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What people want in a prosthetic foot: A focus group study

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INTRODUCTION

Major lower-limb amputation (LLA) is highly prevalent. As of 2005, there were over 600,000 people living in the United States with an LLA.¹ On an average day, more than 230 people in the United States will have amputation surgery of the lower limb.² Most individuals with LLA rely on a prosthetic foot for participation in daily living activities in their homes and in their communities. The absence of one or more limbs and the reliance on prosthetic limbs create long-term physical and psychosocial challenges for people with LLA. Prosthetic feet, as the distal interface between the environment and the person, are important to transmission of forces and motion in a biomechanical sense. While forward walking is often the primary focus of both rehabilitation and research, the success or failure of a prosthesis to recover foot function goes beyond the biomechanics of walking; prostheses also impact the person's identity and comfort level with social interaction.³

Current literature describes several important aspects of body structures and functions that are impacted by prosthetic use, including problems with balance, confidence, and falls.⁴⁻⁶ Mobility after LLA has also been widely studied.⁷ In an extensive review of the literature to identify impairment concepts following LLA which could be cross-linked to the International Classification of Function (ICF), Xu et al.⁸ found that mobility was the most frequently represented concept. It is important to note that self-care, household tasks, relationships, employment, community, and social life can be negatively impacted by impaired mobility.⁸ While the literature examining non-mobility activities is relatively limited, those studies which have been completed document high levels of difficulty in this area. For example, Coffey et al.⁹ used questionnaires based on the ICF to assess functioning for 64 individuals with LLA from the time of admission into a rehabilitation unit to six months post-discharge. The patients reported diminished quality of life in physical, psychological, and social domains which do not improve significantly over time.

A limited number of studies have focused on identifying quality-of-life factors highly valued by those with LLA. Quality-of-life factors that were reported to be significant include regaining mobility, sense of freedom, and self-reliance. Factors that were critical to achieving these outcomes were safety, balance, comfort, and having confidence in walking.^{10,11} Factors that diminished quality of life included impaired mobility, followed by

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pain, progression of limb ischemia in the contralateral limb, and depression/frustration.¹² Participants in one study unanimously agreed that prostheses improve quality of life; however, 83% resorted to a wheelchair for mobility when walking was not feasible.¹² Zidarov et al.¹³ found that life habits associated with social roles appear to be more impaired compared with activities of daily living and concluded that improving outdoor mobility could enhance accomplishment of social roles, especially in community life. Other research has examined characteristics of prosthetic feet that impact users' satisfaction. Stakeholder focus groups convened by Klute et al.¹⁴ identified a lack of flexibility and function in the ankle and foot components as being problematic. Klute's study is notable because the researchers focused specifically on the prosthetic foot, rather than looking more generally at lower-limb prostheses as other studies have done (e.g., Schaffalitzky et al.¹⁰).

The relative lack of both research into, and robust measures of, participation following LEA has been commented on in the literature.^{7,9,15} Qualitative research methods such as focus groups are ideally suited to studying emerging areas of inquiry¹⁶ and are a critical early step in instrument development.¹⁷ Additionally, there are few published accounts focusing on subjective experiences of using prosthetic feet. The purpose of our study was to use an open-ended focus group format to improve our understanding of the impact that prosthetic feet have on participation in the activities of daily life based on the experiences of prosthetic users and health care professionals who prescribe prostheses.

METHODS

Participants

Two categories of participants were recruited for this study. The first category (User Group) included individuals with LLA at or below the knee who use a prosthetic foot (or feet), and the second group consisted of health care professionals who routinely prescribe and/or fabricate lower-limb prostheses (Pro Group). Participants were recruited by word of mouth and by announcements posted in local prosthetic clinics and at professional meetings. Inclusion criteria for both groups included: age 18 or older (or 16-18 with parental consent), and a desire to participate in the focus group. Research staff conducted a brief screening by telephone to confirm eligibility. Potential participants with LLA were asked to endorse statements describing their mobility. Responses to these statements were used by a certified prosthetist to assign a community ambulation mobility level of the Medicare Functional Classification Level (K-level).¹⁸ In order to take part in the study, individuals needed to have a K-level of 2, 3, or 4. Participants who were not able to converse in English were excluded from the study. All study participants provided written informed consent to participate in the study. The University of Washington's Human Subjects Division Institutional Review Board approved this study.

Questionnaires

Prior to participating in a focus group, participants were asked to complete a brief online questionnaire. Variables included on both the User and Pro group questionnaires included sex, age, race, and ethnicity. For the User Group, this questionnaire also included items relating to their LLA, prosthetic use, and falls. The Pro Group questionnaire included items

concerning profession/title, and years/type of practice. Tables 1-3 contain a full list of variables collected.

Data collection and analysis

The study team conducted three focus groups with users of prosthetic feet and two focus groups with health care professionals. In order to accommodate participants for whom travel to the study site would be inconvenient or impractical, four of the focus groups were conducted via a conference call; one User Group took place in a conference room in a regional medical center. General, open-ended questions regarding peoples' experiences were developed and pilot-tested. Questions for the User Group focused on their experiences using a prosthetic foot, the impact of the foot on daily activities, and their satisfaction with the prosthetic feet they were familiar with. The Pro Group questions focused on positive and negative attributes of prosthetic feet they frequently prescribed, requests and complaints about prostheses they often heard from patients, and improvements they would like to see implemented. The moderator, a certified prosthetist, asked each focus group the same set of questions and guided the conversation to stay on point, summarize, or to move ahead, as appropriate. All sessions were audio recorded and transcribed verbatim.

Data analysis was carried out by a team of four researchers in three steps described by Emerson et al.¹⁹ The first step involves reading the transcripts as a complete body of work prior to further analysis. The next two steps involve coding the transcripts. The first round of coding, known as open coding, is intended to identify salient content themes, without regard for the compatibility or coherence of codes. This is followed by focused coding and involves grouping the codes identified in the first round into meta-themes or clusters. The research team then discussed emergent themes so that points could be categorized and cross-referenced if they fell into multiple categories. It is important to note that this analytic process is not intended to produce a set of mutually exclusive categories and that many data points are assigned multiple codes.

RESULTS

Sixteen prosthetic foot users and 11 health care professionals enrolled in this study. Seven participants in the user group were determined to have a K-level of 3, and the remaining nine were K-level 4. Questionnaires were completed and returned by 11 of the 16 User Group members and by all 11 members of the Pro Group (see Tables 1 - 3). Five participants reported that they did not know the type of foot prosthesis they used; the other six identified various energy return feet. Despite the fact that all of the prosthetic foot users rated their difficulty with usual activities as none or slight (1 to 2 on a 4-point scale), 36% of users responded "yes" to the question "have you fallen within the last six months," and 45% endorsed having modified their participation in activities because of the potential for falls.

Focus Groups

Prosthetic foot users (Users) spoke primarily about their own experiences and health care professionals (Pros) tended to describe situations reported to them by their pool of clients. There was a significant overlap in themes discussed by the two groups. Several themes

emerged from the analysis of the focus group transcripts, including: terrain and surface issues, falls and safety, activities of daily living, footwear, prosthetic foot aesthetics, and durability.

Terrain and surface issues—Although participants generally expressed satisfaction with their ability to walk forward over a dry, level surface, many other aspects of mobility which are impacted by varying terrain and weather conditions were described as problematic. The ability to walk up or down steep hills was often reported to cause significant walking difficulty. Users reported that they often needed to traverse hills, rather than walk directly up or down.

“...very steep inclines get to be difficult.... I find myself going back and forth across the side of the driveway or the street. ...I end up having to go cross hill and gain on the hill in a slower way. If it’s too steep I just have to traverse back and forth to get there.” (User 2)

Uneven ground, gravel, and sand were all described as difficult to walk on. Professionals and users recounted issues with any form of uneven ground, especially if it was unanticipated. Rural areas were mentioned, but also challenging urban areas, such as cobblestones, were highlighted. Cognitive demands during walking were described.

“... I take a walk most every day...in the forest, so there are big hills...logs, a lot of different kinds of terrain... I find myself still picking up my leg to get over an obstacle, rather than using my foot.” (User 4)

“I just try to avoid rocky areas just because you can’t get secure footing and you go over a rock it really pushes you forward and it’s really an uncomfortable type of feeling.” (User 6)

“I spend about six weeks in the summer out at a beach, and walking on sand frustrates me.” (User 16)

Surface friction caused by weather conditions, such as snow, rain, or ice, were also cited as making it more difficult to walk safely.

“I have a lot of problems with slippery surfaces...stairs... slippery rocks if I’m on the edge of the beach...just to be safe, I actually sit down on that area to kind of crawl around that area. That’s probably the safest way.” (User 1)

“The thing that bothers me the most is soft snow. Because when you go to walk your toe drops down and my foot just doesn’t adjust well to that. I have no traction to push off the other foot.” (User 11)

Falls and safety concerns—Tripping incidents were often precipitating events in falls. Tripping incidents were mainly due to obstacles such as curbs, cracks in sidewalks, uneven ground, area rugs, pets, sailing, or catching a toe in crevices/tight spaces. One user reported that his leg “flew off” after tripping over a curb in front of his hotel (User 3). Professionals also reported tripping during the swing phase of gait (Pro 4).

“I do a lot of sailing and every now and again I get my ...prosthetic foot caught in the lines and I don’t notice it until it’s about to trip me over and then you got to go back and pull it off and I don’t feel the drag of the line being caught in there and that gets me.” (User 7)

Safety concerns included walking downhill, climbing ladders or stepstools, and stairs.

“I think my biggest, biggest worry as far as falling and foot place would be a ladder. I’m going up and down ladders all the time at home and work and everything and just not knowing when you have your real foot taking a step down hitting a lower rung in the ladder versus having your artificial foot where you really don’t have an idea of where, you can see where the steps going to be, but you really don’t know there’s no perception of how far down the next step should feel.” (User 6)

“Stairs are really a problem in our house because... the tread is only five and a half inches wide on the top so I’ve got to make sure that when I do get the prosthetic foot up that I kick it all the way forward so I have the maximum amount. ... I have to use the railing just to make sure that I am pulling myself upright.” (User 11)

Activities of Daily Living—While concerns about forward walking were not brought up by the groups, simply standing for long periods can be uncomfortable: “I find standing still for a long period of time is very uncomfortable” (User 3). Other aspects of mobility, such as backing up, turning, and moving in different directions was problematic. Several participants felt that their current prosthetic feet limited their maneuverability, creating problems with navigating in confined spaces and changing body positions. Entering and exiting cars or airplane seats were noted. User participants found that the best solution to moving or sitting in cramped areas could be to remove the prosthesis.

“...last weekend I flew and um, there is so little space, my knee, I took my leg off on the airplane, and I got a couple of stares but it was a lot more comfortable that’s for sure.” (User 2)

“Just the rigidity of the prosthetic foot and the fact that you can’t move it the way you want to get into a tight booth or into a tight car.” (Pro 2)

Many users reported issues regarding “spontaneity” (i.e., the need to remove/attach the prosthesis) particularly at night.

“You know one of the big drawbacks of having a prosthetic leg is the fact that I have to take it off and put it on in the middle of the night if I need to get up and do something. If I have to, you know, soothe one of my kids, or use the restroom, I have to actually get up and look for stuff and put it on. That’s kind of an inconvenience.” (User 1)

Moving from one position to another such as crouching or working in a low area was very difficult for people. Playing with children as well as kneeling for religious prayer were identified as activities that were inhibited by the prosthesis. Picking up a child or an object off the floor was performed awkwardly because of the prosthesis. Gardening, housework, or

reaching down to lower shelves were combined issues of cramped working areas and positional changes.

“Gardening is hard. To get down and weed ... your leg is in the way maybe you should just take it off. Gardening is a challenge because it’s like a tight space.”
(User 4)

Footwear—Most participants complained about limitations regarding footwear, including such issues as heel height/density, limited fashion options, and options for sports activities. Heel height, in particular, seemed to be an area of concern because variations in shoe heel height altered alignment of the prosthetic limb. Where prosthetic heel height can be varied, more footwear styles could be worn. Since footwear preferences are determined by indoor/outdoor use and activity context, patients that had only one type of footwear seemed to be disadvantaged. Some people had specialized setups depending on activities, such as a “water foot” for kayaking. On the other hand, some participants were concerned about safety when alignment was off because of footwear. Changing shoes typically requires considerable effort. The spontaneity that comes with changing footwear is lost for people with amputations.

“Heel height is definitely a big fail point for me. I will go in the store and just basically look for all similar heel height shoes so that I don’t have to adjust my prosthesis based on the heel height. If I really like the shoe then I will live with the fact that I’ll either have to put a lift in one of my shoes or adjust it manually.” (User 1)

“People around the house would like to be comfortable and not wear shoes if that’s what they want to do, but the alignment then is messed up if you aren’t using a shoe with your prosthetic foot.” (Pro 2)

“Trying to put a ski boot on, I have even been skiing since I was a kid with a prosthetic so it’s not an easy job. It takes probably 2 people. Because you can’t really help because you’re up here on the top half of the leg and you can’t bend, you can’t bend down that far to help out, or at least I can’t bend down that far to help get the boot on.” (User 6)

Prosthetic foot issues—In addition to heel height, issues such as weight, bulk, and ankle articulation/range of motion were addressed. When practitioners were asked about multiple prostheses, very few had made a second prosthesis for a user. Some had made a shower prosthesis, but for the most part they felt that they were too expensive, and when made, were not used very often by the user.

Cosmesis was important to participants, including shape and color. Either the prosthetic feet were too wide or too narrow or not the right shape in comparison to the opposite side. Change in color over time for the cosmetic coverings was noted. Durability of the prosthetic foot was a concern for many practitioners and users during focus group discussions. Longevity of a prosthetic foot depended on the amount and type of use. While users and professionals hoped that feet could last at least two years, people volunteered stories of

various and unanticipated ways feet failed much sooner. The consequence of feet breaking can vary with the circumstances.

“I have in the past actually broken my feet just by carrying objects.” (User 6)

“...coming out of a hotel room one time the thing snapped and dropped down to the floor...” (User 11)

“I’ve broken two feet. Which is two feet too many to break. One going up some stairs...” (User 16)

“... so the durability is a big thing. ... Just because if it’s broken you can’t use it and I can’t walk...” (User 10)

DISCUSSION

Our study highlights the utility of focus groups in generalizing previously documented issues with foot prostheses^{12,14,20} as well as identifying unrecognized needs and concerns. In combination with other studies, the current report demonstrates unmet needs for community participation in this patient group with significant implications for the design of prosthetic feet.

Participants’ reported confidence in forward walking on even ground suggests that current prosthetic feet are well-suited for this limited use. Previous studies suggest that user satisfaction with forward walking on level ground may be a consequence of improvements in prosthetic foot design, with newer designs preferred over older solid-ankle cushioned-heel designs.^{21,22} However, participants in our study also identified a number of situations in which their current prosthetic feet caused significant difficulties, often with safety implications. Consequently, forward walking may not be the most sensitive test for prosthetic mobility. This finding supports the work of Kark and Simmons²³ who reported that gait deviations in level walking did not correlate with prosthesis satisfaction. Standing tolerance, sideways or backwards movement, traversing uneven ground or slopes and various surfaces constituted significant challenges for people using prosthetic feet.

Some stories recounted by participants highlight issues faced by those who rely on prosthetic feet for mobility that are not well documented in the existing literature. For example, the limited range of motion of currently available prosthetic feet created problems for users when they unexpectedly encountered a small rock or crack in the sidewalk or there was a sudden change in surface height. Range of motion limitations also restricted participants’ ability to maneuver in small spaces, impacting the ability to get in and out of cars, restaurant booths, and airplane seats, to name but a few. Finally, range of motion limitations also contributed to the difficulties in moving between standing and kneeling positions, necessary for activities ranging from gardening to childcare to prayer.

The difficulties that participants experienced in changing shoes had implications beyond the understandable desire for aesthetically pleasing footwear. Many people routinely change footwear when moving between indoor and outdoor spaces, and in some cultures doing so is obligatory. Many activities, such as bowling, cycling, and skiing also require specialized

footwear. Similarly, stories that describe climbing ladders and using stepstools do not appear to be documented elsewhere. It is significant that people with LLA were performing these mobility tasks in spite of the risk involved. Health care professionals might confer with patients to mitigate the risks.

In other areas, the current study supports findings by previous researchers. For example, most participants in the current study revealed how, on occasion, their prosthetic foot broke or fell off, echoing Gallagher and MacLachlan's²⁰ finding that the reliability of the limb was considered to be of extreme importance to users. Our participants, like those in the study by Klute et al.,¹⁴ expressed a desire for foot components that can accommodate a greater variety of terrain, activity, and footwear types.¹⁴ Users also noted the lack of an ankle that allows donning and doffing boots, and a foot that does not rotate to facilitate entering and exiting cars. This supports the general consensus that the ideal prosthetic foot should be more adaptable and accommodating for everyday use and for a wider range of activities.

Common problems encountered by people who have had a lower-limb amputation are often inconsequential to other people, such as finding shoes that fit, using changing rooms in shops, wearing a variety of lower-limb garments, or warm environments. Issues with speed and confidence in mobility such as moving quickly to catch a bus or cross a road, as well as walking on wet floors that make slipping easier, are typical across many people with physical disability.

There are a large number of desirable characteristics and features of current prosthetic feet, but it appears that these prostheses are not meeting all of the needs of users and professionals in this area. As a consequence, new designs that offer to improve particularly challenging activities such walking downhill are being studied.²⁴ Over time, performance optimization across activities will bring about an evolution of prosthetic foot design. Documenting professional awareness of foot design strengths and weaknesses as well as reiterating professional concerns supports the need for research. For example, despite the user groups' high level of ambulation ability, falls remain a serious problem. Swing phase mechanical aspects to prevent trips and contralateral stresses are being studied as a result.²⁵ There are increasingly adaptable designs that should be tested in a variety of conditions.

Accumulating a broad sampling of stakeholder experiences in published literature can promote incorporation of identified issues into outcome questionnaires. As exemplified by the development of the Prosthesis Evaluation Questionnaire (PEQ),²⁶ typical questionnaire development includes sampling stakeholder opinions and synthesizing the literature. In this example, it is possible that both the potential and limitations of current foot designs have changed since the PEQ was published almost two decades ago. Increased awareness of stakeholder experiences should facilitate comparative research concerning aspects that are important to the patient.

Study Limitations

Although our sample size is comparable to those of other qualitative studies in this area, it is not large enough to confidently generalize our findings to the population of prosthetic foot users as a whole. While all of the members of the Pro group completed the preliminary

questionnaire, the response rate for User group was 68.8%, further limiting the generalizability of these findings. However, the consistencies between the current participants' experiences and those reported in other studies suggests these themes are worthy of systematic examination. Also, the focus group sessions were time limited, and it is possible that we did not reach saturation; more time with the participants may have yielded additional novel information. Finally, the participants were a convenience sample and were relatively homogenous with respect to race and mobility level. Future studies that included participants with low levels of mobility could improve understanding of the issues faced by that segment of the population.

Although both the prosthetic users and professionals in this study attributed the participation restrictions to the prosthetic foot, this causal relationship was not systematically evaluated in our study and other factors (e.g., skin integrity, as described in Meulenbelt et al.²¹). Future studies should provide elucidation of the mechanisms or participation restriction to enable stakeholders to overcome barriers to participation.

CONCLUSIONS

Forward walking on level ground was not considered a barrier to community participation by this sample of prosthetic foot users and prosthetic professionals. However, other aspects of household and community mobility were. In particular, when a single activity had multiple challenging aspects (changing positions, moving in cramped spaces, and carrying objects during gardening, for example) people using prosthetic feet had more limited participation.

In combination with other studies, the present study provides information for many stakeholders. Patients might learn from the lived experiences of people with similar physical issues; prosthetic developers should consider the needs of their consumers; professionals might anticipate concerns and barriers of their patients; payers could consider strategies to reduce suffering caused by the inability to participate fully.

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Table 1

Demographic Characteristics of Health Care Professional Participants

Characteristics	Participants (<i>n</i> = 11)
Mean age, yr (range)	48 (31-65)
Gender	
Male	8
Female	3
Mean years in profession (range)	23.5 (4-43)
Primary work environment	
Outpatient	10
Research	1
Ethnicity	
Hispanic/Latino	1
Non-Hispanic/Latino	10

Table 2

Demographic Characteristics of Prosthetic User Participants

Characteristics	Participants (<i>n</i> = 11)*
Mean age, yr (range)	52.5 (32-73)
Gender	
Male	8
Female	3
Body mass index (BMI), avg (range)	27.6 (22.9-32.9)
Mean years since amputation (range)	29.5 (4-55)
Level of amputation	
Between ankle/knee	10
At the knee	1
Ethnicity	
Hispanic/Latino	1
Non-Hispanic/Latino	9
No answer	1

*
11 of 16 user participants completed questionnaires

Table 3**Physical Function and Activities of Prosthetic User Participants**

Characteristics	Participants (n = 16)
K-level	
Level 1	0
Level 2	0
Level 3	7 (43.8%)
Level 4	9 (56.25%)
Characteristics	Participants (n = 11) *
Average hours/day using prosthetic (range)	12 (8-16)
Use of walking aid	
No	8
Yes	3
Type of work activity	
Physical work	2
Sedentary occupation	3
Standing occupation	2
No answer	4
Mean hours/week spent in physical activity/sport (range)	7.5 (0-15)
Overall health rating	
Excellent	4
Good	6
Fair	1
Very poor	0
Difficulty with usual activities	
Considerable	0
Some	2
Slight	4
None	5
Modify activities for fear of falling	
Yes	4
No	7

*
11 of 16 user participants completed questionnaires