Department of Veterans Affairs

JRRD Volume 46, Number 5, 2009
Pages 567–576
Journal of Rehabilitation Research & Development

Prosthesis and wheelchair use in veterans with lower-limb amputation

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Abstract—We determined the demographic, health, functional, and satisfaction factors related to lower-limb prosthesis or wheelchair use among veterans with lower-limb amputation. Forty-two veterans were recruited from the 20th National Disabled Veterans Winter Sports Clinic and the 26th National Veterans Wheelchair Games. Participants were at least 18 years of age, had a lower-limb amputation, and were either prosthesis or wheelchair users. Level of amputation was the most significant health-related characteristic determining the veterans' use of a prosthesis versus a wheelchair ($p = 0.02$). Veterans who had a higher level of amputation and used a prosthesis reported significantly greater difficulty navigating a ramp ($p = 0.03$), getting in and out of cars and buses ($p = 0.03$), carrying 10 lb of groceries ($p = 0.02$), and participating in sports and leisure activities ($p = 0.03$). The parameter "satisfaction related to prosthesis" did not determine selection of mobility device type. The interaction of demographics, health-related characteristics, and mobility device characteristics affects functional performance and influences the use of prostheses, wheelchairs, or both in persons with lower-limb amputation. Long-term outcome assessments may help determine factors associated with either transition from one device to another or combined use of the devices over time.

Key words: function, health characteristics, lower-limb amputation, mobility device, outcome, prostheses, rehabilitation, satisfaction, veterans, wheelchairs.

INTRODUCTION

Lower-limb amputation (LLA) from combat-related injuries and peripheral vascular disease (PVD) has increased in the U.S. veteran population [1–2]. Since the Global War On Terrorism began, more than 1,200 military service members have sustained traumatic limb amputations associated with military operations in Iraq and Afghanistan [3]. These active service members and veterans, who receive care through the Department of Defense (DOD) and the Veterans Health Administration (VHA),

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Abbreviations: DOD = Department of Defense, IRB = Institutional Review Board, LLA = lower-limb amputation, MOTIVATe = Mobility Outcomes and Training in Veteran Adaptive Technology, OPUS = Orthotics Prosthetics User Survey, PPA = Prosthetic Profile of the Amputee (scale), PVD = peripheral vascular disease, SD = standard deviation, TAPES = Trinity Amputation and Prosthesis Experience Scales, VA = Department of Veterans Affairs, VHA = Veterans Health Administration, WRAMC = Walter Reed Army Medical Center.

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DOI:10.1682/JRRD.2008.08.0102

have inspired advances in both medical and prosthetic technology innovations that include improved myoelectric prosthetic arms, motorized lower-limb prostheses, and control strategies [4–5]. Prescription of the right prosthesis depends on multiple factors, such as the characteristics of the prosthesis (fit, comfort, functionality, durability), the availability of other mobility devices, and the health status and goals of the individual. A prior study of 45 veterans with amputation indicated that 54 percent did not consider prosthetic devices useful because of residual-limb pain, discomfort, and misfit [6]. A longitudinal study on veterans with bilateral transfemoral amputations reported that only 22 percent (n = 5) of the study sample population (N = 23) used their prostheses for an average daily duration of 7.7 hours [7]. Dillingham et al. found that 95 percent of their study participants (n = 146) used their prostheses on a regular basis; however, their findings suggested a negative relationship between amputation level and prosthesis use [8]. Bilodeau et al. reported that age, female gender, ownership of a wheelchair, higher levels of physical disability, cognitive impairment, poor self-perceived health, and lack of satisfaction were associated with nonuse of a prosthetic device [9].

Gauthier-Gagnon et al. reported that the determinants for use or nonuse of a prosthesis could be described as “predisposing,” “reinforcing,” or “enabling” factors [10]. Predisposing factors for prosthesis use included physical health (amputation level, comorbidities, and degenerative changes of the intact limb) and demographic characteristics (age and community dwelling) [11]. Reinforcing factors included time between amputation and prosthesis fitting, which was inversely correlated with the device use [11], and enabling factors included prosthesis fit, physical capacity for walking, and use of other mobility aids [10]. Other factors that have been found to be associated with nonuse of a prosthesis include higher amputation level, bilateral amputations, coronary artery disease, and residence in a nursing home [12]. Legro et al. reported that ability to perform functional activities (e.g., walking up or down ramps), dynamic standing balance, and comfort during performance of these activities significantly contributed to prosthesis use [13].

Nonuse of a prescribed mobility device, including a prosthesis, is common and associated with wasted expenses and productivity for healthcare insurers and providers [14–16]. Besides, functional use of the prostheses and perceived benefits play a big role in the determination of use or nonuse of the prescribed devices. One study reported that mobility devices, including upper- and lower-limb prostheses, are the most likely to be abandoned [15]. End user dissatisfaction with prescribed technology has been cited in the literature as the most important factor of device abandonment [14–16]. Dillingham et al., however, found that 95 percent of their sample population of persons with amputation reported daily use of their prostheses despite low satisfaction with them [8]. Pezzin et al. also reported low satisfaction with prostheses despite high usage. Decreased satisfaction with prostheses in this study was due to lack of comfort, poor communication with prescribing and fitting professionals, and increased fitting time [17].

Most current research examining prescription patterns and use of prostheses involves samples drawn from civilian populations, with a high proportion of older individuals with amputation due to PVD or younger nonveterans with traumatic amputation [9,14–16,18–21]. The purpose of our study was to describe the demographics and health-related characteristics of veterans with LLA participating in organized sporting events and to determine the levels of functional performance and satisfaction related to their prescribed prostheses.

METHODS

Study Design

As part of a collaborative effort between the Human Engineering Research Laboratories, Department of Veterans Affairs (VA) Center for Excellence in Wheelchairs and Associated Rehabilitation Engineering in Pittsburgh, Pennsylvania, and the Walter Reed Army Medical Center (WRAMC) Amputee Program in Washington, DC, we performed a cross-sectional study using a questionnaire entitled Mobility Outcomes and Training in Veteran Adaptive Technology (MOTIVATe). Before data collection, the study received VA Pittsburgh Healthcare System Institutional Review Board (IRB) approval and subsequent administrative approval from the WRAMC IRB.

Subjects

Forty-two veterans with LLA who took part in either the 20th National Disabled Veterans Winter Sports Clinic (2006) in Snowmass Village, Colorado, or the 26th National Veterans Wheelchair Games (2006) in Anchorage, Alaska, participated in the study. Inclusion criteria for subject recruitment were age 18 years or older with LLA and use of a prosthesis or wheelchair for mobility.

Those individuals who used attendant-propelled wheelchairs or had significant comorbidities, such as spinal cord injury and traumatic brain injury, were excluded. Out of the 134 participants, only 42 met all the criteria and were consented to complete the mobility portion of the questionnaire.

Outcome Measurements

The study used MOTIVATe, an outcomes-based questionnaire that consists of four parts: (1) demographics, (2) quality of life, (3) mobility, and (4) training. For this article, data from only the demographic and mobility parts of the questionnaire were used. Demographic variables collected included age, sex, race, and prosthesis and/or wheelchair type or model used by the participant. Health characteristics collected included reason for the amputation, type of amputation, location and level of the amputation, pain and fatigue associated with the amputation, and number and nature of comorbid medical problems. Mobility components of the questionnaire comprised a lower-limb functional performance scale and questions about satisfaction with prosthesis use. The functional performance scale was based on the Orthotics Prosthetics User Survey (OPUS), which is a valid and reliable instrument for assessing levels of difficulty in the performance of daily functional activities with use/nonuse of prostheses [22]. Participants used a 1- to 5-point Likert scale (1 = very easy to perform the activity and 5 = cannot perform the activity) to report their level of difficulty performing tasks with use of either a prosthesis or wheelchair [22]. Satisfaction levels with a prosthesis were determined by the standardized Satisfaction subscale of the Trinity Amputation and Prosthesis Experience Scales (TAPES). Psychometric properties of the TAPES were established previously [14]. In the TAPES, participants report aesthetic, functional, and overall satisfaction with prostheses by using a 1- to 5-point rating scale (1 = very dissatisfied and 5 = very satisfied) [14].

Data-Collection Protocol

Veterans participating in these organized sporting events completed the informed consent process before participating in the study. They were then asked to complete the MOTIVATe questionnaire. To ensure that participants consistently and accurately understood each question, we established study booths at each event where the participants completed the survey and had direct access to a member of the research staff, who could answer any particular questions regarding the study.

Data Analyses

The cohort of veterans was divided into two study groups, a prosthesis group and a wheelchair group, based on which device the participants indicated they used primarily for daily mobility. Continuous demographic variables (e.g., age, weight, height, pain, fatigue levels, and number of comorbid conditions) were compared between these groups with use of independent *t*-tests because these data were normally distributed. Categorical variables (e.g., amputation type, side involvement, and upper-limb amputation) were compared with use of nonparametric Fisher's exact statistics. For level of amputation, participants were dichotomized into either (1) lower amputation level (foot amputation and transtibial amputation) or (2) higher amputation level (knee disarticulation, transfemoral amputation, and hip disarticulation). For this classification, a prosthetic limb with an artificial knee was used as grouping criteria; thus, those with artificial knees were put in the higher amputation level group and the rest in the lower amputation level group. Fisher's exact statistics were used to compare levels of amputations. To find differences in mobility device characteristics between the two groups, we performed Fisher's exact statistics and independent *t*-tests.

For functional performance, we compiled amputation levels (lower amputation level and higher amputation level) with prosthesis or wheelchair use to create four subgroups: (1) lower amputation level using wheelchair, (2) lower amputation level using prosthesis, (3) higher amputation level using wheelchair, and (4) higher amputation level using prosthesis. This grouping was done primarily to control for any confounding effect that the amputation level may have on selection of mobility devices and on self-reported degrees of difficulty in functional task performance. Responses to the questions related to the level of difficulty with daily tasks were also combined to form three categories: (1) easy, (2) difficult, and (3) cannot perform activity. The associations between use of prosthesis/wheelchair and level of difficulty were determined with use of chi-square (Fisher's exact) statistics. We identified the most influential case(s) in a significant association by analyzing standardized residuals. Satisfaction levels (e.g., aesthetics, functional performance, and overall satisfaction) between the prosthesis group and the wheelchair group were investigated with use of independent *t*-tests. All statistical analyses were performed with SPSS 15.0 (SPSS, Inc; Chicago, Illinois) with a significance level of 0.05 established a priori. To determine influential case(s), we used a cutoff value of 2.0 for standardized residual of chi-square (Fisher's exact) statistics.

RESULTS

Demographics and Health Characteristics

Although not significant, the prosthesis group was younger than the wheelchair group (41 vs 46 years of average age, respectively). The prosthesis group, however, had lived more years with the amputation(s) and had fewer comorbid conditions, lower pain scores, and lower levels of fatigue than the wheelchair group (**Table 1**).

A higher percentage of participants who primarily used wheelchairs had nontraumatic amputations (amputations due to PVD), whereas participants who primarily used prostheses had a higher percentage of traumatic amputations. This difference, however, was not significant ($p = 0.22$). Also, 38 percent of the wheelchair group had bilateral amputations compared with only 20 percent of the prosthesis group, without any significant differences noted between groups ($p = 0.20$). Since the distribution of unilateral and bilateral amputations was equal in both groups, no control was used for further analyses. A significantly greater number of participants in the wheelchair group had higher levels of LLA (hip disarticulation = 15%, transfemoral amputation = 62%, transtibial amputation = 16%, and foot amputation = 7%) than in the prosthesis group (hip disarticulation = 8%, transfemoral amputation = 19%, knee disarticulation = 11%, and transtibial amputation = 62%) ($p = 0.03$). No association was found between the presence of an upper-limb amputation in addition to an LLA versus only an LLA and between prosthesis use and wheelchair use (**Table 2**).

Mobility Device Characteristics

Among those participants with higher-level amputations, the proportion possessing a prosthesis with a microprocessor knee (C-Leg™ and Rheo Knee™) was nonsignificantly higher in the wheelchair group than in the prosthesis group ($p = 0.65$). Eighty percent of veterans in the prosthesis group had multiaxial energy-storing prosthetic feet, whereas none in the wheelchair group had energy-storing prosthetic feet. However, this difference was not significant ($p = 0.24$).

A greater number of supplemental mobility devices (canes, crutches, and walkers) were possessed by the wheelchair group than the prosthesis group, although not to a significant degree ($p = 0.19$). Veterans in the prosthesis group possessed both manual (69%) and power wheelchairs (11%), which did not differ significantly from the wheelchair group (manual = 77% and power = 24%).

Functional Performance

A significant association between degree of difficulty with daily tasks and amputation level was reported for both groups (**Figure**). For traversing a ramp, the association was significantly different ($p = 0.03$), with a higher proportion of participants in the higher amputation level using prosthesis group reporting greater difficulty than the other subgroups (lower amputation level using wheelchair, lower amputation level using prosthesis, and higher amputation level using wheelchair) (**Figure (a)**). This finding is further supported by the standardized residuals for this subgroup, which indicate that most participants in the higher amputation level using prosthesis group reported greater difficulty

Table 1.
Demographics and health-related variables among 42 veterans with lower-limb amputation who used either prosthesis or wheelchair as their primary mobility device.

Demographic	Prosthesis Group (mean ± SD)	Wheelchair Group (mean ± SD)	*p*-Value*
Age (yr)	40.58 ± 17.14	45.51 ± 13.16	0.32
Amputation Time (yr)	13.78 ± 16.10	8.99 ± 10.19	0.33
Weight (kg)	88.17 ± 26.57	81 ± 26.72	0.44
Height (cm)	179.90 ± 7.77	180.34 ± 8.87	0.88
Comorbid Conditions (No.)	1.16 ± 1.27	1.53 ± 1.80	0.52
Residual Limb Pain (VAS)	3.61 ± 1.98	4 ± 2.82	0.64
Back Pain (VAS)	3.48 ± 3.02	4.09 ± 3.14	0.58
Phantom Pain (VAS)	3.03 ± 2.84	4.27 ± 3.77	0.28
Fatigue (VAS)	4.23 ± 2.61	5.30 ± 2.49	0.27

*Independent *t*-test.
SD = standard deviation, VAS = visual analog scale.

Table 2.
Health-related factors among 42 veterans with lower-limb amputation who used either prosthesis or wheelchair as their primary mobility device.

Factor	Prosthesis Group (*n*)	Wheelchair Group (*n*)	*p*-Value*
Amputation Type†			0.22
Traumatic	23	4	
Nontraumatic	4	9	
Amputation Level†			0.03‡
Lower	16	3	
Higher	10	10	
Limb Involvement†			0.20
Unilateral	20	8	
Bilateral	5	5	
Upper-Limb Amputation			0.48
No	24	10	
Yes	5	3	

*Chi-square (Fisher's exact).
†Missing data.
‡Statistically significant difference at $\alpha = 0.05$.

navigating ramps than the other three subgroups. This trend was similar to that seen for getting in and out of cars and buses, with participants in the higher amputation level using prosthesis group reporting a significantly higher degree of difficulty ($p = 0.03$) than participants from the other three subgroups (**Figure (b)**). Carrying 10 lb of groceries was one activity that had a significant association between degree of difficulty and choice of mobility device after controlling for amputation level ($p = 0.02$). Individuals in the higher amputation level using prosthesis group reported greater degrees of difficulty than the other subgroups (**Figure (c)**). Finally, performing sports and leisure activities was significantly associated with degree of difficulty and amputation level ($p = 0.03$). Compared with the other three subgroups, a greater proportion of those in the higher amputation level using prosthesis group reported an inability to perform these activities (**Figure (d)**).

Satisfaction with Mobility Devices

Veterans primarily using prostheses reported slightly higher levels of satisfaction with functional performance than did those using wheelchairs (mean ± standard deviation [SD] = 18.5 ± 4.5 vs 17.9 ± 5.4, respectively; $p = 0.73$). Satisfaction with device appearance (mean ± SD = 14.4 ± 4.2 vs 14.4 ± 4.9, respectively) and overall satisfaction (mean ± SD = 3.7 ± 0.9 vs 3.7 ± 1.1, respectively) did not significantly differ between the prosthesis group and the wheelchair group.

DISCUSSION

Participants in the wheelchair group were older than those in the prosthesis group, with the older veterans reporting a higher number of comorbid conditions. Clinically, age could be an important indicator for provision of appropriate prosthetic devices or wheelchairs to maximize the utilization of the prescribed devices [23–26]. Some examples include sacrificing degrees of freedom of prosthetic feet to achieve greater stability during ambulation or recommending use of wheelchairs for travelling greater distances to achieve efficient and safe mobility. Another clinically relevant factor is amputation years. In our study, although the difference was not statistically significant, veterans in the prosthesis group had had their amputations longer than those in the wheelchair group. This finding suggests that longer periods of mobility device use could result in greater adaptability with the (prosthetic) devices. Previous literature has indicated age as a determinant factor but has not directly determined the association between years with amputation and the selection of mobility devices [10–11]. The wheelchair group reported higher levels of pain accompanied by increased levels of fatigue than the prosthesis group. Our study found that the individuals with LLA secondary to PVD were more likely to use wheelchairs than were the individuals with traumatic amputations. As reported previously, individuals with PVD-related amputations demonstrated more inefficient ambulation (which could also be associated with age, presence of greater comorbidities, and higher level of amputation) than those with traumatic amputation, which could contribute to wheelchairs (which need lower energy than walking) being their mobility device of choice [11–13,21,23].

A significantly higher proportion of veterans with amputation at the hip, transfemoral, and knee levels was found to use wheelchairs. The veterans using prostheses primarily had lower-level amputations (transtibial and foot amputation). Our results were consistent with those in the literature, indicating an indirect relation between level of amputation and energy efficiency, since individuals with transfemoral amputation require significantly higher levels of energy expenditure during activities than individuals with transtibial amputation [24]. Our study, in fact, was based on self-reported use of wheelchairs and prostheses. We must determine the cause-and-effect relationship between amputation level, metabolic cost, and selection of mobility device in future longitudinal studies by means of objective assessments in addition to subjective responses.

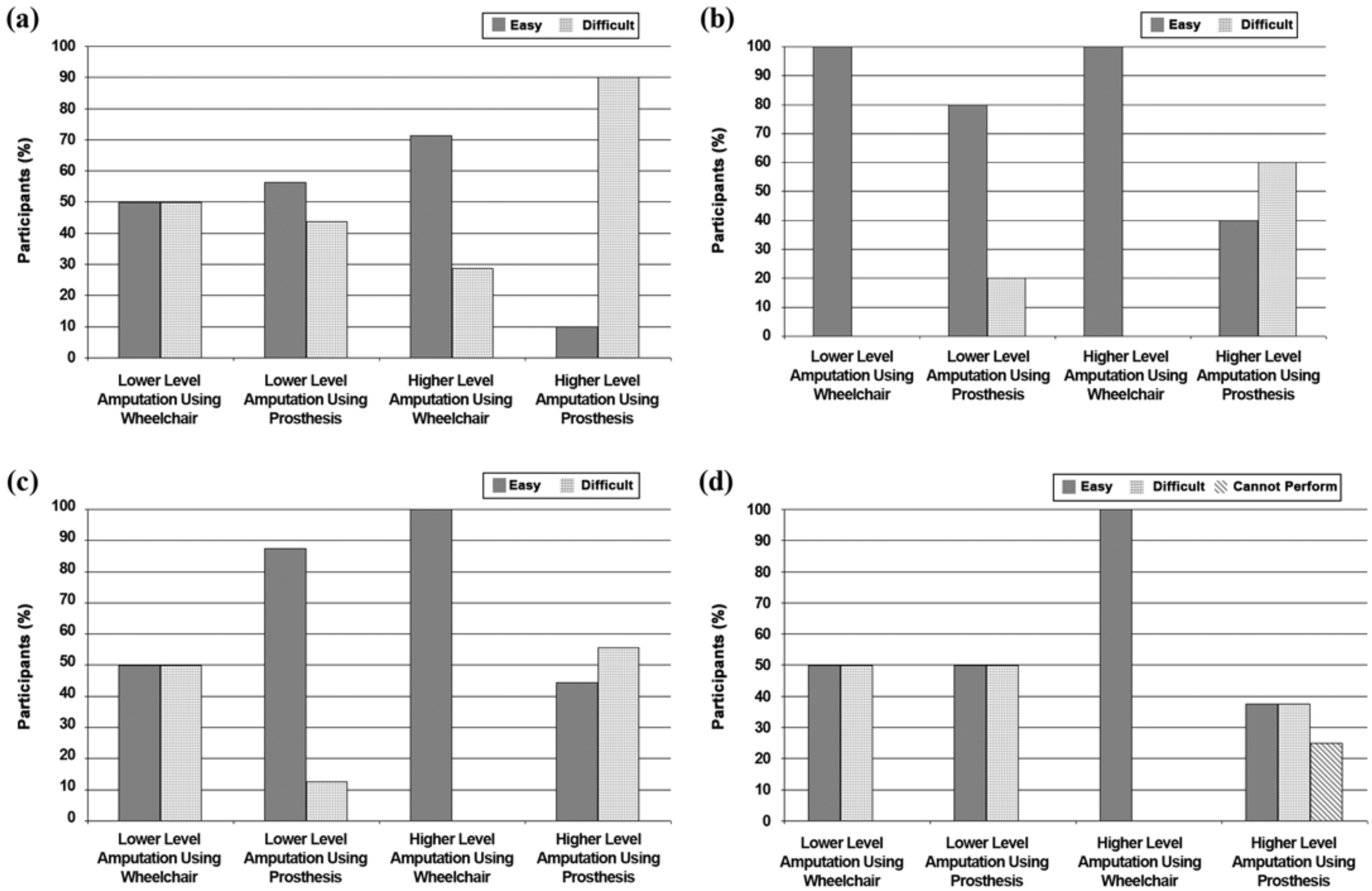

Figure.
Veterans' degree of difficulty performing functional activities by amputation level and mobility device (prosthesis or wheelchair): **(a)** traversing ramp (higher amputation level using prosthesis group reported significantly more difficulty than other subgroups, $p = 0.03$), **(b)** getting in and out of cars and buses (higher amputation level using prosthesis group reported significantly more difficulty than other subgroups, $p = 0.03$), **(c)** carrying 10 lb of groceries (higher amputation level using prosthesis group reported significantly more difficulty than other subgroups, $p = 0.02$), and **(d)** participating in sports and leisure activities (significantly more participants in higher amputation level using prosthesis group reported inability to perform, $p = 0.03$).

No significant difference was reported between the prosthesis group and the wheelchair group with respect to types of mobility devices prescribed (i.e., prostheses and wheelchairs). This finding is especially important for the prescription of prosthetic knees for those with higher-level amputations, considering that all veterans who primarily used wheelchairs were also prescribed prostheses with microprocessor knees (C-Leg or Rheo Knee). Since the cost of a microprocessor knee could be substantial, prescription of such devices must also be based on the functional needs of the end user. A possible explanation for the prescription of microprocessor knee units is that the clinician determined at initial evaluation that the user required substantial stability during ambulation, stability that would be provided by these knee units. Current studies, emphasizing prescription models, only consider the recipient's age; demographic characteristics; health factors, including the presence of comorbid conditions; and cognitive abilities [25–26]. However, one must also consider users' functional performance with the devices and the importance the users give to the devices, because these critical factors have been found to contribute to successful prosthesis utilization.

A significant proportion of participants from both groups reported possessing and using wheelchairs as primary or secondary devices for mobility. Similarly, individuals in both groups reported possessing other mobility devices (canes, crutches, walkers). These findings are consistent with previously published research, which suggested that individuals with LLA use mobility devices other than prostheses for ambulation [10]. However, an interesting finding from our study was that only 18 percent of veterans from both groups self-reported receiving any formal training in the use and propulsion of manual wheelchairs. As indicated previously, inefficient wheelchair propulsion could lead to upper-limb strain injuries [27]. Providing adequate training for primary and secondary mobility devices is essential for controlling the rate of such acquired injuries [27].

Individuals in our study were using prostheses and wheelchairs differently for various functional activities. Degree of difficulty performing these activities, however, depended on amputation level and type of mobility device used. For individuals with higher amputation levels, 72 percent reported traversing a ramp using a wheelchair without difficulty, whereas 90 percent of participants in the prosthesis group with higher amputation level reported difficulty performing this activity. The proportion of veterans who reported getting in and out of cars and buses without difficulty was 100 percent for higher level amputees using a wheelchair versus 60 percent for higher level amputees using a prosthesis. For carrying 10 lb of groceries, the proportions were significantly different: higher level amputees using wheelchairs reported performing this activity without difficulty (100%), while those using prostheses reported difficulty (56%). For physically intense activities like performing sports and other leisure activities, the proportion of wheelchair use with ease was 100 percent as compared with 38 percent of prosthesis use with difficulty, with 25 percent reporting inability to perform the activity. In the comparable study by Gauthier-Gagnon et al., only 42 percent of prosthesis users and 2 percent of nonusers reported performing the same task without any outside help [10]. The differences in results could be due to our use of the OPUS to collect data related to functional performance; the study by Gauthier-Gagnon et al. used the Prosthetic Profile of the Amputee (PPA) scale [10]. The PPA asks individuals to rate degree of difficulty in performing an activity while wearing their prosthesis, while the OPUS allows respondents to choose between use of prosthesis or other mobility device (wheelchair) and then rate the difficulty level. Despite the difference in questioning strategies, results from both studies suggested a direct relation between increased levels of difficulty in task performance and prosthesis use.

Participants from both groups reported satisfaction with three aspects of their prostheses: appearance, function, and overall satisfaction. No significant differences were found in these aspects between the two groups. The results of our study contradict those reported previously by Dillingham et al. and Pezzin et al., who found low satisfaction with prosthetic devices despite high reported use of prostheses among their subjects [8,17]. The difference in the results could be due to the different study samples. These two published studies targeted civilian populations, whereas our study involved veterans. Our objective in collecting satisfaction data was to examine differences between a group that preferred to use prostheses for mobility-related activities and a group that preferred to use wheelchairs. Our results did not identify satisfaction as a significant indicator for selection of one mobility device over another.

This study has several limitations. Being cross-sectional, the study lacks the ability to establish a true cause-and-effect relationship between various factors in the use and nonuse of prostheses. Also, we could not determine a unidirectional or bidirectional relationship between factors such as age, amputation years, comorbidities, and other health factors and use of mobility devices and functional performance. A future longitudinal study could assess the quality and long-term impact of prosthetic services provided through DOD and VHA to military personnel and veterans with LLA. A study of this kind could also help identify changes in the needs of veterans who may require modification of current prostheses or consideration of alternative mobility devices such as wheelchairs. Our study targeted a convenience sample of veterans attending organized sporting events. Therefore, generalization of the results to the civilian population, as well as to those veterans who do not participate in such events, could be limited. With a significant predicted increase of LLA, especially for persons older than 65, a need exists for collecting similar data from the civilian population and a broader veteran population to better understand the effect of various factors on use of prosthetic devices [25]. The sample population was divided into prosthesis versus wheelchair users based on participants' self-report on the survey. This differentiation may not be precise, since the relationship between physical capacity, technologies, environment, and activities desired is complicated. However, from a clinical point of view, such a demarcation would be effective in prioritizing specific needs of primary prosthesis users and primary wheelchair users.

CONCLUSIONS

The results of this study indicate the need for a prospective long-term follow-up study of a veteran population with LLA. The results from our study suggest that a relationship exists among demographics, health-related characteristics, and mobility device characteristics and could affect functional performance and determine the primary mobility device of choice—prosthesis, wheelchair, or both. However, a longitudinal study will help us better understand interchangeability or combined use of mobility devices (prostheses and wheelchairs) by this population based on the context and activities performed. Current rehabilitation models for people with amputation provide mobility devices based on anticipated level of physical activities and environments within which the devices will be used. However, no long-term outcome studies actually relate use of these mobility devices to functional performance while considering demographics, health, and environmental factors. Determining the temporal changes in the needs of people with amputation is critical for both rehabilitation clinicians and prosthetists to provide appropriate prostheses or a combination of prostheses and wheelchairs and training in their use. Collection of long-term follow-up data is crucial for health service providers (DOD and VHA), who spend a significant amount of funds to provide sophisticated prosthetic technology to U.S. veterans.

ACKNOWLEDGMENTS

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Study supervision: P. F. Pasquina, R. A. Cooper.

Financial Disclosures: The authors have declared that no competing interests exist.

Funding/Support: This material was based on work supported by the Armed Forces Amputees Care Program (DOD), Telemedicine and Advanced Technology Research Center (grant 06053001), and VA Center for Excellence in Wheelchairs and Associated Rehabilitation Engineering (grant B3142C).

Participant Follow-Up: The authors do not plan to inform participants of the publication of this study.

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Submitted for publication August 18, 2008. Accepted in revised form January 30, 2009.