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Unilateral lower-limb loss: Prosthetic device use and functional outcomes in servicemembers from Vietnam war and OIF/OEF conflicts

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Abstract—Rehabilitation goals following major combat-associated limb loss in World War II and the Vietnam war focused on treatment of the injury and a return to civilian life. The goal for Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) servicemembers is to restore function to the greatest possible degree and, if they desire, return them to Active Duty, by providing them with extensive rehabilitation services and a variety of prosthetic devices. Our study determines the usefulness of these diverse types of prosthetic devices for restoring functional capability and documents prosthesis use and satisfaction. We compare servicemembers and veterans with major combat-associated unilateral lower-limb loss: 178 from the Vietnam war and 172 from OIF/OEF conflicts. Of survey participants with unilateral lower-limb loss, 84% of the Vietnam group and 94% of the OIF/OEF group currently use at least one prosthetic device. Reasons for rejection varied by type of device, but common reasons were pain, prosthesis too heavy, and poor fit. Abandonment is infrequent (11% Vietnam group, 4% OIF/OEF group). Future efforts should aim to improve prosthetic-device design, decrease pain, and improve quality of life for these veterans and servicemembers.

Key words: abandonment, amputation, limb loss, lower-limb loss, OIF/OEF, prostheses, prosthetic device, rehabilitation, satisfaction, Vietnam.

INTRODUCTION

Lower-limb amputations may be attributable to one of several causes: disease (vascular or infection), congenital reasons, tumor, or trauma (including combat situations)

Abbreviations: AOR = adjusted odds ratio, DOD = Department of Defense, OEF = Operation Enduring Freedom, OIF = Operation Iraqi Freedom, PTSD = posttraumatic stress disorder, TBI = traumatic brain injury, VA = Department of Veterans Affairs.

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[1]. Prolonged lower-limb prosthetic device use and satisfaction are not well documented, especially for veterans of previous combat situations (such as Vietnam veterans), who typically returned to civilian life after their limb loss [2–5]. A Department of Defense (DOD) Rehabilitation Directive aims to return wounded servicemembers from the Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) conflicts to a level of function that allows them the choice of returning to Active Duty or productive civilian employment [6–8]. To meet this goal, all military rehabilitation programs, including Walter Reed Army Medical Center, Brooke Army Medical Center, and the Naval Medical Center San Diego, offer state-of-the-art rehabilitation and sophisticated prosthetic devices with the intent to maximize the functional ability of servicemembers with limb loss [9–10]. OIF/OEF servicemembers with limb loss are prescribed multiple categories of prosthetic devices with the express purpose of enabling them to broaden their functional capabilities. However, we do not know whether the increased number of prostheses is effective in improving functional capability, whether servicemembers will continue to use these multiple prosthetic devices, and whether they are satisfied with the prostheses' performance.

Our national survey compared information on health, combat injuries, comorbidities, functional capability, and prosthetic-device use for veterans and servicemembers whose unilateral lower-limb loss occurred during the Vietnam war and OIF/OEF conflicts. The long-term experience of veterans sustaining major limb loss in Vietnam is useful to help clinicians predict long-term mobility for the OIF/OEF group. The purpose of this study is to determine the use and satisfaction of various categories of prosthetic devices and describe functional capabilities of veterans and servicemembers with unilateral lower-limb loss.

METHODS

Survey Participants

Participants in this study were veterans from the Vietnam war and servicemembers from the OIF/OEF conflicts with at least one major traumatic amputation (excludes digital-only loss) associated with a combat-field injury. After receiving institutional and human subjects approvals from the Department of Veterans Affairs (VA) and DOD, veterans and servicemembers with major limb loss occurring during the Vietnam war (1961–1973) or OIF/OEF (2000–2008) conflicts were sent an invitational letter to participate in a survey on prosthetic use. A waiver of consent was obtained for survey participants. All servicemembers with major limb loss from OIF/OEF were invited to participate, and 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 obtain a number similar to the total of OIF/OEF invitees. Survey participants included 298 from the Vietnam war (65% response rate) and 283 from the OIF/OEF conflicts (59% response rate). Enrolled and target populations were similar for the distribution of sex and type of limb loss, except that more Vietnam participants with multiple-limb loss were successfully enrolled. Participants took the survey by one of three methods (mail, telephone interview, or Web site). Veterans and servicemembers were surveyed from 2007 to 2008.

All 350 participants with unilateral lower-limb loss (178 in the Vietnam group, 172 in the OIF/OEF group) were drawn from a larger national survey of 298 veterans from the Vietnam war and 283 servicemembers and veterans from the OIF/OEF conflicts with major combat-associated unilateral upper-, lower-, or multiple limb losses. These two conflict groups were chosen to reflect prosthetic-device use before and after the DOD paradigm shift in rehabilitation care for battlefield injuries involving limb loss. A description of the detailed study methods is found elsewhere in this issue [11], as is our national *Survey for Prosthetic Use*, available as **Appendix 1**, (available online only).

Survey Measures

Prosthetic Devices

This descriptive, cross-sectional survey collected data on current prosthetic device and assistive device use (number and type of devices and daily frequency of use), as well as satisfaction with current prostheses and services. Current satisfaction with their prostheses was ranked from 0 (not at all satisfied) to 10 (completely satisfied). Survey participants were also asked which types of prosthetic devices and assistive devices they might want to try in the next 3 years.

Retrospective data were 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 it was received through military, VA, or private sources. Survey participants also included prototype prosthetic devices received. Participants reported prosthetic-device data for two time intervals: the first 12 months following limb loss and month 13 to the present. The annual rate of prosthetic-device receipt was calculated with the total number of prosthetic devices ever received (within a category of prosthetic-device-type classification) divided by the total years since initial limb loss (year of survey date minus year of initial amputation). Abandonment of prostheses is defined as receiving at least one lower-limb prosthesis but currently discontinuing use of all lower limb prostheses.

Because of 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. For limb loss at the knee or above (knee, transfemoral, hip, pelvis), the four groups were (1) advanced technology (microprocessor-type device requiring recharging or hybrid [mix of electronic and body-powered parts]), (2) mechanical (does not require recharging), (3) specialty (recreational, athletic, or high-impact use), and (4) waterproof (shower or swimming leg). For limb loss below the knee (transtibial, ankle, or foot), the five groups were (1) advanced technology (hybrid [mix of electronic and body-powered parts]), (2) mechanical (vacuum-assisted system with pump or suction device, or types that do not require recharging), (3) specialty (recreational, athletic, or high-impact use), (4) waterproof (shower or swimming leg), and (5) cosmetic (nonfunctional limb, or foot or ankle only). For limb loss below the knee (transtibial, ankle, or foot limb loss), vacuum-assisted systems are grouped with mechanical devices, because these systems were largely vacuum sockets with mechanical feet. Data for cosmetic devices were also classified according to limb-loss level. For those with foot or ankle limb loss, the cosmetic device data were included, because these devices are used for ambulation and/or balance. For those with higher levels of lower-limb loss, cosmetic device data are excluded, because cosmetic devices are not used for ambulation and some survey participants reported cosmetic coverings for mechanical or microprocessor limbs. Upper-limb prostheses were grouped into three groups: (1) advanced technology (myoelectric or microprocessor types or hybrid), (2) mechanical (body-powered, no batteries needed), and (3) 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.

Functional Capability

Lower-limb functional capability was assessed with seven graded levels: 1 = cannot walk, need assistance to transfer; 2 = cannot walk, does not need help to transfer; 3 = household walker; 4 = community walker; 5 = walks with varying speeds; 6 = low-impact activities, such as swimming or golf; 7 = high-impact activities, such as basketball or skiing.

Health Status

Self-rated health status was assessed with a validated tool [12]. Self-rated quality of life was assessed by asking how participants would rate their current quality of life and was grouped into two categories: better quality of life (excellent or very good survey responses) and worse quality of life (good, fair, or poor survey responses).

Comorbidities

Participants provided information on the presence or absence of 15 types of comorbidities (including arthritis, posttraumatic stress disorder [PTSD], depression, traumatic brain injury [TBI], stroke, diabetes, migraines), and pain (including phantom limb, residual limb, and chronic back).

Combat-Associated Injuries

Participants were asked to report the date and location of all amputations, number of associated surgeries, level of limb loss, and types of combat injuries. The levels of amputation were reported as partial foot, ankle, transtibial, knee disarticulation, transfemoral, hip, or transpelvic. We created a survey question to determine how much their amputation affected their current quality of life. We defined this variable as the "amputation impact rank." Survey participants rated the impact of their amputation on a scale of 0 (does not affect at all) to 10 (strongly affects their current quality of life). Higher values of the amputation impact rank were interpreted as having more impact on their current life. Although the survey did not specifically state whether the impact of

their amputation was negative or positive, a subsample of survey participants were queried, and all reported they interpreted the survey question to mean a negative impact on their life.

Survey participants were asked if they sustained any of seven specific types of other combat injuries (besides their amputation): injury to limb(s) with no amputation, head injury, eye injury, hearing loss, chest injury, abdominal injury, and burns. A detailed description of other combat injuries is presented elsewhere in this issue [13].

Cumulative trauma disorder (or worn-limb syndrome) results from overuse of the nonamputated limb and may include any one of the following: joint arthritis, stiff joints, heel pain, plantar fasciitis, or heterotopic ossification.

Statistical Analyses

We compared the demographic, health, prosthetic-use, and satisfaction data between the Vietnam and OIF/OEF groups. For univariate analyses, statistical significance is based on chi-square (categorical data), Mann-Whitney *U* test (ordinal data), Student *t*-test (continuous data), and Fisher exact test if the cell size is ≤ 5. The level of significance for a two-sided test is $p \leq 0.05$. Univariate, bivariate, and multivariate analyses were performed with Stata 9.2 software (StataCorp; College Station, Texas). Variables significant in univariate analyses were tested in logistic regression multivariate models. Separate models were run for the Vietnam and OIF/OEF survey groups. We used multivariate models to determine factors associated with high functional levels. The outcome for the models was a bivariate outcome variable for high functional levels (low- and high-impact activities such as swimming, trail hiking, golf, jogging, and other sports) compared with more moderate functioning (walking). For the regression models, we excluded survey participants in the two lowest levels, who could not walk and were wheelchair dependent. The nonambulatory group is described elsewhere in this issue [14]. To avoid overfitting the model, we added variables significant in univariate analyses using a forward stepwise selection based on the log likelihood ratio and significance of the coefficient. We compared the model with the added variable with the previous model using the log likelihood ratio chi-square technique and the variable remained in the model if $p \leq 0.05$. The variable was removed from the model if $p > 0.05$ and if it was not a confounding factor. Potential interactions were also assessed with the log likelihood ratio. Goodness of fit of the final model was assessed with the Hosmer-Lemeshow test statistic. A value of $p > 0.05$ indicated a well-fitted model [15–16].

RESULTS

Conflict Group Comparison

Our survey offered a unique opportunity to determine lower-limb prosthetic-device-use patterns for two distinct groups of servicemembers with combat-associated unilateral lower-limb loss. The Vietnam group represented a cross section of veterans who had survived an average of 38 years postinjury and benefited from a long experience with prostheses; the OIF/OEF group represented those who were still fairly early in their rehabilitation process.

We enrolled 178 Vietnam veterans with unilateral lower-limb loss and 172 from the OIF/OEF conflicts, for a total of 350 with unilateral lower-limb loss. The levels of limb loss for the Vietnam and OIF/OEF groups are described in **Table 1**. The majority of limb loss was at the transtibial and transfemoral level in each group. At the time of the survey, the Vietnam group was an average of 38.3 ± 4.9 years since the initial limb loss, while the OIF/OEF group was an average of 3.1 ± 1.3 years post-limb loss. Detailed demographic descriptions of both groups are reported elsewhere in this issue [11]. All participants in the Vietnam group were male (mean age 60.8 ± 3.2 years) and 98 percent of the OIF/OEF group were male (mean age 29.4 ± 6.1 years). In the Vietnam group, 80 percent were currently employed, while in the OIF/OEF group 57 percent were employed (including 22% who returned to Active Duty) and 22 percent were students (**Table 1**).

Combat-Associated Injuries

Overall, the Vietnam group reported a significantly higher specific impact of their lower-limb loss on their current quality of life (average amputation impact rank of 7.5 ± 2.6) compared with the OIF/OEF group (6.8 ± 2.6), although we saw no significant differences by limb-loss level (**Table 1**). The frequency of other combat-associated injuries was higher in the OIF/OEF group (3.3 ± 1.8 injuries) compared with the Vietnam group (2.9 ± 1.8 injuries, $p = 0.005$). Other types of combat injuries were similar by level of limb loss for the two conflict groups (**Table 1**). A detailed description of combat injuries is presented elsewhere in this issue [13]. The OIF/OEF group reported

Table 1.
Comparison of health status and function in Vietnam and OIF/OEF groups with unilateral lower-limb loss by limb-loss level. Values in parenthesis indicate percentage of frequency.

Outcome	Foot		Ankle		Transtibial		Knee		Transfemoral		Hip		Total	
	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF
No. Persons	2	8	13	1	103	93	7	2	46	63	7	5	178	172
Active Duty *n* (%)	0	2 (25)	0	0	0	20 (22)	0	0	0	13 (21)	0	2 (40)	0	37 (22)*
Employed	2	7	10	1	85	48	5	2	34	37	5	2	141 (80)	97 (57)
Combat-Associated (mean ± SD)														
Amputation Impact Rank†	10 ± 0	6.6 ± 2.8	8.2 ± 2.5	10 ± 0	7.0 ± 2.8	6.4 ± 2.6	8.1 ± 2.1	6.5 ± 4.9	7.8 ± 2.5	7.2 ± 2.5	8.6 ± 2.0	8.8 ± 0.8	7.5 ± 2.6*	6.8 ± 2.6
No. Other Combat Injuries‡	2.0 ± 0	2.1 ± 1.1	2.2 ± 1.6	4	2.8 ± 1.5	3.2 ± 1.6	4.7 ± 2.5	2 ± 0	3.3 ± 2.2	3.8 ± 2.0	2.7 ± 2.0	2.2 ± 1.8	2.9 ± 1.8	3.3 ± 1.8*
No. Post-Limb-Loss Surgeries	0.5 ± 0.7	7.4 ± 10.4	1.2 ± 1.4	0	2.5 ± 2.5	5.7 ± 7.0*	1.1 ± 1.6	0.5 ± 0.7	2.2 ± 2.7	5.3 ± 6.2*	4.6 ± 7.2	8.4 ± 5.9	2.3 ± 2.8	5.6 ± 6.8*
Comorbidities														
None *n* (%)	0	2	0	0	5 (5)	3 (3)	0	0	0	3 (5)	0	1 (20)	5 (3)	9 (5)
Mean ± SD	6.5 ± 0.7	3.6 ± 3.1	5.8 ± 2.4	10 ± 0	5.1 ± 2.8	4.7 ± 2.3	5.3 ± 1.6	3.5 ± 2.1	6.0 ± 3.0*	4.8 ± 2.7	7.2 ± 2.3	3.2 ± 1.9	5.5 ± 2.8*	4.7 ± 2.5
Cumulative Trauma Disorder§ *n* (%)	1 (50)	4 (50)	8 (61)	1 (100)	68 (66)*	41 (44)	5 (71)	1 (50)	31 (67)	33 (52)	6 (86)*	0	119 (67)*	80 (46)
Quality of Life *n* (%)														
Excellent/Very Good (%)	1 (50)	7 (88)	3 (23)	0	26 (25)	42 (46)	3 (43)	1 (50)	14 (30)	33 (52)	0	3 (60)	47 (26)	86 (50)
Good/Fair/Poor	1 (50)	1 (13)	10 (77)	1 (100)	77 (75)*	51 (54)	4 (57)	1 (50)	32 (70)*	30 (48)	7 (100)*	2 (40)	131 (74)*	85 (50)
Health Status *n* (%)														
Excellent/Very Good	1 (50)	6 (75)	3 (23)	0	29 (28)	42 (46)*	2 (29)	1 (50)	12 (26)	26 (41)*	1 (14)	3 (60)	48 (27)	78 (46)*
Good (%)	1 (50)	1 (13)	8 (62)	1 (100)	41 (40)	36 (39)	4 (57)	0	18 (39)	29 (46)	1 (14)	0	73 (41)	67 (39)
Fair/Poor (%)	0	1 (13)	2 (15)	0	33 (32)	14 (15)	1 (14)	1 (50)	16 (35)	8 (13)	5 (71)	2 (40)	57 (32)	26 (15)

Note: Numbers denote frequency (number of people), percentage (%), or mean ± standard deviation (SD).
*$p < 0.05$ compared with other conflict groups.
†Amputation impact rank = 3-point scale of 0 (limb loss does not affect quality of life at all), 5 (moderately affects), or 10 (strongly affects).
‡Excludes limb loss.
§Cumulative trauma disorder = symptoms due to overuse of nonamputated lower limb: ankle, knee, and hip arthritis; stiff joints; heel pain or plantar fasciitis.
No. = number, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom.

more frequent surgeries post-limb loss than the Vietnam group, especially for transtibial and transfemoral limb loss levels (**Table 1**).

Comorbidities

The Vietnam group average 5.5 ± 2.8 comorbid conditions compared with the OIF/OEF group average of 4.7 ± 2.5. The frequency of comorbidities did not significantly vary by level of limb loss for either group, except that Vietnam veterans with transfemoral limb loss had more comorbidities compared with OIF/OEF participants with the same level of limb loss (**Table 1**). Significant differences were seen in the types of comorbidities in the two groups (data not shown). In the Vietnam group, 71 percent reported arthritis, compared with 30 percent of the OIF/OEF group. The OIF/OEF group reported more PTSD than the Vietnam group (63% and 46%, respectively; $p = 0.001$) and TBI (35% and 2%, respectively; $p < 0.001$). The frequency of depression was similar in the Vietnam group (28%) and the OIF/OEF group (25%). The frequencies of phantom pain (75% and 77%) and residual limb pain (53% and 62%) were also similar for the Vietnam and OIF/OEF groups, respectively. The Vietnam group also reported a higher frequency of cumulative trauma disorder compared with the OIF/OEF group (67% and 46%, respectively; $p < 0.001$). Significantly more Vietnam veterans with transtibial and hip-level limb loss had cumulative trauma disorder than OIF/OEF (**Table 1**) members with the same level limb loss. Of the Vietnam group with cumulative trauma disorder, 59 percent reported pain in the contralateral limb compared with 31 percent in the OIF/OEF group ($p < 0.001$).

General Health

Fewer Vietnam veterans reported their overall self-reported quality of life was either excellent or very good (26%) compared with the OIF/OEF group (50%). Overall quality of life was lower for Vietnam servicemembers with limb loss at transfemoral, transtibial, and hip-level limb loss (**Table 1**). The Vietnam group also reported significantly lower self-reported health status than the OIF/OEF group (**Table 1**), with only 27 percent reporting excellent to very good health compared with 46 percent of the OIF/OEF group.

Functional Ability

The Vietnam group with unilateral lower-limb loss reported significantly lower self-rated functional ability than the OIF/OEF group. In the Vietnam group, only 5 percent were nonambulatory and only 2 percent were nonambulatory in the OIF/OEF group; all used wheelchairs for mobility. In the Vietnam group, 72 percent identified their functional abilities as "walkers" (household, community, or varying speed walkers). As shown in **Table 1**, the OIF/OEF group who typically wore a lower-limb prosthetic device had higher functional abilities, ranging from varying walking speeds to high-impact activities such as skiing and basketball. Significantly fewer of the Vietnam group reported low- to high-impact recreational activities (23%) compared with the OIF/OEF group (54%, $p < 0.001$). When we compared overall average functional level score (**Table 2**), the Vietnam group was significantly lower (4.6 ± 1.2) compared with the OIF/OEF group (5.5 ± 1.3). Functional ability also varied by the level of limb loss. In the Vietnam group, a trend emerged for more of the transtibial-level limb-loss group to participate in low- to high-impact recreational activities (29%), but only 13 percent of the transfemoral-level limb-loss group participated ($p = 0.06$). Although more of the OIF/OEF group was in this higher functional group, recreational activities were more frequent in the transtibial group (62%) compared with the transfemoral level (41%, $p = 0.008$).

Prosthetic Devices Ever Received

In the Vietnam group, 9 (5%) never received a lower-limb prosthetic device and 169 (95%) received at least one lower-limb prosthesis. In the OIF/OEF group, 3 (2%) never received a lower-limb prosthetic device and 169 (98%) received at least one prosthesis. The annual rate of prostheses prescription for the Vietnam group was significantly lower (0.3 ± 0.2 devices/person/year) than the OIF/OEF group (2.5 ± 2.2 devices/person/year; $p < 0.01$). The annual rate was significantly higher for OIF/OEF members across all limb-loss levels (**Table 3**). The distribution of types of prostheses ever received by level of limb-loss is shown in **Table 3**. Of the 1,738 devices received by Vietnam veterans, most were mechanical (89%). Of the 1,167 devices received by the OIF/OEF group, most were also mechanical (63%) and 12 percent were more advanced technology devices. Because the first year after

Table 2.
Functional ability level by type of limb loss for Vietnam and OIF/OEF groups with unilateral lower-limb loss.

Functional Capability Level	Foot		Ankle		Transtibial		Knee		Transfemoral		Hip		Total	
	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF
No. Persons	2	8	13	1	103	93	7	2	46	63	7	5	178	172
1. Need Help to Transfer, Cannot Walk	0	0	0	0	0	0	0	0	1 (2.2)	1 (1.6)	0	0	1 (0.6)	1 (0.6)
2. Do Not Need Help to Transfer, Cannot Walk	0	0	0	0	3 (2.9)	1 (1.1)	0	0	4 (8.7)	1 (1.6)	1 (14.3)	0	8 (4.5)	2 (1.2)
3. Household Walker	0	0	2 (15.4)	0	9 (8.7)	2 (2.2)	2 (28.6)	0	6 (13.0)	8 (12.7)	3 (42.9)	2 (40.0)	22 (12.4)	12 (7.0)
4. Community Walker	1 (50.0)	0	2 (15.4)	0	17 (16.5)	7 (7.5)	1 (14.3)	0	16 (34.8)	15 (23.8)	1 (14.3)	2 (40.0)	38 (21.4)	24 (14.0)
5. Walk with Varying Speeds Over Uneven Barriers	1 (50.0)	1 (12.5)	5 (38.5)	0	44 (42.7)	25 (26.9)	3 (42.9)	1 (50.0)	13 (28.3)	12 (19.0)	2 (28.6)	1 (20.0)	68 (38.2)	40 (23.3)
6. Low-Impact Activities	0	3 (37.5)	4 (30.8)	1 (100)	24 (23.3)	29 (31.2)	1 (14.3)	0	4 (8.7)	14 (22.2)	0	0	33 (18.5)	47 (27.3)
7. High-Impact Activities	0	4 (50.0)	0	0	6 (5.8)	29 (31.2)	0	1 (50.0)	2 (4.4)	12 (19.1)	0	0	8 (4.5)	46 (26.7)
Functional Level Score (mean ± SD)	4.5 ± 0.7	6.4 ± 0.7*	4.8 ± 1.1	6	4.9 ± 1.1	5.8 ± 1.1*	4.4 ± 1.1	6.0 ± 1.4	4.2 ± 1.3	5.0 ± 1.5*	3.6 ± 1.1	3.8 ± 0.8	4.6 ± 1.2	5.5 ± 1.3*

Note: Numbers denote frequency (number of people), percentage (%), or mean ± standard deviation (SD).
*$p < 0.05$.
OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom.

Table 3.
Comparison of number of lower-limb prosthetic devices used for Vietnam and OIF/OEF groups with unilateral lower-limb loss by level of limb loss.

Outcome	Foot		Ankle		Transtibial		Knee		Transfemoral		Hip		Total	
	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF	Vietnam	OIF/OEF
No. by Level	2	8	13	1	103	93	7	2	46	63	7	5	178	172
Never Received Any Prostheses														
No. Persons	1	0	0	1	7	1	0	0	1	1	0	0	9 (5)	3 (2)
Prosthetic Devices Ever Received														
Annual Rate (mean devices/person-yr)	0.1 ± 0.2	1.9 ± 2.5	0.3 ± 0.2	0	0.3 ± 0.2	3.0 ± 2.5*	0.2 ± 0.1	2.0 ± 0	0.2 ± 0.2	2.2 ± 1.8*	0.1 ± 0.1	0.7 ± 0.4*	0.3 ± 0.2	2.5 ± 2.2*
By No. Devices: Ever Received														
Advanced	0	0	0	0	1	8	1	0	23	126	0	11	25 (1)	145 (12)*
Mechanical	0	15	104	0	981	579	51	6	388	140	20	2	1,544 (89)*	742 (63)
Specialty	0	6	0	0	33	97	0	3	2	48	1	0	36 (2)	154 (13)
Waterproof	0	2	0	0	53	73	0	1	7	35	0	0	60 (3)	111 (10)
Cosmetic	11	15	62	0	0	0	0	0	0	0	0	0	73 (4)	15 (1)
Total	11	38	166	0	1068	757	52	10	420	349	21	13	1,738	1,167
Persons Currently Using Prostheses														
Use Any Type Currently	1	6	13	0	91	91	6	2	37	60	2	3	50 (84)	162 (94)
Abandoned All	0	2 (25)	0	0	5 (5)	1 (1)	1 (14)	0	8 (18)	2 (3)	5 (71)	2 (40)	19 (11)*	7 (4)
By No. Devices: Current Use														
Advanced	0	0	0	0	1	4	1	0	14	61	0	4	16 (7)	69 (11)*
Mechanical	0	5	8	0	117	233	6	4	36	61	3	0	170 (76)*	303 (56)
Specialty	0	5	0	0	5	59	0	3	0	27	0	0	5 (2)	94 (17)
Waterproof	0	2	0	0	19	47	0	1	2	18	0	0	21 (9)	68 (13)
Cosmetic	1	8	11	0	0	0	0	0	0	0	0	0	12 (5)	8 (1)
Total	1	20	19	0	142	343	7	8	52	167	3	4	224	542
By No. Devices: Replaced†														
Advanced	0	0	0	0	0	0	0	0	5	25	0	2	5 (0.4)	27 (10)
Mechanical	0	0	85	0	686	149	38	2	243	52	12	0	1,064 (97)*	203 (77)
Specialty/Waterproof	0	0	0	0	29	26	0	0	1	8	0	0	30 (3)	34 (13)*
Total	0	0	85	0	715	175	38	2	249	85	12	2	1,099	264
By No. Devices: Rejected†														
Advanced	0	0	0	0	0	0	0	0	4	40	0	5	4 (1)	45 (13)
Mechanical	0	10	11	0	178	201	7	0	109	27	5	2	310 (93)*	240 (68)
Specialty/Waterproof	0	6	1	0	16	35	0	0	2	28	1	0	20 (6)	69 (20)*
Total	0	16	12	0	194	236	7	0	115	95	6	7	334	354

Note: Numbers denote either frequency (number of people), percentages (%), or mean ± standard deviation (SD).
*$p < 0.05$.
†Excludes replaced and rejected devices with missing data.
No. = number, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom.

amputation involves the early postoperative and training prostheses, we examined prostheses use during the first year and compared types of definitive prostheses received in the ensuing years. As shown in **Figure 1**, the annual rate of receipt (during the first year postlimb loss) was higher than definitive prostheses use for both advanced technology and mechanical devices for both the Vietnam and OIF/OEF groups. The OIF/OEF group received significantly more advanced technology and mechanical devices/year than the Vietnam group during the first year. After the first year, during which participants underwent intensive of rehabilitation and training, the OIF/OEF group still received more advanced technology prostheses per year compared with the Vietnam group. However, the Vietnam and OIF/OEF groups received similar rates of mechanical devices (averaging one every 2 years).

Current Use of Prosthetic Devices

Most Vietnam participants with unilateral lower-limb loss currently used a prosthesis (84%), but significantly more (94%) of the OIF/OEF group were current users ($p = 0.003$). The mean number of prosthetic devices currently in use was significantly fewer for the Vietnam group (1.2 ± 0.9) compared with the OIF/OEF group (3.1 ± 0.2, $p < 0.001$). The eventual fate of each device type received is visualized in **Figure 2**, which shows most prostheses in

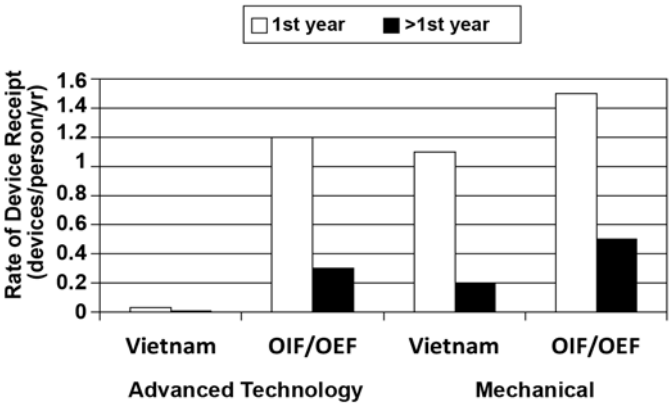

Figure 1.
Annual rate of prosthetic-device receipt by years postlimb loss, type of prosthetic device, and Vietnam or Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) group. Advanced technologies include microprocessors and hybrids of electronic and body-powered components. Mechanical devices include body-powered prostheses that do not require recharging and vacuum-assisted systems. Significant differences ($p < 0.05$) noted in OIF/OEF groups for advanced technology (both in first year and after first year annual rates) and in OIF/OEF for mechanical devices (only during first year), compared with Vietnam group.

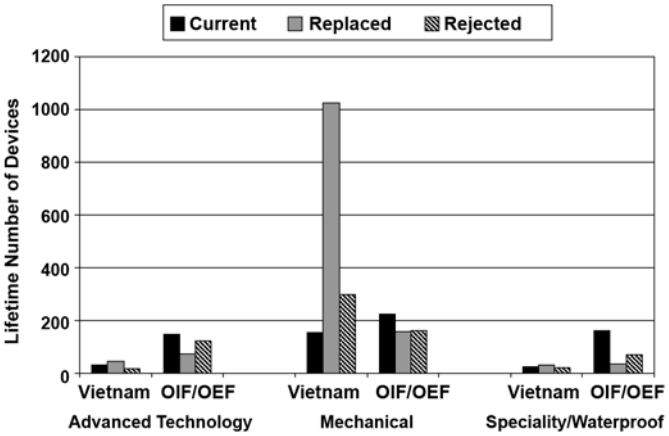

Figure 2.
Fate of prosthetic devices for unilateral lower-limb loss in Vietnam and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) groups. Advanced technologies include microprocessors, vacuum-assisted systems, and hybrids of electronic and body-powered components. Mechanical devices include body-powered prostheses that do not require recharging.

current use were of the mechanical type, and a large number of prostheses requiring replacement were mechanical. Of the 1,738 devices received by the Vietnam group over 38 years, the fate of 1,657 devices was documented: 224 (13%) were in current use, 1,099 (66%) wore out and were replaced, and 334 (20%) were rejected because of dissatisfaction with the device (**Table 3**). Of the 1,167 devices received by the OIF/OEF group over 3 years, the fate of 1,160 were known: 542 (47%) were in current use, 264 (23%) wore out and were replaced, and 354 (31%) were rejected.

The type of prosthetic device currently in use was significantly different by group. More of the Vietnam group (76%) used mechanical prostheses compared with 56 percent of the OIF/OEF group ($p < 0.001$). More of the OIF/OEF group used advanced technology devices (13%) compared with only 7 percent of the Vietnam group ($p < 0.001$). In both groups, advanced technology devices were usually used daily (89% Vietnam and 86% OIF/OEF group). More (92%) of the Vietnam group used mechanical devices on a daily basis compared with 73 percent of the OIF/OEF group, who used their mechanical device daily ($p < 0.001$). In contrast, specialty devices were used more frequently by the OIF/OEF group; 50% of the Vietnam group used them only 1–2 times per year, whereas 92 percent of the OIF/OEF group used them more frequently. Waterproof legs were used at least weekly by 50 percent of both groups.

When asked on a scale of 0 (not at all satisfied) to 10 (completely satisfied) how satisfied they were with their current main prosthesis, both groups had similar satisfaction levels: the Vietnam group (mean score = 7.2 ± 2.3) and OIF/OEF group (mean score = 7.6 ± 1.9, $p = 0.09$). No significant differences were seen in the satisfaction scores by limb-loss level between the two groups (data not shown), except that Vietnam veterans with hip disarticulation were less satisfied (mean score = 5.0 ± 0) compared with OIF/OEF participants with hip disarticulation (mean score = 7.7 ± 0.6, $p = 0.009$).

Prosthetic Devices Replaced

As shown in **Figure 2**, most of the lower-limb prostheses replaced because of daily wear-and-tear or breakage are mechanical-type devices; in contrast, the OIF/OEF group replaced both advanced technology and mechanical devices. Of all the types of prostheses replaced (**Table 3**), significantly more (97%) were mechanical devices in the Vietnam group compared with the OIF/OEF group (77% mechanical, $p < 0.001$). The OIF/OEF group wore out significantly more advanced technology devices (10%) than the Vietnam group (0.4%).

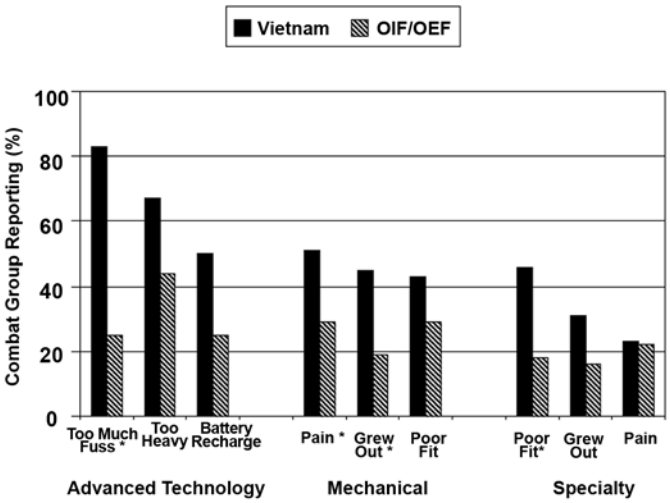

Figure 3.
Reasons for prosthetic-device rejection by device type by Vietnam or Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) group. Battery recharge = battery needs to be recharged; grew out = grew out of prosthesis (usually due to limb shrinkage or weight gain). Advanced technologies include microprocessors, vacuum-assisted systems, and hybrids of electronic and body-powered components. Mechanical devices include body-powered prostheses that do not require recharging. $^{*}p < 0.05$ compared with OIF/OEF group.

Most of the devices replaced were for transfemoral limb loss (**Table 3**). For advanced technology and mechanical devices, the average replacement times are longer for the Vietnam group (60% replaced every 3–5 years) than the OIF/OEF group (92% replaced within 2 years). For specialty devices, replacement times were also longer for the Vietnam group (67% replaced longer than every 6 years); while in contrast, 88 percent of the OIF/OEF group replaced specialty devices within 2 years.

Prosthetic Devices Rejected

Lower-limb prostheses were rejected because of dissatisfaction or problems adapting to the prosthetic device. Of the 334 devices rejected by the Vietnam group, most were mechanical (93%), compared with only 68 percent ($p < 0.001$) in the OIF/OEF group (**Table 3**). Significantly more rejected devices in the OIF/OEF group were either advanced technology (13%) or specialty devices (20%), compared with the Vietnam group ($p < 0.001$). Transtibial- and transfemoral-level limb loss had the highest numbers of rejected devices (**Table 3**). The three most frequent reasons for rejection by type of device are shown for the two groups in **Figure 3**. For advanced technology devices, significantly more of the Vietnam group (83%) rejected the prosthetic because of "too much fuss" compared with the OIF/OEF group (25%, $p < 0.001$). The second and third most common reasons for rejecting advanced technology devices were similar for the Vietnam and OIF/OEF groups: too heavy (67% and 44%, respectively) and need to recharge batteries (50% and 25%, respectively). For mechanical devices, two reasons were significantly more frequent in the Vietnam group compared with the OIF/OEF group: pain (51% and 29%, respectively, $p = 0.002$) and "grew out of it" (45% and 19%, respectively, $p = 0.001$). The third most frequent reason to reject a mechanical device was poor fit (43% Vietnam group and 29% OIF/OEF group). For specialty devices, significantly more of the Vietnam group (46%) rejected the prosthetic because of poor fit compared with the OIF/OEF group (18%, $p = 0.006$). The second and third most common reasons for rejecting specialty devices were similar for Vietnam and OIF/OEF groups: growing out of it (31% and 16%, respectively) and pain (23% and 22%, respectively).

Prosthetic Devices Abandoned

Some survey participants reported complete abandonment of all lower-limb prosthetic devices. Of 169 Vietnam participants who ever received lower-limb prosthetic devices, 19 (11%) abandoned their lower-limb prostheses. The most common limb-loss level associated with abandonment was hip disarticulation (71%), as seen in **Table 3**. Most of the abandoned devices were mechanical (13, 68%), which were used for an average of 13 ± 13.5 years before abandonment (ranging from 6 months to 36 years). The most common reasons for abandonment included insufficient residual-limb length to support body weight (31%), too heavy (25%), and pain (19%). Most had problems with the contralateral leg (50% cumulative trauma disorder). Of the 19 Vietnam participants who abandoned lower-limb prostheses, 14 (74%) relied on wheelchairs for mobility, for an average of 22 ± 16 years. More details on wheelchair use and assistive devices are reported elsewhere in this issue [14].

Of the 169 OIF/OEF participants who ever received at least one lower-limb prosthesis, 7 (4%) abandoned using all lower-limb devices. Abandonment was highest for hip disarticulations (40%), as shown in **Table 3**. Most of the OIF/OEF group used a variety of different types of prostheses before abandoning use (71%). The OIF/OEF group used their prostheses for a significantly shorter time than the Vietnam group before stopping (mean 7 ±

5 months, $p = 0.03$). The most frequent reasons for abandonment were other combat injuries (43%) and cumulative trauma disorder (29%). Of the seven OIF/OEF members who abandoned lower-limb prostheses, four (57%) switched to wheelchairs.

Future Use of Prosthetic Devices

Survey participants were asked if they would consider using a specific type of prosthetic device in the next 3 years, regardless of what type they are currently using. Significantly fewer of the Vietnam group wanted to try advanced technology devices (40%) compared with the OIF/OEF group (73%, $p < 0.001$). A similar number predicted they would use mechanical lower-limb prostheses in the next 3 years (71% of Vietnam and 75% OIF/OEF group, $p = 0.4$). No significant differences of predicted future use were found by other types of devices (specialty, hybrid, or waterproof).

Multivariate Models for Functional Ability

Multivariate models determined several factors that are associated with increased functional mobility level for people with unilateral lower-limb loss (**Table 4**). Modeling the level of limb loss using the seven levels was not productive because of the small numbers in some of the levels (partial foot, ankle, knee, and hip); consequently, we only used the transtibial and transfemoral groups. In the Vietnam group, function was significantly confounded by the level of limb loss (transfemoral having lower functioning), and we adjusted for this in our analyses. Two variables were significantly associated with higher functional ability in the Vietnam group: a higher overall quality of life (adjusted odds ratio [AOR] = 4.1) and higher numbers of currently used prosthetic devices (AOR = 2.3) Two variables were significantly associated with lower functional ability in the Vietnam group: more surgeries postlimb loss (AOR = 0.77) and a higher perceived impact of their limb loss on their current life (AOR = 0.75).

We also adjusted for the level of limb loss in the OIF/OEF model (**Table 4**). Three variables were associated with higher functional ability in the OIF/OEF group: increasing numbers of specialty prosthetic devices in current use (AOR = 5.8), higher overall quality of life (AOR = 2.8), and higher number of total devices ever received (AOR = 1.1). Two variables were significantly associated with lower functional ability in the OIF/OEF group: pain in the contralateral leg (AOR = 0.34) and a higher perceived impact of their limb loss on the current quality of life (aOR = 0.82). No significant interaction terms existed in either model. Other variables investigated in the univariate analysis were not significant in either group model.

Table 4.
Logistic multivariate models of variables associated with higher functional ability in Vietnam and OIF/OEF groups with unilateral lower-limb loss.

Variables by Group*	Adjusted Odds Ratio	95% CI	*p*-Value
Vietnam†			
High Overall Quality of Life	4.10	1.44–11.67	0.008
Total No. of Currently Used Prosthetic Devices	2.30	1.28–4.14	0.006
No. of Surgeries Postlimb Loss	0.77	0.62–0.97	0.02
Amputation Impact Rank	0.75	0.62–0.91	0.003
Transfemoral Limb-Loss Level	0.41	0.13–1.34	—
OIF/OEF†			
Total No. of Specialty-Type Prosthetic Devices	5.79	2.51–13.3	<0.001
Higher Overall Quality of Life	2.83	1.20–6.71	0.02
Total No. of Prosthetic Devices Ever Received	1.13	1.01–1.27	0.03
Pain in Contralateral Leg	0.34	0.13–0.88	0.03
Amputation Impact Rank	0.82	0.69–0.98	0.03
Transfemoral Limb-Loss Level	0.47	0.19–1.18	—

*Dependent variable is lower-limb function on two levels: baseline (walkers in household and/or community on even or uneven surfaces at varying speeds) compared with higher function (low-high impact activities). Other variables are overall quality of life (higher quality of life compared with lower quality of life), total number of currently used prosthetic devices of all types, amputation impact rank ranging from 0 (does not affect current quality of life) to 10 (limb loss greatly affects currents quality of life), and transfemoral limb-loss level compared with transtibial limb-loss level.
†Goodness of fit statistics: Vietnam model, $\chi^2 = 91.8$, degrees of freedom = 101, $p = 0.73$; OIF/OEF model, $\chi^2 = 124.1$, degrees of freedom = 134, $p = 0.72$.
CI = confidence interval, No. = number, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom.

DISCUSSION

Our descriptive survey yielded high numbers of participants with unilateral traumatic lower-limb loss from two combat-related groups: 178 veterans from the Vietnam war with over 38 years of experience with prosthetic devices and 172 from the OIF/OEF conflicts who are fairly new (average of 3 years) to prosthetic devices. These two groups represented two distinct time periods in the lifetime of a person with limb loss: one group who were still adjusting to their limb loss and was early in the rehabilitation process (OIF/OEF group) and another group representing those with decades of experience with their prostheses (Vietnam group). The effect of the DOD paradigm shift in rehabilitation goals for these wounded servicemembers was reflected by a higher frequency of servicemembers returning to Active Duty and an increase in both the number and diversity of lower-limb prostheses used by the OIF/OEF group. In the OIF/OEF group, more (22%) returned to Active Duty compared with historical rates (<3%) during the Vietnam era [17]. Following the unique group who returned to Active Duty and documenting their use of prosthetic devices, special training needs, satisfaction, and challenges during military service would be useful.

Our survey showed an increase in the numbers of prosthetic devices in current use by OIF/OEF participants (3.1/year) compared with Vietnam veterans (1.2/year). Not only did OIF/OEF participants with unilateral lower-limb loss receive more devices, but the technology was more diverse (including microprocessors, vacuum-assisted sockets with feet, specialty devices). The observed diversity of prosthetic devices in the OIF/OEF group may have resulted directly from technological advances in prostheses made since the Vietnam war, the effect of the DOD rehabilitation paradigm shift, and the general health and activity level of the injured servicemember or veteran [18–19]. As shown by the annual rate of prosthetic devices received in the first year, the OIF/OEF group received 40 times the number of advanced technology devices and 1.4 times the number of mechanical devices as the Vietnam group received in their first year. The majority (76%) of the Vietnam group currently relied solely on their mechanical prostheses; in contrast, the OIF/OEF currently used several different types of devices (56% mechanical, 13% microprocessor, 17% specialty). One concern is how many of those who were receiving the advanced and costly microprocessor lower prosthetic devices would continue to use them. Of the 15 Vietnam survey participants who received microprocessor devices, three (20%) stopped using them; all three switched to a mechanical device. Of the 65 OIF/OEF participants who received microprocessors, 23 percent (15) stopped using them; 47 percent switched to solely mechanical devices, 27 percent currently used mechanical and specialty devices, 20 percent used wheelchairs only, and 7 percent had abandoned all prostheses.

Reasons why advanced technology devices were less frequently used by the Vietnam group may be because of availability or prescription practices at prosthetic centers, reluctance to try newer technology, lack of interest, or other health issues. In the OIF/OEF group, 73 percent predicted they would use an advanced technology prosthetic device in the next 3 years, while only 40 percent of the Vietnam group predicted they might try one in the next 3 years. Because the cost of advanced technology including microprocessor limbs is high, projected costs associated with their use may severely impact healthcare costs. Projected costs of the diverse prosthetic devices are examined in detail elsewhere in this issue [20].

The differences in prosthetic-device use may also have been related to the divergence in age, health, and experiences between the Vietnam and the OIF/OEF groups. Because the Vietnam group (60.8 ± 3.2 years) was approximately 30 years older, it was not surprising that this group had higher frequencies of age-related health issues (significantly more comorbidities, in poorer health, more cumulative trauma to the other non amputated limb) than the OIF/OEF group [21]. The OIF/OEF group (29.4 ± 6.1) was younger and reported a higher functional level, but it is reassuring that most of the Vietnam group also reported a good level of mobility (only <5% cannot walk) and still considered themselves community walkers. Changes in the type of blast injuries and changes in medical practices may explain why the OIF/OEF group reported more combat injuries and postamputation surgeries and had a higher frequency of TBI [10,22–24]. PTSD is a significant problem associated with 60 to 97 percent of combat injuries, and effective treatments for PTSD remain elusive [25–26]. Even though the prevalence of PTSD was high in both the Vietnam (45%) and OIF/OEF (64%) groups, PTSD was not significantly associated with either poorer functional capability or the number or types of prosthetic devices used. Phantom-limb pain is another comorbidity that may complicate the recovery of injured servicemembers with limb loss [27]. We found a high

prevalence of phantom and residual limb pain (54–77%), but found no association with function or prosthetic-device use. Pain in the contralateral lower limb was the only comorbid condition that was significantly associated with lower function in the OIF/OEF group in our multivariate analyses. Future research should explore mechanisms that could reduce pain and degenerative changes to the contralateral limb to maintain a higher functional level across the lifespan.

The aim of these diverse types of prosthetic devices is to improve functional capability in people with lower-limb loss. While the majority of recreational activities of people with lower-limb loss do not require specialized prostheses, the development of the specialized prosthetic devices being used by the OIF/OEF group allowed them to take part in a wide diversity of recreational activities [28]. Other studies in non-limb-loss populations have supported the close relationship between functional capacity, higher quality of life, and recreational activities [29–31]. We find an association between high functional ability, higher quality of life, and use of specialty-sports prosthetic devices in the OIF/OEF group. Some elder veterans may elect not to deal with the issues of multiple prosthetic devices or no longer participate in recreational activities that require specialized prostheses. However, it is important the veteran be given the choice to try something new or continue with what is comfortable for them. Multivariate analyses determined independent factors associated with higher functional capability in our study. Both groups shared several factors associated with higher functional capability (higher overall quality of life, use of more prosthetic devices, greater perception of the impact of limb loss on their current quality of life, transtibial level amputation). A higher perceived quality of life is found to be associated with improved functional capabilities in other populations [29,31]. For people with limb loss, the ability to use a prosthesis has been equated to greater functional capacity, which is also related to higher quality of life. The cause and effect relationship between these three attributes has not been fully realized and requires further investigation.

Based on the Vietnam veterans' nearly 40 years experience with prostheses, the OIF/OEF members can look forward to decades of life with good functional ability and high quality of life assisted by prosthetic devices. Of concern is that some may abandon the useful prosthetic devices because of pain, comorbidities, or dissatisfaction with the device. Our study presented reasons for dissatisfaction by type of prosthetic device, which may help steer future areas for improvement including decreasing pain, designing lighter prosthetic devices and suspension systems, and improving socket design. Our results are consistent with previous studies in which the reasons for rejection of a prosthesis included pain, poor fit, or growing out of the socket for mechanical or specialty prostheses [28]. Fortunately, many of these reasons for rejection can be addressed with improvements in prosthetic care and technology. Rejection of advanced technology prostheses is related to weight of the device and too much "fuss" and maintenance, such as charging the battery. Currently, technology is reducing the weight of microprocessor components. However, complaints about advanced technology devices involving charging of batteries or requiring too much fuss is more related to technology tolerance and suggests that candidates be educated and trained in the level of daily maintenance that these devices require.

Study limitations include potential response bias due to exclusion of veterans and servicemembers who did not choose to participate in the survey; differences in survival over time, which may impact the ability to generalize the results; recall bias of the Vietnam group for experiences occurring over 30 years ago; and the cross-sectional design of the survey. While this survey was unique in obtaining relatively high follow-up rates, those who were not located or who refused to participate could have had a substantially different experience and satisfaction with their prostheses and overall quality of life. In addition, recall bias of prosthetic devices received over 38 years ago is possible. We did not have available records of the specific prosthetic device types available to us to validate the self-reported prosthetic-device history. However, we feel this limitation is mild because of the broad classifications of the types of prosthetic devices used for our survey and the limited number of types of devices available to the Vietnam group over 38 years ago. The cross-sectional design of the study limited conclusions regarding causality.

Another potential limitation of our study is the generalizability of our results to people with limb losses that are not due to combat injuries. However, our results are consistent with the literature for the frequency of prosthetic device use in other studies. In our survey, the majority of unilateral lower-limb participants were currently using at least one lower-limb prosthetic device (84% of the Vietnam group and 94% of the OIF/OEF

group). A British survey of 582 servicemembers (75% had combat-related limb loss, 82% lost a lower limb) reported 92 percent current prosthetic-device use after a mean of 53 years after limb loss [2]. Another study of 46 Vietnam veterans with transfemoral limb loss found 87 percent wore a prosthesis after 28 years [4].

Our results of satisfaction with prosthetic devices are also similar to other studies of noncombat-associated limb loss. Raichle et al. studied 752 noncombat lower-limb loss cases (54% due to injury, 44% due to infection): 84 percent continued to use a prosthesis an average of 12 years postlimb loss [32]. Prosthetic wear was greater in people with limb loss who were employed, were married, had greater residual-limb length, and lost their limb because of trauma rather than disease [32]. In a survey of 954 people with noncombat-associated limb loss (39% injury, 37% vascular, and 23% tumor), 89 percent had lower-limb loss, and 93 percent reported current prosthetic use [33]. Dillingham et al. studied 78 trauma-related (noncombat, 54% related to motor vehicle accidents) Maryland residents with lower-limb loss and found 95 percent reported using a prosthesis, but only 43 percent were satisfied with the fit of their device [34]. In a community-based survey of 954 people with limb loss (89% lower limb and 11% upper limb) caused by a variety of incidents (39% trauma, 37% vascular, 23% cancer, etc.), 75.7 percent report being satisfied with the overall performance of their prosthesis, while nearby one-third were dissatisfied [35]. Unfortunately, these studies did not provide information on prosthesis use by type of limb loss or by type of prosthetic device. Even with these limitations in mind, these two groups give insights into the use of prostheses, reasons for abandonment and satisfaction with prostheses, and services at two distinct times over the lifetime of people with limb loss. Differences found in these two groups may be associated with the time period in their life, but also with differences in attitudes in care, advances in prosthetic device technology, and improvements in treatments for combat-related injuries [17–18,36].

Future studies of prosthetic devices should examine satisfaction, quality of life, and abandonment reasons so that practice-based evidence can guide our future clinical standard of care for people with limb loss. We recommend that a common standard of care be available to both new servicemembers and veterans with lower-limb loss, including prosthetic-device training, support services, and availability of newer technologies. Whether the person with limb loss receives these newer technologies should be a collaborative decision by the healthcare team and patient, based on the patient's functional ability, lifestyle considerations, and safety requirements.

CONCLUSIONS

About a 30-year difference in age existed between the Vietnam and OIF/OEF conflict groups of veterans with limb loss. The Vietnam group reported that limb loss had a greater impact on their quality of life, even though the OIF/OEF group sustained a greater number of combat injuries. Both groups had about the same frequency of comorbidities, although arthritis and cumulative trauma disorders to the contralateral lower limb were higher in the Vietnam group and PTSD and TBI were more common in the OIF/OEF group. The Vietnam group also had lower self-rated functional ability and participated in fewer low-/high-impact recreational activities than the OIF/OEF group. Our results also indicate that prosthetic-device use was different according to the stage of rehabilitation and adjustment for people with lower-limb loss. The number and types of prostheses were greater in the first year postamputation versus those used in the subsequent years, when the person had adapted to their limb loss. In addition, veterans of different combat eras had different experiences of use and satisfaction with prostheses because of changes in prosthetic technology, improvements in medical care, and availability of rehabilitation programs. Our study shows that even after nearly 40 years since limb loss, veterans reported good quality of life and ambulatory capability. Improving functional ability for those with lower-limb loss is aided by the use of prostheses. Future efforts should aim to improve satisfaction and use of lower-limb prostheses, decrease pain, and improve the quality of life for these veterans and servicemembers.

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