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RESEARCH ARTICLE

Upper-Limb Prosthetics

Critical Factors in Device Abandonment

ABSTRACT

Biddiss E, Chau T: Upper-limb prosthetics: critical factors in device abandonment. Am J Phys Med Rehabil 2007;86:977–987.

Objective: To investigate the roles of predisposing characteristics, established need, and enabling resources in upper-limb prosthesis use and abandonment.

Design: A self-administered, anonymous survey was designed to explore these factors. The questionnaire was available online and in paper format and was distributed through healthcare providers, community support groups, and one prosthesis manufacturer. Two hundred forty-two participants of all ages and levels of upper-limb absence completed the survey.

Results: Of participants, 20% had abandoned prosthesis use. Predisposing factors, namely, origin of limb absence, gender, bilateral limb absence, and, most importantly, level of limb absence, proved influential in the decision not to wear prostheses. Enabling resources such as the availability of health care, cost, and quality of training did not weigh heavily on prosthesis rejection, with the exception of the fitting time frame and the involvement of clients in the prosthesis selection. Conversely, the state of available technology was a highly censured factor in abandonment, specifically in the areas of comfort and function. Perceived need emerged as a predominant factor in prosthesis use.

Conclusions: Future research should focus on continued development of more comfortable and functional prostheses, particularly for individuals with high-level or bilateral limb absence. Improved follow-up, repair, and information services, together with active involvement of clients in the selection of prostheses meeting their specific goals and needs, is recommended.

Key Words: Upper Extremity, Limb Prosthesis, Prosthesis Fitting, Prosthesis Design, Rehabilitation

From cosmetic hands, to body-powered hooks, to externally powered devices that flatter their natural counterpart in attempts of mimicry, prosthesis design endeavors to address the varying needs and desires of individuals with upper-limb absence. Nevertheless, an estimated 20% of individuals with upper-limb absence reportedly do not use prosthetic devices.[1] Nonuse may be a lifestyle choice based on personal needs, values, and perspectives.[2–6] It may result from medical conditions that preempt prosthesis fitting.[3,7–9] Or, nonuse may be a consequence of external factors such as limited insurance coverage or availability, and inadequate technology.[10,10–12] Defining reasons for prosthesis nonuse is pertinent to health professionals, researchers, and administrators involved in the care of individuals with upper-limb absence, the design of improved prosthetics, and the evaluation of clinical strategies.

In a recent review,[13] literature on the motivating factors in prosthesis use and abandonment was explored using the Anderson behavioral model for healthcare use.[14] Under this framework, prosthesis acceptance is modeled as a function of the predisposing characteristics (e.g., gender, level, or origin of limb absence), the established need, and the enabling resources (e.g., healthcare services). The review identifies the following topics as warranting further exploration[13]:

- The potential roles of specific factors (e.g., origin of limb absence, incidence of pain, fitting time frame) in determining prosthesis use/nonuse.
- The consequences of prosthesis use/nonuse on overall quality of life and health.
- The interaction and relative importance of predisposing characteristics, established need, and enabling resources in prosthesis rejection.

Also of importance in forming a realistic picture of prosthesis use and nonuse is the inclusion of nonwearers who, with one notable exception,[6] are often underrepresented because of the tendency to sample only those actively involved with rehabilitation centers.[6,15–17]

The specific objective of this study was, therefore, to elucidate the motivations for prosthesis use and/or abandonment by a broad examination of the predisposing characteristics, established need, and enabling resources in a population sampled both from hospital- and community-based support networks.

METHODS

Design

The six-part survey, described in Table 1, was developed in consultation with several individuals with upper-limb absence and a number of prominent researchers and clinicians in the field (see Acknowledgments).

The first four sections were completed by all participants. Section V_i, exploring reasons for prosthesis abandonment, was completed by nonusers only, and section V_{ii}, regarding prosthesis use and satisfaction, was completed by current or past users who wished to comment on previous prosthetic experiences. The anonymous survey required 20–30 mins to complete and was available online (www.prismlab.org/survey.htm) or in hard copy by contacting the authors.

Sample Population and Sampling Strategies

All individuals with upper-limb absence were eligible to participate in this study regardless of (1) level of limb absence, (2) origin of limb absence, (3) bilateral/unilateral limb absence, (4) user status, or (5) types of prostheses used. Parents/guardians were asked to complete the survey for children under the age of 12. The survey was available in English, Spanish, French, and Dutch and was circulated through a number of online support groups (i.e., Arm-Amp, I-CAN, Stumps R Us, UpperEx) and healthcare providers (i.e., Bloorview Kids Rehab, Canada; Shriners Hospital for Children in Los Angeles, CA; Sint Maartenskliniek, the Netherlands). In addition, the survey was promoted on the Otto Bock, Inc., Web site, a prominent manufacturer of upper-limb prostheses. The sample group was self-selected.

Distribution and Data Collection

Ten months of data were collected via the online survey. Various measures, as recommended for Web surveys,[18] were implemented to monitor sampling and online data collection:

a. To mitigate nonresponse attributable to spam filtering, incorrect mailing addresses, or mistrust, local collaborators were enlisted to recruit participants. Respondents were asked to specify the organization through which they were recruited.
b. Where possible, prenotification (e.g., mailed flyers) and reminders (e.g., through e-mail or telephone call) were undertaken to increase response rates.
c. A well-established, experienced Web provider (www.vovici.com) was employed to host the survey and to limit any system incompatibilities, such as those introduced by browser settings.
d. The survey was made available in paper format, to reduce sampling bias.

TABLE 1 Breakdown of questionnaire content

Section	Topic	No. and Type of Questions	Relevant Factors
I	Participant demographics	7, categorical	Level of limb loss
		1, Likert	Length of residua
		2, numerical	Origin of limb loss
			Dominant-hand involvement
			Gender
			Frequency of associated medical conditions and pain
			Year of birth
			Year of amputation
II	Personal experiences and lifestyle	1, categorical	Occupation status
		6, Likert	Activity level, work/school
			Activity level, leisure
			Frequency of exposure to sand, dirt, grease, etc.
			Quality of life
			Impact of limb loss on quality of life
			Acceptance of limb loss
III	Healthcare experiences	2, Likert	Satisfaction with healthcare services provided
		1, multiple choice	Satisfaction with healthcare information provided
		1, categorical	Frequency of health visits related to limb loss/prostheses
			Country of healthcare provision
IV	Personal views on prostheses	1, ordinal	Prosthesis design priorities
		1, Likert	Perceived need for a prosthesis
		1, multiple choice	User status
V_i (Nonusers)	Past prosthesis use and reasons for nonwear	1, categorical	Past prosthesis use
		1, Likert	Views on future prosthesis use
		3, multiple choice	Reasons for nonwear
		3, numerical	Challenges encountered in daily life
		2, open ended	
V_{ii} (users)	Prosthesis use and satisfaction	3, categorical	Time of fitting
		11, Likert	Past prostheses
		3, ordinal	Current prostheses
		14, multiple choice	Views on future prosthesis use
		4, numerical	Primary prosthesis
		4, open ended	Model/manufacturer of primary prosthesis
			Technical characteristics of primary prosthesis (e.g., proportional control, control strategy)
			Cost of prosthesis and repairs/maintenance
			Frequency of maintenance
			Personal involvement in prosthesis selection
			Selection factors
			Frequency of wear
			Activities for which worn
			Functional use
			Satisfaction (i.e., appearance, function, control, maintenance, comfort, and cost)
			Detailed design priorities
			Use of secondary prostheses
			Reasons for nonwear
			Challenges encountered in daily life
VI	Qualitative experiences	1, multiple choice	Suggestions for future prosthesis development
		3, open ended	Suggestions for improvements in healthcare provision
			Additional comments/feedback

e. The Internet protocol (IP) address was used to identify and filter repeat respondents.
f. To identify possible false respondents, data were screened for completeness and internal consistency using information patterns (e.g., series of dates, detailed descriptions of limb absence, and prosthesis components).
g. Participant demographics were meticulously collected and reported in an effort to contextualize the sample population and identify possible biases.

Data Analysis

SPSS 15.0 software was used for statistical analyses. Nonuser and user groups were compared via the χ^2 test (with Yates correction where applicable) or the Student's t test for nominal and interval data, respectively. Differences in ordinal ratings (i.e., satisfaction, design priorities, quality of life, etc.) were evaluated using the Mann–Whitney U test (for two groups) or the Kruskal–Wallis test (for more than two groups). Mean rankings were determined and compared using the Friedman nonparametric ANOVA for repeated measures. Other statistical tools included frequency distributions and three measures of central tendency (i.e., mean, median, mode) as appropriate to the distribution of data in question.

Ethics

Ethical approval for this study was obtained from Bloorview Kids Rehab and the University of Toronto.

RESULTS

Study Population Characteristics

A total of 266 respondents completed the anonymous survey of which 242 were included in this study (i.e., responses were excluded on the following basis: repeated IP address and similarity of data [n = 3]; incomplete or inconsistent of data [n = 7]; ineligible limb absence [n = 5]; under the age of 12 [n = 9]). Survey participants were recruited through rehabilitation centers (52%), online support groups (39%), the Otto Bock Web site (3%), or through an independent Internet search or family/friends (6%). Of submissions, 80% were electronic and 20% were by hard copy. The completion rate of the online survey (i.e., the number of surveys submitted divided by the number of times the survey was accessed) was 40%. Previous response rates for surveys addressing upper-limb prosthesis design have ranged from 24%[19] for large-scale mailing campaigns to 69%[15] for sampling strategies using more localized and directed contact.

Levels of limb absence varied, with 16% of the population reporting limb absence at a level distal to the wrist, 54% at the transradial level, 21% at the transhumeral level, and 7% at shoulder level or higher. Of participants, 15% had bilateral limb absence. The occurrence of congenital limb absence was higher in the pediatric population (91%) than in the adult population (41%) ($P < 0.001$). Of individuals with acquired limb absence, 54% had lost their dominant hand. Fifty-one percent of participants were male, and 60% were adults (i.e., 19 yrs or older), with an average age of 43 ± 15 yrs (19–80 yrs). The average age of the pediatric group (n = 97) was 9.5 ± 6 yrs (1–18 yrs) and, consequently, 70% of pediatric responses were submitted by parents/guardians. Respondents were primarily from Canada (35%), the United States (43%), and Europe (17%).

Of participants, 14% had never worn a prosthesis. Two factors characterized individuals who had never worn a prosthesis: (a) limb absence distal to wrist was more frequent than in the general population ($P = 0.001$), and (b) the mean age of children was younger than in the general population ($P = 0.01$), whereas that of adults was older ($P = 0.002$). According to detailed comments on patterns of use, 28% of participants who had been fitted with a device were categorized as prosthesis rejecters (i.e., used a prosthesis once a year or less), whereas 64% were considered frequent wearers (i.e., either full-time or part-time consistent wear). Of note, 45% of participants recruited from the community rejected prosthetic devices as compared with 21% of those contacted through rehabilitation centers or hospitals ($P = 0.002$). Full-time users wore the prosthesis for an average of 13 ± 4 hrs on a typical workday and 10 ± 5 hrs on a day off. Part-time users reported prosthesis wear for 7 ± 4 hrs per workday and 5 ± 4 hrs per day off.

The following will focus on comparisons between prosthesis rejecters and frequent wearers with regards to predisposing factors, established need, and enabling resources.

Predisposing Factors

Level of limb loss

Level of limb absence emerged as a primary predisposing factor in prosthesis acceptance. Specifically, individuals with limb absence proximal to the elbow (high level) or to the wrist (low level) were more likely to reject the device than were those with transradial limb absence ($P = 0.001$).

Origin of limb absence

The relationship between level of limb absence and prosthesis rejection persisted for both congenital and acquired limb absence. Rejection rates for individuals with congenital limb absence were greater for low-level (63%) or high-level (65%)

limb absence and less for transradial (21%) ($P = 0.02$). For acquired limb absence, prostheses were rejected by 0% of individuals with low-level amputations, 16% with transradial, and 39% with high-level amputations ($P < 0.001$). Rejection rates were comparable for individuals with transradial limb absence, regardless of origin. Individuals with acquired amputations at a low or high level seemed less likely to reject prostheses than those with congenital limb absence; however, more data are required for verification.

Gender

Overall, females (39%) were more likely to reject a prosthesis than were males (23%), ($P = 0.022$). For males and females with congenital limb absence at any level, no significant differences in prosthesis use were observed. However, females with acquired limb absence were more likely to reject prostheses than were males at both the transradial ($P = 0.042$) and at high levels ($P < 0.001$); not enough data were available to assess low-level limb absence. Females with high-level, acquired limb absence in particular, rejected prostheses in 80% of cases as compared with 15% of males ($P < 0.001$). A high rate of prosthesis acceptance was observed in males with acquired limb absence (91%) as compared with males with congenital limb absence (60%) ($P = 0.001$). The opposite trend was evident in females, for whom 38% with acquired limb absence accepted prostheses, as compared with 70% with congenital limb absence ($P = 0.011$).

Bilateral limb absence

In general, rejection rates for bilateral and unilateral limb absence did not differ significantly, irrespective of level of limb absence. Rejection rates for unilateral and bilateral limb absence were comparable in individuals with acquired amputations. However, individuals with congenital, bilateral limb absence had significantly higher rates of rejection (75%) in comparison with those with unilateral limb absence (28%) ($P = 0.004$).

Length of residua

The length of residua was not a factor in prosthesis rejection at either the transradial or the transhumeral level.

Dominant-hand amputation

Amputation of the dominant hand was not associated with prosthesis acceptance or rejection.

Medical factors

Discomfort, ranging from predominantly mild to severe, was reported by participants as follows: residual limb pain (32%), phantom pain (32%), skin irritation (46%), blisters (23%), and upper-body pain (44%). Residual limb pain, phantom pain, and upper-body pain were more prevalent in individuals with acquired limb absence ($P < 0.001$) and in individuals with high-level limb absence ($P < 0.025$). Skin irritation and blisters were more prevalent in frequent wearers than in prosthesis rejecters ($P < 0.001$). No significant differences in residual limb, phantom, or upper-body pain were observed between prosthesis rejecters and frequent wearers, whereas the latter were more likely to experience skin irritation and/or blisters ($P < 0.001$) as consequences of prosthesis use. In general, reports of discomfort and pain were low and the majority did not experience upper-body pain, skin irritation, blisters, residual limb, or phantom pain at any point during a typical week.

Age

No differences in prosthesis rejection were observed between adults and children with congenital limb absence, irrespective of gender or level of limb absence. The mean age of prosthesis rejecters and frequent wearers was also not significantly different. However, when grouped by different life stages, as presented in Figure 1, significant differences in rates of rejection were observed ($P = 0.02$), irrespective of origin of limb absence. Rejection rates peaked markedly in three age groups, from 4 to 10 yrs, from 24 to 35 yrs, and for those greater than 65 yrs. These differences are likely related to lifestyle and functional needs, as will be discussed in the subsequent section.

Established Need

Participants were asked to rate their perceived need for a prosthesis on a scale from 1 (not at all needed for daily life) to 7 (absolutely essential for daily life). Perceived need varied significantly for frequent wearers and prosthesis rejecters ($P < 0.001$), with median ratings of 6 and 1 for wearers and rejecters, respectively. No difference in perceived need was observed between users of different prosthesis types.

Participants were asked to comment on any activities found to be challenging in everyday life. Of the 178 individuals who responded to this question, 16% had not encountered any insurmountable challenges in their daily life, whereas 10% of individuals found most activities, particularly bilateral tasks, to be challenging. Almost all individuals who reported a great number of challenges made use of a prosthesis to aid in their daily life, whereas frequent wearers and prosthesis rejecters were equally represented in the group not experiencing challenges.

Self-reported activity levels (i.e., use of upper limbs in recreational and job/school activities) and

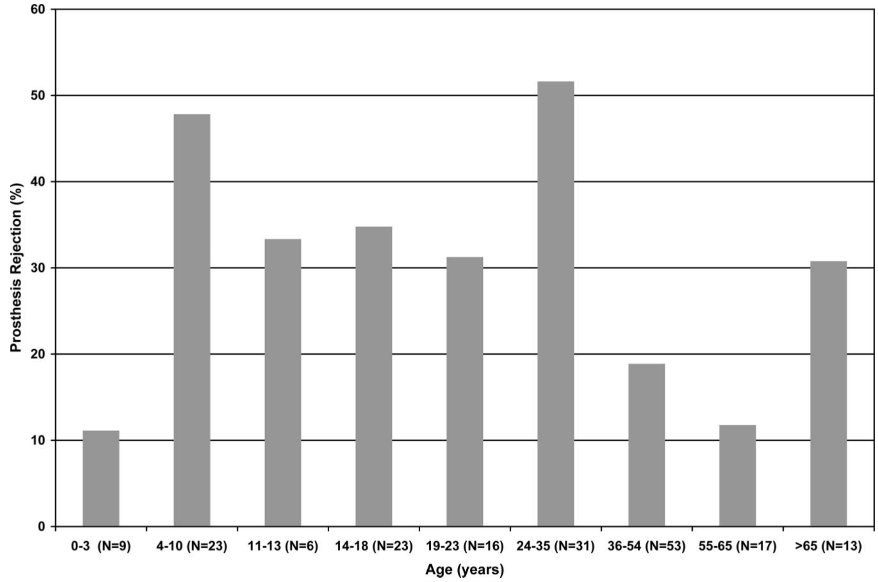

FIGURE 1 *Rates of prosthesis rejection observed between adults and children with congenital limb absence, grouped by different life stages.*

typical operating environments (i.e., exposure to water, grease, dirt, etc.) were comparable for frequent wearers and prosthesis rejecters. Rates of unemployment and disability leave were low (numbering 3% each) and not statistically different for wearers and rejecters. Figure 2 presents rejection rates for various occupations statuses. Of note, students were more likely to reject prostheses than were full-time workers ($P = 0.021$).

Enabling Factors

Healthcare provision and the state of technology are potential enabling factors in prosthesis acceptance and will be explored in this section.

Health care

Satisfaction with health care in all areas, specifically fitting ($P < 0.001$), follow-up ($P < 0.001$),

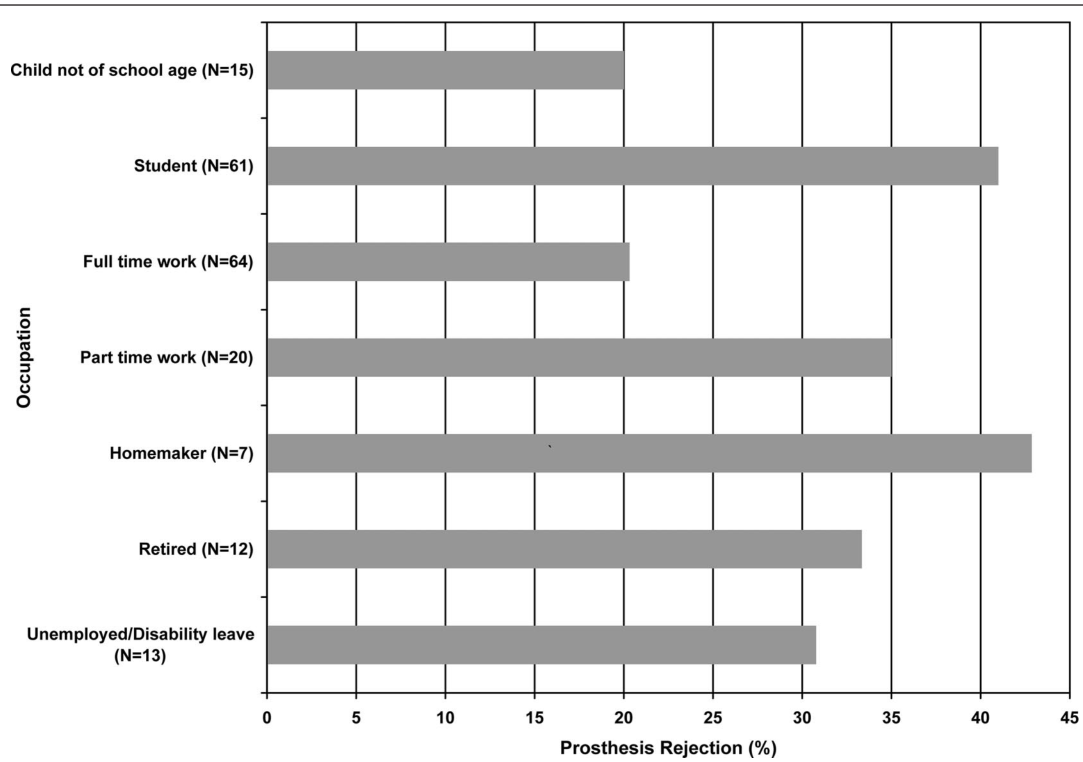

FIGURE 2 *Prosthesis-rejection rates for various occupation statuses.*

repair ($P < 0.001$), training ($P < 0.007$), and information provision ($P = 0.009$), were significantly lower for prosthesis rejecters. Prosthesis rejecters were less satisfied with the information provided with respect to prosthesis technology ($P < 0.001$), sources of funding ($P = 0.01$), use of multiple prostheses ($P = 0.001$), level of expectations set ($P < 0.001$), and the overall knowledge and experience of healthcare providers ($P < 0.001$). Both prosthesis rejecters and frequent wearers were interested in receiving better information on nonprosthetic options (i.e., strategies for accomplishing activities without use of a prosthesis) and resources for peer support. With these two exceptions, frequent wearers were generally satisfied with all other aspects of health care. Prosthesis rejecters reported neutral feelings (i.e., neither satisfied nor dissatisfied) for all other aspects of health care with the exceptions of training and fitting, which elicited median ratings of *satisfied*. Prosthesis wearers were in much more frequent contact with healthcare providers with regard to upper-limb absence than were rejecters ($P < 0.001$), with appointments occurring at a median frequency of every 7–12 mos, whereas 51% of prosthesis rejecters had not been in contact with healthcare providers for 6 yrs or more.

Of note, satisfaction with overall health care ($P = 0.017$) and the knowledge/experience of healthcare providers ($P = 0.022$) was rated significantly lower by bilateral wearers in comparison with unilateral. Prosthesis wearers with acquired limb absence were less satisfied with all areas of health care and information provision ($P < 0.05$) than were those with congenital limb absence. Individuals with high-level limb absence were less satisfied than those with transradial limb absence with information provided on technology ($P < 0.015$), nonprosthetic options ($P = 0.039$), resources for peer support ($P = 0.008$), and training ($P = 0.027$) and fitting ($P = 0.012$) services.

Satisfaction levels of participants from the three major hospitals involved in this study were comparable in all aspects with the exception of information on funding ($P = 0.003$), which was lower, and information on nonprosthetic options ($P = 0.049$) which was higher, for one hospital. Satisfaction with health care and information provision was significantly lower for individuals recruited from community-based support groups in comparison with the hospitals ($P < 0.005$).

The fitting time frame emerged as an important factor in prosthesis acceptance for individuals with congenital limb absence. Prosthesis rejecters were fitted within a median of 3.9 yrs, with an interquartile range (IQR) of 2–6.6 yrs, whereas frequent wearers were fitted more quickly, within 11 mos (IQR: 5 mos to 1.5 yrs). A similar trend was apparent for individuals with acquired limb absence. Rejecters were fitted at a median 6 mos after amputation, with an IQR of 3 mos to 1 yrs, whereas wearers were fitted within a median of 3 mos (IQR: 2–5 mos). At the time of follow-up, pediatric wearers had worn prostheses for an average of 8 ± 5 yrs, whereas adult wearers had worn them for 21 ± 15 yrs. There was no statistically significant difference between the times of follow-up for prosthesis wearers *vs.* rejecters.

When asked to rate their involvement in the selection of their primary prosthesis on a scale from 1 (no choice) to 7 (entirely my choice), frequent wearers reported a median rating of 5, whereas rejecters reported a significantly lower degree of involvement of 2 ($P = 0.001$). Prosthesis rejection and involvement in prosthesis selection were not related to the type of device selected, nor was prosthesis rejection.

Prosthesis technology

Prosthesis rejecters were significantly less satisfied with all aspects of prosthesis design, including appearance ($P = 0.014$), comfort ($P < 0.001$), function ($P < 0.001$), ease of control ($P < 0.001$), reliability ($P < 0.001$), and cost ($P = 0.034$). The distribution of prosthesis types used by both groups was comparable in terms of the shapes of terminal devices used (i.e., hand or hook) and the mode of actuation (i.e., passive, body powered, or electric). Frequency of maintenance activities (i.e., fitting, replacement of components, and repairs) was also not significantly different between frequent wearers and prosthesis rejecters. Of prosthesis rejecters, 74% stated that they might reconsider prosthesis use if technological improvements were made at a reasonable cost.

Relative Importance of Factors

Respondents were asked to specify the importance of a variety of factors in their choice not to wear a prosthesis (a) permanently for the case of nonusers, and (b) on a typical day when the prosthesis is not worn for the case of current users. The percentages of participants who considered each factor to be of some importance in the decision not to wear a prosthesis and the median ratings are presented in Table 2. Evidently, prosthesis rejecters discontinue use largely because of a lack of functional need, discomfort, and impediment to sensory feedback. Discomfort is also a primary factor for occasional nonuse in frequent wearers in conjunction with reasons of necessity (i.e., the prosthesis must be removed for certain activities like swimming or sleeping, for medical reasons, or for repair). Excessive weight was deemed more important by prosthesis rejecters ($P < 0.001$). Heat was considered an important factor in prosthesis non-

TABLE 2 Factors in the decision not to wear a prosthesis (a) permanently for prosthesis rejecters or (b) on a specific day for prosthesis wearers, based on self-reported ratings of importance from 0 (not at all a factor) to 3 (most important factor)

	Prosthesis Rejecters		Frequent Wearers	
Factors in Nonwear	Percentage of Respondents[a]	Median Rating	Percentage of Respondents[a]	Median Rating
Just as or more functional without it*	98	3	60	1
More comfortable without it*	95	3	66	1
Too difficult or tiring to use*	88	2	39	0
Too heavy*	88	2	65	1
Too hot	88	2	77	2
More sensory feedback without it*	85	2	44	0
Inconvenience*	93	2	53	1
Lifestyle	80	2	N/A	N/A
Dissatisfaction with prosthetic technology	70	1.5	N/A	N/A
Appearance of the prosthesis*	70	1	33	0
Medical factors (i.e., skin irritation, blisters, etc.)	55	1	64	1
Stopped working and needs repair	49	0	56	1
Cost	48	0	N/A	N/A
Availability of prostheses	48	0	N/A	N/A
Availability of healthcare services	51	1	N/A	N/A
Lack of information about prosthetic options	28	0	N/A	N/A
Lack of training	28	0	N/A	N/A
Someone else made the decision	15	0	N/A	N/A
Moral, cultural, or religious reasons	8	0	N/A	N/A
Must be removed (i.e., for sleeping, swimming)	N/A	N/A	71	2
Mood	N/A	N/A	51	0
Fear of damage	N/A	N/A	35	0

[a] The percentage of respondents who considered the factor to be of some importance in the decision not to wear a prosthesis.
* Factors that were rated significantly more important ($P < 0.001$) by prosthesis rejecters than by frequent wearers.
N/A: As indicated, some factors (e.g. availability, fear of damage, etc.) were not applicable to both prosthesis rejecters and frequent wearers

wear in both groups, whereas medical factors were considered to be somewhat important by both frequent wearers and prosthesis rejecters in the decision not to wear, as was need for repairs. With the latter three exceptions, prosthesis rejecters rated all other factors of nonwear with greater importance than frequent wearers ($P < 0.001$). Quality of information and training services, along with other enabling factors, such as availability of health care and prostheses, and cost, were generally not considered important in the decision to reject prostheses, although the latter was noted by approximately 50% of individuals as a minor factor in the decision. Technological factors pertaining to prosthesis design were paramount.

DISCUSSION

Summary of Key Findings

Rejection rates, as determined in this study, were comparable with a meta-analysis of previous literature conducted in this area.[1] Table 3 provides a summary of the key findings with respect to the predisposing factors, enabling resources, and established need. Established need and satisfaction with available prosthesis technology emerged as the predominant factors in prosthesis use and rejection. Individuals who felt that a prosthesis was helpful in their daily activities made use of the device, whereas those who felt it to be a hindrance or unreasonably uncomfortable/difficult to use, did not. It is hypothesized that the decision to wear or reject a prosthesis is resolved in a manner to best meet personal priorities and needs. Although not a primary factor, more than 50% of those surveyed considered availability or cost to play at least a minor role in the decision not to wear a prosthesis.

Merits and Limitations

Probably the most interesting attributes of the study presented above are (a) investigation of predisposing factors through exploration of high-order correlations; (b) the ability to assess the relative importance of predisposing factors, enabling factors, and established need on prosthesis use and abandonment; and (c) the opportunity to tap into the opinions and experiences of nonusers recruited outside of the rehabilitation center.

A number of Web-based surveys have been conducted in the past with regards to health care on a large scale (i.e., >100 participants)[20–22] and

TABLE 3 Summary of key findings

Factor	Key Findings
Predisposing characteristics	
Level of limb absence	Higher rejection rates associated with low- and high-level limb absence
Origin of limb absence	Origin of limb absence not a factor in rejection for individuals with transradial limb absence
	Individuals with congenital amputations at a low or high level more likely to reject prostheses than those with acquired limb absence
Gender	Females with acquired, high-level limb absence more likely to reject prostheses than males
	Low rate of prosthesis rejection for males with acquired limb absence
	No gender differences for individuals with congenital limb absence
Bilateral limb absence	Individuals with congenital, bilateral limb absence more likely to reject prostheses than those with unilateral limb absence
Length of residua	Length of residua not associated with prosthesis rejection
Dominant-hand amputation	Dominant-hand amputation not associated with prosthesis rejection
Medical factors	Phantom and residual limb pain and upper-body pain more prevalent in individuals with acquired or high-level limb absence, but not associated with prosthesis rejection
	Skin irritation, blisters, and upper-body pain more prevalent in frequent wearers than in prosthesis rejecters
Age	4–10 and 24–35 age groups associated with higher rates of rejection
Established need	
Perceived need for prosthesis	Prosthesis rejection associated with lower perceived need
Occupation status	Prosthesis rejection higher for students than full-time workers
Activity levels	Self-reported activity levels not associated with prosthesis rejection
Enabling resources	
Health care	Satisfaction with overall health care lower for prosthesis rejecters
	Fitting at an older age for children with congenital limb absence is associated with prosthesis rejection, as is a longer time gap between amputation and fitting for individuals with acquired limb absence
	Low perceived involvement in the selection of a prosthesis is associated with prosthesis rejection
Prosthetic technology	Dissatisfaction with prosthesis technology highly associated with prosthesis rejection

prosthetics on a smaller scale (i.e., <100 participants).[23,24] Internal consistency and test–retest reliability between a large variety of questionnaires administered via the Internet and by other means (i.e., telephone, mail, etc.) have been demonstrated.[22,25] However, it is important to recognize the possible sampling biases inherent to the results presented herein.

1. The sample population was largely self-selected, as is often the case in consumer-based surveys, making it difficult to assess the extent to which the opinions expressed are reflective of the population as a whole. To quantify this potential limitation, rates of prosthesis rejection in samples recruited from the three primary pediatric hospitals were compared. Response rates for the three hospitals were approximately 40%, 55%, and 100%. No significant differences in rates of prosthesis rejection or satisfaction with overall health care were observed, irrespective of the rate of self-selection.
2. It is expected that the study population based in Canada was, in general, younger, with greater use of electric prostheses than the general population, reflecting the expertise of Bloorview Kids Rehab in myoelectric prostheses and pediatric care. Age (i.e., pediatric or adult) and device type were not factors in prosthesis use or abandonment in either Canada or the United States.
3. To quantify possible sampling biases introduced by the use of an online survey, we compared the demographic distribution of this study's electronic respondents from the United States ($n = 92$) with that of a large-scale epidemiologic study ($n = 2477$), also conducted in the United States in 1996.[19] No statistically significant differences with respect to age, prevalence of transradial limb absence, or origin of limb absence were observed. The prevalence of electric hands and body-powered hooks was not statistically different. In this study, 51% of participants were male, as compared with 63% in the Atkins et al.[19] study ($P = 0.02$). Previous research has

found no association between gender and Internet access.[26] It is possible, because of the potential bias of Internet-based surveys to exclude low-income individuals,[27] that concerns regarding high costs of prostheses are actually underestimated in this study. Future research in this area is needed.

The results of this study must be considered in the context of these limitations and should not be generalized to the population en masse.

CONCLUSIONS

Prosthesis use is highly related to established need and enabling resources, particularly the state of available technology. Future research should focus on continued development of more comfortable and functional prostheses, particularly for individuals with high-level or bilateral limb absence. Efforts by healthcare providers to actively involve clients in the selection of a prosthesis most suited to their personal goals and needs should be escalated. Individuals with limb absence are particularly interested in resources for peer support and are desirous to know all of their options, including nonprosthetic. Better support, particularly with regard to information provision, is needed for specialty groups including individuals with bilateral, acquired, or high-level limb absence. Efforts to ensure the availability of quality prostheses and health care should continue.

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