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ORIGINAL RESEARCH

Resilience, Pain Interference, and Upper Limb Loss: Testing the Mediating Effects of Positive Emotion and Activity Restriction on Distress

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Abstract

Objective: To test mediating effects of positive emotion and activity restriction on the associations of resilience and pain interference with distress reported by individuals with traumatic upper limb loss evaluated for prosthetics.

Design: Cross-sectional correlational study of several demographic and self-report measures of resilience, pain interference, activity restriction, positive emotions, and symptoms of depression and posttraumatic stress.

Setting: Six regional centers throughout the United States.

Participants: A total of 263 prospective participants consented to be evaluated for eligibility and need for upper extremity prosthetics; participants (N=202; 57 women [28.2%] and 145 men [71.8%]; mean age, 41.81±14.83y; range, 18.01−72.95y) who sustained traumatic injuries were retained in this study. Most of them were identified as white (70.8%; n=143), followed by black (10.4%; n=21), Hispanic (9.9%; n=20), Asian (3.0%; n=6), other (1.5%; n=3), and missing (4.5%; n=9).

Interventions: Not applicable.

Main Outcome Measures: Primary Care Posttraumatic Stress Disorder Screen and depression screen.

Results: Resilience and pain interference were significantly correlated in predicted directions with positive emotions, activity restriction, and the 2 distress variables. A path model revealed that the associations of resilience and pain interference with both distress variables were completely mediated by positive emotions and activity restriction. There were no significant direct effects of resilience or pain interference on either distress variable.

Conclusions: Resilience may facilitate adjustment via beneficial and predicted associations with positive emotions and active engagement with the environment. These relations are independent of the significant and inverse associations of pain interference with these same variables. Longitudinal research is needed to understand interactions between positive emotions and activity over time in promoting adjustment after traumatic limb loss. Individuals reporting depression and/or posttraumatic stress disorder symptoms may require interventions that reduce avoidance and promote activities that may increase the likelihood of experiencing positive emotions.

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Studies of resilience in persons with disabling conditions have recently proliferated,[1] but definitions of the construct vary across theoretical models. Most construe it as "…the ability to sustain equilibrium and adaptive functioning under stressful circumstances"[2(p259)] and the ability to "bounce back" with "better than expected" adjustment after a traumatic event.[3(p219)] Unfortunately, the study of resilience after acquired disability is hindered by a lack of information on the mechanisms by which it facilitates well-being. This shortcoming complicates its measurement and frustrates attempts to develop interventions that might promote it.[4-7]

Fredrickson's model[8] of positive emotion stipulates that resilient individuals are uniquely characterized by their propensity for positive emotions that promote flexibility in thinking and appraisals of stress and facilitate pleasant social interactions and adaptive coping strategies that, in tandem, circumvent the

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deleterious effects of negative emotions and stress.[9-11] Resilience in persons with disability is positively associated with increases in social functioning measured 3 years later.[12] Increases in positive emotion in stroke survivors at discharge from inpatient rehabilitation are associated with increases in functional ability 3 months later[13] and with greater social participation.[14]

Resilience is significantly associated with depression and life satisfaction in expected directions over the course of inpatient spinal cord injury rehabilitation,[15] and it is significantly predictive of depression 12 months postinjury.[16] Resilience has been associated with higher positive affect in patients with acquired disabilities in a rehabilitation program[17] and in family caregivers assisting a person with a recent-onset spinal cord injury.[18] Ong et al[19] found that positive affect mediated the prospective relation of self-reported resilience to pain catastrophizing in outpatients with chronic pain: The significant relation of resilience to catastrophizing was nullified once ongoing positive affect was taken into account.

Resilience may also promote well-being after traumatic disability through its association with activity. Resilient individuals are more socially competent from childhood to adulthood than are nonresilient individuals,[20,21] and they report a greater flexibility, resourcefulness, and an active engagement with the environment under routine and stressful circumstances.[22-24] After traumatic disability, resilient individuals would be more likely than nonresilient individuals to maintain or develop personally meaningful goals, activities, and experiences that can promote well-being and alleviate distress.

In the present study, we examined the relations between resilience, positive emotion, and activity restriction to brief indicators of posttraumatic stress and depression in persons with traumatic upper limb loss. Individuals with these injuries often experience distressing, persistent pain.[25-27] The degree to which pain interferes with routine and goal-directed activities may be particularly deleterious to individuals with traumatic disabilities.[28,29] Therefore, we included pain interference as a predictor variable. In our a priori model, we expected that higher resilience would be associated with higher positive emotion and less activity restriction. We expected the opposite pattern in the relation of pain interference to these 2 variables. The model tested the potentially mediating effects of both positive emotion and activity restriction on the relation of resilience and pain interference to posttraumatic stress disorder (PTSD) and depression. Our path model would determine whether the anticipated relations of resilience to the mediating and outcome variables are independent of the significant and inverse associations of pain interference with these same variables.

Methods

Participants

Prospective participants consented to an evaluation of eligibility and need for upper extremity prosthetics at 6 regional centers throughout the United States operated by Advanced Arm Dynamics. Two hundred sixty-three participants consented. Seventeen participants (6.5%) reported congenital limb loss, 40 participants (15.2%) reported limb loss due to a disease process, and 2 participants (0.8%) experienced frostbite (missing, 0.8%, n=2). The 202 participants (57 women [28.2%] and 145 men [71.8%]; mean age, 41.81±14.83y; range, 18.01−72.95y) who incurred traumatic injuries were retained in this study. Time since injury ranged from 0.02 to 58.02 years (mean, 5.35±11.51y). Most of these participants were married (43.6%; n=88) or single (37.1%; n=75); others were divorced (7.4%; n=15), widowed (2.0%; n=4), or living with their partner (0.5%; n=1); and 19 participants (9.4%) did not answer. Most of them were identified as white (70.8%; n=143), followed by black (10.4%; n=21), Hispanic (9.9%; n=20), Asian (3.0%; n=6), other (1.5%; n=3), and missing (4.5%; n=9). Most participants (92.5%; n=187) had an injury on only 1 side (left, 47.0%, n=95; right, 45.5%, n=92; both, 7.4%, n=15). The most common injury level was partial hand amputation (left, 30.7%, n=62; right, 28.2%, n=57).

Participants were referred to Advanced Arm Dynamics by various sources including physicians, insurance companies, and workers compensation, and a small number were self-referred. Most prospective participants had insurance coverage for the evaluation and possible fitting, but a few were able to financially cover their own expenses. All new participants assessed by Advanced Arm Dynamics at each site were invited to participate. The total sample represents ∼50% of the total individuals evaluated by Advanced Arm Dynamics for a new prosthesis. The main reasons for nonenrollment were refusal (29%) or patient seen by a prosthetist only (20%).

List of abbreviations:

CFI	comparative fit index
PTSD	posttraumatic stress disorder
RMSEA	root mean square error of approximation
SRMR	standardized root mean square residual
TLI	Tucker-Lewis index

Materials and procedure

Participants were interviewed by an occupational therapist who received at least 2 hours of training in administering the instruments (provided by one of the authors). One occupational therapist was designated at each site to conduct these interviews, but some sites had another occupational therapist trained for this purpose. During the consent process, individuals were advised that the screening did not constitute a formal psychological evaluation. In the event the results indicated a clinical need, the names of qualified local mental health providers were provided. To reduce respondent burden and to ensure consistency and uniformity across sites, all instruments were administered orally. The study was approved by the Institutional Review Board of Texas A&M University.

Predictor variables

Resilience

The Ego Resiliency Scale[23] contains 14 items that are rated on a 4-point Likert-type scale (1 = Does not apply at all to 4 = Applies very strongly). Sample items include "I quickly get over and recover from being startled," "I enjoy dealing with new and unusual situations," and "My daily life is full of things that keep me interested." Total scores range from 0 to 56. Higher scores indicate greater resilience. The scale has been used in studies of the broaden-and-build model of positive emotion including community residents after the terrorist attacks on the United States on September 11, 2001[30] and patients with chronic pain.[19] The scale correlates in predicted directions with measures of positive and negative affect, flexibility, sociability, well-being,

and openness, as well as with another resilience measure.[24] The Cronbach α with the present sample was .79.

Pain interference

Participants completed the item from the 12-Item Short-Form Health Survey[31]: "During the past four weeks, how much did pain interfere with your normal work [including work outside the home and housework]?" The answers were indicated on a 5-point Likert-type scale (1 = Not at all to 5 = Extremely). Higher scores indicate greater pain interference. Item 4 from the Orthotics and Prosthetics Users' Survey also assesses pain interference, and these 2 items together resulted in a Cronbach α of .84, supporting our use of a single pain interference item.

Mediating variables

Activity restriction

Eleven items (eg, How much does your physical condition restrict your ability to run errands? and To what extent do you accomplish less than you would like because of your physical condition?) from the Restriction subscale of the Orthotics and Prosthetics Users' Survey Quality of Life Scale[32] were used to assess activity restriction. Item 4 was excluded to eliminate redundancy with the pain interference variable. Respondents indicated the degree to which they experience each restriction during the previous week on a 5-point Likert-type scale (1 = Not at all to 5 = Extremely). Higher scores indicate greater activity restriction. This abbreviated version had a Cronbach α of .87.

Positive emotions

Four items from the Orthotics and Prosthetics Users' Survey Quality of Life Scale (Emotional Reactions section) were used to assess positive emotions. Participants rate on a 5-point Likert-type scale (1 = None of the time to 5 = All of the time) the degree to which they felt "full of life," "calm and peaceful," and had been "happy" during the previous week. Responses were summed to obtain a total score. Higher scores indicate higher positive emotions. These items are similar to the 4 items used to assess positive emotions in stroke survivors.[13,14] The positive emotion items had a Cronbach α of .87.

Outcome variables

Posttraumatic stress symptoms

The Primary Care PTSD Screen[33] was developed for use in medical settings. Respondents give yes/no answers to 4 items that pertain to reexperiencing, numbing, avoidance, and hyperarousal symptoms associated with PTSD. The test-retest reliability of the Primary Care PTSD Screen in a sample of veterans was .83 over 1 month, and its correlation with an established clinical interview for PTSD was .83.[33] "Yes" responses were coded as 1 and summed to obtain a total score. The Cronbach α for this measure was .80.

Depression

A 4-item depression screen[34] developed for use in primary care was used. Sample items include "In the past year, have you had two consecutive weeks or more during which you felt sad, blue, or depressed or when you lost all interest or pleasure in things that you usually cared about or enjoyed?" and "Have you felt depressed or sad much of the time in the past year?" Higher scores reflect more symptoms. The Cronbach α was .78.

Data analysis

SPSS version 22[a] was used for descriptive statistics. The Mplus 7.4 program[35,b] was used to test the hypothesized path model. Path modeling is recommended for testing theoretical assumptions about the relations between variables.[36,37] The causal pathways between variables (predictors, mediators, outcomes) includes direct and indirect effects of variables on other variables.[36] In the a priori theory-driven model (fig 1), resilience and pain interference were the predictor variables and activity restriction and positive emotion were the mediating variables. PTSD and depression were the outcome variables.

Missing data accounted for <1% for most measure indicators, with one being as high as 3%. Missing values were ignored, and all responses were totaled for each measure for the path modeling. All total scores were within −3/+3 for skewness and kurtosis. There were no univariate outliers, with standardized scores greater than −3/+3 providing evidence of univariate normality. Based on this, all path models used maximum likelihood estimation (ESTIMATOR = ML option in Mplus). Parameter estimate SEs were estimated from 5000 bootstrap samples. Bootstrapping is the recommended way of testing indirect effects in mediation models by using bias-corrected bootstrap confidence intervals.[38]

The following fit indices were used to determine overall model fit: (1) chi-square test of model fit; (2) comparative fit index (CFI); (3) Tucker-Lewis index (TLI); (4) root mean square error of approximation (RMSEA); and (5) standardized root mean square residual (SRMR). A nonsignificant χ^2 ($P>.05$) provides evidence of acceptable fit, given that the sample sizes are not excessively large.[39] CFI and TLI are measures of incremental model fit, and RMSEA and SRMR are measures of absolute model fit.[40] CFI and TLI scores above .90 are typically considered having adequate fit, and values above .95 are considered having good fit.[40] RMSEA and SRMR scores below .08 are considered having adequate fit, and values below .05 are considered having good fit.[40] Indirect effects of predictor variables on outcome variables (via mediators) were assessed using bias-corrected 95% confidence intervals with the Mplus BCBOOTSTRAP command. Confidence intervals with positive lower limits (did not include 0 in the interval) were interpreted as evidence of significant indirect effects of predictors on outcomes through mediators.

Results

Descriptive statistics and correlations are presented in table 1. All the variables were significantly correlated in expected directions ($P<.05$).

The A Priori Model

We estimated the residual covariance of the 2 correlated outcome variables ($r=.58$; $P<.01$) in the model. We also estimated the residual covariance between our 2 mediators (activity restriction, positive emotion). The model was fully saturated using all available degrees of freedom. This does not allow for analysis of fit (N = 202; $\chi_0^2=.00$; $P<.001$; RMSEA = .00; CFI = 1.00; TLI = 1.00; SRMR = .00). The direct paths from resilience to depression ($b=.012$; $P=.43$), from pain interference

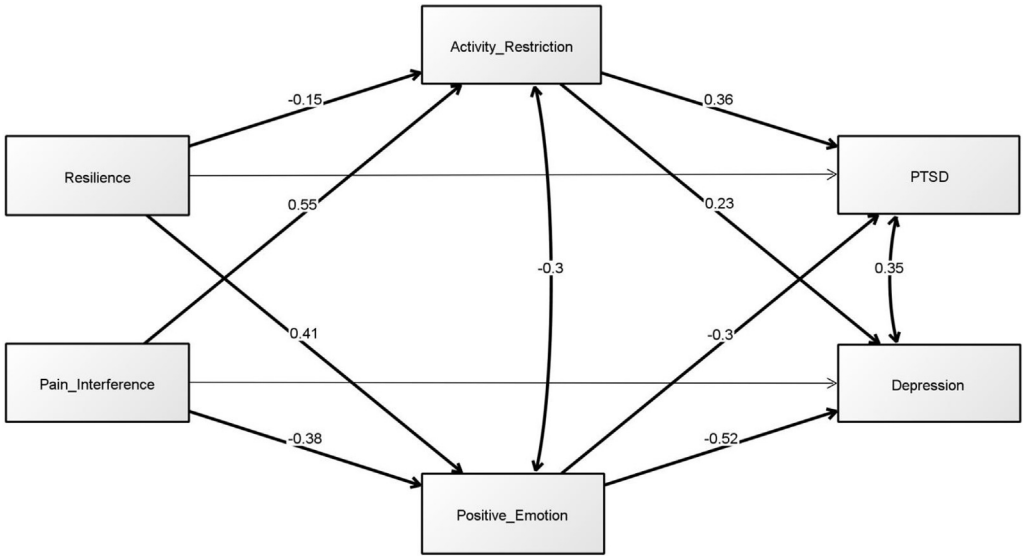

Fig 1 The a priori model and the final model using standardized path coefficients including predictor, mediator, and outcome relations.

to depression ($b=.029$; $P=.70$), from resilience to PTSD ($b=-.03$; $P=.07$), and from pain interference to PTSD ($b=.087$; $P=.31$) were not statistically significant and were removed. Six participants (3%) identified as multivariate outliers according to Cook's distance, Mahalanobis distance, and the log-likelihood distance influence measure were removed from the final model.

The final model had an overall good fit (N=196; $\chi^2_4=6.05$; $P=.20$; RMSEA=.05; CFI=.99; TLI=.98; SRMR=.02). The unstandardized path coefficients and the 2 unstandardized residual covariances are presented in table 2. Resilience was negatively associated with activity restriction and positively associated with positive emotion ($P<.05$ for all). Pain interference was positively related to activity restriction and negatively related to positive emotion. Activity restriction was positively associated with both PTSD and depression ($P<.01$), and positive emotion was negatively associated with both PTSD and depression ($P<.01$). The residual covariance between our mediators was negative ($P<.01$). The residual covariance between the outcome variables (PTSD, depression) was positive and statistically significant, implying that there may be remaining association between the outcome variables after controlling for the effects of all variables included in the model.

The predictor variables in this model accounted for 35% of the variance in activity restriction ($R^2 = .35$), 35% of the variance in positive emotion ($R^2 = .35$), 45% of the variance in depression, and 32% of the variance in PTSD.

Mediation effects

Mediation effects were tested using the Mplus MODEL INDIRECT command. All possible indirect effects of resilience and pain interference on the 2 outcome variables, the parameter estimates of the indirect effects, and confidence intervals are presented in table 3. The confidence intervals were estimated from 5000 bootstrap samples.

Resilience had indirect effects through positive emotion and activity restriction on both outcome variables ($P<.05$). Greater resilience was significantly associated with higher positive emotion and less activity restriction. These, in turn, were associated with lower depression and PTSD scores. Consequently, the relations of resilience to depression and PTSD symptoms are best understood by their unique associations with positive emotion and activity.

Table 1 Descriptive statistics and correlations for all measured variables

Variable	1	2	3	4	5	6
1. Resilience	NA	−.17*	−.26†	.51†	−.34†	−.33†
2. Pain interference	NA	NA	.54†	−.44†	.38†	.37†
3. Activity restriction	NA	NA	NA	−.49†	.51†	.51†
4. Positive emotion	NA	NA	NA	NA	−.47†	−.65†
5. PTSD	NA	NA	NA	NA	NA	.58†
6. Depression	NA	NA	NA	NA	NA	NA
N	202	202	202	202	202	202
Mean	45.13	2.65	28.36	14.28	1.32	1.29
SD	5.99	1.26	8.86	3.33	1.47	1.45
Range	20−55	1−5	11−49	4−20	0−4	0−4

Abbreviation: NA, not applicable.
* $P<.05$.
† $P<.01$.

Table 2 Unstandardized path coefficients of the final model

		Maximum Likelihood Estimation From 5000 Bootstrap Samples			
Dependent Variable	Independent Variable	Estimate	SE	CR	*P*
Activity restriction					
	Resilience	−0.24	0.09	−2.56	<.05
	Pain interference	3.77	0.41	9.28	<.01
Positive emotion					
	Resilience	0.24	0.04	6.83	<.01
	Pain interference	−0.97	0.16	−6.23	<.01
PTSD					
	Activity restriction	0.06	0.01	5.48	<.01
	Positive emotion	−0.13	0.03	−4.18	<.01
Depression					
	Activity restriction	0.04	0.01	3.81	<.01
	Positive emotion	−0.23	0.03	−8.55	<.01
Activity restriction with positive emotion		−5.35	1.31	−4.08	<.01
Depression with PTSD		0.44	0.09	4.62	<.01

Abbreviation: CR, critical ratio.

Similarly, the hypothesized relation of pain interference to both outcome variables was completely mediated by its association with positive emotion and activity restriction. Increased pain interference was directly associated with lower positive emotion and greater activity restriction. These, in turn, were significantly associated with higher PTSD and depression. In this manner, the negative associations with positive emotion and activity restriction may account for the mechanisms that drive the relation of pain interference to distress.[41]

Discussion

Other research[42] has found that higher resilience is associated with less distress after traumatic injury, but the present study demonstrates how positive emotions mediate this relation. Similarly, the present study suggests that pain interference affects PTSD and depressive symptoms via its deleterious effect on positive emotions and activity postinjury. Although resilience and pain interference were significantly and inversely correlated in these data (and in other work as well[29]), our model indicates that resilience and pain interference have independent effects on positive emotions and activity restriction, which, in turn, affect distress.

Resilient individuals are more likely than nonresilient individuals to exhibit proactive behavior, pursue personally meaningful goals, and actively engage with the environment.[11,24] The interplay between positive emotions and activity has been described as a "feedback loop" in which positive emotion after disability motivates social engagement and increases in personal confidence and self-esteem, which then facilitates more positive emotions and meaningful activity.[14] Resilient individuals may experience a "positive cascade" as they engage in positive events and experience emotional benefits from those events.[11] In contrast, restrictions in activity and participation undermine well-being and quality of life in medical patients, in general.[43]

The PTSD screen used in the present study has an item that assesses avoidant symptoms that characterize the syndrome ("…tried hard not to think about it or went out your way to avoid situations that reminded you of it"[33[p10]]). The measure of resilience used in this study has a factor that assesses active engagement with the environment.[24] We know from other research that war zone veterans categorized as nonresilient use more maladaptive avoidant coping strategies than resilient veterans, and avoidant coping is prospectively predictive of higher PTSD and depression.[44] It is possible that individuals higher in resilience in

Table 3 Indirect effect estimates from predictors to outcomes through the mediators in the final path model

Effect	Unstandardized Coefficient	Standardized Coefficient	Unstandardized 95% CI
Resilience → Activity restriction → PTSD*	−0.01	−0.05	−0.03 to −0.003
Resilience → Positive emotion → PTSD†	−0.03	−0.12	−0.05 to −0.02
Pain interference → Activity restriction → PTSD‡	0.22	0.20	0.13 to 0.32
Pain interference → Positive emotion → PTSD†	0.13	0.11	0.06 to 0.21
Resilience → Activity restriction → Depression*	−0.01	−0.04	−0.02 to −0.003
Resilience → Positive emotion → Depression‡	−0.06	−0.21	−0.08 to −0.04
Pain interference → Activity restriction → Depression‡	0.14	0.13	0.7 to 0.23
Pain interference → Positive emotion → Depression‡	0.22	0.20	0.14 to 0.31

NOTE. Arrow indicates direct relation.
Abbreviation: CI, bias-corrected bootstrap confidence interval estimated from 5000 bootstrap samples.
* *P*<.05.
† *P*<.01.
‡ *P*<.001.

the present study were less likely than others to endorse the avoidance item on the PTSD screen, in addition to being more active and participatory in desired pursuits, in general. Future research could examine this linkage between resilience and avoidant behavior.

Pain after limb loss is associated with activity and participation restriction, and it interferes with the use of prostheses.[45] Prospective research indicates that pain secondary to traumatic disability negatively affects participation, and through this relation it has a detrimental effect on subsequent life satisfaction and self-rated health.[28] Importantly, positive emotions appear to be the element of resilience vital in "undoing" the negative effects of pain over time.[19]

Study limitations

The cross-sectional nature of the design prevents strong causal inferences about the relations between the variables. Longitudinal research is required to determine the prospective and possibly reciprocal effects of positive emotion to activity and participation, and the effect of this interplay on the subsequent quality of life of persons who incur traumatic disabilities. Such designs are also needed to determine whether the pathways identified between the variables in this study are indeed causal.

Conclusions

The contributions of positive emotion and activity restriction in predicting distress indicate that these "mediating" variables are particularly important for individuals who lack resilience. The successful pursuit of personally valued activities may increase the likelihood of positive emotions, which may serve to counter distress. Behavioral activation strategies, common in interdisciplinary pain rehabilitation programs, emphasize reengagement in activities that increase the likelihood of pleasurable experiences and positive reinforcement.[46] These strategies may offset activity restrictions that accompany acquired disability.[43] Additional evidence from longitudinal research may provide insights into the possible need for ongoing support for the well-being and pain management skills of patients who receive prosthetics.

Suppliers

a. IBM Corp.
b. Muthén & Muthén.

Keywords

Amputation; Emotions; Pain; Rehabilitation; Resilience, psychological; Social participation

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