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Unilateral upper-limb loss: Satisfaction and prosthetic-device use in veterans and servicemembers from Vietnam and OIF/OEF conflicts

Lynne V. McFarland, PhD;[1*] Sandra L. Hubbard Winkler, PhD, OTR/L, ATP;[2] Allen W. Heinemann, PhD;[3] Melissa Jones, PhD, OTR/L, CHT, LTC;[4] Alberto Esquenazi, MD[5]

[1]Department of Veterans Affairs Puget Sound Health Care System, Seattle, WA; and University of Washington, Seattle, WA; [2]Rehabilitation Outcomes Research Center Research Enhancement Award Program, North Florida/South Georgia Veterans Health System, Gainesville, FL; and University of Florida, Gainesville, FL; [3]Department of Physical Medicine and Rehabilitation, Feinberg School of Medicine, Northwestern University, Chicago, IL; and Center for Rehabilitation Outcomes Research, Rehabilitation Institute of Chicago, Chicago, IL; [4]U.S. Army, Manhattan, KS; [5]Department of Physical Medicine and Rehabilitation, MossRehab and Albert Einstein Medical Center, Elkins Park, PA

Abstract—Prosthetic use and satisfaction in wounded servicemembers and veterans with unilateral upper-limb loss has not been thoroughly explored. Through a national survey, we enrolled 47 participants from the Vietnam conflict and 50 from Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) with combat-associated major unilateral upper-limb loss. Upper-limb prosthetic devices were used by 70% of the Vietnam group and 76% of the OIF/OEF group. Mechanical/body-powered upper-limb devices were favored by the Vietnam group, while a combination of myoelectric/hybrid and mechanical/body-powered devices were favored by the OIF/OEF group. Upper-limb devices were completely abandoned in 30% of the Vietnam and 22% of the OIF/OEF groups. Abandonment was more frequent for transhumeral and more proximal levels (42% of Vietnam and 40% of OIF/OEF) than more distal limb-loss levels. Upper-limb prostheses were rejected because of dissatisfaction with the device by significantly fewer (23%) members of the Vietnam group than the OIF/OEF group (45%) ($p < 0.001$). Most common reasons for rejection included pain, poor comfort, and lack of functionality. A significant paradigm shift has been noted in the OIF/OEF group, who use a greater number and diversity of upper-limb prostheses than the Vietnam group.

Key words: abandonment, activity measure, limb loss, OIF/OEF, prosthetic device, rehabilitation, satisfaction, upper-limb loss, veterans, Vietnam conflict.

INTRODUCTION

The National Limb Loss Information Center reported that in 2007 approximately 1.7 million people were living with limb loss in the United States [1], and this number is projected to reach 3.6 million by 2050 [2]. Although lower-limb loss is more prevalent (80%) than upper-limb (10%) or multiple-limb (10%) loss, upper-limb loss has unique challenges and issues [3]. In 2005, 41,000 persons in the United States were living with major upper-limb loss, 62 percent of whom had trauma-related injuries [2]. The proportion of trauma-related upper-limb loss increases during times of warfare: limb loss involved the

Abbreviations: ADL = activities of daily living, aOR = adjusted odds ratio, CTD = cumulative trauma disorder, DOD = Department of Defense, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom, PTSD = posttraumatic stress disorder, TBI = traumatic brain injury, VA = Department of Veterans Affairs.

***Address all correspondence to Lynne V. McFarland, PhD; VA Puget Sound Health Care System, Health Services Research and Development, 1100 Olive Way, Suite 1400, Seattle, WA 98101; 206-277-1095; fax: 206-764-2935. Email: Lynne.McFarland@va.gov**
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upper limb in 14 to 15 percent of 5,283 Vietnam servicemembers [4–5], 18.5 percent of 89 British World War II veterans [6], 14 percent of 14 Persian Gulf servicemembers [7], and 12.5 percent of 200 Iraq-Iran conflict servicemembers during the late 1980s [8–12]. As of January 2009, 161 (22%) of 737 servicemembers in the Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) conflict had limb loss involving the upper limb.*

Few studies on combat-related injuries focus on unilateral upper-limb loss. Several reasons upper-limb loss research trails that of lower-limb loss include (1) upper-limb loss is less frequent; (2) measurement of upper-limb activity level is more difficult than measurement of lower-limb function, which relies on weight-bearing and ambulation; (3) upper-limb prostheses are more challenging to master than lower-limb prostheses; and (4) trauma is the primary cause of upper-limb loss, as opposed to dysvascular conditions, so the population is generally more heterogeneous and therefore more difficult to study [13].

A recent Department of Defense (DOD) Rehabilitation Directive aims to restore wounded servicemembers from OIF/OEF to the highest possible functional level so the loss of a limb does not prevent a return to Active Duty [14–16]. Factors predicting continued use of and satisfaction with prosthetic devices in these servicemembers and veterans have not been fully explored [17–18]. Our study explores the effect of this rehabilitation paradigm shift by comparing the prosthesis use of veterans with combat-associated unilateral upper-limb loss from the Vietnam group (predirective) with that of the OIF/OEF group (postdirective). The purpose of this study was to describe prosthetic-device use patterns in two large groups of servicemembers and veterans with combat-associated upper-limb loss.

METHODS

Study Design

This descriptive, cross-sectional survey collected data on current prosthetic- and assistive-device use (number and type of devices and daily frequency of use) and satisfaction with current prostheses and services from two distinct groups of veterans and servicemembers with combat-associated major limb loss (digit-only loss excluded).

Survey Participants

Participants in this study were veterans from the Vietnam conflict and veterans and servicemembers from the OIF/OEF conflict with at least one major traumatic amputation (digit-only loss excluded) associated with a combat-field injury. Veterans and servicemembers with major limb loss occurring during the Vietnam (1961–1973) or OIF/OEF (2000–2008) conflicts were sent an invitation to participate in a survey on prosthesis use. All servicemembers with major limb loss from OIF/OEF were invited to participate. A selection of Vietnam veterans were also invited (all unilateral upper-limb loss, all multiple limb loss, and a subsample of unilateral lower-limb loss) to match the total number of OIF/OEF invitees. Survey participants included 298 from the Vietnam conflict (65% response rate) and 283 from the OIF/OEF conflict (59% response rate). Participants took the survey by one of three methods: mail, telephone interview, or Web site. Veterans and servicemembers were surveyed during 2007 and 2008. A description of the detailed study methods and the survey are found elsewhere in this issue [19], and a copy of the *Survey for Prosthetic Use* can be found in **Appendix 1** (available online only). This study focuses on servicemembers and veterans with combat-associated unilateral upper-limb loss occurring during the Vietnam and OIF/OEF conflicts: unilateral lower-limb [20] and multiple limb loss [21] are described elsewhere in this issue.

Survey Measures

The survey collected data on basic demographics, current military status, and employment. The presence of self-reported comorbidities, such as arthritis, diabetes, depression, migraines, phantom pain, residual-limb pain, posttraumatic stress disorder (PTSD), or traumatic brain injury (TBI) was also reported. The combat injury impact rank score was collected and assesses the effect of different types of combat injuries on current life. It ranges from 0 (does not affect at all) to 10 (strongly affects). The types of combat injuries reported were amputated limb, injury to nonamputated limb, head and eye injuries, hearing loss, chest injury, abdominal injury, burns, or other injuries. Self-rated health status was classified into three groups: (1) very good-to-excellent, (2) good, or (3) fair-to-poor.

*Scoville, Charles R. (Amputee Patient Care Service, Integrated Department of Orthopaedics and Rehabilitation, National Naval Medical Center, Walter Reed Army Medical Center, Washington, DC). Email to: Gayle E. Reiber (Program Analyst, Department of Prosthetic and Sensory Aids, VA Puget Sound Health Care System, Seattle, WA). Email on amputee patient numbers through January 2009. 2009 Jan 31.

Cumulative trauma disorder (CTD) (or worn-limb syndrome) was also reported; it results from overuse of the nonamputated limb and may include any one of the following: carpal tunnel syndrome, cubital tunnel syndrome, tendonitis, arthritis, stiff or painful joints, or ganglion cysts. The number of surgeries before and after the initial amputation was also reported. Use of three types of upper-limb prosthetic devices was recorded: myoelectric/hybrid, mechanical/body-powered, or cosmetic. Data on 23 activities of daily living (ADL) were collected. These items included performance of tasks related to eating and dressing, community activities, housekeeping, automobile operation, use of tools, and sporting activities.

Prosthetic Devices

Current satisfaction with prostheses was ranked from 0 (not at all satisfied) to 10 (completely satisfied). Survey participants were also asked which types of prosthetic and assistive devices they might want to try in the next 3 years.

Retrospective data were also collected on the number and types of prostheses received in the past (total for the first year postamputation and then total since that time). Data were collected on the number of prostheses that wore out and the average replacement time by type of device. For prostheses that were discontinued because of dissatisfaction, the number and types of devices were collected, as well as the reasons why participants discontinued the prosthesis. Survey participants self-reported any prosthetic-device receipt, regardless of whether received through military, Department of Veterans Affairs (VA), or private sources. Survey participants also included whether they had ever received prototype prosthetic devices.

Due to the complexity of prosthetic systems, we summarized prosthetic-device types into major groups defined by the degree of technology, device use, and level of limb loss. Upper-limb prostheses were grouped into three groups: myoelectric/hybrid (advanced technology), mechanical/body-powered (no batteries needed), and cosmetic (nonfunctional). Assistive technology use (walkers, canes, crutches, car modifications, wheelchairs, terminal upper-limb devices, etc.) was collected for current use and predicted use in the next 3 years.

Health Status

Cross-sectional data were collected for current quality of life, health status, comorbidities, overuse problems with nonamputated limb(s), social support (marital status, employment, children, current military status), ability to perform ADL, current lower-limb function, and the effect of prior combat injuries on current life. Self-rated health status was assessed with a validated tool [22]. Retrospective data were collected on the date and location of all amputations, number of associated surgeries, level of limb loss, and types of combat injuries.

Statistical Analysis

Univariate, bivariate, and multivariate findings were analyzed with Stata 9.2 (StataCorp; College Station, Texas). For univariate analyses, statistical significance was based on chi-square (categorical data), Mann-Whitney *U*-test (ordinal data), Student *t*-test (continuous data), and Fisher exact test if cell sizes <5. The level of significance was a two-sided $p \leq 0.05$.

We assessed upper-limb function by using psychometric properties of a 23-item, 4-category rating-scale instrument for upper-limb activity status using Rasch analysis and Winsteps software, version 3.64.2 [23]. Rasch analysis provides information about a summed scale that cannot be obtained using classical test theory approaches [24–26]. Rasch analysis defines a construct inferred from a hierarchy of item difficulties and the functioning of response categories. The validity of a measure is assessed by evaluating the fit of the items to an underlying construct. From our survey, 23 ADL were used as items for the hierarchy of difficulty. Function response categories on how survey participants performed each task were collected for each of the ADL. The four possible response categories were "uses prosthetic device," "does with other hand," "does with assistance," and "does not do." More positive activity-score values indicated tasks that were typically more difficult and were performed with an upper-limb prosthesis. More negative activity-score values indicated less difficult tasks that were typically not done or required the assistance of another person. We specified a partial-credit model that allowed the response-category thresholds to vary across items. The initial Rasch rating-scale analysis of the 23 ADL revealed that the rating-scale categories did not increase monotonically. For 13 items, the difficulty of category 4 ("does not do") was inverted; that is, "does with assistance" (category 3) reflected greater dependence. We rescored responses so that categories 3 and 4 were combined to reflect a maximum level of dependence. Combining these categories eliminated category inversion, which resulted in improved person reliability (0.89) without lowering the ceiling of the measure. Three items did not fit well (mean square infit values ranging from 1.42 to 1.69). We removed the most misfitting item ("high aerobic sport activities," mean square infit = 1.69) and the most overfitting item ("raking," mean square infit = 0.67). Our analysis then showed only one item ("drying dishes") slightly misfit (mean square infit = 1.42), while preserving good reliability (0.88). We used the activity-score measure produced for each person from this 21-item, 3-category rating-scale analysis for subsequent comparisons of upper-limb activity for participant groups.

Multiple linear regression was used to fit a model for the continuous outcome variable (upper-limb activity) for each of the groups separately. The outcome for the models was a continuous upper-limb activity measure derived using Rasch analysis. Variables significant in univariate analyses were tested in multivariate models. To avoid overfitting the model, we added variables significant in univariate analyses using forward stepwise selection based on the log-likelihood ratio and the significance of the coefficient. The new model was compared with the previous model using the log-likelihood ratio chi-square test, and the variable was kept in the model if $p \leq 0.05$. The variable was removed from the model if $p > 0.05$ and it was not a confounding factor. Potential interactions were assessed using the log-likelihood ratio. Goodness of fit of the final model was assessed using diagnostic plots of residual errors, and outliers were investigated [27]. Due to the low frequency of limb loss in the wrist, elbow, and shoulder levels, only individuals with transfemoral and transradial limb-loss levels were included in the models.

RESULTS

Vietnam and OIF/OEF Groups

Forty-seven Vietnam veterans and fifty servicemembers wounded in the OIF/OEF conflict with unilateral upper-limb loss were enrolled in our study. The mean (± standard deviation) age of the Vietnam group was 60 ± 2 years, and the mean age of the OIF/OEF group was 30 ± 6 years. Seven (14%) of the OIF/OEF participants returned to Active Duty after rehabilitation. Surprisingly, more than half those returning to Active Duty had transhumeral limb loss. A comparison of the health status of the Vietnam and OIF/OEF groups is shown by level of limb loss in **Table 1**. The level of limb loss was diverse for both groups; transradial and transhumeral limb loss being the most frequent for both the Vietnam (32% and 43%, respectively) and OIF/OEF groups (40% and 28%, respectively). A detailed description of the demographic characteristics of the Vietnam and OIF/OEF groups with unilateral upper-limb loss can be found in another article in this issue [19].

Comorbidity

The Vietnam group reported a mean of 4 ± 3 comorbidities, and the OIF/OEF group reported a similar mean number of comorbidities (5 ± 3), but the type of comorbidities differed by group. Arthritis was more frequently reported by the Vietnam group (55%) than the OIF/OEF group (26%, $p = 0.003$). Diabetes was more common in the Vietnam group (19%) than the OIF/OEF group (4%, $p = 0.02$). The OIF/OEF group reported more PTSD (68% vs 27%, $p < 0.001$), residual-limb pain (68% vs 32%, $p < 0.001$), and TBI (32% vs 6%, p = 0.00l) than the Vietnam group. Phantom pain was reported by 66 percent of the Vietnam group and 82 percent of the OIF/OEF group ($p = 0.07$). The frequencies of other comorbidities did not significantly differ in the Vietnam versus OIF/OEF groups: depression (19% and 26%, respectively) and stroke (2% and 6%, respectively).

Combat-Associated Injuries

When survey participants were asked to rank how their upper-limb loss affected their current quality of life, the average combat injury impact rank for the Vietnam group was 7 ± 3 versus 8 ± 2 for the OIF/OEF group ($p = 0.04$). In the Vietnam group, those with transhumeral limb loss reported their limb loss had the greatest effect on their current life, while in the OIF/OEF group, through-the-hand limb loss had the greatest effect on quality of life.

In addition to limb loss, other combat-related injuries were more frequent in the OIF/OEF group: 60 percent of the Vietnam group reported other combat injuries compared with 90 percent of the OIF/OEF group ($p = 0.01$). The mean number of types of combat-related injuries was significantly higher for the OIF/OEF group (3.9 ± 2.3) than the Vietnam group (2.9 ± 2.3, $p = 0.03$). Head injuries were more frequent in the OIF/OEF group than the Vietnam group (44% vs 11%, respectively, $p < 0.001$); hearing loss was more frequent in the OIF/OEF group than the Vietnam group (62% vs 34%, respectively, $p < 0.01$); and TBI was more frequently reported by the OIF/OEF group than the Vietnam group (32% vs 6%, respectively, $p <$

Table 1.
Comparison of health status and prosthetic use frequency (% of limb-loss level category) for Vietnam (V) and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) groups with unilateral upper-limb loss (data presented as percent unless otherwise noted).

Outcome	Carpal	Wrist		Transradial		Elbow		Transhumeral		Shoulder		Total	
	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF
No. Persons	3	6	4	15	20	2	3	20	14	4	6	47	50
Active Duty	0	0	25	0	11	0	0	0	29*	0	0	0	14
Comorbidities†													
None	0	0	0	7	0	0	0	5	0	50	0	8	0*
Mean ± SD	6 ± 4	4 ± 2	8 ± 3	5 ± 2	5 ± 4	6 ± 2	5 ± 1	5 ± 3	4 ± 2	2 ± 2	4 ± 2	4 ± 3	5 ± 3
Limb-Loss Impact Score‡ (mean ± SD)	10 ± 0	6 ± 3	7 ± 3	6 ± 3	8 ± 3	8 ± 4	9 ± 1	8 ± 2	9 ± 1	5 ± 4	8 ± 3	7 ± 3	8 ± 2*
Other Combat Injuries§	67	67	100	67	85	100	100	50	93	50	100	60	90*
Health Status													
Very Good–Excellent	33	33	50	33	55	50	33	20	14	50	67	30	42*
Good	67	33	25	40	30	0	67	40	57	0	17	34	40*
Fair–Poor	0	33	25	27	15	50	0	40	29	50	17	36	18
CTD¶	0	17	50	53	50	100	33	75	36	50	17	60	38*
Activity Measure (mean ± SD)**	0.5 ± 1.6	2 ± 2	0.9 ± 1.5	2 ± 3	1.6 ± 1.7	0.2 ± 0.5	–0.9 ± 1.6	–0.7 ± 0.9	0.2 ± 1.5	–0.7 ± 0.7	–0.6 ± 0.5	0.6 ± 2	0.7 ± 2
Current Use of Any Prosthesis													
Do Not Use	0	0	50	20	10	50	0	40	36	50	50	30	22
Current Use	100	100	50	80	90	50	100	60	64	50	50	70	76*

Note: No carpal limb loss in Vietnam group. Data may not add to 100% because of rounding.
*$p < 0.05$ for frequency by conflict.
†Comorbidities: 1 of 21 categories, such as arthritis, chronic back pain, depression, phantom pain, PTSD, stroke.
‡Limb-loss impact score: defined as values ranging from 0 (limb loss does not affect quality of life at all) to 5 (moderately affects) to 10 (strongly affects).
§Other combat injuries include eye, head, chest, abdominal, and nonamputated-limb injuries; burns; or hearing loss.
¶Cumulative trauma disorder (CTD) defined as any of following symptoms caused by overuse of nonamputated upper limb: carpal or cubital tunnel syndrome, tendonitis, epicondylitis, tenosynovitis, ganglion cyst, or osteoarthritis/degenerative joint disease.
**Activity measure: score from Rasch analysis of 21 activities of daily living task difficulties. More positive values indicate more difficult task done using prosthesis, while negative values indicate tasks not done or done with assistance of another person.
Carpal = carpal disarticulation or partial hand, elbow = elbow disarticulation, PTSD = posttraumatic stress disorder, SD = standard deviation, shoulder = shoulder disarticulation, wrist = wrist disarticulation.

0.001). Other types of combat-related injuries were not significantly different for the OIF/OEF group compared with the Vietnam group: injuries to the nonamputated upper limb (32% vs 28%, respectively), burns (24% vs 13%, respectively), chest injuries (20% vs 11%, respectively), abdominal injuries (18% vs 19%, respectively), and eye injuries (16% vs 17%, respectively).

General Health

In general, more of the OIF/OEF group self-rated their health as very good-to-excellent (42%) than the Vietnam group (30%, $p = 0.04$). Level of limb loss was not associated with significant differences in self-rated health (**Table 1**). Transhumeral-level limb loss had the lowest frequency of very good-to-excellent health rating: 20 percent of Vietnam and 14 percent of OIF/OEF groups. For shoulder-level limb loss, 67 percent of the OIF/OEF group reported very good-to-excellent health status compared with only 50 percent of the Vietnam group.

More of the Vietnam group reported CTD problems with the nonamputated limb than the OIF/OEF group (60% vs 38%, respectively, $p < 0.001$). Of the 28 in the Vietnam group with CTD, the most frequent symptoms reported for the nonamputated limb were elbow pain and rotator cuff tendonitis. Of the 19 in the OIF/OEF group with CTD, the problems reported most frequently were elbow pain, wrist pain, and tendonitis.

Upper-Limb Activity Measure

The Rasch analysis successfully assigned a mean activity-measure score to 21 of the 23 ADL. The measure assigned to each task and other Rasch statistics are presented in **Table 2**: the easiest item was driving (measure = –1.05), while the hardest item was drying dishes (measure = +1.30). How participants performed the

Table 2.
Upper-limb activity-measure scores and statistics used for Rasch analysis.

Item*	Measure	Model SE	Infit Mean Square	Infit *Z*	Item-Measure Correlation
Dry Dishes with Towel	1.30	0.20	1.42	2.6	0.62
Peel and Cut Vegetable	0.99	0.19	1.38	2.4	0.63
Hand Wash Dishes	0.67	0.19	1.19	1.4	0.62
Operate Gauges and Dials	0.44	0.26	1.01	0.1	0.62
Use Cell Phone and Take Notes	0.40	0.27	1.04	0.3	0.61
Cut Meat	0.39	0.19	1.07	0.5	0.65
Butter Bread	0.34	0.19	0.93	–0.5	0.68
Open and Close Jar	0.23	0.23	0.95	–0.3	0.66
Low Aerobic Sports (golfing, fishing)	0.14	0.18	1.30	2.1	0.57
Shovel	0.11	0.18	0.77	–1.8	0.69
Fold Laundry	0.04	0.20	0.86	–1.1	0.68
Lace and Tie Shoes	0.01	0.19	0.96	–0.3	0.65
Open Lid of Can	–0.02	0.22	0.89	–0.8	0.67
Fold Letter and Seal Envelope	–0.11	0.24	0.88	–0.7	0.67
Use Power Tools	–0.18	0.19	0.91	–0.7	0.64
Carry Tray	–0.47	0.20	0.94	–0.4	0.62
Manage Zippers and Snaps	–0.61	0.24	1.01	0.1	0.62
Open and Close Door, Trunk, and Hood	–0.62	0.27	0.90	–0.5	0.65
Take Bill from Wallet	–0.99	0.26	0.88	–0.7	0.61
Use Toothpaste and Brush Teeth	–1.01	0.34	1.04	0.2	0.66
Drive	–1.05	0.23	0.78	–1.6	0.66
Mean ± SD	0.00 ± –0.62	0.22 ± 0.04	1.00 ± 0.18	0.0 ± 1.2	—

*Dropped items: raking and high aerobic sports (basketball).
SD = standard deviation, SE = standard error.

different ADL differed by limb level. **Figure 1** shows the percentages of these activities performed (using prosthesis, one-handed techniques, or another person's assistance) or not performed. The Vietnam and OIF/OEF groups with distal limb loss (wrist, transradial, and elbow) used prostheses for a similar proportion of ADL (21% vs 25%, respectively). Of the OIF/OEF group, 21 percent with transhumeral-level limb loss used a prosthesis for ADL compared with 4 percent in the Vietnam group. Overall, for proximal limb loss (higher than the elbow level), 37 percent of the Vietnam group and 26 percent of the OIF/OEF group performed ADL using their other hand rather than relying upon their prosthetic devices.

The upper-limb activity scores were also associated with the level of limb loss, with a trend for activity to increase the more distal the limb-loss level (**Figure 2**). In both groups, higher upper-limb activity scores were found for the wrist and transradial limb-loss levels (**Table 1**), whereas lower activity scores were found in the elbow, transhumeral, and shoulder limb-loss levels. We did not find a significant difference in upper-limb activity measure by group: the mean activity score was 0.6 ± 2 for the Vietnam group and 0.7 ± 2 for the OIF/OEF group ($p = 0.83$).

Prosthetic Devices: Ever Received

The total number of upper-limb prosthetic devices ever received by type of device and level of limb loss is provided in **Table 3** for the Vietnam and OIF/OEF groups. As the mean time since limb loss to survey date was significantly longer for the Vietnam group (39.1 ± 2.3 years) than the OIF/OEF group (3.4 ± 1.0 years), the different time periods at risk were adjusted by using person-years as the denominator. In the first year after limb loss, the Vietnam group received a mean of 1.2 ± 0.5 devices (usually mechanical/body-powered), while the OIF/OEF group received a mean of 3.0 ± 1.6 devices ($p < 0.001$) (typically one myoelectric/hybrid, one mechanical/body-powered, and one cosmetic). In subsequent years, the Vietnam group received significantly fewer upper-limb prostheses per year (0.1 ± 0.1) than the OIF/OEF group (0.5 ± 0.8, $p < 0.001$). Rates for the first year after limb loss were higher than mean annual rates thereafter in both groups, probably

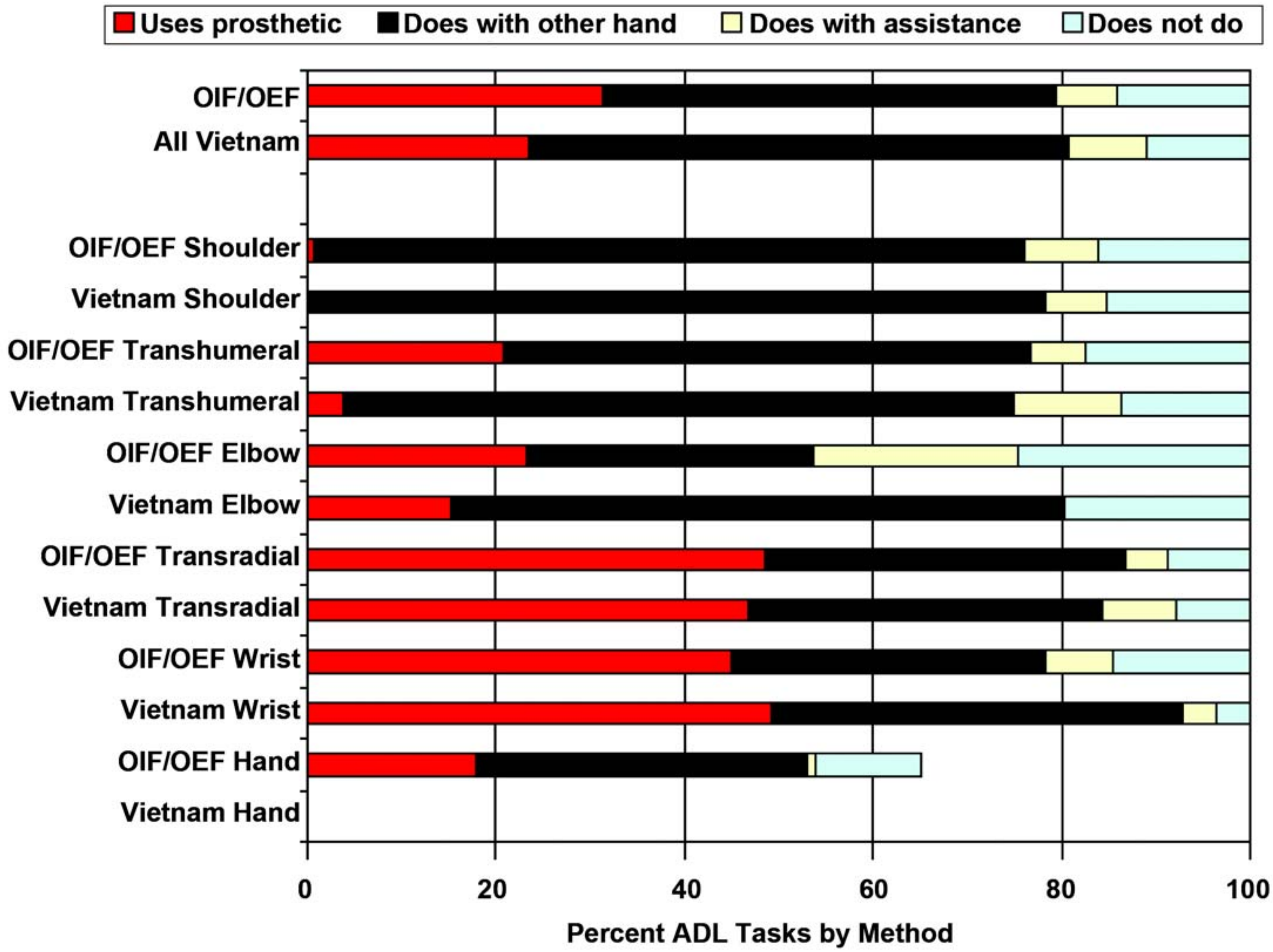

Figure 1.
Percent of 23 activities of daily living (ADL) performed by one of four methods by Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) and Vietnam groups overall and according to level of unilateral upper-limb loss. Note: No hand limb loss in Vietnam group.

because of limb adaptation and early rehabilitation adjustments. Overall, the annual mean rate of all prosthetic devices ever received was significantly higher for the OIF/OEF group (1.6 ± 1.3 devices/person-year) than the Vietnam group (0.13 ± 0.11/person-year, $p < 0.001$) (**Table 3**). Little effect of limb-loss level was noted, except for a higher annual rate (3.3/person-year) for those with an elbow disarticulation in the OIF/OEF group.

The patterns for upper-limb devices ever received, currently used, replaced, and rejected were different depending upon the type of device and by group (**Figure 3**). The Vietnam group has received significantly more mechanical/body-powered devices (89%) to date, and most of these devices have worn out and been replaced. In contrast, the OIF/OEF group has received more myoelectric/hybrid (44%) and cosmetic devices (18%) and fewer mechanical/body-powered devices (38%). In the OIF/OEF group, more of the myoelectric/hybrid and mechanical/body-powered devices were rejected instead of being in current use or replaced because of daily wear and tear (**Figure 3**).

Prosthetic Devices: Current Use

The overall frequency of survey participants currently using any type of prosthetic device was not significantly different for the pre- and postdirective groups. Of the Vietnam group, 33 (70%) were currently using at least one

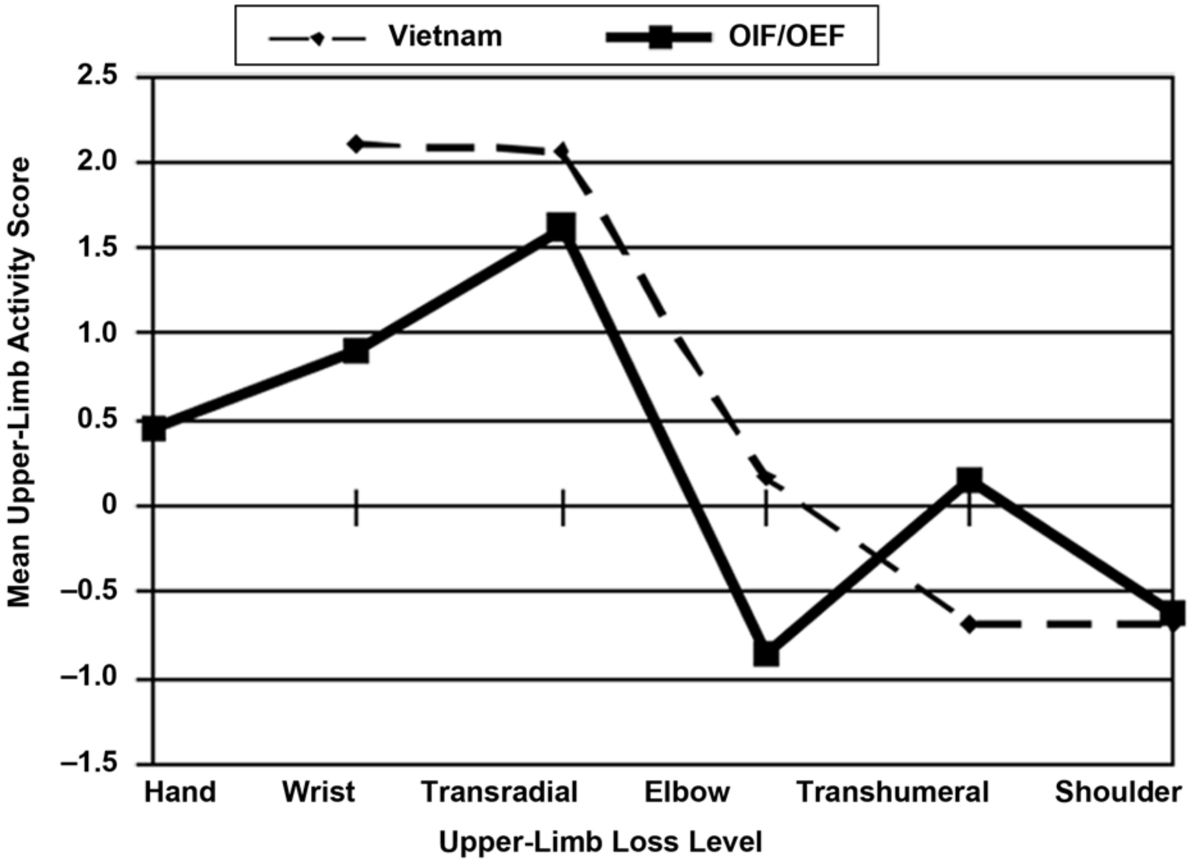

Figure 2.
Mean upper-limb activity measure score by Vietnam and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) groups. More positive score indicates combination of more strenuous activities of daily living usually done using prosthesis. More negative values indicate less strenuous activities usually not done or done with assistance. Note: No hand limb loss in Vietnam group.

upper-limb prosthetic device compared with 38 (76%) of the OIF/OEF group (**Table 1**). However, the Vietnam group used only an average of 0.8 ± 0.8 upper-limb prostheses compared with 1.4 ± 1.7 in the OIF/OEF group ($p = 0.001$). Of the 37 devices in use by the Vietnam group, 78 percent were mechanical/body-powered, 14 percent were myoelectric/hybrid, and 8 percent were cosmetic (**Table 3**). Of the 69 devices in use by the OIF/OEF group, significantly fewer were mechanical/body-powered (38%, $p < 0.001$) and significantly more (46%) were myoelectric/hybrid. Use of cosmetic devices was similar for both the Vietnam and OIF/OEF groups. Prosthesis use by type of upper-limb device is presented in **Table 3** by level of limb loss. Myoelectric/hybrid devices were used more frequently by the OIF/OEF group for the transradial limb-loss level. In contrast, more myoelectric/hybrid devices were used by the Vietnam group for the transhumeral limb-loss level.

Assistive Devices

We asked participants what upper-limb assistive devices they currently used (**Table 4**). The number of participants who used any type of upper-limb assistive device was similar in the Vietnam group (30%) and the OIF/OEF group (44%). A variety of assistive devices was used, most frequently adaptors for sporting activities (significantly more in the OIF/OEF group, 36% compared with 2% in the Vietnam group), grasping tools, computer adaptations, kitchen or cooking devices, and car steering wheel knobs. No significant differences were found by type of assistive device by level of limb loss.

Prosthetic Devices: Replaced

Upper-limb prosthetic devices needing replacement because of wear and tear or breakage are presented in **Table 3** by level of limb loss and group. We have data on

Table 3.
Frequency of number of prosthetic devices by use for Vietnam and OIF/OEF groups with unilateral upper-limb loss by level of limb loss (data presented as percent unless otherwise noted).

Outcome	Carpal	Wrist		Transradial		Elbow		Transhumeral		Shoulder		Total	
	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF	V	OIF/OEF
No. Persons	3	6	4	15	20	2	3	20	14	4	6	47	50
Prosthetic Devices Ever Received													
Rate*	1.30 ± 0.76	0.17 ± 0.13	2.02 ± 1.60	0.17 ± 0.12	1.42 ± 0.84	0.06 ± 0.05	3.3 ± 4.04	0.12 ± 0.11	1.5 ± 1.18	0.10 ± 0.07	1.07 ± 0.73	0.13 ± 0.11	1.6 ± 1.3
Range	1–8	2–16	2–15	1–19	1–9	1–4	3–8	1–14	0–15	1–7	2–5	1–19	0–15
Myoelectric	5	20	15	30	38	0	3	40†	28	10	10	4	34†
Hybrid	0	0	0	25	17	0	9	12	56	62	17	3	10†
Mechanical/Body-Powered	6	15	12	40	45	2	8	39†	27	3	2	89†	38
Cosmetic	7	10	15	50	36	0	10	20	19	20	12	4	18†
Total (No.)	12	37	28	99	88	5	15	94	66	15	19	250	228
Prosthetic Devices Currently Used													
Myoelectric/Hybrid	0	20	3	20	44†	0	6	40†	34	20	12	14	46†
Mechanical/Body-Powered	8	21	8	38	58	3	4	34	23	3	0	78†	38
Cosmetic	9	0	9	33	45	0	18	33	0	33	18	8	16
Total (No.)	3	7	4	13	34	1	5	13	17	3	6	37	69
Prosthetic Devices Replaced‡													
Myoelectric/Hybrid	0	0	46	50	46	0	0	50	8	0	0	1	32†
Mechanical/Body-Powered	21	18	21	44	36	2	7	34†	14	2	0	95†	35
Cosmetic	0	17	7	50	36	0	14	7	36†	17	7	4	34†
Total (No.)	3	25	10	62	16	3	3	47	8	4	1	141	41
Prosthetic Devices Rejected‡													
Myoelectric/Hybrid	9	12	9	12	22	0	2	12	41†	62	17	15	51†
Mechanical/Body-Powered	0	4	16	35†	28	2	12	52†	38	6	6	85†	36
Cosmetic	8	0	8	0	42	0	0	0	25	0	17	0	13†
Total (No.)	5	3	10	17	24	1	5	25	34	8	12	54	90

Note: No carpal limb loss in Vietnam group.
*Annual rate of all upper-limb prosthesis ever received (mean ± SD).
†$p \le 0.05$ for frequency by conflict.
‡Nonresponse for 18 in Vietnam group and 28 in OIF/OEF group for replaced and rejected devices.
Carpal = carpal disarticulation or partial hand, elbow = elbow disarticulation, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom, V = Vietnam, SD = standard deviation, shoulder = shoulder disarticulation, wrist = elbow disarticulation.

replaced and rejected devices for 232/250 of the Vietnam group and 200/228 of the OIF/OEF group. In the Vietnam group, significantly more (141/232, 60.8%) upper-limb prosthetic devices were replaced because of wear and tear than in the OIF/OEF group (41/200, 20.5%, $p < 0.001$). Not surprisingly, most of the devices replaced in the Vietnam group were mechanical/body-powered (95%); in the OIF/OEF group, the distribution by device types was similar. Most levels of upper-limb loss were not associated with higher replacement frequency, except for the transhumeral level, at which significantly more mechanical/body-powered devices were replaced in the Vietnam group. More cosmetic devices wore out in the OIF/OEF group at the transhumeral level.

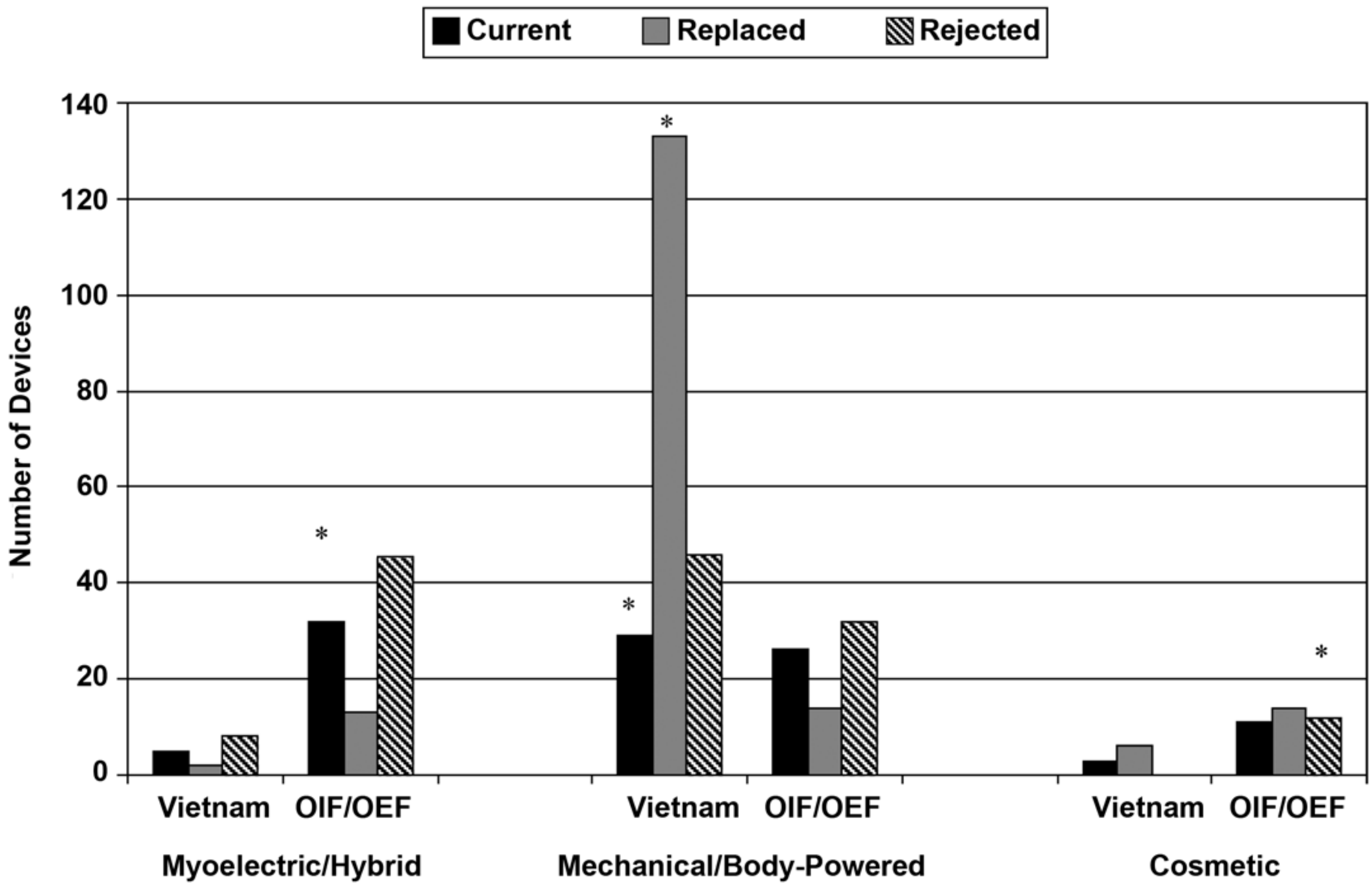

Figure 3.
Fate of upper-limb prosthetic devices by type of prosthesis for Vietnam and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) groups with unilateral upper-limb loss. *$p < 0.05$ compared with other group in same category and device-type group.

Average replacement times were different by type of device. The Vietnam group reported a trend for using myoelectric/hybrid devices longer before replacement (100% reported 3 years or longer) than the OIF/OEF group (only 12% reported 3 years or longer, $p = 0.08$). The Vietnam group also reported using mechanical/body-powered devices significantly longer before replacement (92% reported "replaced every 3 years or longer") than the OIF/OEF group (11% "replaced every 3 years or longer" [$p < 0.001$]; 89% replaced myoelectric/hybrid devices in under 2 years). The mean time of replacement for cosmetic devices averaged 1 to 2 years for both the Vietnam and OIF/OEF groups.

Prosthetic Devices: Rejected

We also collected data on the number of prosthetic devices rejected over the lifetime (i.e., no longer used because of dissatisfaction or problems) and found significantly different patterns between the two groups. In the OIF/OEF group, significantly more (90/200, 45%) of all prosthetic devices ever received were rejected than in the Vietnam group (54/232, 23%, $p < 0.001$). In the Vietnam group, 85 percent of the rejected upper-limb devices were mechanical/body-powered, whereas in the OIF/OEF group 51 percent of the rejected devices were myoelectric/hybrid and 13 percent were cosmetic (**Table 3**). Rejection of mechanical/body-powered upper-limb devices was significantly more frequent in the Vietnam group for transradial and transhumeral limb-loss levels (35% and 52%, respectively). In contrast, OIF/OEF members with transhumeral level limb loss rejected significantly more myoelectric/hybrid upper-limb devices (41%). The most common reasons for rejection are shown in **Figure 4** by group and type of prosthetic

Table 4.
Survey participants' use of upper-limb assistive devices in Vietnam and OIF/OEF groups with unilateral upper-limb loss (data presented as percent unless otherwise noted).

Outcome	Carpal	Wrist		Transradial		Elbow		Transhumeral		Shoulder		Total	
	OIF/ OEF	V	OIF/ OEF	V	OIF/ OEF	V	OIF/ OEF	V	OIF/ OEF	V	OIF/ OEF	V	OIF/ OEF
No. Persons	3	6	4	15	20	2	3	20	14	4	6	47	50
None	67	67	0	67	65	50	67	70	50	100	67	70	56
Any Assistive Device	33	33	100	33	35	50	33	30	50	0	33	30	44
Kitchen or Cooking Device	0	17	50	13	15	0	0	20	7	0	17	15	14
Dressing Attachment	33	17	0	7	10	50	0	0	7	0	0	6	8
Eating Attachment	0	17	25	7	5	50	0	10	7	0	17	11	8
Household Device	0	0	25	0	5	0	0	10	0	0	0	4	4
Car Modifications[*]	0	17	25	13	10	50	0	5	14	0	33	11	14
Grasping Tool Device	0	0	50	13	20	0	0	5	21	0	0	6	18
Computer Modifications	0	0	25	7	10	0	33	10	21	0	17	6	16
Telephone Attachment	0	0	0	7	0	0	0	0	0	0	0	2	0
Sports Device[†]	67	0	50	0	40	0	0	5	43	0	0	2	36[‡]
Other Work Devices	0	0	50	13	15	0	33	5	14	0	17	6	18

Note: No carpal limb loss in Vietnam group.
[*]Car modifications for unilateral upper limbs included steering wheel knob (100%).
[†]Sports terminal devices included gloves and adaptors for sports such as golfing, fishing, skiing, bicycling, archery, and bowling.
[‡]$p \leq 0.05$ for frequency by conflict.
Carpal = carpal disarticulation or partial hand, elbow = elbow disarticulation, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom, V = Vietnam, shoulder = shoulder disarticulation, wrist = elbow disarticulation.

device. Myoelectric/hybrid devices were most frequently rejected because of pain (23% in Vietnam group and 11% in OIF/OEF group), whereas mechanical/body-powered upper-limb devices were rejected because of poor comfort (11% in Vietnam group and 8% in OIF/OEF group). Cosmetic devices were rejected because of a lack of functionality (22% in OIF/OEF group). The reasons for device rejection did not differ significantly by amputation level (data not shown).

Prosthetic Devices: Abandoned

Some members of the Vietnam and OIF/OEF groups with unilateral upper-limb loss completely discontinued use of any type of upper-limb prosthetic device. Of the Vietnam group, 14/47 (30%) of participants completely abandoned the use of all prosthetic devices for their upper limb (**Table 1**). Of the Vietnam group, shoulder- and elbow-level limb loss had the highest frequency of abandonment (50%). The Vietnam group used prosthetic devices for a mean of 4 ± 8.2 years before abandoning them (range = 2 months to 30 years of use). The most frequent reason for abandoning all devices was "too much fuss" (57%); other reasons included pain, weight of the device, short residual limbs (could not support device), and the need to use residual limbs. All but one had comorbid conditions including CTD (65%) and other combat injury problems (14%) or chronic back pain (data not shown).

Of the OIF/OEF group, 11/49 (22%) of participants completely abandoned the use of all prosthetic devices for their upper limb (one person never received any prostheses). Shoulder, elbow, and wrist levels had the highest frequency of abandonment (**Table 1**). Most tried a variety of prosthetic types before abandoning the use of all prosthetics: 9 (82%) tried myoelectric/hybrid, mechanical/body-powered, and/or cosmetic devices, while 2 had tried only myoelectric/hybrid devices. The OIF/OEF group used prosthetic devices for a mean of 8 ± 7 months before abandoning them (range = 1 month to 1 year of use). The most frequent reasons for abandoning all devices were "residual limbs were too short" (30%), pain (20%), weight of the device (20%), too much fuss (10%), or inability to control the device (10%). Fewer in the OIF/OEF group had CTD (30%) or other combat injury problems (10%) than in the Vietnam group, but the difference was not significant (data not shown).

Multivariate Models Predicting Activity

Separate multivariate linear regression models were evaluated for each group (**Table 5**). In the Vietnam group, higher upper-limb activity was associated with the

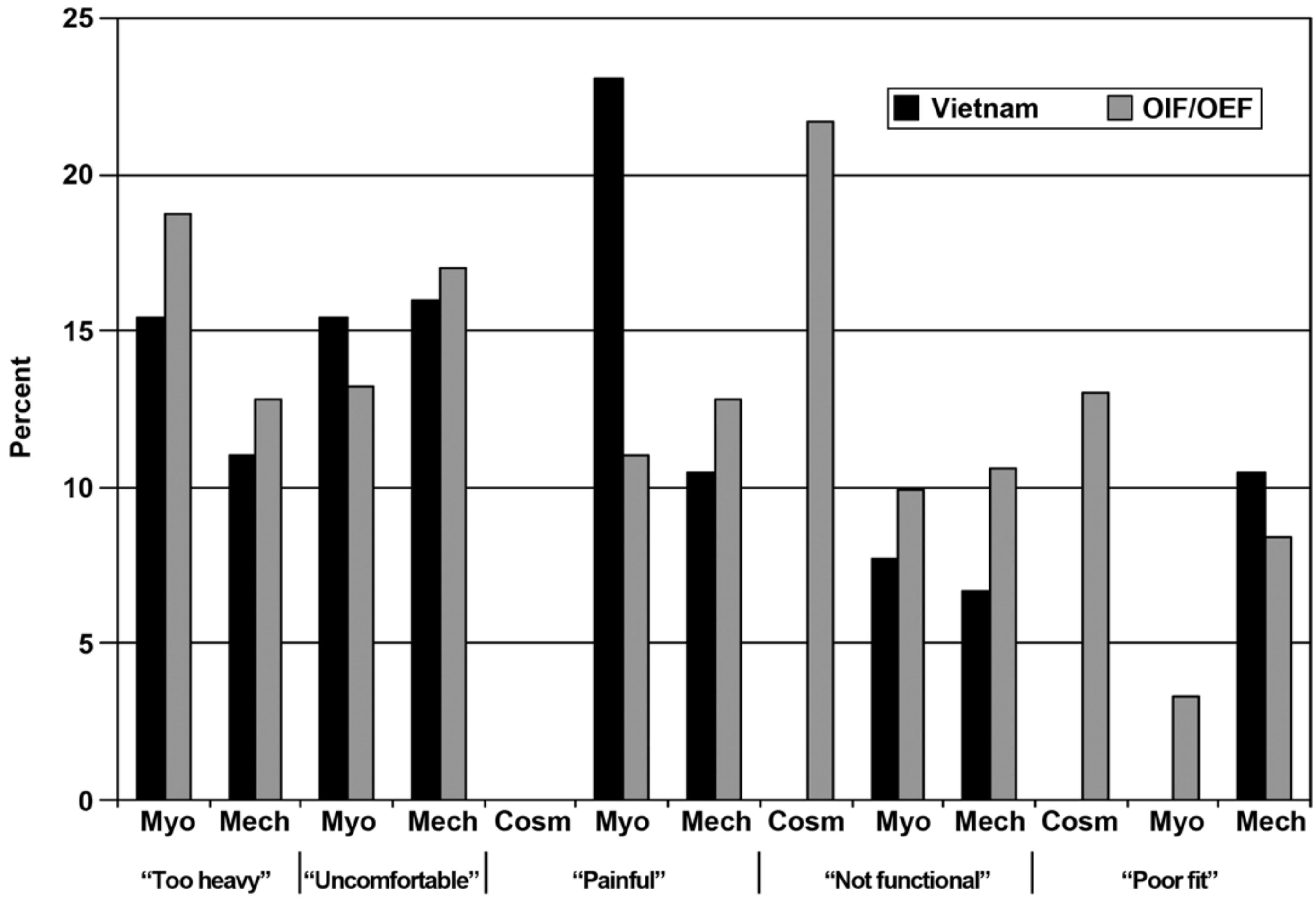

Figure 4.
Reasons for upper-limb prosthetic-device rejection by device type for Vietnam and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) groups. Myo = myoelectric/hybrid, Mech = mechanical/body-powered, Cosm = cosmetic.

use of mechanical/body-powered prosthetic devices (adjusted odds ratio [aOR] = 2.66). Four variables were associated with significantly lower upper-limb activity level: a higher number of comorbidities (aOR = 0.73), rotator-cuff tendonitis in the opposite shoulder of the limb loss (aOR = 0.30), arthritis (aOR = 0.25), and transhumeral-level limb loss (aOR = 0.15). In contrast, in the OIF/OEF group, one variable was significantly associated with higher upper-limb activity: current use of mechanical/body-powered prosthesis (aOR = 3.39) and one was associated with lower activity: transhumeral-level limb loss (aOR = 0.50). No significant interactions were found for either model, and other variables investigated in the univariate analysis were not significant in the multivariate analysis (age, sex, race, number or type of combat injuries, PTSD, TBI, self-rated health, prosthetic-device satisfaction factors, pain, or mental-health scores).

DISCUSSION

Our survey offered a unique opportunity to determine upper-limb prosthetic-device use patterns for two distinct groups of servicemembers with combat-associated unilateral upper-limb loss. The Vietnam group has the benefit of long experience with prostheses, while the OIF/OEF group benefits from the availability of more advanced technologies and improvements in treatments for injuries in the combat field. These improvements include changes in body armor; improvements in combat casualty care,

Table 5.
Multivariate regression models assessing variables associated with upper-limb activity for Vietnam and OIF/OEF groups with unilateral upper-limb loss.

Variable	aOR	95% CI	*p*-Value
Vietnam Group			
No. Currently Used Mechanical/Body-Powered Prostheses	2.66	1.14–6.21	0.02
No. of Comorbidities	0.73	0.57–0.93	0.01
Rotator Cuff Tendonitis on Contralateral Arm	0.30	0.08–1.02	0.05
Arthritis	0.25	0.06–0.99	0.05
Transhumeral Level	0.15	0.05–0.48	0.002
OIF/OEF Group			
No. Currently Used Mechanical/Body-Powered Prostheses	3.39	1.98–5.80	0.001
Transhumeral Level	0.50	0.16–1.11	0.08*

Note: Goodness of fit: Vietnam model, F statistic = 11.6, $p < 0.001$; OIF/OEF model, F statistic = 16.0, $p < 0.001$.
*Inclusion resulted in better fitting model.
aOR = adjusted odds ratio, CI = confidence interval, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom.

including the use of artificial blood and rapid evacuation to combat field hospitals; newer myoelectric/hybrid prosthetic-device technologies; and state-of-the-art rehabilitation techniques [9,28–30]. Improved body armor and protective vests have increased survival rates after blast injuries, resulting in an increase in the survival of more severely injured servicemembers. The DOD rehabilitation programs at Walter Reed Army Medical Center, Brooke Army Medical Center, and the Naval Medical Center San Diego have also implemented a paradigm shift, increasing the duration and complexity of rehabilitation programs, including the availability of technologically advanced prostheses. Special programs are also in place for wounded servicemembers with upper-limb loss, including the Defense Advanced Research Projects Agency [31–33] and the Occupational Therapy Section at Fort Independence, which is developing competencies for the performance of ADL [34].

Unilateral upper-limb loss accounts for 16 percent of our Vietnam survey study cohort and 18 percent of our OIF/OEF survey study cohort [19]. An important outcome of the DOD rehabilitation paradigm shift is the provision of three technologically advanced upper-limb prostheses: myoelectric/hybrid, mechanical/body-powered, and cosmetic or passive devices. Unique to this shift is that the myoelectric/hybrid prostheses are typically provided first, followed by the mechanical/body-powered, and then cosmetic prostheses. Traditionally (in the Vietnam war era), mechanical/body-powered prostheses were provided initially, which was problematic because use of a mechanical/body-powered prosthesis requires the surgical site to be healed and the residual limb shaped and desensitized. Subsequent studies have shown a positive relationship between early fitting, satisfaction, and use [3,6,31,35–40]. An additional benefit of myoelectric/hybrid prosthesis use has been the reduction in phantom limb pain [41]. How these shifts in medical care and availability of advanced technologies may improve upper-limb function is not known.

Returning to pre-limb-loss activities may indicate restoration of normal functioning. In the case of OIF/OEF servicemembers wounded in combat, return to Active Duty is encouraged. In the Vietnam conflict, only 3 percent of servicemembers with upper- or lower-limb amputations returned to duty after rehabilitation [30]. We found 14 percent of our OIF/OEF study group with upper-limb loss returned to Active Duty, which demonstrates a positive effect of the DOD paradigm shift in rehabilitation goals.

Age-related or combat-associated comorbidities may complicate the recovery process. The Vietnam group had a mean of 4 ± 3 comorbidities, and the OIF/OEF group, though younger, had a mean of 5 ± 3 comorbidities. In the civilian population with upper- or lower-limb loss, Pezzin et al. reported a mean of 5 ± 2 comorbidities for people with dysvascular-related limb loss and 2 ± 2 comorbidities for trauma-related limb loss [3]. The mean number of comorbidities of individuals with military-service-connected limb loss is more similar to an older, dysvascular disease group than a non-service-connected, trauma-related limb loss group. CTD, or worn-limb syndrome, is frequently found in people with unilateral upper-limb loss [12,42]. Black et al. found that 53 percent of unilateral upper-limb patients using a prosthetic device had pain in their remaining arm, most of which was associated with CTD [43]. CTD and overuse injuries are also estimated to be three times more likely in people with unilateral upper-limb loss than in the general workforce, in which CTD is also frequently reported [43–47]. In our study's two groups, CTD was significantly higher (60%) in the Vietnam group, who are 40 years from their limb loss, than in the OIF/OEF group (38%), who are 3 to 4 years from their limb loss. As CTD takes time to develop, we may see an increase in CTD in the OIF/OEF group as they age, or perhaps CTD will occur less frequently in this group because the use of multiple types of prosthetic devices has a protective effect. Efforts that spare overuse on the nonamputated upper limb need to be more thoroughly researched to limit the development of this complication.

The ability to perform routine ADL largely depends upon the upper limbs. Unlike instruments for lower-limb loss functional levels, which measure function by ambulatory ability, no standard tool has been recognized for upper-limb loss functional levels. Upper-limb function instruments are being developed for children [48] and adults [49] with limb loss but have not been fully validated. We measured upper-limb activity using Rasch analysis with ADL. A national survey of adults with upper- and lower-limb loss (37% due to vascular conditions and 39% due to trauma), of whom only 11 percent had upper-limb loss, indicated that 30 percent of the sample experienced difficulty with bathing and 7 percent required help with ADL [42]. In our survey, an even higher percentage of both Vietnam and OIF/OEF groups with upper-limb loss reported they required assistance with ADL (34% and 36%, respectively). A surprisingly large proportion of our survey participants with upper-limb loss did not use an upper-limb prosthetic device; rather, they switched to the other hand to perform routine activities.

Ours is the first known study to use multivariate adjusted methods to investigate the relationship between factors associated with upper-limb activity in combat-associated upper-limb loss. Mechanical/body-powered upper-limb prostheses were associated with higher upper-limb activity measures, but myoelectric/hybrid or cosmetic prostheses were not. Transhumeral-level limb loss was negatively related to higher activity measure in both groups, suggesting servicemembers and veterans with limb loss at high levels have more difficulty performing ADL. Lower upper-limb activity scores were associated with more comorbid conditions (total number, CTD, and arthritis) but only for the older Vietnam group. When these factors are examined to plan areas for improving upper-limb activity, little can be done about the site of the limb loss, but efforts may be focused on other types of upper-limb prostheses to improve use and to reduce the development of CTD in the nonamputated upper limb (especially since this limb is used for routine activities rather than the limb with the amputation).

One challenge in comparing research investigating use of prosthetic devices is inconsistency in the definitions of prosthetic-device "use" [50]. Prosthetic-device use has been measured with both continuous scales (counting days/week and hours/day the prosthesis is worn) and categorical scales (regularly, a lot of the time, all the time, occasionally, not at all, never) [12,42,51–52]. In our study, we collected both the number of each type of upper-limb prosthesis used and the frequency used (daily, weekly, monthly, yearly). Most participants reported use of an upper-limb prosthesis (70% of Vietnam and 76% of OIF/OEF groups), but differences were found by group according to the type of upper-limb device. Confounding investigation of prosthetic use is the type of prosthesis used. A person with upper-limb loss may have more than one type of prosthesis, each with different use patterns. Early research did not mention type of prosthesis, presumably because mechanical/body-powered prostheses were all that were available [12]. Biddiss et al. collected data from 242 people with non-combat-associated limb loss from the United States, Canada, and the Netherlands, asking about devices tried, devices currently used, and the primary device [53]. In this study, 81 percent were using myoelectric/hybrid prostheses, 58 percent were using mechanical/body-powered, and 33 percent were using a passive hand. In our study, we did document a shift in the type of upper-limb prostheses used. While most of the Vietnam group used mechanical/body-powered upper-limb prostheses (78%), the OIF/OEF group used significantly more myoelectric/hybrid prostheses (46%), supporting the effect of the DOD paradigm shift.

The evidence that the level of limb loss is associated with prosthetic-device use is conflicting; however, the majority of findings support a positive relationship. People with more proximal and below-wrist-level loss are less likely to use their prostheses than those with transradial disarticulations [11]. Reasons may include a longer prosthesis that is heavier and requires more energy expenditure or shorter residual limbs that provide less sensory information important for function [40]. In a survey of people with upper-limb loss (non-combat-associated), those with more proximal limb loss were more likely to use mechanical/body-powered prostheses [53]. In our study, in both the Vietnam and OIF/OEF groups, a lower percentage of participants with upper-limb loss with more proximal amputations (transhumeral and shoulder) currently used prostheses.

The reasons why different types of upper-limb prostheses are rejected are beginning to be understood. In one study, 39 percent of myoelectric/hybrid, 50 percent of mechanical/body-powered, and 53 percent of cosmetic devices were rejected [53]. Datta et al. found in 80 participants that 34 percent rejected their upper-limb prosthetic devices [12]. Reasons given for rejection were pain, no functional benefit, poor cosmesis, and weight of the prosthesis. In our study, rejection or dissatisfaction with the upper-limb prosthesis was associated with the type of prosthetic device and the level of limb loss. Myoelectric/hybrid upper-limb devices were often rejected because of their heavy weight, pain, and lack of comfort. Mechanical/body-powered upper-limb devices were rejected because of their heavy weight, lack of comfort, pain, and poor fit. Cosmetic upper-limb devices were rejected mainly because of lack of functionality. More proximal limb-loss levels had a higher proportion of device rejection (transhumeral and shoulder) than more distal levels (transradial, wrist, and partial hand). Advances in lighter upper-limb prosthetic devices for higher limb-loss levels are needed to improve comfort, lighten weight, and increase use of upper-limb prostheses.

Dealing with limb loss is difficult in and of itself without having to deal with the complications and routine of using a prosthetic device. In contrast to people with lower-limb loss, a significant proportion of people with upper-limb loss completely abandon use of all prostheses and rely upon their nonamputated upper limb to perform daily tasks. Unfortunately, reliance upon the uninjured arm often results in CTD or fatigue due to overuse. Of 60 people with upper-limb loss surveyed in the United Kingdom, 45 percent developed shoulder pain in the contralateral upper limb and 35 percent abandoned using their prosthetic devices [12]. In another study of 242 people with upper-limb loss, 20 percent abandoned prosthetic devices [11]. In our study, 30 percent of the Vietnam group and 22 percent of the OIF/OEF group completely abandoned upper-limb prostheses. Although the Vietnam group used prosthetic devices for a longer time (average 4 years) before abandonment than the OIF/OEF group (average 8 months), the reasons were similar (pain, weight, fuss), and most of those who abandoned prosthetic devices had other comorbid complications. More research is needed to elucidate preventable reasons for upper-limb prostheses abandonment and policies to correct deficiencies.

One limitation to our survey is the concern over generalizability. All of our study participants were active servicemembers in combat-field operations at the time of their limb loss. Several things can cause upper-limb loss: congenital conditions [10–11,54–55], non-combat-related trauma [10,12,56–57], complications from infections [10,58], dysvascular conditions [3,10], or combat-associated injuries [9]. Surveys from non-combat-associated upper-limb loss populations show similar trends for prosthetic-device use as our population. Recruiting subjects with trauma or congenital upper-limb loss from the National Amputee Statistical Database for the United Kingdom, Datta et al. studied 60 upper-limb loss subjects who had a mean age of 58 years and were 24 years from their limb loss [12]. Most (73%) had returned to work, 45 percent developed CTD, and 29 percent no longer used a prosthesis regularly. Biddiss and Chau recruited 242 Canadian subjects with upper-limb loss from health-care providers, support organizations, and a prosthesis manufacturer [11]. Most (79%) of them had lost the upper limb because of congenital conditions, 20 percent abandoned upper-limb prostheses, but 64 percent reported frequent prosthetic-device use. Pezzin et al. recruited 935 subjects in the United States with upper- or lower-limb loss from the Amputee Coalition of America registry; 362 of the participants had trauma-related limb loss, and 10 percent had upper-limb loss [3]. Although detailed upper-limb data were not specifically presented, few differences were noted for current use, whether the cause was dysvascular, trauma, or cancer. Comparison of our two combat-associated groups to population-based surveys that encompass all origins of upper-limb loss shows more diversity in the levels of limb loss in combat-related limb loss.

CONCLUSIONS

The soldiers from Vietnam and those returning from OIF/OEF with upper-limb loss are in a position to influence current clinical care practice and research focuses. Clinical implications and limitations of these two groups are different. The Vietnam group is dealing with the effects of aging, reliance upon the contralateral arm that may have CTD, and the presence of other comorbidities, but their advantage is they have usually adjusted to life with upper-limb loss and have done well. The OIF/OEF group faces challenges that include balancing the rehabilitation of the lost limb in conjunction with other combat injuries and combat-related comorbidities with the wish to return to an active lifestyle.

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Author Contributions:
Study concept and design: L. V. McFarland.

Acquisition of data: L. V. McFarland, M. Jones.
Analysis and interpretation of data: L. V. McFarland, S. L. Hubbard Winkler, A. W. Heinemann, M. Jones, A. Esquenazi.
Drafting of manuscript: L. V. McFarland, S. L. Hubbard Winkler, A. W. Heinemann.
Critical revision of manuscript for important intellectual content: L. V. McFarland, S. L. Hubbard Winkler, A. W. Heinemann, A. Esquenazi.
Statistical Analysis: L. V. McFarland, A. W. Heinemann.
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Participant Follow-Up: The authors do plan to notify study subjects of the publication of this article.

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