal" than they would have without it, and this also moderates other people's reactions [113]. Providing cosmetic restoration for a finger or a complete arm will allow them to live under the illusion that they have not suffered such damage, restoring a normal appearance [151]. The use of cosmetic prostheses improves self-image perception, reducing cases of depression and improving user confidence, facilitating social engagement [170]. The study conducted by Gaine et al. found that most users employed different types of prostheses depending on the occasion, with aesthetic and myoelectric prostheses being preferred for social outings [37]. According to Lee et al., if the user is satisfied with the aesthetic appearance of their prosthesis, they will be more involved in its use [171].

Together with the aesthetic factor, there are other ways to increase feelings of embodiment; one of these is certainly sports practice. Sport is a powerful tool for amputated people to embrace prosthetics, promoting not only the integration of the aid into their body image, but also their psychophysical well-being and social participation, helping to rebuild confidence, autonomy, and a sense of belonging. Laferrier et al. emphasize how sport, exercise, and recreation (SER) following an amputation can improve quality of life [172]. A combination of these three not only prevents cardiovascular disease, obesity, diabetes, and chronic pain, but also has beneficial effects on depression and increased self-esteem. Practicing a sport can help with the embodiment of the prosthesis. Sport allows you to see concrete results, such as improved performance, which also increases motivation to use the prosthesis. Today, the opportunity to see highly visible sporting events, such as the Paralympic Games or the Cybathlon, combats prejudice and normalizes the presence and use of prostheses in society. Earley et al. observed that the agonistic motivation for participating in a sporting challenge, such as Cybathlon, increased the number of hours of prosthetic use at home by approximately 66% [173]. Sport allows people to socialize and promotes positive coping strategies, counteracting social isolation and promoting inclusion [172,174].

4. Discussion

The information collected in this literature review suggests that upper limb prosthesis abandonment is the result of a complex interplay between technological limitations, psychosocial adjustment issues, and contextual barriers, rather than being solely attributed to one cause.

While significant progress has been made in materials, control algorithms, osseointegration, and neural interfaces, ongoing challenges remain. Users often encounter problems like excessive weight, socket discomfort, mechanical fragility, and unreliable control, as noted in early studies [58,175].

Additionally, limited energy efficiency can cause rapid battery drain in some devices, restricting their practical use. These technical issues collectively reduce daily performance and impact embodiment. Myoelectric systems offer improved functionality and a more lifelike appearance but are still especially vulnerable to rejection. Factors such as a steep learning curve, sensitivity of surface electrodes, limited battery life, and a lack of intuitive sensory feedback often discourage prolonged use [176], particularly among unilateral amputees who may prefer using only their intact limb.

Control is among the most critical issues in this type of prosthesis. The control chain of a myoelectric prosthesis is based on three key aspects: the generation of the electromyographic signal, the ability to acquire the electromyographic signal, and finally, the ability of the terminal to respond to the command [177]. No matter how good the signal generation is, if the interface between the electrodes and the skin fails to provide accurate and reliable signal transfer, the user will struggle to control the device. If the socket is too loose, the arm may move within it, causing electrodes to lose contact with the skin. This can result in signal artifacts or failure to activate the hand [177,178]. Furthermore, the skin–electrode interface varies throughout the day because of socket fit issues, which can be worsened by sweat, rain, or humidity [179,180]. Below the socket, changes in arm posture during muscle contraction may lead to alteration of the EMG features [181,182]. Due to this alteration, a sensor can receive different signals for the same intended movement, leading to unpredictable movement in the terminal device [177].

These findings highlight the urgent need for device-specific improvements to lower abandonment rates and increase user satisfaction. For myoelectric prostheses, greater attention must be paid to the design of the socket and the optimization of the electrode–skin interface in order to ensure durability and reliability throughout the day. Recently, epidermal electronics have demonstrated the ability, in controlled environments, to enable both the acquisition of biopotentials [183–186] and electrical stimulation for sensory feedback [187] through the use of tattoo technology, which, thanks to its mechanical properties, can optimize adhesion to the skin and maximize the contact surface [188,189].

Although tattoo electrodes represent an interesting technological solution, their use in real-world conditions still needs to be demonstrated.

For BP prostheses, design priorities should be moved towards the fulfilment of user requirements, prioritizing and investigating new design approaches and solutions capable of reducing the number of harnesses and facilitating control. Particular attention should be given to innovative designs, such as the "Self-Grasping Hand" [190–192], which represents a passive hand with a grasping mechanism. Another option is the "Wilmer Elbow Control,' a harness-free, elbow-controlled body-powered prosthesis that uses the elbow's flexion and extension movements as control inputs instead of a traditional harness [193]. Finally, the Breathing-Powered UL prosthesis proposed by Nagaraja et al. [194,195] may overcome some of the limitations of current BP technology in cabled systems, including limited operational space and user discomfort from the harness to which the cables are affixed.

A recurring theme in the literature is the gap between users' expectations and the actual performance of commercial devices. Marketing and popular media often exaggerate the capabilities of advanced bionic hands, creating unrealistic expectations of full "restoration" [196]. When real-world control or sensory feedback falls short, users may become frustrated and eventually abandon the device [197].

Study Limitations and Future Directions

Although this work focused on reviewing the most relevant literature on prosthetic abandonment from technological and psychological perspectives, it is important to highlight some limitations of this study. The research was conducted using the main search platforms (Google Scholar, PubMed, and Scopus) without a systematic approach in selecting the inclusion and exclusion criteria. This may have introduced a bias in the definition of the main factors influencing prosthesis abandonment, favoring certain aspects over others. Nonetheless, we believe this work represents a significant step in identifying key psychological and technological factors related to prosthetic abandonment. Many of these aspects will require further analysis to establish guidelines that connect them to cultural and socio-economic contexts. In this work, the technological and psychological aspects of prosthetic abandonment have been examined from a global perspective, without emphasizing the national context and, therefore, socio-cultural factors. We believe that future studies need to analyze in more detail how the factors identified in this work change and evolve from one country to another, depending on different national healthcare systems.

The resolution of the problem of prosthetic abandonment requires a complex effort involving legislative bodies, orthotics and prosthetics specialists, rehabilitation personnel, and engineers. As seen throughout this article, while from a technological perspective the issue of abandonment is related to functional problems, comfort, or reliability, the causes of abandonment can also stem from psychological and social aspects. Social inequality can disadvantage certain groups, who may not receive the appropriate psychological support before and after amputation, thereby delaying the process of psychological acceptance and adaptation. Poor healthcare coverage may also fail to ensure the pursuit of the best prosthetic device. It is essential to develop new patient-centered care models, ensuring that the entire "prosthetic journey" meets the patient's needs, as stated by Cain et al. [118].

Several technological priorities have emerged as critical in improving upper limb prostheses. The prosthetic socket represents the most critical part. Improving fitting and reducing the weight of prostheses must be a priority for designers. New materials should be explored, and 3D printing technology should be investigated further to reduce costs and enhance prosthetic personalization. The use of anchored-bone prostheses should be widespread due to their better weight distribution [198].

Then, improving functionality through a new human–machine interface is the next cross-technological challenge. As explained before, improving functionality is a priority for users who are inclined to use a neural implant to enhance dexterity and gain more natural control of the device. It is necessary to develop new neural interfaces and surgical implantation procedures to scale up the devices currently observed in academic research, which have already demonstrated the potential to improve dexterity and prosthetic use [55,56,82,121,122,151,176,199]. It is also necessary to develop new paradigms for acquiring muscle and neural biopotentials, as well as ensuring bidirectional communication with the nervous system [200,201]. Delivering tactile and proprioceptive cues through peripheral or non-invasive stimulation has shown promise for improving grasp control, sense of agency, and relief from phantom limb pain, ultimately supporting longer and more confident device use. It is essential to focus research on the development of devices that can restore somatotopic tactile and thermal sensations using both invasive and non-invasive approaches [202–204].

Equally important are the social and psychological factors. Amputation has a profound impact on identity, body image, and social roles [205,206]. Poor embodiment, social stigma, or a lack of access to peer role models can undermine adherence, even when technology is adequate. Structured rehabilitation should map each psychosocial barrier to specific clinical disciplines, transforming broad recommendations into actionable pathways. For example, occupational therapy can facilitate daily living adaptations and routine integration; peer mentoring can offer social role models; and psychological counselling can support grief processing and self-concept development. This interdisciplinary approach promotes coordinated care and provides more holistic support for amputees. Addressing this gap requires not only ongoing technical innovation but also honest, transparent counselling during device prescription. Among the promising psychological support activities that may have an impact on the prosthesis acceptance rate, we can list the following: personalized goal setting and training, that could enable users to master functional tasks relevant to work, self-care, and leisure; psychological support and coping strategy development to address grief, altered self-concept, and fear of judgment; opportunities for sport, recreation, and community engagement, all of which have been shown to support prosthesis embodiment, enhance well-being, and reduce isolation; and inclusive funding and service policies to reduce inequities in access to high-performance devices and follow-up care.

Finally, research on prosthesis abandonment would benefit from greater methodological consistency. Many studies vary in definitions, outcome measures, and sampling methods, often overlooking individuals who choose not to use prostheses at all. Standardized protocols, combined with qualitative research into lived experiences, would yield a more nuanced understanding of success and failure. Effective strategies for addressing users' prosthetic needs require a comprehensive clinical assessment that offers a holistic view of the individual's symptoms, health, function, and environmental barriers and facilitators [207]. Recent initiatives include restructuring educational curricula for orthotics and prosthetics students [208,209] and providing prosthetists with interactive training in test administration [210]. Despite these efforts, the lack of standardized assessments in prosthetics and orthotics services persists in many developed countries [211–214]. To address this gap, Dupuis et al. [215] developed an innovative solution based on an online interactive platform for clinical assessment and follow-up. Dupuis and colleagues used a three-round electronic Delphi method, involving focus groups with prosthetists, prosthesis users, and decision-makers, to identify essential elements for assessing prosthetic services in lower-limb amputees. A total of 78 elements were identified as crucial for the evaluation of prosthetic service provision and classified into various domains, encompassing the acquisition of personal and medical data, contextual information pertaining to the environment, and technical aspects (including prosthetic components, usage, comfort, and user satisfaction), as well as the physical health status of the prosthesis recipient (pain and clinical evaluation, which includes mobility assessments both with and without the prosthesis).

Although the study has so far been conducted only in Canada, the potential of the framework proposed by Dupuis and colleagues should be investigated on a broader scale.

Incorporating continuous sensing technologies, such as wearable activity trackers or onboard usage logs, into standard protocols could provide objective adherence data across various contexts [216]. This approach would enhance methodological rigor and enable deeper insights into user behavior and device utilization.

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Abbreviations

The following abbreviations are used in this manuscript:

BP	Body-Powered
EMG	Electromyography
sEMG	Surface Electromyography
TD	Terminal Device
QoL	Quality of Life
PLP	Phantom Limb Pain
RHI	Rubber Hand Illusion
LD	Linear Dichroism
SER	Sport, Exercise, Recreation

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