RESEARCH ARTICLE

Does Resiliency Mediate the Association of Psychological Adaptability with Limitations and Pain Intensity after Upper Extremity Trauma?

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Abstract

Background: Given the influence of psychosocial factors on musculoskeletal symptoms and limitations, this study assessed if the ability of resilience (an individual's ability to adapt under stress) mediates the association of psychological adaptability with magnitude of physical limitations and pain intensity during recovery from an upper extremity injury.

Methods: A total of 107 patients were enrolled in this prospective, longitudinal, observational cohort study. Patients completed the Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF), an 11-point ordinal measure of pain intensity, the Brief Resilience Scale (BRS), and the Psychological Adaptation Scale (PAS). We used structural equation modeling to assess the mediation effect by resiliency and psychological adaptability on patient-reported disability and pain at initial assessment and after three months.

Results: PAS and BRS were not independently associated with PROMIS PF or pain intensity at enrollment or after three months, so it was not possible to assess if resiliency mediated the association of psychological adaptability with physical function or pain. There were no factors independently associated with resilience.

Conclusion: General measures of psychological adaptability and resiliency do not correlate with symptoms and limitations as well as specific measures of adaptiveness in response to nociception.

Level of evidence: II

Keywords: Resilience, Brief Resilience Scale, Psychological Adaptation Scale, Structural Equation Modeling, Mediation Analysis

Introduction

Pain intensity and magnitude of limitations after upper extremity injury are related to pathophysiology (objective impairment), symptoms of depression and anxiety (psychological distress), and effectiveness of cognitive coping strategies (e.g. less catastrophic thinking and more self-efficacy) (1). Resilience refers to an individual's ability to adapt when facing adversity such as stress or trauma (2). It is considered a protective factor that can limit symptom intensity and magnitude of limitations over the short and long-term (3,4). Psychological adaptability is the dynamic and multidimensional process of coming to terms with the implications of a health threat and the outcome of that psychological process, also referred to as adjustment and acceptance (5). Because mental and social health have such a strong influence on musculoskeletal symptoms and limitations, psychological adaptability may be affected by (or effect) resilience in people recovering from injury.

This study assessed whether resilience mediates the association of psychological adaptability with magnitude of physical limitations (measured with Patient-Reported Outcomes Measurement Information System Physical Function: PROMIS PF) and pain intensity during recovery

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from an upper extremity injury. Second, we assessed factors independently associated with (1) resilience (measured with the Brief Resilience Scale: BRS), (2) physical limitations, and (3) pain intensity.

Methods

Study Design

After institutional review board approval, a total of 107 patients were enrolled in this prospective, longitudinal, observational cohort study. Enrollment took place intermittently over a 12-month period at five orthopaedic offices in a large urban area. All new English-speaking patients, aged 18 years old or older, with one or more traumatic injuries to the upper extremity, within two weeks of trauma, and who were able to provide informed consent were approached by research assistants after the visit with the surgeon to participate in this study. A waiver of written informed consent was granted. By completing the surveys patients indicated their informed consent. To assess the mediation effect by resiliency and psychological adaptability on the improvement effects of patient-reported outcomes after three months, a second survey was sent to participants three months after trauma by email. All questionnaires were completed using an encrypted tablet via a secure, HIPAA-compliant electronic platform: REDCap (Research Electronic Data Capture): a secure web-based application for building and managing online surveys and databases (6).

Measures

Diagnosis was recorded by the surgeon. Patients were asked to complete a set of questionnaires at enrollment (i.e. Time 1): (1) a demographic survey (including email for follow-up, age, sex, ethnicity, marital status, education, work status, presence of current psychological disorder, presence of another pain condition, use of opioids, history of orthopedic condition, and history of orthopedic surgery); (2) PROMIS PF, which is a computer adaptive test (CAT) is a measure of physical limitations (7–10). CAT uses item response theory, which customizes the subsequent question based on answers to the previous questions, resulting in a high level of precision through lesser questions (11). Higher scores reflect better physical function; (3) Pain intensity on an 11-point ordinal rating scale, with scores ranging from 0 “No pain at all” to 10 “Worst pain possible”(10); (4) BRS, which is a six-item scale to assess resilience, the ability to bounce back or recover from stress (4,10,12). A higher score represents greater resilience. The BRS consists of three positively worded statements and three negatively worded statements, with answers ranging from 1 “Strongly disagree” to 5 “Strongly agree”. It has a highly scored internal consistency, with Cronbach alpha scores ranging from 0.89-0.91; (5) and Psychological Adaptation Scale (PAS). PAS is a 20-item scale to assess adaptation to a chronic condition or disease risk (5,12). Answer possibilities range from 1 to 5 and the total score is the sum of all items. Higher scores reflect more adaptation. It is divided in four subscales assessing coping efficacy, self-esteem, social integration, and spiritual/existential well-being. After three months (i.e. Time 2) patients were asked to complete the second survey by email, consisting of PAS, PROMIS PF, and pain intensity.

Study Population

The survey was completed by 107 patients and after three months the follow-up survey by email was completed by 39 patients (36%). The mean age of patients was 46 ± 16 years and 52 (49%) were men [Table 1]. The most frequent reported diagnoses were distal radius fractures (12%), metacarpal fractures (12%), and finger fractures (11%) [Appendix 1]. Responders differed from non-responders on bivariate analysis [Table 2]. Multivariable analysis for variables with P <0.10 on bivariate analysis showed that a marital status of divorced/widowed (odds ratio [OR] 0.19; 95% CI 0.04 to 0.97; P=0.045) and a better PROMIS PF score (OR 0.95; 95% CI 0.91 to 1.0; P=0.041) were independently associated with loss to follow-up after three months [Appendix 2].

Appendix A. Diagnoses and frequencies.

Diagnoses, N=107	Frequency
Distal Radius Fracture	13 (12)
Metacarpal fracture	13 (12)
Finger fracture	12 (11)
Finger Sprain	5 (4.7)
Nonspecific arm pain	4 (3.8)
Wrist fracture	4 (3.8)
Finger Laceration	3 (2.8)
Finger Osteoarthritis	3 (2.8)
Mallet Finger	3 (2.8)
Wrist Sprain	3 (2.8)
Elbow fracture	2 (1.9)
Finger Tendon Tear	2 (1.9)
Hand Sprain	2 (1.9)
Proximal radius fracture	2 (1.9)
Trigger Finger	2 (1.9)
Wrist Pain	2 (1.9)
Arm pain	2 (1.9)
Biceps tendon tear	2 (1.9)
Biceps tendinitis	1 (0.93)
Bursitis and infection olecranon	1 (0.93)
Carpal Tunnel Syndrome	1 (0.93)
Carpal Tunnel Syndrome and Ganglion Cyst	1 (0.93)
Clavicle fracture	1 (0.93)
De Quervain Tenosynovitis	1 (0.93)
Distal Phalanx Fracture	1 (0.93)
Elbow dislocation	1 (0.93)
Elbow Sprain	1 (0.93)
Finger flexon tendon rupture	1 (0.93)
Finger injury unspecified	1 (0.93)
Finger nailbed tear	1 (0.93)
Fracture unspecified	1 (0.93)
Gamekeepers thumb	1 (0.93)
Hand laceration	1 (0.93)
Humerus fracture	1 (0.93)
Mallet Finger and Trigger Thumb	1 (0.93)
Medial Epicondylitis	1 (0.93)
Medial Epicondylitis and Cubital Tunnel Syndrome	1 (0.93)
Pectoral muscle tear	1 (0.93)
Proximal phalanx fracture	1 (0.93)
Proximal ulnar fracture	1 (0.93)
Radius fracture	1 (0.93)
Rotator Cuff Injury	1 (0.93)
Scapholunate ligament injury	1 (0.93)
Shoulder dislocation	1 (0.93)
Ulnar Fracture	1 (0.93)
Wrist sprain and Finger Fracture	1 (0.93)

Discrete variables as number (percentage).

Appendix B. Multivariable logistic regression analysis of factors associated with completing a follow-up assessment.

Dependent variable	Retained variables	Odds Ratio (95% Confidence interval)	Standard error	P value	C statistic[1]
Completing follow-up assessment	**Age in years**	1.0 (0.97 to 1.0)	0.02	0.759	0,75
	Marital status				
	Married/Unmarried couple	Reference value			
	Single	0.40 (0.11 to 1.4)	0.26	0.156	
	Divorced/Widowed	0.19 (0.04 to 0.97)	0.16	**0.045**	
	PROMIS PF	0.95 (0.91 to 1.0)	0.02	**0.041**	
	Current other pain condition	3.2 (0.79 to 13)	2.2	0.102	
	Previous orthopaedic condition	1.9 (0.71 to 5.1)	0.95	0.205	

Bold indicates statistically significant difference; [1] The C statistic is a measure of model fit and is the area under the receiver operating characteristics curve.

Appendix C. Multivariable linear regression of factors associated with PROMIS PF and Pain at baseline and 3 months, and with BRS at baseline after mean imputation.

Dependent variables	Retained variables	Regression coefficient [β] (95% Confidence interval)	Standard error	P value	Semipartial R-squared (R^2)	Adjusted R^2
PROMIS PF Time 1	**Current psychological disorder**	-4.6 (-9.7 to 0.43)	2.5	0.072		0.10
	Current other pain condition	-3.7 (-9.5 to 2.2)	2.9	0.217		
	Current use of opioids	-8.2 (-15 to -1.8)	3.2	**0.013**	0.05	
	BRS	1.8 (-0.80 to 4.4)	1.3	0.173		
PROMIS PF Time 2	**Age**	-0.09 (-0.30 to 0.13)	0.1	0.411		0,12
	Men	5.1 (-1.5 to 12)	3.5	0.125		
	Current other pain condition	-6.4 (-13 to 0.61)	3.5	0.072		
	BRS	-0.14 (-4.3 to 4.0)	2.1	0.946		
Pain Time 1	**Men**	-0.91 (-1.8 to -0.04)	0.44	**0.041**	0.04	0.08
	White race	-1.1 (-2.2 to -0.00)	0.56	**0.049**	0.03	
	BRS	-0.50 (-1.1 to 0.09)	0.30	0.098		
Pain Time 2	**White race**	-2.7 (-4.5 to -0.85)	0.89	**0.005**	0.18	0.25
	Current psychological disorder	-1.1 (-2.8 to 0.48)	0.80	0.163		
	Previous orthopaedic condtion	0.58 (-0.76 to 1.9)	0.66	0.388		
	BRS	-0.57 (-1.4 to 0.26)	0.41	0.169		
BRS Time 1	**White race**	0.30 (-0.07 to 0.66)	0.18	0.107		0.04
	PAS	-0.00 (-0.01 to 0.00)	0.00	0.165		

Bold indicates statistically significant difference; Only the semipartial R^2 of significant variables is displayed; BRS=Brief Resilience Scale; PAS=Psychological Adaptation Scale; PROMIS PF=Patient-Reported Outcomes Measurement Information System Physical Function.

Table 1. Patient and clinical characteristics and comparison between available and lost to follow-up.

Variables	Total N=107	Lost to follow-up N=68	Available for follow-up N=39	P value
Time 1				
Age in years	46 ± 16 (20-83)	44 ± 15 (20-83)	51 ± 15 (23-78)	**0.024**
Men	52 (49)	37 (54)	15 (38)	0.159
Race/Ethnicity				
White	85 (79)	51 (75)	34 (87)	0.213
Other	22 (21)	17 (25)	5 (13)	
Marital status				
Married/Unmarried couple	59 (55)	31 (46)	28 (72)	
Single	33 (31)	26 (38)	7 (18)	**0.034**
Divorced/Widowed	15 (14)	11 (16)	4 (10)	
Level of education				
High school or less	24 (22)	18 (26)	6 (15)	
2-year college	21 (20)	14 (21)	7 (18)	0.528
4-year college	37 (35)	21 (31)	16 (41)	
Post-college graduate degree	25 (23)	15 (22)	10 (26)	
Work status				
Employed	77 (72)	52 (77)	25 (64)	
Retired	15 (14)	7 (10)	8 (21)	0,253
Other (unemployed, homemaker, etc.)	15 (14)	9 (13)	6 (15)	

BRS	3.8 ± 0.75 (1.7-5)	3.9 ± 0.76 (2.2-5)	3.6 ± 0.71 (1.7-5)	0.126
PAS	56 ± 22 (20-100)	57 ± 23 (20-100)	53 ± 20 (20-88)	0.300
Pain	4.3 ± 2.4 (0-9)	4.2 ± 2.3 (0-9)	4.6 ± 2.5 (0-9)	0.474
PROMIS PF	46 ± 10 (24-73)	47 ± 11 (25-73)	43 ± 9.6 (24-61)	**0.047**
Current psychological disorder	19 (18)	11 (16)	8 (21)	0.606
	N = 99	**N = 64**	**N = 35**	
Current other pain condition	14 (14)	5 (7.8)	9 (26)	**0.031**
Current use of opioids	11 (11)	8 (13)	3 (8.6)	0.742
Previous orthopaedic condition	40 (40)	21 (33)	19 (54)	0.054
Previous orthopaedic surgery	38 (38)	23 (36)	15 (43)	0.523
Time 2	**N = 33**			
PAS	50 ± 21 (20-100)	-	-	-
	N = 39			
Pain	2.0 ± 2.0 (0-8)	-	-	-
PROMIS PF	52 ± 9.7 (28-73)	-	-	-

Bold indicates statistically significant difference; Continuous variables as mean ± standard deviation (range); Discrete variables as number (percentage); BRS=Brief Resilience Scale; PAS=Psychological Adaptation Scale; PROMIS PF=Patient-Reported Outcomes Measurement Information System Physical Function.

Table 2. Bivariate analyses of factors associated with PROMIS PF and Pain at baseline and 3 months

Variables	PROMIS PF Baseline	P value	PROMIS PF 3 months	P value	Pain Baseline	P value	Pain 3 months	P value	BRS Baseline	P value
Age *(r)*	-0.15	0.127	-0.28	0.088	-0.14	0.149	0.06	0.740	0.12	0.231
Sex										
Women	45 ± 10	0.423	49 ± 9.7	**0.037**	4.8 ± 2.5	0.061	2.2 ± 1.8	0.358	3.8 ± 0.78	0.997
Men	47 ± 11		56 ± 8.3		3.9 ± 2.2		1.6 ± 2.3		3.8 ± 0.72	
Race/Ethnicity										
White	46 ± 11	0.801	52 ± 9.8	0.170	4.1 ± 2.2	**0.031**	1.6 ± 1.6	**0.005**	3.8 ± 0.73	**0.042**
Other	45 ± 8.9		46 ± 7.4		5.3 ± 2.7		4.2 ± 2.9		3.5 ± 0.77	
Marital status										
Married/Unmarried couple	47 ± 10		52 ± 9.1		4.4 ± 2.4		2.3 ± 2.0		3.9 ± 0.69	
Single	45 ± 10	0.576	54 ± 12	0.575	4.5 ± 2.4	0.873	1.0 ± 1.8	0.217	3.6 ± 0.78	0.212
Divorced/Widowed	45 ± 13		47 ± 10		4.1 ± 2.5		1.3 ± 1.5		3.7 ± 0.87	
Level of education										
High school	44 ± 10		52 ± 5.0		4.5 ± 2.5		2.5 ± 2.2		3.7 ± 0.81	
2-year college	47 ± 8.7	0.781	53 ± 7.4	0.235	4.0 ± 3.1	0.179	1.9 ± 1.9	0.834	3.6 ± 0.91	0.376
4-year college	46 ± 10		54 ± 8.1		4.9 ± 2.2		1.7 ± 1.5		3.8 ± 0.72	
Post-college graduate degree	46 ± 13		46 ± 14		3.6 ± 1.7		2.2 ± 2.7		4.0 ± 0.55	
Work status										
Employed	47 ± 10		52 ± 9.6		4.5 ± 2.2		2.2 ± 2.2		3.7 ± 0.74	
Retired	41 ± 10	0,153	49 ± 6.3	0,605	3.5 ± 2.8	0,364	1.1 ± 1.1	0,393	3.9 ± 0.75	0,712
Other (unemployed, homemaker, etc.)	45 ± 11		54 ± 14		4.5 ± 2.6		2.0 ± 2.0		3.7 ± 0.85	
Current psychological disorder										
No	47 ± 10	**0.038**	52 ± 9.4	0.271	4.3 ± 2.4	0.797	2.3 ± 2.1	0.078	3.8 ± 0.70	0.172
Yes	41 ± 9.5		48 ± 10		4.5 ± 2.5		0.88 ± 0.83		3.6 ± 0.93	
Current other pain condition										
No	47 ± 10	0.058	53 ± 10	0.086	4.4 ± 2.4	0.940	2.2 ± 2.2	0.809	3.8 ± 0.72	0.812
Yes	41 ± 11		46 ± 7.3		4.4 ± 2.6		2.0 ± 1.5		3.8 ± 0.85	
Current use of opioids										
No	47 ± 9.5	**0.007**	51 ± 9.0	0.919	4.3 ± 2.3	0.243	2.3 ± 2.0	0.312	3.8 ± 0.74	0.841
Yes	38 ± 15		50 ± 21		5.2 ± 3.0		1.0 ± 1.7		3.8 ± 0.67	
Previous orthopaedic condtion										
No	46 ± 11	0.662	51 ± 9.3	0.983	4.3 ± 2.3	0.572	1.5 ± 1.2	0.083	3.8 ± 0.77	0.513
Yes	45 ± 10		51 ± 11		4.6 ± 2.5		2.7 ± 2.4		3.9 ± 0.67	
Previous orthopaedic surgery										
No	46 ± 10	0.918	50 ± 11	0.682	4.5 ± 2.4	0.572	1.9 ± 1.6	0.419	3.7 ± 0.77	0.466
Yes	46 ± 11		52 ± 8.9		4.2 ± 2.5		2.5 ± 2.5		3.9 ± 0.68	
BRS Time 1 (*r*)	0.14	0.155	-0.02	0.888	-0.19	**0.043**	-0.05	0.775	-	-
PAS Time 1 (*r*)	-0.02	0.809	0.06	0.700	0.13	0.198	0.26	0.109	-0.18	0.062
Pain Time 1 (*r*)	-0.33	**0.001**	-0.08	0.615	-	-	0.52	**0.001**	-0.20	**0.043**
PROMIS PF Time 1 (*r*)	-	-	0.65	**<0.001**	-0.33	**0.001**	-0.22	0.185	0.14	0.155

Bold indicates statistically significant difference; Pearson correlation indicated by *r*; Continuous variables as mean ± standard deviation (range), unless otherwise indicated; Discrete variables as number (percentage); [1]=Only 1 value; BRS=Brief Resilience Scale; PAS=Psychological Adaptation Scale; PROMIS PF=Patient-Reported Outcomes Measurement Information System Physical Function.

Statistical Analysis

Continuous data were reported with mean, standard deviation (SD), and ranges.

Categorical data are presented as frequencies and percentages. Using structural equation modeling (SEM), we created four mediation models to assess the mediation effect by resiliency and psychological adaptability on patient reported disability and pain at initial assessment and after three months [Figure 1]. These models reveal a total -, direct -, and indirect effect of mediator (and other independent) variables on the dependent variable. To select confounding variables for our final mediation model, we first selected confounding variables with P <0.10 on bivariate analysis [Table 2] in a multivariable model. Consecutively, we selected confounding variables with P <0.05 on multivariable analysis [Table 3] in our mediation model [Table 4]. Adjusted R^2 indicates how much variability in the outcome variable the model accounts for. The proportion total effect mediated in the mediation table shows the proportion of the total effect (resiliency and adaptability combined) that is mediated through resilience. We considered P <0.05 significant.

Based on the Fritz and Mackinnon's sample size stimulation study a minimum sample size of 71 was necessary to detect a medium effect size (0.13) with 0.80 power for inferring an indirect effect through mediation analysis (13). We enrolled 50% more patients (total of 107), to cover for measurement error inherent in psychosocial measures and loss to follow-up (14).

Results

PROMIS PF Mediation

PAS and BRS were not independently associated with PROMIS PF at enrollment or after three months [Table 2] so we did not perform mediation analysis.

Pain Intensity Mediation

PAS and BRS were not independently associated with pain intensity at enrollment or after three months [Table 2], so we did not perform mediation analysis.

Factors Associated with Resilience

Using multivariable linear regression, there were no factors independently associated with resilience (BRS)[Table 3].

Factors Associated with PROMIS PF

Patients with a diagnosed psychological disorder (β -7.8; 95% CI -14 to -1.4; P=0.018) and patients with current use of opioids (β -7.8; 95% CI -14 to -1.4; P=0.017) had worse physical function (lower PROMIS PF scores) at baseline, accounting for potential confounding using multivariable regression analysis [Table 3]. No factors were independently associated with PROMIS PF 3 months after enrollment.

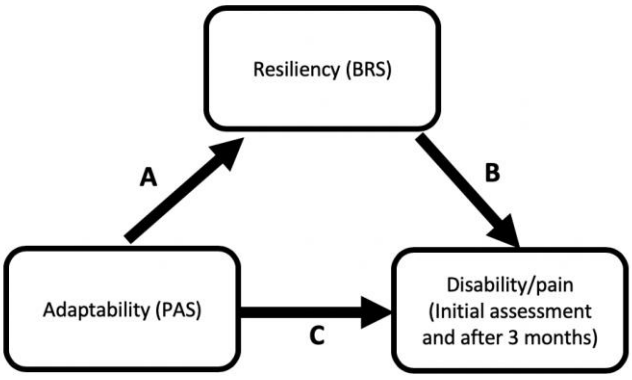

Figure1. Indirect effect (mediation)=path A x path B (mediation model hypothesis). Total effect=direct effect (path C)+indirect effect.

Table 3. Multivariable linear regression of factors associated with PROMIS PF and Pain at baseline and 3 months, and with BRS at baseline.

Dependent variables	Retained variables	Regression coefficient [β] (95% Confidence interval)	Standard error	P value	Semipartial R-squared (R^2)	Adjusted R^2
	Current psychological disorder	-7.8 (-14 to -1.4)	3.2	**0.018**	0.05	
PROMIS PF	**Current other pain condition**	-2.7 (-8.7 to 3.2)	3.0	0.364		0.14
Time 1	**Current use of opioids**	-7.8 (-14 to -1.4)	3,2	**0.017**	0.05	
	BRS	2.3 (-0.38 to 5.0)	1.4	0.091		
	Age	-0.09 (-0.32 to 0.15)	0.12	0.455		
PROMIS PF	**Men**	5.3 (-2.0 to 13)	3.6	0.150		0.10
Time 2	**Current other pain condition**	-5.9 (-13 to 1.7)	3.7	0.123		
	BRS	0.20 (-4.4 to 1.8)	2,3	0.932		
Pain	**Men**	-0.91 (-1.8 to -0.04)	0.44	**0.041**	0.04	0.08
Time 1	**White race**	-1.1 (-2.2 to -0.00)	0,56	**0.049**	0.03	

	BRS	-0.50 (-1.1 to 0.09)	0.30	0.098		
	White race	-2.7 (-4.6 to -0.77)	0,95	**0.008**	0.19	
Pain	**Current psychological disorder**	-1.1 (-3.3 to 1.1)	1.1	0.304		0.20
Time 2	**Previous orthopaedic condtion**	0.57 (-0.84 to 2.0)	0,69	0.416		
	BRS	-0.68 (-1.6 to 0.24)	0,45	0.142		
BRS	**White race**	0.30 (-0.07 to 0.66)	0.18	0.107		0.04
Time 1	**PAS**	-0.00 (-0.01 to 0.00)	0.00	0.165		

Bold indicates statistically significant difference; Only the semipartial R^2 of significant variables is displayed; BRS=Brief Resilience Scale; PAS=Psychological Adaptation Scale; PROMIS PF=Patient-Reported Outcomes Measurement Information System Physical Function.

Table 4. Mediation analyses of resiliency in the relationship between psychological adaptibility and PROMIS PF and pain at baseline and 3 months.

Dependent variable	Sample size	Mediator variable	Independent variable	Confounding variables	Effect	Regression coefficient [β] (95% Confidence interval)	Standard error	P value	Proportion total effect mediated
PROMIS PF at baseline	99	BRS	PAS	Current psychological disorder Current use of opioids	Total effect PAS	-0.02 (-0.11 to 0.07)	0.05	0,656	0.89
					Total effect psychological disorder	-9.1 (-15 to -2.9)	3.2	**0.004**	
					Total effect use of opioids	-8.3 (-14 to -2.2)	3.2	**0.008**	
					Direct effect PAS	-0.00 (-0.09 to 0.09)	0.05	0.962	
					Indirect effect through BRS	-0.02 (-0.04 to 0.01)	0.01	0.172	
PROMIS PF after 3 months	39	BRS	PAS	-	Total effect PAS	0.03 (-0.12 to 0.18)	0.08	0.690	0.03
					Direct effect PAS	0.03 (-12 to 0.18)	0.08	0.703	
					Indirect effect through BRS	0.00 (-0.02 to 0.02)	0.01	0.931	
Pain at baseline	107	BRS	PAS	Men White race	Total effect PAS	0.01 (-0.01 to 0.03)	0.01	0,549	0.37
					Total effect men	-0.90 (-1.8 to -0.04)	0.44	**0.041**	
					Total effect white race	-1.2 (-2.3 to -0.10)	0.56	**0.033**	
					Direct effect PAS	0.00 (-0.02 to 0.02)	0.01	0.704	
					Indirect effect through BRS	0.00 (-0.00 to 0.01)	0.00	0.284	
Pain after 3 months	39	BRS	PAS	White race	Total effect PAS	0.02 (-0.01 to 0.05)	0.01	0.165	0.14
					Total effect white race	-2.4 (-4.0 to -0.74)	0.83	**0.004**	
					Direct effect PAS	0.02 (-0.01 to 0.04)	0.01	0.234	
					Indirect effect through BRS	0.00 (-0.00 to 0.01)	0.00	0.449	

Bold indicates statistically significant difference; BRS=Brief Resilience Scale; PAS=Psychological Adaptation Scale; PROMIS PF=Patient-Reported Outcomes Measurement Information System Physical Function.

Factors Associated with Pain Intensity

At baseline, men (β -0.91; 95% CI -1.8 to -0.04; P=0.041) and patients that self-described as white race (β -1.1; 95% CI -2.2 to 0.00; P=0.049), had lower pain intensity [Table 3]. White race was still independently associated after 3 months (β -2.7; 95% CI -4.6 to -0.77; P=0.008).

Discussion

Symptom intensity and physical limitations are affected by psychological distress and effectiveness of cognitive coping strategies in patients recovering from trauma (15). Resilience is the ability to adapt to stressful adverse events (16). The purpose of this study was to assess if greater resilience mediates the association of psychological adaptation with disability and pain. We found that resiliency, measured using the BRS, does not correlate with magnitude of limitations, and pain intensity in people with upper extremity injury, which made it impossible to study mediation.

The following limitations should be considered when interpreting our results. First, the sample size for the longitudinal part of the study is limited due to low participation rate 3 months after enrollment. Married patients, older patients, and patients with less physical limitations were more likely to participate at 3 months.

Performing the second evaluation by phone instead of by email might have improved participation (17). Second, this study was conducted with English-fluent traumatic upper extremity trauma patients in one large urban area, limiting the external validity of this study, as well as the racial and socioeconomic diversity. Third, 19 patients (8.9%) did not answer questions about having another pain condition, previous orthopaedic surgery, a previous orthopaedic condition, or use of opioids. We used complete case analyses for our main study as these variables were not of main interest to the study. Additionally, we used mean imputation for the missing data and reran our multivariable models [Appendix 3]. The only difference we found was that having a current psychological disorder was not independently associated with PROMIS PF at baseline anymore. No further differences were found. Fourth, 10 patients (9.3%) were included because they presented with acute pain they believed was related to trauma, but were eventually diagnosed with a non-traumatic disease (misperception of etiology).

We found that neither resilience nor psychological adaptability correlated with physical limitations or pain intensity in patients recovering from upper extremity trauma. This was an unexpected finding given the consistent association of measures of stress, distress, and less effective cognitive coping strategies with symptoms intensity and magnitude of limitations. For instance, greater self-efficacy is associated with less physical limitations in patients with elbow fractures and proximal humerus fractures (18,19). Our findings replicate those from a separate study, where neither measures of resilience nor psychological adaptability correlated with physical limitations nor pain intensity among people with non-traumatic upper extremity illness (20). The questions used to assess resilience ask about things such as recovering from stressful events or set-backs in life (12). People may have a tendency to identify with these statements, perhaps in an aspirational way, or thinking of themselves at their best (21). Consistent with the findings of the current study, Esteve et al. found that resilience was not associated with pain-related disability over time (22). In contrast, some studies have shown that resilience may be a protective factor for chronic pain (22–24). There are several measurements for resilience, for example the Connor-Davidson Resilience Scale (CD-RISC) or the Resilience Scale for Adults (RSA) (25,26). Neither the CD-RISC nor the RSA seem to assess the ability to adapt to painful disease. Using a scale that focuses on cognitions in response to nociception (e.g. catastrophic thinking, kinesiophobia, self-efficacy), may be preferred as it may get at one's inner voice in the moment and better measures important resiliency factors specific to the illness.

We found that a concurrent, diagnosed mental health disorder is associated with less resilience. Resilient individuals often use emotion regulation strategies, replacing less adaptive thoughts with more adaptive thoughts (27). A person with greater symptoms of depression or anxiety may have difficulty replacing less adaptive thoughts. More limited symptoms of anxiety is associated with greater resiliency (28). We did not measure symptoms of depression or anxiety, which are likely to have a stronger association than a diagnosed mental disorder, which can be well-treated or even misapplied.

The finding that a concurrent mental health disorder and current use of opioids were associated with greater physical limitations at enrollment further supports the link between mental health and physical health. A study by Uddin et al. suggested the fear-avoidance model, where pain-related outcomes as physical limitations are determined by psychological factors such as catastrophic thinking in response to nociception and pain-related fear (29). Greater pain intensity and greater use of opioids are also associated with less effective cognitive coping strategies and greater psychological distress (30–35).

The finding that men and white race were independently associated with lower pain intensity at enrollment likely reflects social standing and social health. More research is likely to identify that differences according to social constructions such as race and ethnicity are explained by psychological and social confounders rather than inherent racial characteristics or genetics (24,36–40).

The evidence that psychological adaptability and effective cognitive coping strategies limit pain intensity and magnitude of activity intolerance can be considered to reflect the cognitive aspects of resiliency. Our findings suggest that general measures of resilience (in other words, measures that are not specific to physical symptoms, pain in particular) are less well correlated with pain intensity and magnitude of activity intolerance. It seems that resilience in the context of musculoskeletal health may be quite specific to health thoughts (effective cognitive coping strategies) in response to nociception (pathophysiology of actual or potential tissue damage) - a concept for future studies.

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CN, JK, AG, TC, GV, and LR certify that they have no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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Ethical Committee Approval

This study received approval from the Institutional Review Board of the University of Texas at Austin. This study has been performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study has been carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act (HIPAA).

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