Course of Depressive Symptoms in Patients Undergoing Heart Surgery: Confirmatory Analysis of the Factor Pattern and Latent Mean Structure of the Center for Epidemiologic Studies Depression Scale

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Objective: The purpose of this study was to examine the dimensionality, stability, and course of depressive symptoms over the 12-month period beginning approximately 1 week before heart surgery. **Methods:** The Center for Epidemiological Studies Depression Scale (CES-D) was administered to 570 patients before heart surgery and 1, 3.5, 6.5, and 12.5 months later. **Results:** Confirmatory factor analysis rejected a four-factor model as a result of small variances for two interpersonal items. With their elimination, a three-factor solution (negative affect, low positive affect, somatic/vegetative symptoms) showed good psychometric properties. Except for the somatic/vegetative factor at the 1-month follow up, there was a high degree of stability in the factor pattern over a 12-month period beginning approximately 1 week before heart surgery. Latent mean structure analysis indicated that, apart from elevations in several somatic/vegetative symptoms during the month after surgery, means for all three depressive symptoms declined over time. The recovery of positive affect showed a steeper trajectory toward the end of the follow-up period by comparison with the rates of decline for depressed affect and somatic/vegetative symptoms. **Conclusions:** These findings support using 18 CES-D items to measure three depressive symptom dimensions in heart patients and may reflect a normative pattern of adjustment to heart surgery. **Key words:** Center for Epidemiologic Studies Depression Scale, depressive symptoms, coronary artery bypass graft surgery, valve surgery, confirmatory factor analysis, latent mean structure analysis.

CES-D = Center for Epidemiological Studies Depression Scale; **CABG** = coronary artery bypass graft surgery; **CHD** = coronary heart disease; **MI** = myocardial infarction; **CFA** = confirmatory factor analysis; **RWJUH** = Robert Wood Johnson University Hospital; **UMDNJ** = University of Medicine and Dentistry of New Jersey; **EM** = expectation maximization; **MAR** = missing at random; **DA** = depressed affect; **PA** = positive affect; **S/V** = somatic/vegetative; **RMSEA** = root mean square error of approximation; **CI** = confidence interval; **CFI** = comparative fit index.

INTRODUCTION

Symptoms of depression appear to indicate poor prognosis in patients with coronary heart disease (CHD) (1). Much research in this area has focused on outcomes of myocardial infarction (MI), for which both major depressive disorders and subclinical levels of depressive symptoms have demonstrated predictive value. Recently, depression has begun to receive attention in research on the large and growing population of patients undergoing interventions such as coronary artery bypass graft surgery (CABG) (2). Among outcomes associated with depressive symptoms in patients undergoing heart surgery are poor surgical recovery (3), declining quality of life (4), morbidity, and mortality (5).

The investigation of depressive symptoms in heart patients requires clear understanding of scores that are generated by relevant assessment tools. Although diagnosis of clinical depression presents significant challenges, there are equally important questions concerning subclinical depression. Little is known about the meaning of symptom scores with respect to psychometric properties such as the nature, number, and distinctiveness of specific facets of depression. Other issues concern stability and change. Psychological and biomedical aspects of coronary disease and associated interventions may affect depression subcomponents in different ways. If so, this would have implications for understanding outcomes, because the course of depression appears to carry prognostic information independently of its severity (4). To understand the predictive value of depression scores in heart patients, and to evaluate the impact of surgical, medical, and psychological interventions, research is needed to characterize structural and temporal parameters of symptom measures.

We examined these issues using the Center for Epidemiologic Studies Depression Scale (CES-D) (6). The CES-D is a widely used measure of depressive symptomatology. Originally designed for large-scale population-based surveys, the CES-D has also been used in medical patients and has recently seen increased use in research on cardiovascular disorders (7). Although generally regarded as a reliable and valid measure of depressive symptoms, examination of the CES-D factor structure across populations has not yielded consistent results (8). In individuals with health problems, these inconsistencies may reflect aspects of physical disease and its treatment that alter factor structure, internal consistency, and/or temporal stability of CES-D item responses. To address some of these issues, Rhee et al. (9) conducted a confirmatory factor analysis of the CES-D in patients with rheumatoid arthritis and found evidence of four underlying dimensions similar to those observed in some research conducted in noninstitutionalized populations: depressed affect, (low) positive affect, somatic/vegetative symptoms, and negative interpersonal feelings. Such an analysis has yet to be conducted in cardiovascular patients.

Heart surgery has some interesting characteristics as a model for examining structural and temporal aspects of depressive symptoms. It involves both a chronic medical condi-

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tion (atherosclerosis and/or valve disease) with symptomatic and functional effects, and a significant life event (major surgery). Moreover, unlike many stressful events, major surgery is a crisis in the sense of a turning point that, once resolved, may have either significant positive (symptom relief, improved functioning) or negative consequences (complications, death) (10). In this respect, adaptive challenges faced by patients undergoing heart surgery are different and more complex than those of patients who may be facing either a health crisis or a chronic medical condition but not both.

The purpose of this study was to evaluate CES-D measurement models in patients undergoing heart surgery. Confirmatory factor analysis (CFA) was used to evaluate the four-factor model described previously (9) and an alternative, three-factor model in CES-D item response data collected in patients before heart surgery and on follow up 1, 3.5, 6.5, and 12.5 months later. We tested the adequacy of the factor model at each assessment point as well as its stability over time. In addition to factor loading patterns, interfactor correlations, and the temporal stability of those parameters, we also examined variations in latent factor means across time. The analysis of these mean structures permitted an assessment of change in symptom severity in terms of latent dimensions of depression.

METHOD

Participants

Study participants were 570 patients who underwent CABG, valve surgery, and/or other forms of heart surgery at the University of Medicine and Dentistry of New Jersey (UMDNJ)–Robert Wood Johnson University Hospital (RWJUH) in New Brunswick, New Jersey, between October 11, 2000, and October 8, 2003. Potential participants were approached during time periods in which recruitment staff and interview facilities were available. All of these patients were considered eligible for recruitment unless they did not speak English or had any condition that would interfere with interviewing. This study was approved by Institutional Review Boards at both Rutgers University and the UMDNJ–RWJ Medical School.

Procedures

Elective surgery patients were interviewed in the hospital at the time of preadmission testing. Urgent or emergent patients hospitalized before nonelective surgery were interviewed bedside. Baseline interviews were conducted an average of 5.7 days before surgery. Follow-up interviews were attempted for all patients who underwent surgery and were conducted by telephone approximately 1, 3.5, 6.5, and 12.5 months later.

Measures

Demographic and Biomedical Factors

Demographic information collected by interview included age, gender, education (in years), marital status, and ethnicity. Patients' medical history, health status, and surgical procedures were determined by medical chart review.

Depressive Symptomatology

The CES-D (6) was administered by interview. Its 20 items assess symptoms such as sad and positive mood, fatigue, and negative interpersonal feelings. Patients were asked to respond in terms of how they had been feeling during the past week. Responses were made using the following scale: 0 = rarely or none of the time, 1 = some of the time, 2 = much of the time, and 3 = most or all of the time. Total scores can range from 0 to 60.

Statistical Analysis

Confirmatory factor analysis was conducted using Mplus software version 3.01 (11). All 570 patients provided data at baseline. Patients were subsequently lost from one or more of the postsurgical follow ups either because they could not be reached by telephone or were unwilling to participate at that time. As a result, 379 (66.5%) patients provided data at the 1-month follow up, 369 (64.7%) at 3.5 months, 408 (71.6%) at 6.5 months, and 398 (69.8%) at 12.5 months. Overall, 242 (42.5%) patients provided data for all five time points, 124 (21.8%) did so for four time points, 81 (14.2%) for three time points, 52 (9.1%) for two time points, and 71 (12.5%) patients provided data for just one time point. Maximum likelihood estimation of item variances and covariances was conducted using the expectation maximization (EM) algorithm, a method for handling missing data that has received support in methodological work published over the past decade but is still relatively new in medical research (12). Maximum likelihood estimation with missing data assumes ignorable missingness or nonresponse. Ignorable missingness means that the probabilities of missingness depend only on observed data but not on missing data themselves (i.e., missing at random [MAR]) (13). Under the MAR assumption, missing values can be predicted from other observed variables that are not missing. In the case of longitudinal studies, MAR is generally met when observed (complete) baseline data predict missingness at subsequent follow ups (14). Even if the MAR assumption is not fully met, analyses of all cases (complete and incomplete) tend to yield less biased parameter estimates than analyses restricted to cases with complete data (15).

When CFA is used in longitudinal data to evaluate measurement invariance, the focus typically is on the equivalence of factor loadings across time points. Evidence of invariance suggests that latent factors, in this case, different dimensions of depressive symptomatology, are defined by the same set of observed variables (CES-D items) at each measurement point and that the pattern and magnitude of factor loadings are temporally stable. These are important psychometric properties. If measurement invariance does not hold with respect to these parameters, quantitative changes in CES-D item (and in scale) scores over time cannot unambiguously be attributed to quantitative changes in the underlying constructs, that is, specific dimensions of depressive symptoms.

Less common is the use of CFA to test hypotheses about the means of latent factors in what is referred to as latent mean structure analysis. In longitudinal CES-D data, latent mean structure analysis provides an evaluation of changes in factor means. These changes reflect variations over time in levels of different aspects of depressive symptomatology. This is an important consideration because it provides a differentiated picture of the course of different depressive symptoms after CABG. In addition to generating estimates of these common factor means, latent mean structure analysis includes intercept terms that represent the mean of the unique component of each item. These are components of item responses whose variance is not shared with other items in defining latent factors. Mean changes in observed item scores may reflect changes in these item intercepts, changes in common factor means, or both. The common components of item responses reflect the underlying factor, whereas unique components reflect other sources specific to a given item. As a result, the means of common and unique item components may not change in the same manner over time. Only if item intercepts are invariant across time are observed mean changes in item scores fully accounted for by mean changes in the common factors. The issue of unique and common components in the psychometric analysis of CES-D data in patients with heart surgery is particularly relevant in connection with somatic/vegetative items. These involve symptoms that may contain unique components representing physical effects of cardiovascular disease or its treatment as opposed to common components reflecting depression. We therefore evaluated latent mean structures as well as the usual parameters of interest in CFA.

RESULTS

Sample Characteristics

Descriptive data are presented in Table 1. There were 416 men (73%) and 154 women (27%) aged 28 to 89 (mean =

TABLE 1. Descriptive Statistics

	n^a	Number	Percent	Mean	*SD*
Demographic variables					
Age	569			65.31	11.55
Sex	570				
Female		154	27.0		
Male		416	73.0		
Marital status	570				
Married		407	71.4		
Unmarried		163	28.6		
Education	565			13.44	2.99
Ethnicity	570				
White		501	87.9		
Non-white		69	12.1		
CESD total score	570			11.18	8.96
Type of surgery	570				
Isolated CABG		375	65.8		
Isolated valve		91	16.0		
CABG + valve		51	9.0		
CABG/valve + other		40	7.0		
Other		12	2.1		
Presurgical biomedical variables	567				
Hypertension		439	77.4		
History of congestive heart failure		101	17.8		
Diabetes		194	34.2		
Previous myocardial infarction		86	15.2		
History of renal failure		25	4.4		
Chronic lung disease		74	13.1		
Cerebrovascular accident[b]		25	4.4		
Prior open heart surgery[c]		49	8.6		
Urgent or emergent operative status[c]		237	41.7		
Ejection fraction	545			48.79	12.67
Body surface area	567			1.96	0.22

[a] Variation in n across variables reflects missing values due to incomplete or unobtainable medical chart data.
[b] $n = 566$.
[c] $n = 569$.

65.3, standard deviation [SD] = 11. 6). The sample was predominantly white ($n = 501$ [88%]) and married ($n = 407$ [71%]) and reported a mean of 13. 4 years of education (SD = 3. 0). The average total CES-D score for the sample at baseline was 11.18 (SD = 8.96). The majority ($n = 375$ [65.8%]) underwent isolated CABG, 16.0% ($n = 91$) had isolated valve surgery, 9.0% ($n = 51$) had combined CABG and valve surgery, 7.0% ($n = 40$) had CABG and/or valve surgery in combination with other forms of heart surgery (e.g., repair of atrial septic defect or left ventricular aneurysm), and 2.3% ($n = 13$) had other forms of heart surgery without a CABG or valve procedure. Additional data presented in Table 1 provide information regarding presurgical biomedical characteristics reflecting cardiovascular health status and comorbidities.

Patients who did and did not return for the 6.5-month follow up were compared on baseline characteristics because preliminary analyses revealed only minor variations in comparisons based on nonreturners defined with respect to the different follow ups. Those who did not contribute 6.5-month data were slightly more depressed at baseline (means = 12.69 versus 10.58), less likely to be married (58% versus 77%), less well educated (means = 12.7 versus 13.7), more likely to have a history of congestive heart failure (24% versus 15%) and of prior MI (20% versus 13%), more likely to undergo urgent/emergent versus elective surgery (50% versus 38%), and more likely to undergo CABG plus valve surgery (11% versus 5%) (p values $<.05$). Participation at 6.5 months was not related to age, gender, ethnicity, hypertension, ejection fraction, body surface area, diabetes, or history of renal failure, lung disease, stroke, prior heart surgery, or the proportions of isolated CABG or isolated valve surgeries (not significant).

Confirmatory Factor Analysis

Based on previous findings, an oblique, four-factor model (preliminary model) was specified for all five assessment points: depressed affect (DA), positive affect (PA), somatic/vegetative symptoms (S/V), and negative interpersonal feelings (Table 2 describes how items were allocated to factors in this model). However, a solution for this model could only be obtained by constraining error variances of the interpersonal items to zero. Inspection of raw data indicated that at all five time points the two interpersonal items had very low means (range, 0.05–0.12) and very small variances (range, 0.09–0.22). By contrast, means and variances were generally higher

TABLE 2. Item Allocations for the Preliminary Model

Item
F1: depressed affect
6. depressed
3. blues
9. failure
10. fearful
14. lonely
17. cry
18. sad
F2: (lack of) positive affect
12. happy
4. good
8. hopeful
16. enjoy
F3: somatic/vegetative
20. get going
1. bothered
2. appetite
5. mind
7. effort
11. sleep
13. talked less
F4: interpersonal
15. unfriendly
19. disliked

Note. Items are numbered in all tables as in Radloff (1977).

for other items (means ranging from 0.10 to 1.21, variances ranging from 0.12 to 1.16) (1).[1]

Accordingly, data for the two interpersonal items were deleted and an oblique model specifying three factors (DA, PA, and S/V) was tested (model 1). Items were constrained to load on one and only one factor (see Table 2). Factor loadings were constrained to be invariant across the five assessment points. To make it possible to estimate the model, time 1 factor means were fixed at 0.0 with time 2 to 5 means free. Item intercepts (means of uniquenesses) were assumed to be invariant from time 1 to 5 and fixed at the time 1 item means to represent the assumption that variations in observed item means reflect variations in common factors corresponding to dimensions of depressive symptoms. This three-factor model provided a fair degree of fit to the data (χ^2 (df = 3,948) = 9,292.72, $p < .001$, root mean square error of approximation [RMSEA] = 0.049; 95% confidence interval [CI] = 0.047–0.050; comparative fit index [CFI] = 0.691).

Examination of residuals and modification indices suggested several modifications that would improve fit and these were incorporated into a new model (modified model). A subset of factor loadings and item intercepts were freed, and a subset of uniquenesses (residuals) were allowed to intercorrelate. This modified model provided good fit to the data (χ^2 (df = 3,886) = 7,570.15, RMSEA = 0.041; 95% CI = 0.039–0.042; CFI = 0.787) and improved fit significantly by comparison with model 1 (χ^2 change (df = 62) = 1,722.57, $p < .001$). In particular, an RMSEA less than .05 indicates a close fit of the model in the population (16).

Table 3 presents the modified model factor loadings for each assessment point. It can be seen that most of the factor loadings that were freed were in the time 2 data. It also can be seen that freeing those parameters resulted in only modest variations in loadings for factor 1 (depressed affect) and factor 2 (low positive affect) with somewhat larger variations appearing in the loadings for factor 3 (somatic/vegetative symptoms). Thus, the meaning of the depressed affect and low positive affect factors, as defined by item loadings, is reasonably stable across time, whereas the meaning of the somatic/vegetative factor is stable across time except for time 2. In particular, symptoms involving appetite, effort, and sleep had more salient loadings at time 2 than they did for the other assessment points, whereas the item reflecting difficulties concentrating had a lower loading at time 2 than it did at the other assessment points.

Table 4 presents item intercepts (means of unique components) and common factor means for the modified model and the latter are plotted in Figure 1. Results for all three factors indicated reductions in depressive symptoms over time with means for the somatic/vegetative factor decreasing more sharply from time 1 to time 2 than did the means for factors reflecting depressed affect and (low) positive affect (see Fig. 1). Declining means for each of the three factors converge for times 3 through 5, except that (low) positive affect scores showed a steeper decrease, indicating that positive affect increased at a rate that exceeded the declines in negative affect and somatic/vegetative symptoms.

For comparison purposes, the observed means for CES-D subscales are plotted in Figure 2. One difference between Figures 1 and 2 is the scaling of the means. For Figure 1, it was necessary to fix the time 1 means of all three depression factors at some arbitrary value (i.e., 0.0), because this constraint was a requirement of the CFA. The more important difference between the two figures is that, whereas means for all three latent factors decline over time (Fig. 1), observed means for somatic/vegetative symptoms increased from time 1 to time 2 before declining from time 2 through time 5 (Fig. 2). This reflects a difference between the latent and manifest trajectories in somatic/vegetative symptoms. That is, the common factor components of the relevant items, which presumably reflect somatic depression, declined from time 1 to time 2 (Fig. 1), whereas their unique components, reflecting specific somatic symptoms, increased (Fig. 2).

Data in Table 4 indicate that, for factor 1, the mean of the unique component of the fearfulness item was elevated at time 1 (mean = 0.72), apparently reflecting a high level of presurgical apprehension, and was followed by lower fearfulness means at subsequent time points (means = 0.40). All the remaining item intercepts that were freed on the basis of large residuals were in the time 2 data for somatic/vegetative symptoms. These items concerned difficulties with getting going, appetite, effort, sleep, and talking less. Unique variance components of these items showed mean increases from time 1 to time

[1]Item means and standard deviations and interitem correlations for each assessment point are available from the first author on request.

TABLE 3. Factor Loadings for the Modified Model

Item	Pre-Surgery	1 Month	3.5 Months	6.5 Months	12.5 Months
F1: depressed affect					
6. depressed	1.00	1.00	1.00	1.00	1.00
3. blues	.82	**.93**	.82	.82	**.77**
9. failure	.43	**.50**	.43	**.34**	.43
10. fearful	.69	**.61**	.69	.69	**.72**
14. lonely	.74	.74	.74	**.59**	.74
17. cry	.60	.60	.60	.60	.60
18. sad	.92	.92	.92	.92	.92
F2: (lack of) positive affect					
12. happy	1.00	1.00	1.00	1.00	1.00
4. good	.52	**.69**	**.44**	.52	.52
8. hopeful	.76	.76	.76	.76	.76
16. enjoy	.74	**.91**	.74	.74	.74
F3: somatic/vegetative					
20. get going	1.00	1.00	1.00	1.00	1.00
1. bothered	1.17	1.17	1.17	1.17	1.17
2. appetite	.67	**1.18**	.67	.67	.67
5. mind	1.16	**.84**	1.16	1.16	1.16
7. effort	1.14	**1.53**	1.14	1.14	1.14
11. sleep	1.06	**1.25**	1.06	1.06	1.06
13. talked less	.90	.90	.90	.90	.90

Note. Loadings for items 6, 12, and 20 were fixed at 1.00. Free loadings appear in bold. All other loadings were constrained to be invariant across time.

2 at the same time that the common component that defined the somatic/vegetative depression factor decreased from time 1 to time 2. Increases in unique components appear to represent somatic effects of surgery and associated procedures.

There were 42 nonzero residual correlations (less than 1% of all residual covariances). Of these, all but one involved longitudinal associations, the exception being a residual correlation for the sleep and appetite items at time 2 ($r = 0.16$). Most of the other residual correlations reflected associations between residuals for the same item at two adjacent time points, indicating some degree of temporal stability of the unique components of those items. Of these, the large majority were small to modest in magnitude, ranging from 0.07 to 0.29.

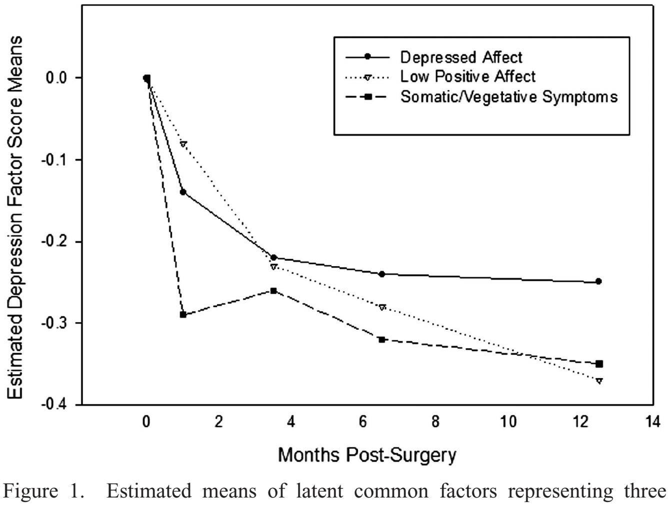

Figure 1. Estimated means of latent common factors representing three dimensions of depressive symptoms measured by the Center for Epidemiologic Studies Depression Scale. Factor means at the presurgical baseline (month 0) are arbitrarily fixed at 0.0.

Two reflected somewhat larger associations between residuals for the sleep item as assessed at times 3 and 4 ($r = 0.48$) and times 4 and 5 ($r = 0.35$). The rest reflected correlated residuals for the sleep item at nonadjacent time points (r values from 0.13 to 0.32).

Table 5 displays interfactor correlations. Temporal stability across adjacent time points was modest, ranging from 0.52 to 0.72 for DA, 0.59 to 0.67 for PA, and 0.40 to 0.77 for S/V. Cross-sectional interfactor correlations at each time point were greater in magnitude. Associations linking DA to (low) PA ranged from 0.63 to 0.74, those linking DA to S/V ranged from 0.78 to 0.87, and those linking (low) PA to S/V ranged from 0.63 to 0.71.

DISCUSSION

Findings of this study indicate that, in patients undergoing heart surgery, 18 of the original 20 CES-D items measure three correlated but separable dimensions of depressive symptoms. These facets of depression—depressed affect, (low) positive affect, and somatic/vegetative symptoms—show substantial stability with regard to factor loading patterns and interfactor correlations over a time period beginning 1 week before heart surgery and extending over the next 12 months. Departures from this pattern of temporal stability in factor structure were minor except for data obtained at the second assessment, which took place on average approximately 1 month after surgery. These departures primarily involved a subset of the somatic/vegetative items of the CES-D whose loadings on the somatic/vegetative factor were more pronounced at the 1-month follow up than they were at the other assessments.

TABLE 4. Item Intercepts (means of unique components) and Factor Means for the Modified Model

Item	Pre-Surgery	1 Month	3.5 Months	6.5 Months	12.5 Months
F1: depressed affect					
6. depressed	.55	.55	.55	.55	.55
3. blues	.41	.41	.41	.41	.41
9. failure	.18	.18	.18	.18	.18
10. fearful	**.72**	*.40*	*.40*	*.40*	*.40*
14. lonely	.41	.41	.41	.41	.41
17. cry	.34	.34	.34	.34	.34
18. sad	.56	.56	.56	.56	.56
F1 mean	.00	**−.14**	**−.22**	**−.24**	**−.25**
F2: (low) positive affect					
12. happy	1.04	1.04	1.04	1.04	1.04
4. good	.61	.61	.61	.61	.61
8. hopeful	.77	.77	.77	.77	.77
16. enjoy	.65	.65	.65	.65	.65
F2 mean	.00	**−.08**	**−.23**	**−.28**	**−.37**
F3: somatic/vegetative					
20. get going	.59	**.84**	.59	.59	.59
1. bothered	.73	.73	.73	.73	.73
2. appetite	.42	**1.34**	.42	.42	.42
5. mind	.72	.72	.72	.72	.72
7. effort	.68	**1.34**	.68	.68	.68
11. sleep	1.01	**1.59**	1.01	1.01	1.01
13. talked less	.61	**.97**	.61	.61	.61
F3 mean	.00	**−.29**	**−.26**	**−.32**	**−.35**

Note. Free intercepts appear in bold. Intercepts constrained to be invariant across time are italicized. All other intercepts were fixed at the T1 item means. T1 factor means were fixed at .00. Free factor means appear in bold.

The foregoing CFA findings reflect patterns of covariances among dimensions of depressive symptoms measured by subsets of CES-D items. Latent mean structure analysis, which is instead concerned with patterns of means, indicated that average scores for the three CES-D factors declined over time. It also revealed that unique components of a subset of somatic/vegetative symptoms had higher means at the 1-month postsurgical follow up than they did at the other time points. Overall, the findings indicate that caution is in order regarding the interpretation of CES-D scores in the weeks immediately after cardiac surgery, mainly regarding somatic/vegetative symptoms that may be directly affected by surgery and associated procedures. They also suggest that the CES-D otherwise maintains a relatively invariant set of measurement properties up to 12 months after heart surgery despite reductions in overall mean scores.

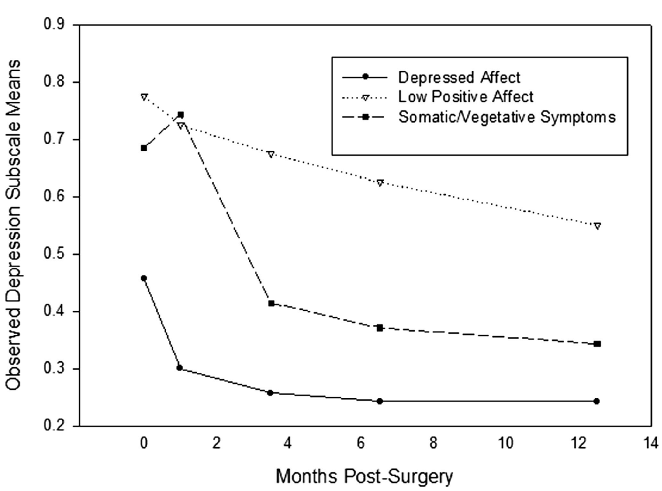

Figure 2. Observed means for Center for Epidemiologic Studies Depression Scale subscales. Subscale scores are based on the average response to items comprising each scale. Table 3 specifies the allocation of items to subscales.

The Three-Factor Structure of the Center for Epidemiological Studies Depression Scale

The three dimensions identified in CFA of the 18-item CES-D administered using a 1-week response time window were intercorrelated but partially independent at each time point (Table 5). With just a few minor departures, latent factors reflecting depressed and positive affect showed substantial longitudinal invariance in that they were defined by the same pattern of loadings across all five administrations. By contrast, four of the seven items that defined the somatic/vegetative factor showed factor loadings at time 2 that differed from those at time 1 and at times 3 to 5. Three items, involving appetite, effort, and sleep, had larger loadings at time 2, whereas the fourth, involving ability to concentrate, had a smaller loading at time 2. This indicates that the relative contribution of specific symptoms in defining the latent somatic/vegetative construct differs at time 2, the assessment point that most closely follows heart surgery. At that assessment, poor appetite, feeling that everything was an effort, and restless sleep were more prominent in defining the construct than they were at other time points, and difficulty concentrating was less prominent in this regard. These variations in loading patterns indicate a qualitative difference in the mean-

TABLE 5. Correlations Among Factors

	Pre-Surgery			1 Month			3.5 Months			6.5 Months			12.5 Months		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
Pre-Surgery															
F1	—														
F2	.74	—													
F3	.87	.63	—												
1 Month															
F1	.56	.52	.44	—											
F2	.40	.59	.26	.66	—										
F3	.39	.37	.40	.78	.67	—									
3.5 Months															
F1	.59	.43	.55	.68	.29	.46	—								
F2	.39	.57	.38	.54	.67	.45	.63	—							
F3	.41	.46	.55	.52	.39	.52	.82	.66	—						
6.5 Months															
F1	.51	.40	.47	.43	.35	.37	.52	.47	.51	—					
F2	.36	.52	.41	.48	.47	.44	.50	.66	.65	.73	—				
F3	.37	.38	.46	.40	.39	.54	.45	.46	.66	.87	.71	—			
12.5 Months															
F1	.52	.42	.44	.49	.33	.27	.62	.43	.54	.72	.62	.53	—		
F2	.38	.37	.35	.38	.43	.28	.44	.53	.49	.51	.64	.47	.71	—	
F3	.36	.39	.44	.42	.36	.39	.51	.42	.75	.74	.69	.77	.83	.65	—

Note. F1 = depressed affect; F2 = (low) positive affect; F3 = somatic/vegetative.

ing of the somatic/vegetative factor at time 2 compared with times 1, 3, 4, and 5. It is interesting to note that the somatic/vegetative factor also had a lower stability coefficient (r = 0.40) for the interval from presurgical baseline (time 1) to 1-month follow up (time 2) than was seen over any other pair of adjacent time points for any of the three factors (r values from 0.52 to 0.77).

Course of Depressive Symptoms After Heart Surgery

As in the case of the pattern and stability of factor loadings, analysis of the latent mean structure also pointed to the time 2 data for somatic/vegetative symptoms as a source of departure from measurement invariance. Items reflecting difficulty getting going, poor appetite, feeling that everything was an effort, restless sleep, and talking less than usual had larger intercepts at time 2 than at all other time points (Table 4). This indicates elevations in each of these symptoms that do not reflect variance shared with any other CES-D items. Because variance that is shared by CES-D items, defining the three common factors, presumably reflects depression, these symptom elevations presumably do not. Instead, they likely reflect effects of procedures and conditions associated with surgery (e.g., anesthesia, surgical complications, wound pain, physical inactivity) that are salient during postoperative recovery.

Latent mean structure analysis also revealed a decline in mean levels of the common variance portions of the three factors over the four postsurgical time points with level of somatic/vegetative symptoms dropping more sharply from time 1 to time 2 than the means for the two affective dimensions (Fig. 1). The time 2 mean for the somatic/vegetative factor must be viewed guardedly. Although it may reflect a steeper reduction in somatic/vegetative symptoms of depression than was seen for the two affect dimensions, it may also be the case that somatic/vegetative aspects of depression could not be adequately measured by the time 2 administration of the CES-D because of difficulties in disentangling these symptoms from physical effects of surgery. The steep and sustained increase in positive affect across the latter portion of the follow-up period is interesting in suggesting that changes in positive and negative affect after CABG follow different time courses and may reflect different influences.

Overall, the findings suggest what may be a normative adjustment pattern in patients undergoing heart surgery. The decline over time in depression factor scores (see Fig. 1) may, in part, reflect reductions from a presurgical baseline that was elevated in response to impending surgery and possibly also as a result of effects of untreated heart disease. Continued reductions in depressive symptoms may reflect relief associated with having survived surgery and effects of physical recovery and of perceptions of recovery. It may be speculated that social benefits of successful surgery and recovery (e.g., resumption of work, family, and recreational role activities) occur mainly in later phases of the follow-up period, which might explain the tendency for recovery of positive affect to show greater acceleration during that time than was seen for relief of negative affect (10). This would imply a sequence in which physical recovery proceeds before and is to some extent required before psychosocial recovery can occur and in which physical recovery is more closely related to negative affect, and psychosocial recovery, to positive affect. It should be noted that whatever the interpretation of the present findings, it involves temporal characteristics of depressive symptoms for the sample as a whole. It remains possible, even likely, that different patient subgroups showed different trajectories of depression, and that the latter may have prognostic value with regard to subsequent outcomes (4).

Interpersonal Depression

The CFA findings raise questions about two CES-D items that in previous research have been identified as measures of interpersonal depression. These items ("People were unfriendly" and "I felt that people disliked me") had distributional properties that required they be excluded from CFA. Their means and standard deviations were clearly lower than those of all other items, and it is reasonable to conclude that the low rate of endorsement of these items underlies their statistical performance in the analyses. It is possible that patients in the present study tended not to report that people were unfriendly and did not like them because, during this time of health crisis, patients were in fact experiencing, or at least perceiving, a mobilization of sympathy, social support, and good will from relatives, friends, and healthcare providers. Another possible explanation is that the low endorsement rates were a consequence of the interview mode of assessment of a potentially sensitive topic (17). Patients may be less willing to admit these negative beliefs directly to another individual than they are to report them during the course of completing a self-administered questionnaire.

Low mean scores for the CES-D interpersonal items are not unique to the present study. In the National Health and Nutrition Examination Survey (National Center for Health Statistics, 1977), the CES-D was tested on a sample of respondents ($N = 3023$) representative of the U.S. population aged 25 to 74. The item "I felt that people disliked me" had the highest percentage of people responding that they "rarely or never" felt that way (88.9%). The other interpersonal item, "people were unfriendly," also had a very high percentage failing to endorse it: 86.1% said "rarely or none of the time." Another large study with an older population more comparable to ours found even lower rates of endorsement; the Established Populations for Epidemiologic Study of Elderly (18) New Haven site ($N = 2812$) found that 91.9% of respondents "rarely or never" "felt that people disliked me" and 87.9% of respondents said that "people were unfriendly" "rarely or never" (analysis by authors). Thus, the low endorsement rates of these two items in our sample were similar to those from other large well-known data sets.

Implications for Using the Center for Epidemiological Studies Depression Scale in Patients Undergoing Heart Surgery

The present findings have several implications for the use and interpretation of the CES-D in patients undergoing heart surgery. One is that there is a clear basis for scoring the CES-D separately for the DA, PA, and S/V subscales. Although correlated, these dimensions are sufficiently separable to permit researchers to distinguish among three clusters of depressive symptoms. In particular, except for the time period immediately after surgery and possibly other cardiac events, they may be used to separate out somatic/vegetative symptoms that may directly reflect physical disease and its treatment from other aspects of depression (5). With regard to positive affect, psychological theory calls attention to factors that may enhance emotional well-being in medical patients through processes that are separable from those whereby depressed affect or somatic/vegetative symptoms are reduced (19).

The findings have particular relevance for research concerning the course of depressive symptoms. Previous work has indicated that changes in total depressive symptom scores after heart surgery may have prognostic value beyond that associated with symptom levels (4), but this question has yet to be addressed in a manner that takes into account possible differences in the antecedents and consequences of specific symptom clusters. In addition to evaluating their differential predictive value, future research should seek to determine whether the DA, PA, and S/V symptom dimensions are differentially affected by cardiac interventions or by the treatment of depression in heart patients. In particular, the experience of S/V symptoms after heart surgery and other cardiac interventions warrants further investigation. In this work, measures of depressive symptoms such as the CES-D should be supplemented with instruments for assessing relevant physical symptoms.

The findings also have implications for the concept and measurement of interpersonal depression. The present results might be taken to suggest that the interpersonal CES-D items need not, or should not, be administered, because they largely fail to discriminate among patients. On the other hand, the interpersonal items may be useful for certain purposes. For example, the present study did not address the use of the CES-D to identify cases of clinically significant depression. It is possible that the low endorsement rate of these items allows them to contribute to specificity in the detection of probable major depression. As in the case of S/V symptoms, the two interpersonal feelings items of the CES-D should be supplemented with additional measures reflecting social relationships and interactions.

Limitations

Several factors should be borne in mind in evaluating the present study. As is typical of research on heart surgery, the patients were not representative of the larger population. We recruited patients from a single, albeit major heart surgery center, and patients who failed to contribute data to one or more assessment points differed in several ways from those who did not. This selective attrition was offset, to some extent, by the use of all available data for patients who missed one or more assessments. Nonetheless, our findings most likely generalize to populations of patients undergoing heart surgery comprising a similar mix of CABG and non-CABG heart surgery patients, and a similar mix of urgent/emergency versus elective patients, who otherwise resemble ours in terms of level of depressive symptoms and other factors. A much larger and more diverse sample would be required to determine whether our findings generalize to patients with more depressive symptoms and physical health problems and to test hypotheses regarding possible variations in structural and temporal characteristics of the CES-D across patients undergoing heart surgery differing with regard to age, gender, socioeconomic status, race/ethnicity, and biomedical factors, including medical history, type of heart surgery, and surgical urgency. It is also worth noting that although individuals referred for heart surgery represent a large and clinically important cardiac patient group, the possibility that various cardiovascular patient groups (e.g., heart surgery, acute myocardial infarction, congestive heart failure) differ with regard to CES-D factor structure warrants attention in future studies.

CONCLUSIONS

Confirmatory factor analysis indicates that three factors, reflecting variations in DA, S/V symptoms, and PA, underlie depressive symptoms measured by 18 items of the CES-D in heart patients. These dimensions show good psychometric properties. Except for the data for S/V symptoms obtained at the 1-month follow up, there was a high degree of stability over a 12-month period beginning approximately 1 week before scheduled heart surgery. Two items that have formed a fourth, interpersonal depression factor in previous research had low means and variances, requiring they be excluded from the analysis. Latent mean structure analysis indicated that apart from elevations in S/V symptoms during the weeks after surgery, all three dimensions of depressive symptoms declined over time. Further research making use of these measures may increase understanding of depressive symptoms in heart patients.

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