

CENTER FOR EPIDEMIOLOGIC STUDIES DEPRESSION SCALE (CES-D) FACTOR
STRUCTURE AMONG OLDER ADULTS WITH OSTEOARTHRITIS:
ASSOCIATIONS WITH PAIN AND DISABILITY

By

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ABSTRACT

This analysis evaluated the association of depressive factors with symptoms of osteoarthritis of the knee including pain and disability. Analyses used a sample of community-dwelling older adults. A comparison of potential confirmatory models for the Center for Epidemiologic Studies Depression (CES-D) Scale was performed. Resultant factors of depression were used to predict cross-sectional and longitudinal pain and disability after controlling for demographic and general health covariates. Results indicated a second-order four-factor model had the best fit in this population for the CES-D. In cross-sectional regressions the somatic/vegetative factor was the sole unique predictor of variance in pain of the CES-D factors individually. In addition, the CES-D factors as a group accounted for significant unique variance in both pain and disability. Longitudinal regressions found that CES-D factors as a group significantly predicted change in disability and change in pain over one year; however, none of the CES-D factors had significant coefficients. Results support a biopsychosocial evaluation of depression in osteoarthritis, suggest depression as a unidimensional construct predicts increased pain and disability, and support the continued use of the CES-D in community populations of older adults with osteoarthritis.

DEDICATION

This thesis is dedicated to everyone who helped me and guided me through the process of writing this manuscript. I would like to particularly thank my family and friends for helping me through the last three years.

LIST OF ABBREVIATIONS AND SYMBOLS

α	In statistical hypothesis testing, the probability of making a Type I error; Cronbach's index of internal consistency
df	Degrees of freedom: number of values free to vary after certain restrictions have been placed on the data
β	Population values of regression coefficients
F	Fisher's F ratio: A ratio of two variances
N	Statistical notation for total sample size
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value.
r	Estimate of the Pearson product-moment correlation coefficient
R^2	Multiple correlation squared; measure of strength of association
SD	Standard deviation
Δ	Increment of change
X^2	Satorra–Bentler scaled chi-square
<	Less than
>	Greater than
=	Equal to

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CONTENTS

ABSTRACT.....	II
DEDICATION.....	III
LIST OF ABBREVIATIONS AND SYMBOLS.....	IV
ACKNOWLEDGEMENTS.....	V
INTRODUCTION.....	1
METHODS.....	10
SAMPLE AND PROCEDURES.....	10
MEASURES.....	12
ANALYTIC PLAN.....	13
RESULTS.....	18
DISCUSSION.....	26
REFERENCES.....	32
APPENDIX.....	38

LIST OF TABLES

Table 1. Sample characteristics.....	12
Table 2. Fit indices for alternative models at time 1.....	19
Table 3. Factor correlations for the CES-D 4-factor model using Sheehan’s item allocation at time 1.	21
Table 4. Hierarchical regression of pain onto demographics, general health, and a four-factor model of the ces-d.....	23
Table 5. Hierarchical regression of disability onto demographics, arthritis history, general health, and a four-factor model of the ces-d.....	25

LIST OF FIGURES

1. Biopsychosocial Model of Depression in Osteoarthritis 3
2. Figure 2: Model 9, 2nd order 4-factor model, Sheehan Item Allocation..... 20

Introduction

Osteoarthritis (OA) can produce debilitating joint pain, swelling, and stiffness and is strongly associated with and a predictor of depression. Indeed, there is a call for research investigating the role of depression in persons with OA (Keefe et al., 2002). Such an investigation would benefit from the inclusion of potential outcomes of the combination of depression and OA including increased pain and disability. Confirmation of the factor structure of a depressive measure, the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), in OA would enable this research agenda by providing somatic and other depressive factors necessary for examining the potential differential roles of physical and mental health related to depression in OA, and their ability to predict pain and disability. Although there has been significant work on the factor structure of the CES-D in rheumatoid arthritis (RA), there is a dearth in the study of OA, an epidemiologically and etiologically disparate form of arthritis (Rhee et al., 1999; Sheehan, Fifield, Reisine, & Tennen, 1995). This analysis addresses this gap by investigating relevant factor structures, such as those supported in RA work, and determining a best fit model for the CES-D in an older adult OA sample. The best fit model was used to examine the associations of the factors of the CES-D with pain and disability in a sample of older adults with knee OA.

Depression, Pain, and Disability

Major depression is a primary health concern for older adults, affecting 5-10% of community residents with sequelae including increased morbidity through disability, functional decline, and reduced quality of life as well as increased mortality (Centers for Disease Control and Prevention, 2010; Charney et al., 2003; Lyness, Caine, King, Cox, & Yoediono, 1999). Osteoarthritis may increase risk for depression and other comorbidities (Gore, Tai, Sadosky,

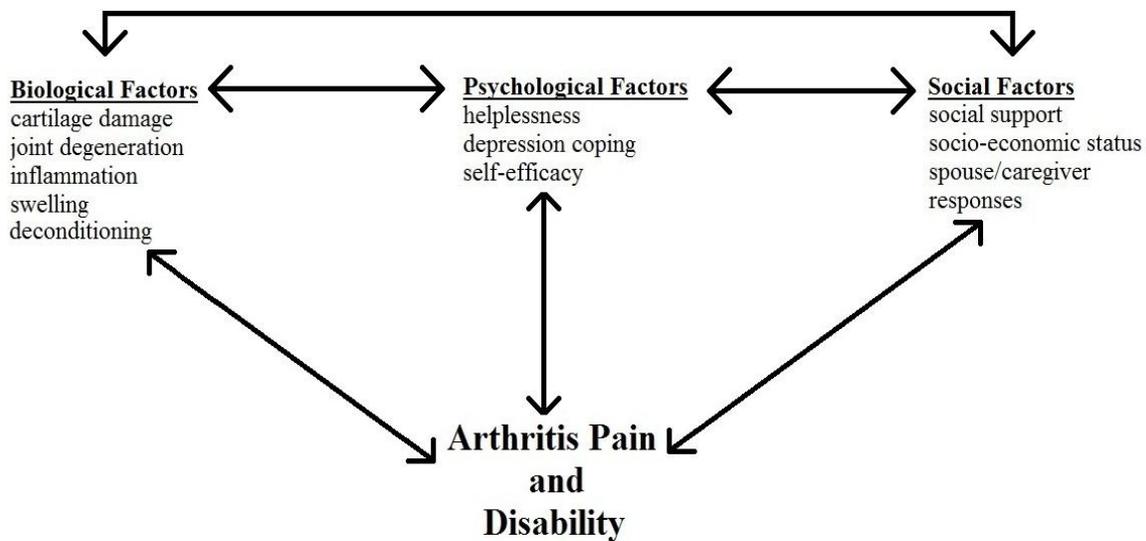
Leslie, & Stacey, 2011). Gore et al. (2011) found 12% of OA patients versus 6% of controls had depression in a sample of rheumatology clinic patients ($M = 57$ years old). They also report that patients with OA were significantly more likely to have comorbid conditions identified based on healthcare claims and linked ICD-9-CM (National Center for Health Statistics, 2006) diagnosis codes including musculoskeletal pain, neuropathic pain, anxiety, and sleep disorders.

Osteoarthritis is particularly worthy of concern given the aforementioned comorbidities; symptoms such as debilitating joint pain, swelling, and stiffness, and OA prevalence rates ranging between 50 - 80% of those 65 years and older (Felson and Zhang, 1998), and 80% for those 75 years and older (Cooper, 1995). Depression in OA is associated with worsening health outcomes through greater functional impairment and aggravated arthritic symptomatology. This emphasizes the importance of research on the associations of depression, pain, and disability in OA (Keefe et al., 2002).

Engel's biopsychosocial (BPS; 1977) model is a particularly useful framework for examining OA and associated depression, pain, and disability (Dieppe, 2011; Keefe et al., 2002). A BPS model of OA suggests that symptoms including pain and disability are affected by biological factors such as the disease process, as well as psychological and social factors (Keefe et al., 2002). Thus, the BPS model offers a systems perspective on OA in which changes in one portion of a system can effect changes in other parts of the system. Under this framework one would expect increased disease activity, a biological factor, to potentially lead to negative outcomes in both the psychological and social factors through depression, anxiety, and social isolation, which could in turn increase pain and disability. For example, depression and anxiety might lead a person with OA to stay home, relatively immobile, thereby eventually depriving osteoarthritic joints of supportive musculature, facilitating the breakdown of cartilage and

leading to greater pain and disability. Indeed, the literature generally supports cross-sectional and longitudinal associations among depression, pain, and disability both in the general population (Geerlings, Twisk, Beekman, Deeg, & van Tilburg, 2002) and in people with OA (Hawker et al., 2011; Dekker, Boot, van der Woude & Bijlsma, 1992). A summary of the BPS model of depression in OA is presented in Figure 1.

Figure 1: Biopsychosocial model of depression in osteoarthritis



Recent literature provides evidence for the associations proposed by a BPS model of OA. In one recent study of OA patients, researchers found that severity of depressive symptomatology was the single most important factor linked to pain intensity, and that lower body disability was the second most important factor (Rosemann, Laux, Szecsenyi, Wensing, & Grol, 2008). Literature on anxiety in OA also supports the associations proposed in the BPS model as noted in Figure 1. Specifically, researchers found pain catastrophizing explains

significant variance in pain severity as well as psychological and physical disability (Somers et al., 2009). Additionally, as noted above, there is support for an association between the symptoms of OA and depressive symptomatology (Gore et al., 2011). However, though the literature generally supports the associations laid out in the BPS model of OA, recent findings by Hawker et al. (2011) suggest potential controversy over the role of depression.

Hawker et al. (2011) used path modeling to examine longitudinal relations among pain, depression (CES-D), disability, and fatigue in older adults with OA. They found that: (a) current OA pain strongly predicted short- and long-term disability, but did not predict depression when controlling for disability and fatigue; (b) disability in turn predicted depressed mood and fatigue and led to worse OA pain; and (c) depression failed to predict anything except further depression. Hawker et al. (2011) note that depression's inability to predict pain was in opposition to their hypotheses, and find this surprising given literature that suggests depression amplifies pain sensitivity (Klauenberg et al., 2008; Strigo, Simmons, Matthews, Craig, & Paulus, 2008), and that depression interferes with pain medication adherence (DiMatteo, Lepper, & Croghan, 2000; Wing, Phelan, & Tate, 2002).

Indeed, the literature on chronic pain generally supports depression as predictive of poor pain outcomes including more pain complaints and greater impairment (Bair, Robinson, Katon, & Kroenke, 2003). Patients with pain and depression experience more pain complaints (Betrus, Elmore, & Hamilton, 1995), more intense pain (Lamb et al., 2000), and longer duration of pain (Burton, Tillotson, Main, & Hollus, 1995). This relationship also has strong longitudinal support from research that found that depression predicted change in musculoskeletal pain eight years out (Magni, Moreschi, Rigatti-Luchini, & Merskey, 1993). Though relatively sparse, there is also research that suggests depression's potential relationship to increased pain in OA, although

the research is limited by a study design that placed pain assessment at most a few weeks out from baseline (Zautra & Smith, 2001). The bulk of literature contrasting with Hawker et al. (2011) is not specific to OA and what little exists points to the need for further research on the associations among pain, depression, and disability. Thus, following the recommendations of Hawker et al. (2011), the present study adds to the literature by reexamining the associations of depression, pain, and disability.

The importance of this study's analyses can also be drawn generally from the somatization literature and specifically from questions surrounding the role of somatic symptoms in depression recognition (Kroenke, 2003). The literature indicates approximately two-thirds of depressed patients in primary care report only somatic symptoms, suggesting somatization of depressed mood may be the most common form of expression of depressive symptomatology in primary care, regardless of culture (Kroenke, 2003; Simon, Von Korff, Piccinelli, Fullerton, & Ormel, 1999). Unsurprisingly, there is continuing controversy among prevalence estimates for depression related to the confounding of somatic symptoms of depression with chronic illness and even normal aging processes. This is particularly important among older adults with OA, and unsurprising given life-long associations between depression and physical illness (Aneshensel, Frerichs, & Huba, 1984; Moldin et al., 1993). Somatic issues such as insomnia, weight change, and fatigue act as symptoms both of depression and of chronic disease, increasing the difficulty of differential diagnosis (Cole & Dendukuri, 2003; Lavidor, Weller, & Babkoff, 2002; Wallace & Schwartz, 1997). Indeed, research has found that fewer than 50% of patients with depression are correctly classified by their primary care physician (Cepoui et al., 2007; Jackson, Passamonti, & Kroenke, 2007).

Arguments for criterion contamination add further weight to the need to re-examine the structure of the CES-D in a sample with OA. Research has supported a bias related to somatic items on depressive measures such as the CES-D (Blalock, DeVellis, Brown, & Wallston, 1989; Callahan, Kaplan, & Pincus, 1991). Blalock et al. (1989) reported four items on the CES-D may be affected by RA symptomatology including: “I felt that everything I did was an effort,” “I felt hopeful about the future,” “My sleep was restless,” and “I could not get going.” Blalock et al. (1989) suggest these items may not reflect depression so much as the disease process, potentially inhibiting accurate prevalence and severity assessment of depression in patients with RA. Furthermore, Callahan et al. (1991) found that some items on commonly used depression scales, including the CES-D, differed between RA and control patients regardless of psychological status—additional evidence for the potential biasing effect of somatic items.

However, there is evidence to the contrary in the literature, suggesting no bias due to somatic symptoms in the prevalence of depression among older adults. Radloff and Teri (1986) performed a qualitative review of studies using the CES-D with older adults and found that somatic item scores did not disproportionately affect the total score. Davidson, Feldman, & Crawford (1994) looked at disabled and frail elderly and similarly found no support for a disproportionate effect of the CES-D somatic items on the CES-D total symptom score. While contrasting evidence presented so far is not specific to OA, more recent research has been published based on an OA sample. Parmelee, Harralson, McPherron, DeCoster, and Schumacher (2012) found no evidence for confounding of physical and mental health symptoms in a sample of 363 older adults with OA, when comparing analyses using CES-D total scale scores with and without items tapping somatic symptoms. Despite this strongly related result, the conflicting

evidence in RA suggests reason for caution in generalizing the CES-D factor structure to populations with chronic disease.

Assessment of Depression

Among depression screening measures, the CES-D and Geriatric Depression Scale (GDS; Yesavage et al., 1982-1983) are two of the most commonly used for older adults. Both scales have been found to be valid and reliable measures for older adults in the community (Lewinsohn, Seeley, Roberts, & Allen, 1997; Yesavage et al., 1982-1983). The two have been suggested to have the most potential of the various screening measures given considerations including physician time and patient comfort; they are both free, relatively easy to score, and brief (Scogin & Shah, 2006). Scogin and Shah (2006) suggest the GDS may be better at achieving patient comfort in some samples given its yes-no response format. However, while the yes-no format may be advantageous for people with incipient cognitive impairment or low literacy (Scogin & Shah, 2006), it may not be as acceptable to literate older adults without impairment.

Parmelee and Katz (1995) examined responses to the CES-D and GDS in three samples of frail older adults including one group in long-term care and two in the community, one with breast cancer and the other with OA. They found that the community samples with breast cancer and OA had fewer missing items on the CES-D compared to the GDS, and that CES-D scores more closely matched a DSM-III-R (American Psychiatric Association, 1987) depression checklist. The reverse was found in long-term care patients: fewer missing items on the GDS versus CES-D and the GDS was a better match to the DSM-III-R depression checklist. This suggests the CES-D may be preferable to the GDS in community older adults who are not cognitively impaired. As a result the CES-D is likely to continue in common use in research as

evidenced by the body of literature on the CES-D (Shafer, 2006). This strongly suggests the need for continued research on this particular depressive measure.

The CES-D is suggested to have four factors including depressed affect (DA), positive affect (PA), somatic vegetative (SV), and interpersonal (IP; Radloff, 1977). Radloff's four-factor model has been replicated and affirmed through multiple studies and summarized using meta-analytic techniques (Shafer, 2006). Shafer's meta-analysis supported the four-factor model based on 28 studies between 1977 and 2001 covering 22,340 people including patients, adults, and students; average sample size was 797. Although the four-factor model is strongly supported generally, population subset factor structure differences, such as those associated with culture and minority status, suggest caution in generalizing.

The CES-D factor structure has been analyzed in RA samples with somewhat varying results. Fifield and Reisine (1992) found support for a three factor solution using principal component analysis in a sample of patients with RA. In their analyses, they compared patients diagnosed less than three years ago to those diagnosed more than three years past and found differing item loadings suggesting two versions of the three factor solution. For newly diagnosed patients the three factors were PA/DA, SV, and IP; whereas, for those with long-term diagnoses the three factors were DA/SV, PA, and IP. In contrast, Sheehan, Fifield, Reisine, and Tennen (1995) compared one, three, four, and second-order factor models and found the four-factor structure as the best fit. Rhee et al. (1999), noting Sheehan et al.'s differing item allocation versus Radloff (1977), contrasted the two item allocations again on one, three, four, and second-order factor models, with the addition of the second three factor found by Fifield and Reisine (1992) which combined DA and SV. In short, despite potentially stronger support for the four-factor model, in accord with the general population, the contrasting support for three-

and four-factor models suggests caution in generalization. This is particularly relevant to the current project given the lack of evidence in osteoarthritic samples. Indeed, no prior analysis of the factor structure of the CES-D in a sample of older adults with OA could be found. This is strong evidence for the importance of establishing the CES-D factor structure in this population prior to analyzing associations of depression, pain, and disability in OA.

Aims and Hypotheses

In summary, application of the BSP model to older adults with OA suggests likely predictive associations of psychological factors with social and biological factors in addition to symptoms of OA such as pain and disability. However, literature on depression in OA is relatively sparse and in contrast to a large literature supporting associations of pain and disability with depression, one recent study suggests depression may not predict pain or disability. Evidence for criterion contamination in the CES-D is also mixed, thus leaving the question open on the role of somatic and emotional symptoms in the relationships among depression, pain, and disability. The literature also lacks a factor analysis of the CES-D in a sample with OA. To fill this gap the analyses herein first confirm the best fit factor structure for the CES-D in OA, as an independently useful but also necessary step in order to examine the differential role of somatic and other depressive symptom factors in predicting pain and disability in a sample with OA. The project had three aims: (a) to test single, three, four, and second-order factor models using both the Radloff (1977) and Sheehan, Fifield, Reisine, and Tennen (1995) item allocations as detailed in Rhee et al. (1999); (b) to compare the factor structures and identify a best fit model; (c) to examine the cross sectional and longitudinal relations of the resulting best fit model's CES-D factors with pain and disability.

It was hypothesized that the first-order four-factor structural model using Radloff's (1977) item allocation would best fit the data as found in structure comparisons in RA populations. However, differences among the first-order four-factor models and the second-order models and comparisons between the differing item allocations were expected to be minor. Second, it was hypothesized that depressed mood would be associated with pain and disability. Specifically, the DA and SV factors of the best fit model for the CES-D were predicted to be associated cross sectionally and longitudinally with pain and disability, based on related findings in RA (Beckham et al., 1992; Fifield et al., 1998; Keefe et al., 2002) and OA (Hawker et al., 2011).

Methods

Sample and Procedures

This study applied secondary data analytic methods to a data set based on research conducted at the Philadelphia Geriatric Center and the University of Pennsylvania. The original study was supported by the National Institute of Mental Health grant 1-R01-MH51800 to Dr. Patricia Parmelee. Drawing from the original data set, the current analysis used the entire sample of 369 greater Philadelphia residents with physician-confirmed OA of the knee; because of missing values, the sample size was slightly smaller for confirmatory factor analyses (see page 15). Participants in the original study were recruited from a variety of sites including roughly half from public service announcements in newspapers and on the radio (48.2%). The remainder were recruited from a university rheumatology clinic (14.6%), Veteran's Affairs Medical Center (12.2%), two general geriatric outpatient clinics (12.2%), and participants from a previous study of OA. Study eligibility criteria included: (a) a medical diagnosis of OA of the knee confirmed through either chart review or contact with physician; and (b) minimum of 50 years age. Study

exclusion criteria included: (a) cognitive impairment (< 6 on the Short Portable Mental Status questionnaire; Pfeiffer, 1975); (b) inability to complete the interview in English; (c) additional rheumatological disorder potentially confounding with OA; (d) other life threatening or severely disabling physical illness (e.g., cancer, chronic obstructive pulmonary disease); and (e) participation in other OA related research in past 6 months.

Recruitment methods for the original study were IRB-approved at participating institutions. At Time 1 (T1), potential participants were screened by telephone and were mailed consent forms and questionnaires if eligible. Forms were retrieved within two weeks during an in-person interview to collect additional data. All participants were contacted a year later at Time 2 (T2) for follow-up assessment.

Baseline participants (Table 1, Time 1) were a majority female, White, slightly more than half with income <\$20,000 per year, and approximately half with one year of college or more. At follow-up (Table 1, Time 2) 294 T2 completers (79%) remained. Attrition, overwhelmingly due to refusal, was greatest among T1 participants who were younger, nonwhite, more poorly educated, in poorer perceived health, and greater pain and disability. Based on a widely used 16 point cutoff for likely depression on the CES-D, 24.2% met criteria for probable significant depression. A summary of sample characteristics is presented in Table 1.

Table 1. Sample characteristics

	Time 1	Time 2
	Baseline N = 369	One Year Follow-up N = 294
Characteristic	<i>n</i> (%)	<i>n</i> (%)
Age	68 (10) ^a	69 (10) ^a
Female	236 (64)	194 (53)
Income <\$20,000	159 (55)	96 (44)
Education 1+ years college	187 (51)	157 (54)
Number of joint problems	2.7 (2.1) ^a	---
Number of health conditions	2.6 (2.1) ^a	---
CES-D (0 – 60)	11 (10) ^a	10 (9) ^a

Note: OA = osteoarthritis.

- a. Values represent mean and standard deviation (within parentheses).
- b. Higher values represent worse self-rated health

Measures

Demographic characteristics. Variables included age, sex, ethnicity (white vs. nonwhite), income (8 categories, “under \$10,000” to “more than \$70,000”), and education (7-point scale).

Depressive symptomatology. The Center for Epidemiological Studies Depression Scale is a 20-item scale designed to assess depressive symptomatology over the past week (CES-D; Radloff, 1977), T1 $\alpha = .891$. Items scores range from 0 to 3, indicating increasing frequency of

symptoms over the past week, resulting in a scale score range of 0-60. Higher scores indicate greater depressive symptomatology. The CES-D has demonstrated good internal consistency for use among the elderly, ranging from .86 to .89 (Schein & Koenig, 1997).

General health covariates. (a) A joint count, specific to OA, assessed up to nine problem sites other than the knee. (b) A count of comorbid health conditions from a checklist of 31 conditions (e.g., flu, diabetes, high blood pressure), where higher scores represented more coexisting health problems.

Health outcomes. (a) Pain intensity was measured with the six-item Philadelphia Geriatric Center Pain Scale (Parmelee, Katz, & Lawton, 1991), T1 $\alpha = .84$. (b) Functional disability was assessed using Arthritis Impact Measurement Scales, 2nd Edition (AIMS-2; Meenan, Mason, Anderson, Guccione, & Kazis, 1992). This 78 item questionnaire has 12 subscales of which six were used tapping mobility, walking and bending, hand and finger function, arm function, self-care and household tasks for a total of 28 items, T1 $\alpha = .504$. On the AIMS-2, higher scores indicate greater impairment. The measure has demonstrated acceptable to excellent internal consistency for persons with OA, ranging from .74 to .96 (Meenan et al., 1992).

Analytic Plan

Data were generated and prepared using PRELIS and confirmatory factor analyses were performed using LISREL to compare nine structural models for the CES-D (Version 8.80, Jöreskog & Sörbom, 2006). All three-factor and four-factor models were tested twice using differing item allocations as per Radloff's (1977) item allocation (fearful and failure items load on the depressed affect factor) and the Sheehan, Fifield, Reisine, and Tennen (1995) item

allocation (fearful and failure load on the interpersonal factor). Models chosen were intended to assess research supported structural models for adults with chronic pain. Models included: model 1, a one-factor model; model 2, a three-factor model combining the depressed affect and positive affect factors using Radloff's item allocation; model 3, a repeat of 2 with Sheehan's item allocation; model 4, a three-factor model combining the depressed affect and positive factors using Radloff's item allocation; model 5, a repeat of 4 with Sheehan's item allocation; model 6, a four-factor model with Radloff's item allocation; model 7, a 4-factor model with Sheehan's item allocation; model 8, a model with four factors predicting a second-order depression factor using Radloff's item allocation; and model 9, a repeat of 8 with Sheehan's item allocation (Brown, 1990; Fifield & Reisine, 1992; Morin et al., 2011; Rhee et al., 1999; Sheehan, Fifield, Reisine, & Tennen, 1995).

Confirmatory factor analysis is commonly performed using maximum likelihood (ML) which assumes continuous and normally distributed observed variables. The CES-D uses a four-point Likert-type ordinal scale and scores tend to cluster on one end, violating normality and suggesting the need for alternative methods. Furthermore, analysis of the CES-D data for multivariate skewness ($p < .001$) and kurtosis ($p < .001$) were both significant, as was a chi-square test for multivariate normality, $X^2 = 1982.279, p < .001$, all suggesting evidence for non-normality. Polychoric correlations have been shown to be robust to violations of normality (Quiroga, 1992). Furthermore, confirmatory factor analysis using the diagonally weighted least squares (DWLS) procedure has resulted in more accurate parameter estimates and a model fit that is more robust to variable type and non-normality in comparison to ML (Flora & Curran, 2004; Forero, Maydeu-Olivares, & Gallardo-Pujol, 2009; Mindrila, 2010). Accordingly, this analysis used PRELIS to generate a polychoric correlation matrix based on CES-D data and to

produce an asymptotic covariance matrix. Missing data points were identified in PRELIS and dealt with listwise. This resulted in an effective sample size of 347 for the confirmatory analysis. LISREL was then used to run the DWLS procedure based on the polychoric correlation matrix and using the asymptotic variance from the asymptotic covariance matrix to conduct the confirmatory factor analyses.

Model fit was assessed using the chi-square statistic and the Root Mean Square Error of Approximation (RMSEA; Browne & Cudeck, 1993). The chi-square statistic divided by degrees of freedom was used as an initial measure of fit where values of 2 or less indicated a good fit (Rhee et al., 1999). The RMSEA served as a second measure of fit where models with RMSEA values $<.08$ and $<.06$ indicated adequate and good model fit respectively (Hu & Bentler, 2007).

Recent reports suggest applying several modifications to chi-square difference tests used for model comparison that are relevant to the current project (Bryant & Satorra, in press; Satorra & Bentler, 2010). First, multivariate non-normality, such as found in this study, may distort overall goodness-of-fit statistics (Kaplan, 2000). To address this issue, these analyses applied a scaling correction factor developed by Satorra and Bentler (1988, 1994). Second, Bryant and Satorra (in press) note that LISREL 8 software bases the Satorra-Bentler (SB) chi-square value on a rescaling of the normal-theory weighted least-squares (NTWLS) chi-square. This is as opposed to the maximum-likelihood (ML) minimum-fit function chi-square used in EQS 6 (Bentler, 1995) and Mplus 6 (Muthen & Muthen, 2007). Bryant and Satorra (in press) argue that this results in either miscomputed chi-square difference tests or false comparisons between program results. For comparative purposes, they recommend and detail a technique for manipulating LISREL results to transform the NTWLS chi-square into ML chi-square. Accordingly, this analysis reports SB chi-square values based on ML chi-squares. A third issue

arises out of the potential for negative values in scaled difference testing, which represent a failure of the asymptotic approximation (Bryant & Satorra, in press). Bryant and Satorra (in press) report that the use of ML chi-square based SB values in chi-square difference tests reduces the likelihood of obtaining negative values. However, the current set of analyses resulted in a negative scaling correction value, and thus negative difference test results. To resolve this, Satorra and Bentler's (2010) improved scaling correction procedure was applied to ensure positive results for the scaled difference chi-square test statistic (Bryant & Satorra, in press).

Model comparison was performed using chi-square difference tests as detailed above and the Akaike Information Criterion (AIC; Akaike, 1973). In SEM, nested models can be compared using a chi-square difference. Thus, models 1, 2, 4, and 6 were compared with the chi-square statistic as were models 1, 3, 5, and 7. A test of significant difference cannot be performed for non-nested models. In this case, a best fit model was chosen using both the AIC index, where lower values indicated better fit, and using the lowest RMSEA value, ideally $< .05$ (Browne & Cudeck, 1992; Rhee et al., 1999). The chosen structural model for the CES-D was used to derive factor item composites for use in further analyses.

The depressive symptom factor item composites were used to investigate the relationship of the CES-D factors with pain and disability. Symptom factor item composites were generated based on the mean value for relevant items, with 20% maximum missing data. The symptom composites resulted in a sample size of 353 individuals for regression analyses. Analyses used ordinary least squares regression (OLS) with hierarchical block entry of variable classes. Ordinary least squares was used as opposed to ML as a result of both the limited T2 sample size and the complexity of hypothesized associations. Initial OLS regression was used to identify significant covariates of pain and disability for statistical control, including demographics (age,

sex, race, income, and education) as well as significant general health covariates (joint count and count of comorbid health conditions). Cross-sectional OLS hierarchical analyses then examined demographic influences on time 1 (T1) pain. Analysis then entered joint count and count of health conditions in a second step. Analysis then entered the depressive factor item composites in a third step. This three step hierarchical regression was repeated using T1 disability as the dependent variable. Longitudinal OLS hierarchical analyses was used to examine change in pain and disability at Time 2 (T2). For the analysis of T2 pain, T1 pain was entered in the first step, demographics were entered in the second step, general health covariates were entered in the third step, and the depressive factor item composites were entered in the fourth step. This four step hierarchical regression was repeated for T2 disability as the dependent variable.

A power analysis for a-priori sample size suggested a minimum sample of 122 given a medium effect size, $\beta = .80$, 11 predictors, and $\alpha = .05$; alternatively, to detect a small effect size, the study would need at least 847 participants. With 369 baseline participants, this analysis precluded the detection of small effect sizes, but had adequate power for detecting medium effects.

Results supporting the somatic factor predicting pain and disability in isolation, with nonsignificant results for the other depression factors, would suggest potential support for the physical symptoms of depression driving the association with pain or disability. Results suggesting no support for the somatic factor's predictive ability, but support for another factor, would support the psychosocial symptoms of depression as driving the association of depression and pain or disability. Results of the somatic factor and other factors simultaneously predicting either pain or disability might suggest that the confluence of physical and mental symptoms of depression drive the associations of depression with pain and/or disability.

Results

CES-D Factor Structure

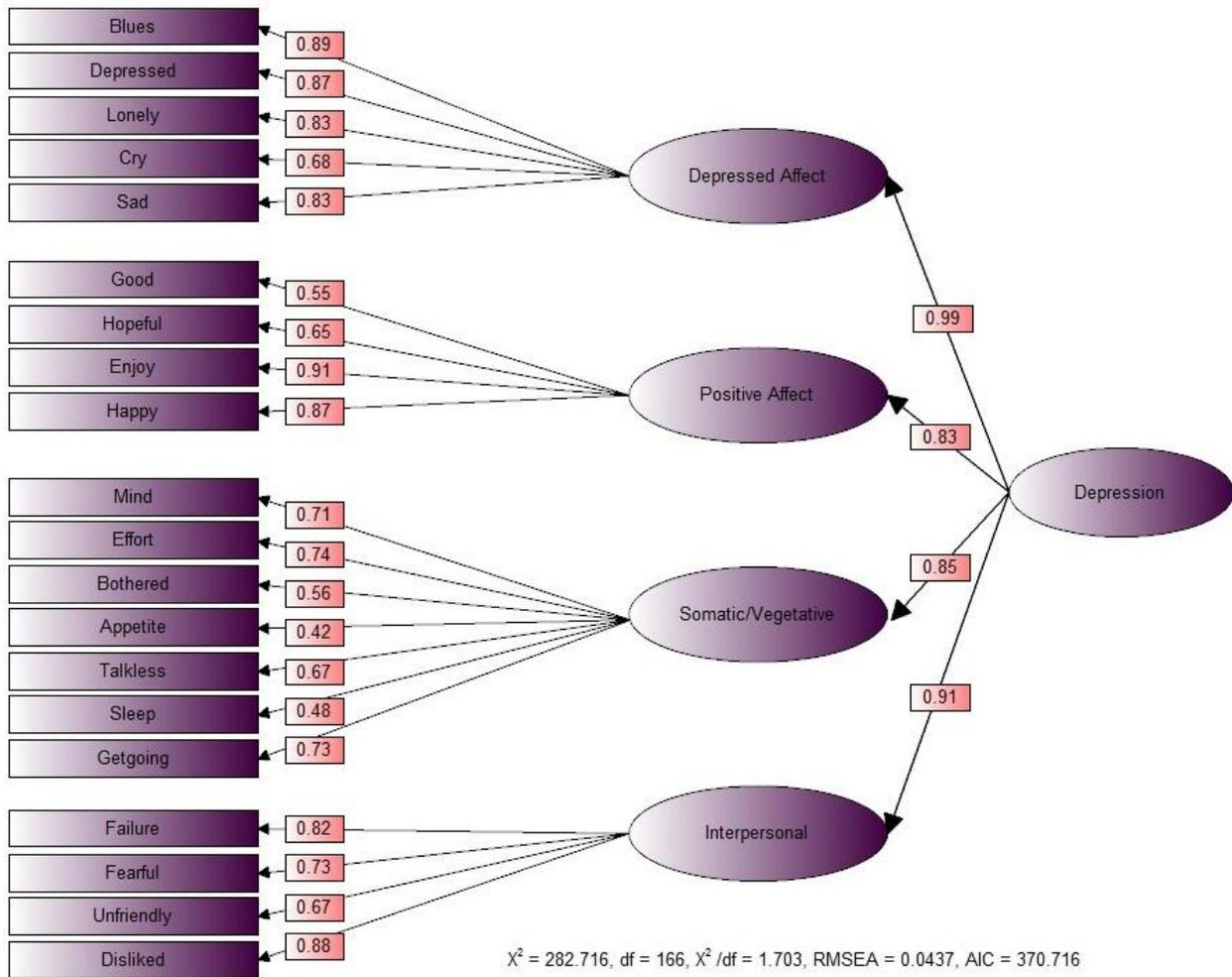
Results of confirmatory factor analyses (CFA) comparing nine models based on both Sheehan, Fifiield, Reisine, and Tennen's (1995) and Radloff's (1977) item allocations are presented in Table 2. Four-factor and second-order models all had better fit versus three-factor models and the one factor model as assessed by the AIC. Differences were minimal among the four-factor and second-order model using both Radloff and Sheehan's item allocations. Given the potential equivalent fit of these four alternate models, remaining analyses were conducted using the factor model with the best absolute AIC value. Thus, the remaining analyses were conducted using model 9, a second-order four-factor model using Sheehan's item allocation, as shown in Figure 2.

Table 2. Fit indices for alternative models at Time 1

Model	X^2	df	X^2/df	RMSEA	AIC
Independence	14801.035	190	77.9		14841.035
Model 1: 1 factor	411.897	170	2.423	0.0622	491.897
Model 2: 3 factors (DA+PA, SV, IP), Radloff	336.486	167	2.015	0.0525	422.486
Model 3: 3 factors (DA+PA, SV, IP), Sheehan	333.809	167	1.999	0.0521	419.809
Model 4: 3 factors (DA+SV, PA, IP), Radloff	314.870	167	1.885	0.0491	400.870
Model 5: 3 factors (DA+SV, PA, IP), Sheehan	309.995	167	1.856	0.0482	395.995
Model 6: 4 factors, Radloff	284.069	164	1.732	0.0446	376.069
Model 7: 4 factors, Sheehan	280.213	164	1.709	0.0439	372.213
Model 8: 2 nd order 4-factor, Radloff	283.529	166	1.708	0.0439	371.529
Model 9: 2 nd order 4-factor, Sheehan	282.716	166	1.703	0.0437	370.716

Note: X^2 = Satorra–Bentler scaled chi square; df = degrees of freedom; RMSEA = root mean square error of approximation; AIC = Akaike information criterion; DA = depressed affect; PA = positive affect; SV = somatic/vegetative; IP = interpersonal.

Figure 2: Model 9, 2nd order 4-factor model, Sheehan Item Allocation



Based on these findings, symptom cluster composites were computed representing Depressed Affect ($\alpha = .836$), Positive Affect ($\alpha = .729$), Somatic/Vegetative ($\alpha = .717$), and Interpersonal ($\alpha = .674$). The symptom composites were generated, allowing for 20% maximum missing data, resulting in a sample size of 353 individuals for regression analyses. The four symptom composites were moderately correlated, with significant correlations ranging between 0.479 - 0.641, as described in Table 3.

Table 3. Factor correlations for the CES-D 4-factor model using Sheehan’s item allocation at Time 1.

Factor	DA	PA	SV	IP
DA	—	.625	.639	.641
PA	.625	—	.486	.479
SV	.639	.486	—	.497
IP	.641	.479	.497	—

Note: DA = depressed affect, PA = positive affect, SV = somatic/vegetative, IP = interpersonal

Note: All correlations were significant at $p < .001$

Covariates of Pain and Disability

Initial OLS regressions identified significant covariates of pain and disability including demographics and significant general health covariates. Analyses of pain began with blockwise entry of significant demographics, $p < .05$, including sex, $\beta = .153$, income, $\beta = -.156$, and education, $\beta = -.110$, $\Delta F(5, 363) = 5.888$, $p < .001$. At step two, the only significant general health covariate was number of joint problems, $\beta = .407$, $\Delta F(2, 361) = 40.775$, $p < .001$.

Analyses of disability began with blockwise entry of significant demographics, $p < .05$, including age, $\beta = .111$, sex, $\beta = .126$, and income, $\beta = -.212$, and in addition, a marginal effect of education, $\beta = -.098$, $\Delta F(5, 363) = 10.249$, $p < .001$. At step two of disability, significant general health covariates, $p < .001$, included both number of health conditions, $\beta = .302$, and number of joint problems, $\beta = .326$, $\Delta F(2, 361) = 66.551$, $p < .001$. As a result of these analyses, all covariates save race were included in primary analyses.

Analyses of CES-D Factors with Pain

Cross-sectional OLS regressions assessed the relation of pain with CES-D factors including: DA, PA, SV, and IP. Variables were entered blockwise with demographics in the first step, general health covariates in the second step, and CES-D factors in the third step, as presented in Table 4. After controlling for demographic, $\Delta F(4, 348) = 8.011, p < .001$, and general health covariates, $\Delta F(2, 346) = 38.713, p < .001$, CES-D factors as a whole were significantly associated with pain, $\Delta F(4, 342) = 12.154, p < .001$. Somatic/Vegetative was the sole significant coefficient, $\beta = .326$, though IP was marginal, $\beta = -.100$.

Longitudinal OLS regressions assessed the ability of CES-D factors to predict change in pain from baseline to T2 after controlling for T1 pain in the first step, demographics in the second step, and general health covariates in the third step, as seen in Table 4. In step two, demographics failed significantly to add to explained variance, $\Delta F(4, 274) = 1.247, p = .291$, but general health covariates in step three were significant, $\Delta F(2, 272) = 15.300, p < .001$. In step four, CES-D factors significantly predicted change in pain as a group, $\Delta F(4, 268) = 2.766, p = .028$; however, none of the CES-D factors were significant coefficients individually.

Table 4. Hierarchical regression of pain onto demographics, general health, and a four-factor model of the CES-D

Regressed onto Disability:	Cross Sectional – Final Step 3			Longitudinal– Final Step 4		
	Adjusted			Adjusted		
	R	R ²	β	R	R ²	β
	.587	.326		.719	.497	
Pain Time 1						.504 ^a
Age			-.099 ^b			-.018
Sex			.068			.019
Income			-.070			-.016
Education			-.083 ^b			-.030
Number of Health Conditions			.003			.177 ^a
Number of Joint Problems			.361 ^a			.148 ^a
Depressed Affect			.012			.048
Positive Affect			.063			.111 ^b
Somatic Vegetative			.342 ^a			.066
Interpersonal			-.100 ^b			-.096 ^b

Note: Cross-sectional: Step 3, $\Delta F(4,348) = 8.011, p < .001$.

Note: Longitudinal: Step 4, $\Delta F(4,268) = 2.766, p = .028$.

^a = $p < .05$

^b = $.10 > p > .05$

Analyses of CES-D Factors with Disability

Cross-sectional OLS regressions assessed the relation of disability with CES-D factors similar to cross-sectional analyses of pain. Analysis controlled for demographics in the first step, general health covariates in the second step, and then entered CES-D factors in the third step, see Table 5. After controlling for demographic, $\Delta F(4, 348) = 12.203, p < .001$, and general health covariates, $\Delta F(2, 346) = 65.049, p < .001$, CES-D factors as a whole were significantly associated with pain, $\Delta F(4, 342) = 3.887, p = .004$; however, none of the CES-D factors were significant coefficients, though SV was marginal, $\beta = .103$.

Longitudinal OLS regressions assessed the ability of CES-D factors to predict change in disability over one year after controlling for T1 disability in the first step, demographics in the second step, and general health covariates in the third step, see Table 5. After controlling for demographics, $\Delta F(4, 274) = 6.918, p < .001$, and general health covariates, $\Delta F(2, 272) = 11.495, p < .001$, CES-D factors as a group significantly predicted change in disability, $\Delta F(4, 268) = 4.729, p = .001$; however, none of the CES-D factors had significant coefficients, though both PA, $\beta = .079$, and SV, $\beta = .088$, were marginal.

Table 5. Hierarchical regression of disability onto demographics, arthritis history, general health, and a four-factor model of the CES-D

Regressed onto Disability:	Cross Sectional – Final Step 3			Longitudinal– Final Step 4		
	R	Adjusted R ²	β	R	Adjusted R ²	β
	.625	.373		.828	.672	
Disability Time 1						.569 ^a
Age			.041			.108 ^a
Sex			.060			.055
Income			-.128 ^a			.016
Education			-.070			-.118 ^a
Number of Health Conditions			.283 ^a			.078 ^a
Number of Joint Problems			.299 ^a			.157 ^a
Depressed Affect			.058			.061
Positive Affect			.080			.079 ^b
Somatic Vegetative			.103 ^b			.088 ^b
Interpersonal			-.055			-.061

Note: Cross-sectional: Step 3, $\Delta F(4,342) = 3.887, p = .004$.

Note: Longitudinal: Step 4, $\Delta F(4,268) = 4.729, p = .001$.

^a = $p < .05$

^b = $.10 > p > .05$

Discussion

Confirmatory Factor Analyses

Despite broad application of the CES-D and longstanding support for its factor structure, this analysis produced the first confirmation of the factor structure of the CES-D in a population of older adults with OA. Use of the DWLS procedure was suggested by the ordinal nature of the CES-D and likely non-normality. This analytic plan was supported by significant multivariate skewness and kurtosis as well as a chi-square test for multivariate normality.

In this sample the four-factor and second-order models using both Radloff and Sheehan's item allocations all had good fit and similar AIC values, suggesting possible equivalence. The four-factor and second-order models all had better fit than the three-factor models as well as the one-factor model. This result suggests, first, that the CES-D may have a four-factor structure in older adults with OA similar to that for other populations. This evidence for a four-factor solution also fails to support the findings of Fifield and Reisine (1992), suggesting that the DA, SV, and IP items all load on separate factors. The first-order four-factor structure of the best-fit model is in line with support for a four-factor structure in the general population (Shafer, 2006) and with a portion of the literature on people with RA (Rhee et al., 1999; Sheehan, Fifield, Reisine, & Tennen, 1995). It is also noteworthy that the strong fit of both second-order models suggests that despite the four first-order factors, the instrument may also be described as unidimensional.

There was no single best-fit model, given the equivalence of the top four models' AIC and RMSEA fit indices, against study hypotheses. This finding agrees with the results of Sheehan et al. (1995) and the findings of Rhee et al. (1999) in supporting the four-factor and second-order models over three-factor and one-factor models. However, the equivalence of

models using Radloff versus Sheehan item allocations makes it difficult to comment on the superiority of either item allocation in OA samples. This suggests ambiguity over allocating the items, “I thought my life had been a failure,” and “I felt fearful” to either the IP or DA factors in OA. Ambiguity over item allocations at the first-order provides further support for the utility of second-order models and unidimensional interpretations of the CES-D in OA.

CES-D Factors and Item Loadings

Despite relative equivalence of the top four models, further study hypotheses were pursued. Symptom clusters were computed and used to examine associations of depression, disability, and pain all based on the model with the best absolute AIC value (model 9). It was hypothesized that depressed affect and somatic/vegetative factors of the CES-D would cross-sectionally and longitudinally predict pain and disability. This was based on an examination of the biopsychosocial (BPS) model for depression in OA as well as the majority of literature on depression, pain, and disability in chronic illness generally and arthritis specifically.

Factor loadings for the symptom clusters suggest potential issues in the somatic/vegetative factor. This factor was labeled following the convention seen in related literature (Rhee et al., 1999; Sheehan et al., 1995), which in turn is similar to the label used in the general literature on the CES-D, *somatic and retarded activity* (Radloff, 1977; Shafer, 2006). Yet, the label *somatic/vegetative* and the label *somatic and retarded activity* both seem potentially misrepresentative. In this sample the factor labeled *somatic/vegetative* was most strongly identified by items including, “I had trouble keeping my mind on what I was doing,” “I felt that everything I did was an effort,” “I could not get going,” and to a lesser extent, “I talked less than usual.” These items all seem less related to somatic or vegetative processes and more related to cognition and motivation. In comparison to related work by Sheehan et al. (1995),

Rhee (1999), and Radloff (1977), in this sample, the item loadings for SV were more sharply divided between the motivation and cognition items and the more purely somatic/vegetative items such as “I did not feel like eating; my appetite was poor” and “My sleep was restless.” In this analysis, effort had the highest loading for SV at .74, whereas appetite had the lowest loading at .42. In contrast, the more purely somatic/vegetative items appetite and sleep had higher loadings in results reported by Sheehan et al. (1995), Rhee (1999), and Radloff (1977) in all but one case. Hence, as just noted, the SV factor for this sample appears most strongly to represent elements of motivation and cognition. Given the prior evidence, it is possible that the items may load differently in other samples as well, suggesting the need for replication in other samples of older adults with OA.

Primary Regression Hypotheses

In a cross-sectional analysis of pain, the SV factor accounted for a significant portion of variance after accounting for covariates; this is in agreement with this study’s hypotheses. If the SV factor is tapping elements of disability related to OA, this finding is reasonable given strong support for disability’s association with pain in OA (Hawker et al., 2011; Rosemann, Laux, Szecsenyi, Wensing, & Grol, 2008). If the SV factor is instead more representative of somatic elements of depression, this finding contrasts with Hawker et al. (2011); however, it agrees with the majority of the literature in chronic illness and OA specifically, which posits depression as a predictor of poor pain outcomes broadly (Bair, Robinson, Katon, & Kroenke, 2003; Klauenberg et al., 2008; Rosemann et al., 2008; Strigo, Simmons, Matthews, Craig, & Paulus, 2008).

The SV factor of the CES-D did not predict longitudinal changes in disability, which suggests a lack of support for criterion contamination in the CES-D. This is in contrast to findings in RA (Blalock, DeVellis, Brown, & Wallston, 1989; Callahan, Kaplan, & Pincus,

1991), but in agreement with other literature on criterion contamination in older adults and the chronically ill (Davidson, Feldman, & Crawford, 1994; Radloff & Teri, 1986). This is also consistent with findings in OA (Parmelee, Harralson, McPherron, & Schumacher, in press). However, results for the longitudinal analysis of disability produced a marginal result for both PA and SV. This tempers conclusions regarding criterion contamination and suggests that the potential confluence of physical and mental symptoms of depression may have some effect on the overall association of depression with disability.

In the cross-sectional analysis of disability and in both longitudinal analyses of pain and disability, the results were against hypotheses. The CES-D factors as a whole were significant predictors, but individual factors did not achieve significance in the regression equations. These results are in contrast to a BPS model interpretation of depression in OA as well as much of the literature on the associations of depression with pain and disability in OA.

An Alternative Interpretation

The aforementioned results suggest a high potential for multicollinearity among the CES-D factors. The multicollinearity is suggested by the lack of significant CES-D factor coefficients in longitudinal analyses. Moderate correlations among the factors provide further support for multicollinearity, ranging between .479 and .641. Multicollinearity among the CES-D factors is one explanation of the general lack of support for hypotheses. Lack of significant CES-D coefficients in longitudinal regressions related to multicollinearity fails to support this study's hypotheses; however, alternate interpretations of the data offer support for depression's ability to predict changes in pain and disability longitudinally.

Another interpretation of the discordance between study hypotheses and results is provided by the results of the CFA comparisons. The top four models suggest support for both a

four-factor solution and a second-order solution. Thus, examination of the second-order solution is equally viable. The best absolute fit model for the CES-D was a second-order model positing an overall depression factor predicting the four factors of DA, PA, SV, and IP. This suggests a second-order unidimensional model for depression as measured by the CES-D, and would make multicollinearity unsurprising. Indeed, when results are interpreted using the CES-D as a whole, each overall block entry of CES-D factors explained a significant portion of variance. Such a significant finding suggests strong cross-sectional associations of depression with disability and pain, as well as depression's ability to predict change in pain and disability over time. This interpretation would suggest support for the BPS model of depression in OA and would fit with much of the literature, in contrast to Hawker et al. (2011).

Limitations and Conclusions

The current analyses were limited by a number of factors. First, the sample size at T1 of 369 decreased significantly in the parent study to 294 at T2. Due to T2 sample size, temporal cross-validation was not pursued in the present study, limiting validity and generalizability. Validity based on selective attrition is a second limitation to these analyses. Attrition was greatest among younger, nonwhite, and less educated people experiencing greater pain and disability. As a result, future analyses should attempt to replicate these findings while utilizing temporal cross-validation in new and ideally larger samples of older adults with OA.

Limitations notwithstanding, study results suggest a few clear findings. First, interpreting the data using the total CES-D score is supported equally strongly, as is the four-factor solution. This suggests a viable unidimensional interpretation of the CES-D for community older adults with OA. This is unsurprising given that the scale was designed to tap a unidimensional construct. Radloff noted that the high internal consistency of the scale, $\alpha = .84$ to $.90$ for Radloff

and $\alpha = .891$ in the current analysis, argues against a focus on separate factors, as the items are all symptoms related to depression. Second, taken as a unidimensional measure, the CES-D has strong predictive ability and suggests depression may predict increased pain and disability in older adults with OA. This interpretation suggests strong support for the utility of the CES-D, support for a BPS model for depression in OA, and a fit with the majority of literature on depression, pain, and disability. This interpretation of present study results limits the ability to comment on criterion contamination, but supports the continued use of the CES-D in community populations of older adults with OA.

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Appendix

Table 6. Center for Epidemiologic Studies Depression Scale

Item	Abbreviation
1. I was bothered by things that usually don't bother me.	Bothered
2. I did not feel like eating; my appetite was poor.	Appetite
3. I felt that I could not shake off the blues even with help from my family or friends.	Blues
4. I felt that I was just as good as other people.	Good
5. I had trouble keeping my mind on what I was doing.	Mind
6. I felt depressed.	Depressed
7. I felt that everything I did was an effort.	Effort
8. I felt hopeful about the future.	Hopeful
9. I thought my life had been a failure.	Failure
10. I felt fearful.	Fearful
11. My sleep was restless.	Sleep
12. I was happy.	Happy
13. I talked less than usual.	Talkless
14. I felt lonely.	Lonely
15. People were unfriendly.	Unfriendly
16. I enjoyed life.	Enjoy
17. I had crying spells.	Cry
18. I felt sad.	Sad

19. I felt that people disliked me.

Disliked

20. I could not get going.

Getgoing
