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Self-Reported Cognitive Concerns in People with Lower Limb Loss

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Abstract

Objective—To investigate differences between self-reported cognitive concerns in people with lower limb loss (LLL) and normative data derived from the U.S. general population. A secondary aim was to determine if there were cognitive differences based on amputation etiology or age.

Design—Survey.

Setting—General community.

Participants—A volunteer sample of 1086 persons with LLL resulting from trauma or dysvascular complications who regularly use a prosthetic limb.

Interventions—Not applicable.

Main Outcome Measure—The Quality of Life in Neurological Disorders Applied Cognition General Concerns v1.0 Short Form (Neuro-QoL ACGC), an eight-item self-report measure of general cognitive concerns.

Results—People with LLL reported significantly more cognitive concerns than the Neuro-QoL normative sample. Mean Neuro-QoL ACGC scores were significantly lower than normative values ($p < 0.001$) across subgroups defined by age (i.e., <40, 40–49, 50–59, 60–69, and 70+ years) and subgroups defined by etiology (i.e., traumatic and dysvascular LLL). However, there were no significant differences in cognitive concerns among age subgroups ($p = 0.84$) or between the etiology subgroups ($p = 0.58$).

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Conclusions—When compared to the Neuro-QoL normative sample, individuals with LLL report greater concerns with cognitive health. Cognitive concerns were not differentially affected by age or cause of amputation. The presence of cognitive concerns in people with LLL suggests a need to assess perceived cognitive function in order to tailor education and training in prosthetic use and care.

Keywords

cognition disorders; patient outcome assessment; artificial limb; amputation; rehabilitation

Introduction

Limb loss profoundly impacts an individual's physical health and often requires the provision of complex rehabilitation services, such as prosthetic care and physical therapy.¹ Common causes of lower limb loss (LLL) include dysvascular conditions (e.g., peripheral vascular disease) and traumatic events (e.g., motor vehicle accidents).² Although LLL has been traditionally viewed as a focused, musculoskeletal condition, research suggests that people with LLL experience greater cognitive impairment (CI) than the general population.^{3, 4} In a review by Coffey and colleagues, CI in people with LLL was attributed to two primary factors: the typical age of people with LLL and the common presence of comorbid conditions, like diabetes or dysvascular disease.³ In the United States (U.S.), an estimated 54% of people with LLL experience amputation due to vascular conditions and 42% of people with LLL are over age 65.² Older age,⁵ diagnosis of diabetes,⁶ and comorbid dysvascular conditions⁷ have each been associated with a decline in cognitive function. Because previous research of cognitive function in people with LLL primarily involved older participants with LLL from dysvascular conditions,³ little is known about cognitive functioning in people with LLL from non-dysvascular conditions or in younger people with LLL. It is sometimes assumed that these individuals do not experience CI, but its presence in these subpopulations could have significant impacts on rehabilitative care.

CI may manifest as deficits in learning, memory, and executive functions,^{8, 9} thereby increasing challenges with prosthetic rehabilitation. In addition to walking with a prosthesis, people with LLL need to properly don and clean their prosthesis, maintain prosthetic components, accommodate limb volume changes, address wounds, and manage pain. These activities require the cognitive ability to acquire, remember, and adapt new information.¹⁰ Presence of CI is also associated with undesirable functional outcomes (e.g., poor mobility, decreased prosthesis use, and loss of independence) among people with LLL.^{3, 11–14} As such, identifying and understanding cognitive issues in people with LLL may be critical to optimizing treatment and promoting long-term health outcomes. It is also important to know whether CI differentially affects people of different ages or LLL etiologies so as to inform which individuals may be candidates for cognitive assessment.

The aim of this study was therefore to compare self-reported cognitive concerns between persons with LLL and the general population. A secondary aim was to determine if there were differences in cognitive concerns based on etiology or age. We hypothesized that people with LLL would experience greater cognitive concerns than a normative sample

based on the U.S. general population. In addition, we hypothesized that people with traumatic LLL would experience less cognitive concerns than people with dysvascular LLL and that young people with LLL would experience less concerns than older people with LLL.

Methods

Participants

Volunteers with LLL were recruited using magazine advertisements, mailings, internet postings, and flyers located in clinics across the U.S. Eligibility criteria were age of 18 years or older, unilateral LLL below the hip and at or above the ankle, no other amputations, traumatic or dysvascular amputation etiology, use of a prosthesis to walk, and ability to read, write, and understand English. The enrollment target was 500 people with traumatic amputation and 500 people with dysvascular amputation. Study procedures were reviewed and approved by an institutional review board, and all participants provided informed consent.

Procedure

Self-reported cognitive concerns were measured in a cross-sectional study conducted between December 2011 and November 2012. Data were collected during large-scale testing of candidate items for the Prosthetic Limb Users Survey of Mobility (PLUS-M), a self-report measure of prosthetic mobility.^{15, 16}

Candidate participants were directed to a website for study information and self-screened by answering non-identifiable questions about the stated inclusion/exclusion criteria. Eligible participants were directed to the Assessment Center website (Northwestern University, Chicago, IL)¹⁷ to complete the survey. Alternatively, candidates could contact research staff to be screened and, if eligible, receive a paper survey. Paper surveys were double-entered by research staff to minimize data entry errors.¹⁸ Both paper and electronic surveys were reviewed by research staff for completeness and consistency. Respondents were contacted about missing data or potentially invalid responses.

Survey

Participants' health outcomes were assessed with a self-report survey. The 8-item Quality of Life in Neurological Disorders Applied Cognition – General Concerns v1.0 short form (Neuro-QoL ACGC) was included to evaluate perceived concerns with cognitive abilities, including memory, attention, and decision-making.¹⁹ The Neuro-QoL ACGC includes questions such as, “I had to read something several times to understand it,” and, “I had trouble keeping track of what I was doing if I was interrupted.” The Neuro-QoL ACGC solicits information from respondents about the frequency with which they experience cognitive concerns over the prior seven days. Neuro-QoL instruments (including ACGC) were developed using Item Response Theory (IRT) and have been tested in people without health concerns and in people with neurological conditions, including multiple sclerosis, epilepsy, stroke and Parkinson's disease.²⁰ Neuro-QoL ACGC is brief, has normative scores,

and has demonstrated evidence of reliability and validity across a range of clinical populations.²⁰

Neuro-Qol ACGC was scored according to the developers' instructions.²¹ Neuro-Qol T-scores are centered on a normative sample mean of 50 and SD of 10. A higher T-score indicates that the respondent reports fewer cognitive concerns. Normative T-scores for the Neuro-Qol ACGC item bank are based on a general population sample (n=533).¹⁹

In addition to cognitive health, participants answered questions about demographic (e.g., age, sex, race, ethnicity) and clinical (e.g., coexisting medical conditions, amputation etiology, amputation level) characteristics. Respondent age at survey completion was classified into five age categories (i.e., <40, 40–49, 50–59, 60–69, and 70+ years) to assess the effect of age on cognitive concerns.

Analysis

Demographic and clinical characteristics for the study sample were summarized using descriptive statistics. ACGC T-score distributions were evaluated for normality using the Shapiro-Wilk test, and visual inspection of the histogram and Quantile-Quantile plot. Student *t*-tests and chi-square tests were performed to assess differences in continuous and categorical characteristics between subgroups based on amputation etiology. To test the hypothesis that individuals with LLL report greater cognitive concerns than the Neuro-QoL normative sample, one-sample *t*-tests were used to compare the normative sample mean T-score (i.e., 50) to means of the overall sample and age and etiology subgroups. To test the hypothesis that individuals with dysvascular LLL report greater cognitive concerns than individuals with traumatic LLL, T-scores were compared between etiology groups using Student *t*-tests. ANOVA was similarly used to compare scores among the five age groups. An alpha level of 0.05 was used as the level of significance for all tests and was adjusted using the Holm-Bonferroni method to account for multiple comparisons.²² All analyses were conducted using SAS software v9.3 (SAS Institute, Cary, NC).

Results

Participants

A total of 1,091 people with unilateral LLL completed the survey. Of those, 1,086 participants provided complete Neuro-QoL ACGC data (n=945 electronic, n=141 paper) and were included in this study (Table 1). The mean age of the sample was 54.9 years (SD=13.4). A slightly larger proportion of the sample experienced amputation due to trauma than dysvascular causes (55.4% and 44.6%, respectively). Compared to people with dysvascular LLL, people with traumatic LLL were younger at the time of their amputation ($t(1082)=-24.5, p<0.0001$) and at the time of the survey ($t(1083)=-11.6, p<0.0001$), had a greater number of years since their amputation ($t(767)=17.2, p<0.0001$), used their prosthesis for a greater number of hours each day ($t(923)=8.4, p<0.0001$), and had fewer comorbid conditions ($X^2(3, N=1086)=372.6, p<0.0001$). In addition, a greater percentage of people with traumatic LLL reported amputation above the knee ($X^2(3, N=1086)=47.4, p<0.0001$) compared to people with dysvascular LLL. Compared to those with traumatic

LLL, a larger percentage of people with dysvascular LLL were black ($X^2(3, N=1080)=12.0$, $p=0.0074$), retired or on disability ($X^2(5, N=1083)=140.8$, $p<0.0001$), reported an education of some college or lower ($X^2(4, N=1081)=16.9$, $p=0.0021$), and reported annual income levels of less than \$40,000 ($X^2(6, N=1061)=68.8$, $p<0.0001$).

Neuro-QoL Applied Cognition General Concerns T-scores

Shapiro-Wilk tests indicated that the ACGC T-scores were not normally distributed ($W(1086)=0.947$, $p<0.001$). However, use of parametric tests, such as t -tests and analyses of variance (ANOVA), were deemed appropriate as these tests are robust to violation of normality in large samples.^{23–26} Such an approach has been used previously to identify differences in standardized measures between groups with large sample sizes.²⁷

Comparisons to Neuro-QoL Normative T-scores—The sample, as a whole, reported significantly worse (i.e., lower) ACGC T-scores, relative to the Neuro-QoL normative sample (mean difference=4.1 points, $t(1085)=-16.0$, $p<0.0001$). A comparison of the Neuro-QoL normative sample to subgroups defined by etiology found that mean ACGC T-scores for both the trauma and dysvascular groups were significantly worse than the normative sample T-score of 50 (mean differences: trauma=3.9 points, $t(601)=-11.6$, $p<0.0001$), dysvascular=4.2 points, $t(483)=-11.0$, $p<0.0001$). Finally, respondents in all age groups reported mean ACGC T-scores that were significantly worse than the normative sample (p -values between 0.01–0.001, Table 2). Compared to the normative sample mean T-score of 50, the difference in age subgroups' T-scores ranged from 3.7 points (<40 age group) to 4.7 points (70+ age group) (Table 2).

Comparisons between Etiology and Age Subgroups—People with traumatic LLL and people with dysvascular LLL reported similar levels of cognitive concerns (mean difference=0.3 points, $p=0.58$). There were no significant differences in ACGC T-score among the five age groups (largest mean T-score difference was 1.0 points between age groups <40 and 70+ years, $p=0.84$) (Figure 1).

Discussion

The purpose of this study was to assess differences in cognitive concerns between people with LLL and a normative sample. We also examined differences in cognitive concerns between people with dysvascular and traumatic LLL, and among people of different ages.

Results of this study indicate that people with LLL, irrespective of etiology, report significantly greater cognitive concerns than the U.S. general population. These results are supported by a recent review by Coffey et al. of 30 manuscripts that collectively included over 11,000 people with LLL.³ Coffey and colleagues found that between 5 and 50 percent of people with LLL exhibit signs of CI and/or dementia. The present study builds on prior research in two meaningful ways. First, the current study includes a fairly balanced group of people with LLL from both traumatic (55%) and dysvascular (45%) etiologies, while most (i.e., between 85–100%) participants in prior studies had amputation etiologies related to vascular disease and/or diabetes.³ The high number of individuals in both etiology groups in this study allowed for novel comparisons between etiology groups. A second difference

between the current study and prior studies is the method used to evaluate potential cognitive problems. Prior studies assessed cognitive function in a variety of ways, including documentation of dementia in the medical record and neuropsychological tests, and this may have contributed to variability in previous estimates of CI in those with LLL. The current study used a self-report measure to assess concerns with cognition, which allows for assessment of concerns from the respondent's perspective and may identify areas of concern that would not be measured through typical clinician assessments.¹⁹ For example, a prosthetist may not measure each patient's ability to comprehend written information prior to providing care instructions for a prosthesis. However, their ability to understand this information may be critical to success with the device.²⁸

Each etiology (i.e., dysvascular, trauma) and age (i.e., <40, 40–49, 50–59, 60–69, 70+ years) subgroup in this study reported significantly more cognitive concerns than the normative sample, including those with traumatic LLL and young people with LLL. This finding differed from our expected results, which were based on the supposition that people with LLL experience more CI than the general population because of higher age and prevalence of diseases such as peripheral vascular disease and diabetes.³ In addition, perceived cognitive concerns did not differ between people with traumatic and dysvascular etiologies, nor did they differ among age groups. The lack of differentiation in cognitive concerns between age and etiology groups was also unexpected and suggests that cognitive concerns in people with LLL may be more prevalent than initially expected.

Cognitive concerns in people with non-dysvascular etiologies and of younger ages are not well understood.³ The results of the current study indicate that CI may be present in people with LLL, regardless of etiology or age. There are reasons why ACGC scores may be greater relative to normative scores in people with amputation from non-dysvascular etiologies. Trauma, which is the most common cause of non-dysvascular amputation,²⁹ may also result in injury to brain tissue. Rauh et al. recently reported concurrent diagnosis of traumatic brain injury (TBI) in 23% of 546 Service members with combat-related amputations.³⁰ The authors noted that the measured prevalence may be an underestimation of brain injury, due to potential underdiagnosis of mild TBI. TBI is also common in other traumatic events, such as motor vehicle accidents, motorcycle accidents, firearm accidents, and falls.³¹ As these injuries are causes of amputation,³² TBI may be common in people with LLL from traumatic injuries. TBI often results in temporary or permanent cognitive problems, including difficulties with memory, attention, and executive functions,³³ and may explain the cognitive concerns reported in this study.

Another reason people with LLL, irrespective of amputation etiology, report cognitive concerns may be use of medication to treat chronic phantom limb, back, and residual limb pain.^{34, 35} Use of pain medication is common in both people with traumatic and non-traumatic amputation.³⁶ Pain medications such as antidepressants, anticonvulsants, and opioids^{37–39} are associated with side effects, such as sedation or confusion.^{37, 38, 40} Thus, medications used regularly by people with LLL may negatively affect their cognitive function.

There are also reasons why cognitive concerns may be similar among both younger and older individuals. First, cognitive concerns associated with injury (e.g., TBI) may have affected younger people in our sample. Traumatic amputation is about 2.5 times more common in people below age 65 than above 65.² Conversely, cognitive concerns reported by older participants may be more often due to disease (e.g., diabetes). Dysvascular amputation is about 1.25 times more common in people above age 65 than below 65.² Thus, both younger and older people with LLL may have greater cognitive concerns than the general population, but they may derive from different underlying conditions. There is also a possibility that respondents with age-related cognitive issues reported less concerns because older people with cognitive deficits have been known to overestimate their cognitive abilities.⁴¹

Although significant differences were found in cognitive concerns between people with LLL and a normative sample, the observed differences were smaller than those seen in other populations with CI. Mean ACGC T-scores in our sample of people with LLL were 4.1 points below the normative sample mean, which was smaller than normative differences found for people with stroke (6.3 points), multiple sclerosis (7.4 points), Parkinson's disease (5.7 points), and epilepsy (8.1 points).²¹ Further, while estimates of minimum detectable change or minimum clinically important differences (MCID) are typically used to establish thresholds of clinically meaningful differences, these estimates for the Neuro-QoL ACGC domains are not yet available. Alternatively, a 0.5 SD difference may be considered an approximation for clinically important difference.⁴² Since Neuro-QoL instruments are on a T-score metric with a SD of 10, the approximated MCID would be 5 points. Using this criterion, statistical differences in average ACGC T-scores between our LLL sample and the Neuro-QoL normative sample (i.e., T-score difference of 4.1) did not reach clinical significance. All age group average scores were also significantly lower than the normative sample. However, differences between age groups and the normative sample (i.e., between 3.7 and 4.7) also did not reach clinical significance. In addition, we did not observe clinically significant differences between the etiology groups and the Neuro-QoL normative sample (i.e., largest T-score difference 4.2). Collectively, these results suggest that individuals living with LLL, regardless of etiology and age, experience clinically small, but statistically significant cognitive health concerns.

The finding that people with LLL report greater cognitive concerns compared to the general population has important implications for clinical care. People with LLL who report cognitive concerns may require different prosthetic care approaches, including tailored written or visual instructions, more intensive follow-up procedures, and simpler prosthetic prescriptions. Clinical use of a brief, self-report measure of cognitive concerns, such as Neuro-QoL, could inform care and improve rehabilitation outcomes. However, more research is needed to assess the usefulness of Neuro-QoL ACGC in clinical settings.

Limitations

Use of a self-report instrument to assess cognition may limit interpretation of study findings, because of the influence of depression⁴³ and psychological distress⁴⁴ on self-reported cognitive concerns. For example, Julian et al. found that presence of depression decreases

the correlation between self-reported and clinician-assessed cognition in people with multiple sclerosis.⁴³ However, clinician-assessed cognitive measures are often time-consuming and require an appointment with a specialist. Therefore, the influence of psychological factors on self-reported cognitive concerns may be balanced by the potential benefit of quick and convenient assessment of perceived cognitive function in clinical environments that do not typically include neuropsychological services, such as prosthetic clinics.

In addition, the volunteer sample and inclusion criteria applied in this study may limit generalizability. It is possible that individuals who volunteered for this study had higher cognitive abilities than those who chose not to participate, since we required participants be able to read and write. In addition, only people with LLL who used prostheses for walking were eligible for this study. Because use of prostheses generally requires cognitive abilities,¹⁰ people with LLL who do not use prostheses may have more cognitive concerns than prosthetic limb users. Finally, people with congenital limb absence, LLL from infection or tumor, and bilateral LLL were not included in this study. As such, study results cannot be generalized to these individuals.

Conclusions

Individuals with LLL report greater concerns with cognitive function than normative values based on the U.S. general population. Self-reported cognitive concerns were not limited to those of older age or those with dysvascular etiologies, which implies that other mechanisms contribute to lower cognitive function in people with LLL. Clinicians should consider using brief self-report measures to assess perceived cognitive concerns in patients with LLL and customize care plans and educational materials for those who report cognitive challenges.

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List of Abbreviations

LLL	lower limb loss
Neuro-QoL ACGC	Neurology Quality of Life – Applied Cognition General Concerns Short Form version 1
CI	cognitive impairment
PLUS-M	Prosthetic Limb Users Survey of Mobility
TBI	traumatic brain injury
U.S.	United States

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Figure 1.
Mean Neuro-QoL ACGC T-scores for individuals with lower limb loss ($\pm$ SD).

Table 1

Participant demographic and amputation characteristics.

		Overall n=1086	Amputation Etiology	
			Trauma n=602	Dysvascular n=484
		Mean (SD)	Mean (SD)	Mean (SD)
Age at survey (yrs) ***		54.9 (13.4)	51.0 (13.8)	59.8 (11.2)
Age at amputation (yrs) ***		43.1 (17.7)	33.8 (15.6)	54.7 (12.5)
Years since amputation ***		11.8 (13.9)	17.2 (16.2)	5.1 (5.5)
Hours of prosthetic use per day ***		12.4 (4.1)	13.4 (3.6)	11.3 (4.4)
		% (N)	% (N)	% (N)
Gender	Male	70.3 (764)	69.6 (419)	71.3 (345)
	Female	29.4 (319)	29.9 (180)	28.7 (139)
	Not reported	0.3 (3)	0.5 (3)	0.0 (0)
Race/Ethnicity *	Non-Hispanic White	80.0 (869)	81.4 (490)	78.3 (379)
	Non-Hispanic Black	9.0 (98)	6.5 (39)	12.2 (59)
	Hispanic	6.2 (67)	6.5 (39)	5.8 (28)
	Other	4.2 (46)	5.0 (30)	3.3 (16)
	Not reported	0.6 (6)	0.7 (4)	0.4 (2)
Education **	High school grad or less	29.4 (319)	25.7 (155)	33.9 (164)
	Some college/Tech school	38.1 (414)	36.7 (221)	39.9 (193)
	College grad	20.3 (220)	22.9 (138)	16.9 (82)
	Advanced degree	11.8 (128)	14.0 (84)	9.1 (44)
	Not reported	0.5 (5)	0.7 (4)	0.2 (1)
Employment Status ***	On disability	32.0 (348)	22.9 (138)	43.4 (210)
	Employed	31.7 (344)	44.2 (266)	16.1 (78)
	Retired	25.0 (271)	18.1 (109)	33.5 (162)
	Unemployed	5.2 (56)	6.3 (38)	3.7 (18)
	Homemaker	2.9 (32)	3.8 (23)	1.9 (9)
	Student	2.9 (32)	4.2 (25)	1.4 (7)
	Not reported	0.3 (3)	0.5 (3)	0.0 (0)
Individual Income ***	<\$25,000	47.3 (514)	39.0 (235)	57.6 (279)
	\$25,000–\$39,999	19.4 (211)	17.6 (106)	21.7 (105)
	\$40,000–\$54,999	10.1 (110)	12.1 (73)	7.6 (37)
	\$55,000–\$69,999	7.0 (76)	9.3 (56)	4.1 (20)
	\$70,000–\$84,999	5.3 (58)	7.0 (42)	3.3 (16)
	\$85,000–\$99,999	3.1 (34)	5.0 (30)	0.8 (4)
	\$100,000+	5.3 (58)	7.3 (44)	2.9 (14)
	Not reported	2.3 (25)	2.7 (16)	1.9 (9)

		Overall n=1086	Amputation Etiology	
			Trauma n=602	Dysvascular n=484
		Mean (SD)	Mean (SD)	Mean (SD)
Limb loss due to military service**		2.9 (31)	4.3 (26)	1.0 (5)
Amputation level***	Transfemoral	31.6 (343)	39.0 (235)	22.3 (108)
	Knee Disarticulation	3.7 (40)	4.8 (29)	2.3 (11)
	Transtibial	63.6 (691)	54.7 (329)	74.8 (362)
	Symes	1.1 (12)	1.5 (9)	0.6 (3)
# comorbidities***	0	37.1 (403)	59.8 (360)	8.9 (43)
	1	34.1 (370)	30.6 (184)	38.4 (186)
	2	16.9 (183)	7.6 (46)	28.3 (137)
	3+	12.0 (130)	2.0 (12)	24.4 (118)

Dysvascular mean/distribution significantly different from trauma mean/distribution at: * = $p < 0.05$;

** = $p < 0.01$;

*** = $p < 0.001$. The list of comorbidities in the self-report survey included the following: (1) asthma, emphysema, or chronic bronchitis; (2) arthritis or rheumatism; (3) cancer, diagnosed in the last three years; (4) diabetes; (5) digestive problems (such as ulcer, colitis, or gallbladder disease); (6) heart trouble (such as angina, congestive heart failure, or coronary artery disease); (7) HIV illness or AIDS; (8) kidney disease, (9) liver problems (such as cirrhosis); and (10) stroke.

Neuro-QoL ACGC T-scores, overall and by etiology and age groups, in persons with lower limb loss compared to a Neuro-QoL normative sample mean T-score of 50.0.

Table 2

	N	Mean	SD	(df)
<i>U.S. normative sample</i>	533	50.0	10.0	--
Overall study sample	1086	45.9***	8.4	t(1085)=−16.0
Etiology				
Trauma	602	46.1***	8.3	t(601)=−11.6
Dysvascular	484	45.8***	8.4	t(483)=−11.0
Age group				
<40 years	153	46.3***	8.2	t(152)=−5.6
40–49 years	196	46.2***	8.5	t(195)=−6.3
50–59 years	334	45.9***	8.6	t(333)=−8.8
60–69 years	266	46.0***	8.5	t(265)=−7.7
70+ years	136	45.3***	7.4	t(135)=−7.5

Sample mean significantly different from normative sample mean of 50 (one-sample *t*-test): * = *p* < 0.05;

** = *p* < 0.01;

*** = *p* < 0.001.