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REGULAR ARTICLE

Resilience and Function in Adults With Chronic Physical Disabilities: A Cross-Lagged Panel Design

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Abstract

Background Resilience is a psychological construct referring to one's positive adaptation in response to adversity. Evidence suggests that resilience may contribute to various function domains in adults with chronic physical disabilities.

Purpose To test hypothesized temporal associations between resilience and four function domains (anxiety, depression, social role satisfaction, and physical function) in individuals with chronic physical disabilities.

Methods Participants were 1,574 adults with one of four chronic physical disabilities (spinal cord injury, muscular dystrophy, multiple sclerosis, or postpolio myelitis syndrome) who were participating in a large, ongoing USA-based longitudinal survey study. Three surveys were mailed on an approximately yearly basis. Resilience was assessed using the Connor–Davidson Resilience Scale 10-item (CDRSC-10) and each function domain was assessed using the respective Patient Reported Outcome Measurement System (PROMIS) short-form.

Results Cross-lagged path models evidenced statistically significant reciprocal relationships between resilience and each function domain except physical function. The standardized lagged coefficients corresponding to resilience predicting social role satisfaction (T1–T2 = 0.09, T2–T3 = 0.09) had similar effect sizes as those corresponding to social role satisfaction predicting resilience (T1–T2 = 0.11, T2–T3 = 0.04), although resilience was a slightly stronger predictor in the second lag. In models assessing psychological function, resilience was a stronger predictor of later psychological function (resilience-to-anxiety, T1–T2 = −0.15, T2–T3 = −0.11; resilience-to-depression, T1–T2 = −0.21, T2–T3 = −0.13) than the inverse (anxiety-to-resilience, T1–T2 = −0.11, T2–T3 = −0.06; depression-to-resilience, T1–T2 = −0.12, T2–T3 = −0.05).

Conclusions The study findings suggest that resilience is a significant prospective predictor of psychological and social function over time in individuals with chronic physical disabilities.

Keywords Resilience · Psychological · Depression · Anxiety · Longitudinal studies · Disabled persons

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Introduction

Individuals with chronic physical disabilities experience a variety of complex health problems that often result in substantially greater functional impairment and poorer quality of life relative to the general population [1, 2]. In addition to the inherent physical limitations typically associated with these disabilities, such as issues with ambulation and difficulties carrying out activities of daily living, individuals with physical disabilities are also at greater risk of developing secondary symptoms, such as pain and fatigue, and psychological conditions, such as anxiety and depression, when compared with the general population [3–6]. As a result of this high prevalence and severity of problematic secondary conditions, alongside the inherent physical limitations resulting from a primary physical condition, it can be challenging for persons with chronic physical disabilities to engage with their communities, participate in social activities, and actualize their social role potentials [7–9]. Ultimately, it is important for researchers to identify protective factors that promote healthy function and overall well-being, despite the numerous and complex challenges experienced by individuals with physical disabilities.

There is a substantial body of research that suggests resilience is one such protective factor that is particularly

relevant for individuals with physical disabilities [10–15]. Resilience is a psychological construct that is commonly defined as one's ability to cope and adapt in the face of adversity [16]. Research and theory suggest that resilience is a complex, multifaceted construct [17]. Resilience is thought to be influenced by many factors, including learned skills (e.g., mindfulness and acceptance), character traits (e.g., optimism), environmental factors (e.g., social support), and cultural factors (e.g., traditions and cultural practices) [16–20]. In addition, although resilience was initially conceptualized to be protective in the context of acute trauma, more recent research has suggested that it may also play a protective role in managing day-to-day difficulties related to and resulting from a chronic physical disability [14, 15].

Research examining the association between resilience and function domains in populations with physical disabilities is promising [10–13]. Several cross-sectional studies have found associations between resilience and various health domains, including psychological function (i.e., depression) and social role satisfaction [10, 21]. Furthermore, there is some longitudinal evidence that suggests resilience may protect against psychological dysfunction and promote social role satisfaction over time [13]. One cross-sectional study found that resilience remained significantly associated with social role satisfaction and overall quality of life, even after controlling for other measures of psychological distress (anxiety and depression) and symptom severity (fatigue, pain, and sleep disturbance [10]). Another study demonstrated that resilience showed similar (modest) levels of stability over time as other health domains that are commonly treatment targets, suggesting that resilience may be a feasible treatment target in rehabilitation populations [11]. Although research evaluating whether resilience can be directly modifiable (via treatment or otherwise) in populations with physical disabilities is lacking, preliminary research supports resilience interventions for various other populations [22].

Despite this evidence supporting a relationship between resilience and various nonphysical health domains, research does not support the presence of a significant relationship between resilience and physical function among individuals with physical disabilities. Although there is research indicating a weak cross-sectional association between resilience and physical function, evidence does not support the presence of a longitudinal association [13]. Moreover, the concurrent relationship between resilience and physical function was not found to remain statistically significant when symptoms and psychological function were controlled [10]. Taken together, research supports a significant relationship between resilience and various psychosocial health domains, but does not support a longitudinal relationship between resilience and physical function.

Although the body of research examining the relationship between resilience and nonphysical health domains is promising, there are still elements of this relationship that remain largely unclear. A key limitation of this research is that it has relied primarily on cross-sectional or correlational predictive designs. Therefore, little is known about the temporal features of the association between resilience and function. For example, it is still unclear if higher levels of resilience at one point predict subsequent improvements in function, if higher levels of function at one point predict subsequent increases in resilience, or if each prospectively predicts the other simultaneously.

Cross-lagged panel designs are particularly well suited to assess these temporal qualities [23, 24]. Cross-lagged analyses allow one to estimate the lagged relationships (i.e., relationship between a construct at an earlier time and a construct at a later time) between two separate constructs (i.e., the association between one construct at an earlier time with the other construct at a later time, and vice versa). This estimation of lagged relationships allows one to compare the effect size and statistical significance of each construct's relationship with the other over time. Given these components, cross-lagged analyses can ultimately provide preliminary evidence to indicate whether a causal relationship may exist, and if so, the potential direction of the possible causal relationship.

Discerning the temporal qualities of the relationship between resilience and function could also have substantial clinical and research implications. Knowledge about these temporal qualities may provide necessary empirical evidence to support the current commonly supported theory, which asserts that resilience plays a protective role against the worsening of function over time among individuals with chronic physical disabilities. Additionally, understanding the intricacies of the temporal relationships between resilience and function could inform the development of future research on resilience in rehabilitation settings, as well as how rehabilitation clinicians should most optimally approach treatment. For example, if resilience is implicated as being a robust predictor of subsequent improvements in function over time, this finding would support the inclusion of resilience as an outcome in future clinical trials, and establish resilience as a key treatment target for rehabilitation clinicians. Conversely, if it is found that resilience is not a significant predictor of later function, but rather the inverse is true (function predicts later resilience), this would suggest rehabilitation researchers and clinicians should prioritize researching and targeting for treatment more traditional health and function domains, rather than resilience. Finally, if both lagged-relationships are significant and the effects are comparable, this would suggest that clinicians and researchers should consider resilience and other traditional health domains simultaneously, and continue to explore both their distinct and interconnected roles in promoting health of persons with physical disabilities.

Given these considerations, the current study sought to clarify the temporal nature of the relationship between resilience and function (anxiety, depression, social role satisfaction, and physical function) among individuals with chronic physical disabilities. Using a cross-lagged panel design, we assessed the extent to which early resilience was predictive of later function and early function was predictive of later resilience. Although we hypothesized that both lagged associations would be statistically significant (i.e., resilience significantly predicted subsequent function and vice versa), we expected that heightened resilience at one point in time would have a larger lagged association with subsequent improvements in function than earlier function on later resilience. However, given that past research does not support the presence of significant or longitudinal associations between resilience and physical functioning, we did not anticipate that either resilience or physical function would predict subsequent changes in the other.

Methods

Participants

The current study used data from a large USA-based longitudinal survey study tracking adults living with a spinal cord injury (SCI), muscular dystrophy (MD), multiple sclerosis (MS), or postpoliomyelitis syndrome (PPS). These physical disabilities were examined because they each represent a unique trajectory in terms of condition onset and course, and are each associated with substantial impairment. For example, each condition commonly presents with many of the same secondary health conditions, including issues with physical function and ambulation, symptoms such as pain and fatigue, and psychological conditions such as depression. Despite these similarities, each condition also represents a unique segment of the disability spectrum, particularly regarding disability onset. Postpolio syndrome represents late onset conditions resulting from an earlier medical condition. Spinal cord injury represents conditions with traumatic onset that can occur across the lifespan. Multiple sclerosis represents conditions with gradual onset later in life. Finally, muscular dystrophy represents conditions with rapid onset early in life. Data from these surveys have been used in several other publications [3, 10, 11]. However, none of these publications have addressed the current study's aims. Study inclusion criteria were: (a) the ability to read, write, and understand English; (b) self-report of a physician's diagnosis of the primary physical condition (MS, SCI, MD, or PPS); and (c) being at least 18 years of age.

The 2,202 individuals who expressed interest at study onset and were screened over the phone by research staff; 2,041 individuals were found eligible. These 2,041 eligible participants learned about the study through advertisements in organizational newsletters and websites (661; 33%), involvement in a previous survey study at the University of Washington (473; 23%), a University of Washington disability registry (398; 20%), disability specific registries (375; 18%), referral from a friend or relative (90; 4%), and other sources (44; 2%). Eligible participants were sent a copy of the baseline survey and a study consent form between June 2009 and March 2010.

Procedures

Of the 2,041 eligible participants who were sent the baseline survey, 1,862 returned the baseline survey and consent form. Follow-up surveys were mailed on an approximately yearly basis. Because surveys prior to year 5 did not have data relevant to the current study, only surveys corresponding to years 5, 6, and 7 were used in the current study. The year five survey (T1) was mailed between October 2014 and April 2015 to 1,949 individuals. These 1,949 individuals consisted of 1,753 participants recruited at baseline, and an additional 196 newly recruited refresher participants. These refresher participants were recruited through the same means and using the same eligibility criteria, aside from the additional requirement of being ≥45 years of age. The age cap was increased for refresher participants to ensure that they would be representative of the broader population of adults aging with physical disability. In total, 1,574 of the 1,949 individuals responded to the T1 mailing. Of these 1,574 individuals, 1,457 went on to complete the year 6 survey (T2; mailed between October 2015 and April 2015), and 1,396 went on to complete the year 7 survey (T3; mailed between October 2016 and May 2017).

If no response survey was received by 4 weeks after the initial mailing, research staff sent a reminder letter. If no response was received by 6 weeks after the initial mailing, research staff made reminder calls. After receiving the surveys, research staff assessed the surveys for completeness. If surveys were incomplete, research staff attempted to call the participant to obtain the missing data. Participants were reimbursed US$25 for completing each survey. All study procedures were approved by the Institutional Review Board at the University of Washington.

Measures

Demographic/descriptive data

Participants provided demographic data for descriptive purposes, including age, ethnicity, diagnosis, and gender.

Resilience

Resilience was assessed using the 10-item Connor-Davidson Resilience Scale (CD-RISC10 [25, 26];). The

CD-RISC10 has been validated and used in samples of individuals with a variety of chronic physical disabilities [26–30]. The CD-RISC10 assesses resilience by asking respondents to indicate their level of agreement with statements (e.g., "I am able to adapt when changes occur" and "I tend to bounce back after illness, injury, or other hardships") over the past month. The CD-RISC10 demonstrated excellent reliability in the current sample (Cronbach's alpha = 0.92).

Function

Each measure of function was assessed using the respective Patient Reported Outcome Measurement System (PROMIS) 4- to 8-item short form [31, 32]. PROMIS measures have been extensively validated for use in a broad range of clinical populations, including populations with chronic physical disabilities present in the current sample [33–35]. PROMIS measures assess the respective domain by asking participants to respond to a collection of individual items from a central item bank. These items are then scored and standardized into a *t*-score metric in which the U.S. general population mean is 50 and *SD* is 10. Although anxious and depressive symptoms often overlap and co-occur, previous research suggests that each is a distinct psychological function domain that makes unique contributions to physical and social function [3]. The internal consistencies (Cronbach's alpha) for each PROMIS measure in our sample were as follows: 0.93 (physical function), 0.92 (social role satisfaction), 0.90 (depression), and 0.89 (anxiety).

Data Analysis

We computed descriptive statistics of demographic variables to describe our sample. To assess the predictive lagged relationship between resilience and each measure of function, we conducted longitudinal cross-lagged path models using a structural equation modeling framework [23, 24]. To assess the appropriateness of the data for the planned primary analyses, we assessed for multivariate normality by using a skewness cutoff of 3 or greater [36], alongside a visual inspection of histograms, to identify potentially problematic multivariate abnormality.

We modeled the longitudinal cross-lagged relationship between resilience and function separately for each of the four measures of function, although we used the same modeling approach in each of the four models. We included age (at T1), gender (those who identified as female were the reference group), and primary diagnosis (individuals with SCI were the reference group) as exogenous control variables. Controlling for these demographic variables is common practice in rehabilitation research and serves to better isolate the unique variance associated with the relationship between resilience and function over and above these constructs. SCI was chosen as the reference group in order to remain consistent with previous research from our group [10]. Although we intended for the final models to include these demographic covariates, we also evaluated the models without these covariates to determine whether the patterns of results (statistical significance of lagged path coefficients) were affected by their inclusion. We included the measures of resilience and function at each time point in the model as endogenous variables. To account for auto-correlations (the association between the same variable at later time points), we added auto-regressive paths between each measure of resilience and function and the same measure at the later consecutive time point. We also added additional auto-regressive paths between the T1 measure of resilience and function and the T3 measure of the same construct to account for long-term auto-correlations. We allowed error corresponding to the measures of resilience and function at the same time points to correlate in order to account for synchronous correlation (the association between different variables at the same time point, also commonly referred to as contemporaneous). Finally, we included auto-regressive paths between resilience and function and the opposite measure at the later consecutive time point (i.e., T1 resilience predicts T2 function and vice versa) to assess the cross-lagged associations between resilience and function. Cross-lagged path coefficients were evaluated using post-estimation analyses, via the Stata *lincom* command, to determine whether differences in coefficients were statistically significant. See Fig. 1 for a visual depiction of the longitudinal cross-lagged panel model.

Model fit was evaluated using root mean square error of approximation (RMSEA), χ^2, the comparative fit index (CFI), and the Tucker–Lewis index (TLI) [37]. Cutoff values indicating adequate fit were ≤0.06 for RMSEA and ≥0.95 for both CFI and TLI [37]. Full information maximum likelihood estimation was used to account for missing data. The longitudinal cross-lagged path analyses were conducted in Stata version 12.1 for Windows. The descriptive statistics were computed in SPSS version 19 for Windows.

Results

Participant Characteristics

Table 1 reports descriptive statistics for the demographic and diagnostic variables of the sample. Of note, the sample identified primarily as female (n = 1,014; 64%) and white (n = 1,401; 90%). The sample was also well-educated, with 30% reporting having completed college, and an additional 27% reporting completing graduate or professional school. Table 2 reports the means and

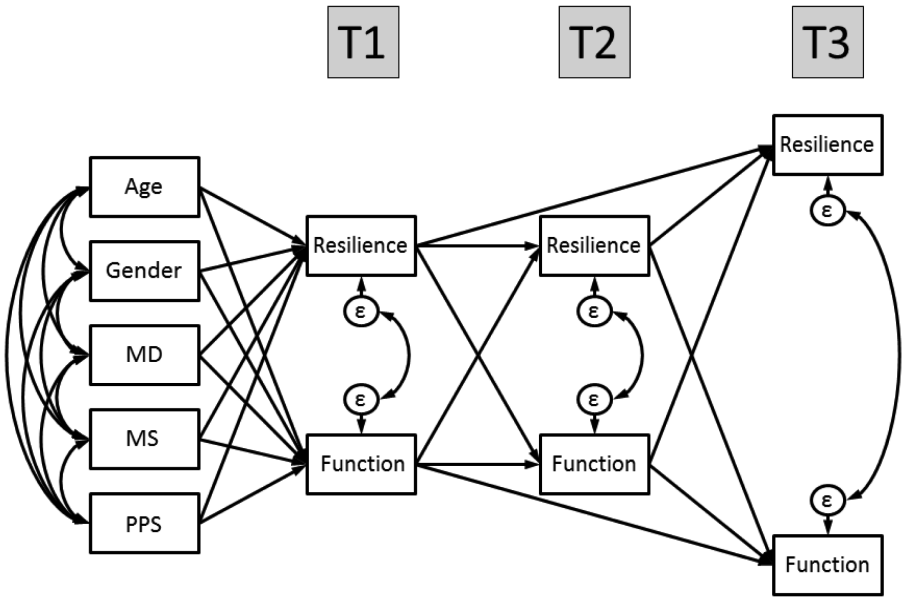

Fig. 1. Depiction of cross-lagged path model.

Table 1. Demographics

Variable	*N*	Mean ± *SD* or Percent
Age	1574	61.48 ± 12.32
Gender		
Men	560	36%
Women	1014	64%
Education level		
9th grade or less	8	<1%
Some high school	20	1%
High school graduate or GED	188	12%
Vocational or technical school	102	7%
Some college	364	23%
College graduate	469	30%
Professional/Graduate School	422	27%
Missing	1	<1%
Ethnicity/race		
White/Caucasian	1401	90%
Black/African American	65	4%
Native American/Alaska Native	11	<1%
Asian	12	<1%
Hispanic	33	2%
More than one race	40	3%
Unknown	3	<1%
Missing	9	<1%
Diagnosis		
Spinal Cord Injury	379	24%
Muscular Dystrophy	303	19%
Multiple Sclerosis	488	31%
Postpoliomyelitis Syndrome	404	26%

standard deviations of the primary study variables at each time point. Table 3 presents the bivariate correlation coefficients for the resilience and function variables at T1.

We also evaluated the data to determine whether there were any systematic differences between individuals with (n = 290) and without (1,284) some degree of missing data across the three time points (listwise missingness in all primary variables, T1 N = 51[3%], T2 N = 149[10%], and T3 N = 206[13%]). Table 2 also includes a description of missingness for each key study variable at each time point. Individuals with and without at least some missing data were not statistically different in terms of gender (χ^2[1] = 0.43, p = 0.51) or primary diagnosis (χ^2[4] = 8.23, p = 0.08). However, participants who had at least some missing data were slightly older (mean, 63.33±13.94y) than those without any missing data (mean, 61.06 ± 11.89 years; t_{1572} = 2.84, p = 0.005).

Given the possibility of trends in missingness, we computed Little's test of missing completely at random (MCAR) to evaluate whether data were missing completely at random [38]. Little's test revealed that these data were likely not MCAR, χ^2(447) = 534.93, p = .003. We therefore conducted multiple imputation using multivariate normal regression [39] and compared the results from models using imputed values against models using FIML. We found only negligible differences between models using either approach—path coefficients that were significant in one model remained significant in the other (p's <.05), path coefficients that were not significant in one model remained non-significant in the other (p's > .05), and overall model fit statistics were very similar (i.e., the largest absolute difference in RMSEA was .003 and in CFI/TLI was .002). Therefore, we elected to report models using FIML to avoid potential bias associated with the use of imputed data.

Cross-Lagged Analyses

See Table 4 for cross-lagged path coefficients; full results of the cross-lagged panel models are available as online Supplementary Figs. S1–S3. Table 5 reports model fit and variance statistics. All model fit indices were well within range of their respective cutoffs, indicating excellent fit (CFIs and TLIs = .99; RMSEAs ranged from 0.03 to 0.04). The inclusion of the demographic covariates did not influence the pattern of results found (the effect size and statistical significance of path-coefficients remained similar regardless of their inclusion in the model).

Table 2. Mean (*SD*) and summary of missingness of the primary study variables

Outcome	T1	T2	T3	Normative Score
Resilience (CD-RISC10)	28.72 (7.11)	29.08 (7.12)	28.91 (7.15)	31.8 (5.40)[a]
Missing N (%)	11 (1%)	127 (8%)	183 (12%)	
Depression (PROMIS-SF)	52.29 (8.88)	51.49 (9.22)	51.60 (9.24)	50 (10)
Missing N (%)	7 (<1%)	118 (8%)	180 (11%)	
Anxiety (PROMIS-SF)	51.17 (9.19)	50.90 (9.07)	51.42 (9.10)	50 (10)
Missing N (%)	5 (<1%)	120 (8%)	181 (12%)	
Satisfaction with Social Roles (PROMIS-SF)	44.99 (9.06)	45.24 (9.35)	45.00 (8.81)	50 (10)
Missing N (%)	13 (1%)	130 (8%)	194 (12%)	
Physical Function (PROMIS-SF)	36.23 (10.48)	35.92 (10.38)	35.61 (10.54)	50 (10)
Missing N (%)	17 (1%)	123 (8%)	185 (12%)	

CD-RISC10 10-item Connor-Davidson Resilience Scale; *PROMIS-SF* Patient Reported Outcome Measurement System static Short-Form.

All PROMIS measures are reported as *t*-scores.

[a]Based on data from Campbell-Sills, Ford, & Stein, 2009.

Table 3. Correlation matrix of study criterion and predictor variables at T1 (n = 1,523)

	Resilience	Anxiety	Depression	Social Role Satisfaction
Anxiety	−0.50*			
Depression	−0.56*	0.75*		
Social Role Satisfaction	0.42*	−0.38*	−0.52*	
Physical Function	0.15*	−0.14*	−0.26*	0.47*

*p < .001.

Table 4. Summary of cross-lagged model results

Estimate	Social Role Satisfaction	Physical Function	Anxiety	Depression
T1 to T2 Lagged Paths				
Resilience to Function	0.09* [0.05, 0.13]	0.00 [−0.02, 0.02]	**−0.15* [−0.19, −0.11]**	**−0.21* [−0.26, −0.17]**
Function to Resilience	0.11* [0.08, 0.15]	0.03 [−0.01, 0.06]	**−0.11* [−0.14, −0.07]**	**−0.12* [−0.16, −0.08]**
T2 to T3 Lagged Paths				
Resilience to Function	**0.09* [0.05, 0.13]**	0.02 [−0.00, 0.03]	**−0.11* [−0.15, −0.06]**	**−0.13* [−0.17, −0.09]**
Function to Resilience	**0.04* [0.01, 0.07]**	0.01 [−0.02, 0.04]	**−0.06* [−0.09, −0.02]**	**−0.05* [−0.08, −0.01]**

Values in brackets are 95% confidence intervals. All coefficients are standardized values.

Bold coefficients were statistically significantly different from the corresponding inverse lag.

*$p < .05$.

Table 5. Model fit indices and variance statistics

	Social Role Satisfaction	Physical Function	Anxiety	Depression
Fit Indices				
CFI	0.99	0.99	0.99	0.99
TLI	0.99	0.99	0.99	0.99
RMSEA	0.04	0.03	0.03	0.03
RMSEA 90% CI	0.03–0.05	0.02–0.04	0.02–0.04	0.02–0.04
χ^2 (DF)	64.15 (22)	60.36 (22)	44.66 (22)	48.84 (22)
BIC	74716.49	72313.66	74931.66	74410.02
R^2				
Resilience T1	0.02	0.02	0.02	0.02
Resilience T2	0.62	0.61	0.62	0.62
Resilience T3	0.69	0.69	0.69	0.69
Function T1	0.02	0.15	0.01	0.01
Function T2	0.52	0.86	0.48	0.53
Function T3	0.60	0.91	0.53	0.59

Overall, the results demonstrated that each measure of function (except physical) had significant reciprocal relationships with resilience. In other words, each of the lagged paths between nonphysical function at the earlier times significantly predicted resilience at the later adjacent time-points, and the lagged paths between resilience at the earlier times significantly predicted nonphysical function at the later adjacent time points. The directions of the effects were as expected, as resilience and social role satisfaction were positively associated, and resilience was negatively associated with both anxiety and depression. Additionally, the R^2 values reported in Table 5, which represent the proportion of variance explained by the model in the respective domain, suggest that the models tended to account for [1] slightly more variance in resilience than in function and [2] more variance in both function and resilience at later time points than at T1.

The lagged coefficients corresponding to resilience predicting social role satisfaction (T1 to T2 standardized coefficient = 0.09; T2 to T3 = 0.09) were comparable to those corresponding to social role satisfaction predicting resilience (T1 to T2 standardized coefficient = 0.11; T2 to T3 = 0.04). Postestimation analyses demonstrated that resilience was a stronger predictor than social role satisfaction in the second time lag but not the first time lag (T1 z = 0.79, $p = .431$, 95% CI [−0.04, 0.08]; T2 z = 2.83, $p = .005$, 95% CI [0.14, 0.03]). The lagged coefficients were also similar for resilience and anxiety (T1 resilience to T2 anxiety standardized coefficient = −0.15; T1 anxiety to T2 resilience = −0.11; T2 resilience to T3 anxiety = −0.11; T2 anxiety to T3 resilience = −0.06). Postestimation analyses showed that resilience was a stronger predictor of later anxiety than the inverse for both time lags (T1 z = 3.30, $p = .001$, 95% CI [0.05, 0.18]; T2 z = 2.75, $p = .006$, 95% CI [0.03, 0.16]). The lagged coefficients corresponding to resilience predicting depression (T1 to T2 standardized coefficient = −0.21; T2 to T3 = −0.13) were larger than those corresponding to depression predicting resilience (T1 to T2 standardized coefficient = −0.12; T2 to T3 = −0.05). As was the case

with models assessing anxiety, postestimation analyses again showed that resilience was a stronger predictor of later depression than the inverse for both time lags (T1 z = 5.22, $p < .001$, 95% CI [0.11, 0.25]; T2 z = 3.82, $p < .001$, 95% CI [0.06, 0.20]). Again, none of the coefficients corresponding to lagged associations between resilience and physical function were statistically significant.

Discussion

The current study examined the cross-lagged associations between resilience and four function domains (physical function, depression, anxiety, and social function). We hypothesized that analyses would demonstrate significant reciprocal associations between resilience and each function domain, but that earlier resilience would be a more robust predictor of later function than earlier function of later resilience. The study findings were generally congruent with this hypothesis. The analyses demonstrated statistically significant cross-lagged associations between resilience and each nonphysical measure of function, providing evidence of reciprocal relationships between resilience and each of these function domains over time. However, and also consistent with the study hypothesis, analyses did not support cross-lagged associations between resilience and physical function. These findings have important clinical and research implications.

The current study is the first (to the best of our knowledge based on our review of the literature) to use a cross-lagged panel design to assess the longitudinal associations between resilience and various function domains in individuals with chronic physical disabilities. Building on past research that has relied primarily on cross-sectional or correlational-predictive designs, the current findings clarify the temporal qualities of the longitudinal association between resilience and function in populations of individuals with physical disabilities. The findings provide robust preliminary evidence to suggest resilience and nonphysical function domains prospectively predict each other over time.

Given that the effect sizes were comparable for both lagged relationships in analyses assessing the relationship between resilience and social role satisfaction, the results support a reciprocal relationship between resilience and social role satisfaction over time. In other words, having greater social role satisfaction is associated with a subsequent increase in resilience over time, and endorsing higher levels of resilience is associated with subsequent increases in social role satisfaction over time. However, resilience was a stronger predictor than social role satisfaction in the second time lag, suggesting the possibility that resilience may be a slightly stronger predictor of social health in the long-term. This finding is congruent with past research, which has found concurrent and predictive correlations between resilience and social role satisfaction [10, 13]. These findings are also in agreement with the theory that social factors (such as social support) may contribute to an individual's resilience [27]. Furthermore, a growing body of literature has confirmed that social functioning, social participation in particular, is strongly related to a broad variety of health domains among individuals with chronic physical disabilities [7]. Given this importance of social health, and our findings that resilience appears to uniquely predict subsequent increases in social role satisfaction, researchers should continue to clarify the nature of the relationship between resilience and social factors.

The findings related to the cross-lagged associations between resilience and psychological function (anxiety and depression severity) were slightly more complex. Although both lagged paths were statistically significant, providing evidence of a reciprocal relationship between these factors, the effect sizes corresponding to earlier resilience predicting later psychological function were larger than the inverse (especially in models assessing depression). Postestimation analyses also demonstrated that the coefficients corresponding to resilience predicting later psychological functioning were larger than the inverse. These findings are congruent with past research which has found predictive correlations between earlier resilience and later depression [13]. Our findings are among the first to demonstrate a longitudinal relationship between anxiety severity and resilience among individuals with chronic physical disabilities. These findings suggest that, pending replication, resilience may contribute in important and distinct ways to psychological function and well-being.

In agreement with the study hypothesis, the results did not support a reciprocal relationship between resilience and physical function. This finding is congruent with past research, which has shown weak or statistically insignificant associations between resilience and physical function [10, 13]. Taken together, research to date suggests that resilience may have only minimal relevance, if any, for individuals who are primarily interested in improving their physical functioning. One qualification, however, is that most studies that have found a lack of longitudinal association between resilience and physical function have used the same measure (CD-RISC10) to operationalize resilience. Future researchers may wish to replicate this finding using a different measure or technique to operationalize resilience.

Age and age-related processes may also have relevance to one's resilience. Theoretical aging models suggest that psychological and social processes change systematically as one grows older and differentially contribute to one's capacity to handle negative events [40, 41]. However,

we are not aware of any theoretical model of aging that pertains specifically to adults aging with physical disabilities. Future research should examine how such age-related processes might influence one's resilience across the lifespan.

The current study also has implications for future directions in the field of rehabilitation medicine. Given the growing body of research demonstrating a strong relationship between resilience and a variety of health domains, researchers should place greater emphasis on resilience when studying health in populations with chronic physical disabilities. In particular, given the apparent complexity of resilience, researchers should continue to clarify its components and features. Future research should also explore mechanisms through which resilience may influence different health domains. In addition, given that the current study used a relatively long-term (yearly) time scale, the current findings may not reflect the relationships between resilience and these function domains when assessed more frequently (i.e., hourly, daily, or weekly). Ecological Momentary Assessment methods could be used to evaluate these relationships on a more granular basis [42].

Furthermore, in conjunction with the broader body of literature examining resilience among rehabilitation populations, the current findings provide strong evidence to suggest that resilience may be an important treatment target. There is some preliminary research investigating the feasibility and efficacy of different resilience training programs, which aim to increase resilience by targeting a broad range of factors that are theorized to contribute to one's resilience [43–46]. However, we are not aware of any research that has investigated the use of training programs to specifically target and increase resilience among individuals with chronic physical disabilities. In addition, rehabilitation researchers should consider assessing whether different treatments that are known to be effective for health promotion and disease management (such as cognitive behavioral therapy, behavioral activation, self-hypnosis, and mindfulness meditation training) are also effective for increasing resilience, and if so, explore the mechanisms by which these different treatments may increase one's resilience. Future research should also explore the extent to which the improvements in various health domains associated with different treatments can be explained by increases in resilience (in other words, the extent to which improvements in resilience serve as a mediator of treatment gains).

Study Limitations

The current study has several important limitations. Primarily, the study used a convenience sample that was primarily white and well-educated. The extent to which the findings generalize to samples that are less educated or are nonwhite is not known. Given this, future research is needed to replicate these findings in additional samples of individuals with physical disabilities. Analyses also revealed that missing data across follow-up time points were marginally associated with older age, suggesting that missingness may have been systematic. This provides further support for evaluating the reliability of the findings, especially in older individuals. Although we did control for primary physical disability in these models, it is possible that the associations between resilience and function domains may vary as a function of the individual's primary physical disability. Future research should address this possibility.

Additionally, although cross-lagged panel analyses are among the most robust statistical methods to assess the temporal qualities of a relationship between two variables, these analyses can only provide preliminary evidence of a potential causal relationship. Although the cross-lagged panel modeling approach we employed is commonly used and well-validated, there are additional cross-lagged modeling approaches (such as those outlined in ref. 47) that may be well-suited to address elements of the longitudinal relationship between resilience and function. For example, future research in this area may consider using latent difference score modeling to better evaluate changes in the constructs studied over time. Furthermore, there may be additional factors that were not assessed in the current study models that may play a role in the associations found (i.e., residual confounding). Experimental research (or other more robust observational methodologies) is needed to confirm the presence or absence of a causal relationship between resilience and different function domains.

Although the current study used a common and well-validated instrument to assess resilience (CD-RISC), research has not yet directly examined the factor validity and measurement invariance (across time and between different primary physical disabilities) of the CD-RISC in populations with the chronic physical disabilities studied here. Future rehabilitation researchers should explore the construct validity of the CD-RISC and its variants in these populations. Furthermore, resilience is recognized as a particularly complex phenomenon; self-reported measures may be insufficient in capturing all of resilience's facets and intricacies. For example, resilience is purported to be composed of both state and trait qualities (e.g., dispositional factors [48, 49]), of which the former may not be adequately addressed by the CD-RISC. Along these lines, the CD-RISC may have captured variance in domains other than resilience that were not adequately controlled for in these models. Given these considerations, the current findings should be viewed as preliminary. In order to build upon our understanding of resilience's role in patient functioning

over time, future research should examine resilience using a broad array of methodologies, including those that extend beyond self-report.

Conclusions

The current study sought to clarify the temporal qualities of the longitudinal relationship between resilience and multiple health domains (anxiety, depression, physical function, and social role satisfaction) using a cross-lagged panel design. The results support the presence of reciprocal relationships between resilience and each nonphysical measure of function, suggesting the possibility that resilience and nonphysical function each influence each other simultaneously over time. Resilience was a stronger predictor of future psychological function (depression and anxiety) than the inverse, however, suggesting that resilience may be a more important consideration than individual manifestations of psychological dysfunction. Future researchers should continue to investigate the potential causal role of resilience in ameliorating dysfunction and promoting long-term health among individuals with chronic physical disabilities, as well as the potential role of various treatments in influencing one's resilience.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Authors Samuel L. Battalio, Connie L. Tang, and Mark P. Jensen declare that they have no conflict of interest. Samuel L. Battalio conceptualized the approach, drafted and revised the manuscript, and conducted the analyses. Connie L. Tang assisted with drafting, literature review, and computation of data analyses. Mark P. Jensen assisted with conceptualization and drafting, and provided editorial commentary. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

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