RESEARCH ARTICLE

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Validation of the Perceived Stress Scale in a community sample of older adults

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Background: Three versions of Perceived Stress Scale (PSS-14, PSS-10, and PSS-4) are among the most widely used measures of stress. The aim of the current study was to validate this instrument in a sample of nondemented older adults to facilitate studies of the impact of stress on health.

Methods: Seven hundred sixty-eight nondemented adults over the age of 70 years completed the PSS-14 questionnaire and other neuropsychological tests. Exploratory factor analysis was used to determine the underlying factor structure of all PSS versions, and confirmatory factor analysis was used to test the construct validity of factors. The internal consistency reliability of the scales was assessed using Cronbach's alpha, and concurrent validity was evaluated by examining PSS relation with age, gender, depression, anxiety, and Positive Affect and Negative Affect Schedule.

Results: A two-factor model was the optimal fit for the 14-item and 10-item versions of PSS. For PSS-14, all items' loadings exceeded 0.4 for one of the two factors except item 12. Therefore, we studied a 13-item version of PSS and 10-item and 4-item subsets representing PSS-10 and PSS-4. Internal consistency coefficients were satisfactory for the full scale of PSS-13 and PSS-10 but not for PSS-4. Women reported higher levels of stress than men. Higher levels of total PSS scores showed association with higher levels of depression, anxiety, and negative affect, and lower level of positive affect.

Conclusions: The 13-item and 10-item versions of PSS may be used to understand the experience of stress among older adults.

Key words: Perceived Stress Scale; older adults; coping; distress; psychometric properties
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Introduction

Stress in the American population has increased significantly in recent years and is considered a major health issue (American Psychological Association, 2007). Several studies show that stress is also very common in older adults and plays a major role in the development of both physical and psychological health problems including depression (Fiske *et al*., 2009), anxiety (Kogan *et al*., 2000), sleep disorders (Jean-Louis *et al*., 2001), and cognitive decline (Dickinson *et al*., 2011). Therefore, a psychometrically sound global measure of perceived stress in older adults could provide valuable additional information about the relationship between stress and age-associated pathology (Cohen *et al*., 1983).

Stress can be studied by assessing life events and daily hassles, by measuring perception of events or biological consequences. One method quantifies life events over a defined period (Holmes and Rahe, 1967) to produce a cumulative stress score. These scores are usually based on either the number of events or a sum of events weighted to reflect adjustment difficulties that have occurred within a specified time frame. Although higher life-event scores are associated with increased physical or psychological dysfunction, the magnitude of the association has been low (Rabkin and Struening, 1976).

Perceived stress occurs when an individual judges that situational demands exceed his or her resources (Lazarus and Folkman, 1984). Stressful events presumably increase the risk of disease when coping resources are insufficient to address the threat or demand. The Perceived Stress Scale (PSS) (Cohen *et al*., 1983) is a 14-item scale developed in accordance with the transactional perspective. Instead of focusing on a particular event, the PSS provides a global appraisal of stress by asking respondents to report whether their lives seem to be unpredictable, uncontrollable, or overloaded. Rather than tying appraisal to particular situations, the PSS is sensitive to the nonoccurrence of events and to ongoing life circumstances, to stress resulting from events occurring in the lives of friends and relatives, and to expectations concerning future events (Cohen and Williamson, 1988).

In samples of college students, Cohen and colleagues (1983) showed that the PSS was reliable and correlated with life-event scores, depressive and physical symptomatology, utilization of health services, social anxiety, and smoking-reduction maintenance. They showed that the PSS was a better predictor of the outcomes than life-event scores and that it measures a different and independently predictive construct than a depressive symptomatology scale. PSS scores were significantly correlated with physical symptoms even after controlling for the life-event scores (Pbert *et al*., 1992). Furthermore, it has been shown that higher levels of cortisol, a biological indicator of stress, are associated with higher PSS scores (van Eck and Nicolson, 1994).

The PSS has 14-item, 10-item, and 4-item versions and has emerged as one of the more common noninvasive measures of subjective stress in psychophysical health research (Sharp *et al*., 2007). The 4-item and 10-item versions are subsets of items from the 14-item scale. A few prior studies of the psychometric properties of the English version of PSS have used principle component analysis or exploratory factor analysis (EFA). These studies were conducted on samples of community-dwelling adults (Cohen and Williamson, 1988), psychiatric populations including adult outpatients (mean age of 36.20 years, $SD = 10.81$; Hewitt *et al*., 1992), adolescent inpatients (mean age of 14.28 years, $SD = 1.22$; Martin *et al*., 1995), women recovering from breast cancer (mean age of 51 years, $SD = 10$; Golden-Kreutz *et al*., 2004), college students (Roberti *et al*., 2006), and adults who had survived the death of a family member or significant other by suicide (mean age of 43.3 years, $SD = 13.7$; Mitchell *et al*., 2008). Moreover, the PSS has been translated into several other languages, and its psychometric properties have been evaluated in a variety of populations (Remor, 2006; Leung *et al*., 2010; Andreou *et al*., 2011). Despite wide usage of the PSS, it has not been assessed in community samples of older adults.

Stress plays an important role in the aging process. The importance of stress in older adults is likely to increase as the population of adults above the age of 65 years will double to constitute nearly 20% of the US population by 2030 (He *et al*., 2005). Therefore, ensuring that we have reliable and valid tests to measure stress in the older population is critical. The aim of the current study was to verify the psychometric properties, internal consistency reliability, and validity of different versions of PSS (4-item, 10-item, and 14-item) in a community-based sample of nondemented older adults.

Methods

Participants

The participants were 768 nondemented adults over the age of 70 years drawn from the Einstein Aging Study. The study design and methods of the Einstein Aging Study are described elsewhere (Katz *et al*., 2011). Briefly, potential participants were recruited through systematic sampling from voter registration lists for Bronx County, New York. Eligible participants were at least 70 years old, Bronx residents, noninstitutionalized, and English speaking. Exclusion criteria included visual or auditory impairments that preclude neuropsychological testing, active psychiatric symptomatology that interfered with the ability to complete assessments, and nonambulatory status.

Participants who were demented before their initial assessment with the PSS, or were diagnosed with dementia at the time of their initial PSS, were excluded from these analyses. A diagnosis of dementia was based on standardized clinical criteria from the Diagnostic and Statistical Manual, Fourth Edition (American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, forth edition, DSM-IV, 2000) and required impairment in memory plus at least one additional cognitive domain, accompanied by evidence of functional decline. Diagnoses were assigned at consensus case conferences, which included a comprehensive review of cognitive test results, relevant neurological signs and symptoms, and functional status. For this cross-sectional analysis, we included only the first administration of the PSS.

In addition, participants were categorized into two groups of normal and mild cognitive impaired (MCI) on the basis of the criteria described in detail previously (Katz *et al.*, 2011). Briefly, the MCI group consisted of participants with either amnestic MCI (aMCI) or nonamnestic MCI. Participants were classified as having aMCI if the memory domain was impaired or naMCI if there was impairment in one or more domains other than memory including attention, executive function, visuospatial ability, or language. NaMCI was diagnosed in nondemented participants without functional impairment who did not meet the memory criterion for aMCI but had impairment (1.5 *SD* below the age-adjusted mean) in at least one nonmemory cognitive domain.

All studies were approved by the institutional review board of Albert Einstein College of Medicine. After informed consent was obtained, participants received medical, neurological, and neuropsychological assessments.

Psychological evaluation

The PSS-14 was used to assess perceived stress (Cohen *et al.*, 1983). Seven out of the 14 items of PSS-14 are worded negative (1, 2, 3, 8, 11, 12, and 14), and the remaining seven are positive (4, 5, 6, 7, 9, 10, and 13). Each item was rated on a five-point Likert-type scale (0 = never to 4 = very often). Total scores are calculated after reversing positive items' scores and then summing up all scores. Possible total scores for PSS-14 range from 0 to 56. A higher score indicates greater stress.

Depressive symptoms were assessed using the 15-item Geriatric Depression Scale that assesses mood disturbance symptoms that are commonly associated with depression experienced among older adults (Sheikh and Yesavage, 1986). Anxiety symptoms were measured using the Beck Anxiety Inventory, which is designed to obtain a measure of anxiety that is relatively independent of depression (Beck *et al.*, 1988). These instruments have high reliability and validity in community-based samples (Osman *et al.*, 1997; Walters *et al.*, 2001).

The Positive Affect and Negative Affect Schedule (PANAS) questionnaire was used to assess general affect or mood (Watson *et al.*, 1988). This questionnaire consists of 10 positive affect (PA) traits (interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, and active) and 10 negative affect (NA) traits (distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid). These are considered higher level mood states and account for most of the important variances from many discrete moods (Cooper and Mcconville, 1989). The responses were recorded on a five-point Likert scale ranging from 1 = not at all to 5 = extremely. A score for each scale was obtained by summing the item scores. The scales have high internal consistency, with Cronbach's alpha ranging from 0.84 to 0.87 for the NA scale and 0.84 to 0.90 for the PA scale (Watson and Walker, 1996). PANAS scales have been shown to have convergent, construct, and discriminant validity (Watson *et al.*, 1988) and have been previously employed in studies of older adults (Segal *et al.*, 1999; Simpson *et al.*, 2008).

The 36-item Short Form (SF-36) health survey was used to evaluate quality of life. This questionnaire has been previously validated for use in older adults (Walters *et al.*, 2001). We measured memory using the Free and Cued Selective Reminding Test-Immediate Recall (FCSRT-IR) (Buschke, 1984) and the Logical Memory I (LM I; Wechsler, 1987) subtest from the Wechsler Memory Scale-Revised. Global cognitive status was measured by the Blessed Information-Memory-Concentration Test (Roth *et al.*, 1967). Details of neuropsychological tests have been previously described (Katz *et al.*, 2011).

Statistical analysis

Exploratory factor analysis and confirmatory factor analysis. Exploratory factor analysis was used to determine the factor structure of the PSS, and confirmatory factor analysis (CFA) was used to confirm the factor structure. Model evaluations were made using a variety of fit indices, including the comparative fit index (CFI), standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). Values of $CFI > 0.9$, $SRMR < 0.08$, and $RMSEA < 0.08$ are indicative of a good fit with the data (Hoyle, 1995). Model chi-square test statistics and associated degrees of freedom and *p*-values were reported for completeness, although they were not used in model evaluation (Beckstead *et al.*, 2008).

Split-half analysis. To further examine the validity of our factor solution, we repeated EFA and CFA by running a split-half analysis. For this purpose, we randomly selected half of the sample and performed the EFA. Subsequently, on the basis of the factor solution proposed by EFA, we performed CFA on both halves of the sample.

The internal consistency reliability of the scale was assessed by Cronbach's alpha, and concurrent validity was evaluated by examining the PSS relationship with gender, depression, anxiety, and PANAS. Divergent validity was assessed by examining the PSS correlation with Bodily Pain Index from SF-36 health survey. Total stress scores were computed by first reversing the scores of the positive items and then summing all the items of the PSS. Spearman's correlations, *t*-tests, and analysis of variances were used as appropriate.

All analyses were conducted using SPSS 20 (SPSS Inc., Chicago, IL, USA) and STATA version 12 (STATA Corp., TX, USA).

Results

The sample had a mean age of 80.0 years ($SD = 5.5$). The sample was 60.5% women and 67.3% white, with a mean of 14.1 years ($SD = 3.4$) of education. Sample demographics are presented in Table 1.

Perceived Stress Scale factor analysis

Exploratory factor analysis on the entire sample resulted in a two-factor model. Table 2 displays the items and the standardized factor loadings based on EFA. All loadings exceeded 0.3 for one of either of the factors except item 12 (How often have you been thinking about things that you have to accomplish?), which loaded highly on both factors. Therefore, we removed item 12 from the scale, and all further analyses were based only on 13 items (PSS-13). Seven items loaded on the first factor, and six items loaded on the second factor. The first factor involved positive questions (reverse-keyed items), and the second factor involved negative questions. The two factors were associated with each other ($r_s = -0.28$, $p < 0.001$). Hewitt and colleagues (1992) named the factor with negative questions "perceived distress" and the factor with positive questions "perceived coping."

We assessed goodness of fit for the one-factor and two-factor models to the 13-item, 10-item, and 4-item versions of PSS using CFA (Table 3). The two-factor model fitted well to PSS-10 and marginally well to PSS-13 as reflected by higher CFI and lower RMSEA and SRMR. For PSS-4, the model did not converge for the two-factor model. One-factor model did not fit well to any of the three PSS versions. Nested model comparisons using chi-square test also confirmed that the two-factor model fit better than the one-factor model for both PSS-10 ($\chi^2(1) = 718$, $p < 0.001$) and PSS-13 ($\chi^2(1) = 1312$, $p < 0.001$).

Subsequently, we performed the split-half analysis by performing EFA on half of the sample and CFA on both halves. Because the results were similar to a full-sample analysis, here we present only the results from the entire sample and provide the split-half results as supporting information (see Tables S-1 and S-2).

Table 1 Sample demographics ($N = 768$)

	Total sample	Non-MCI	MCI
	$N = 768$	$N = 644$	$N = 124$
Women (%)	60.5	60.9	58.9
White (%)	67.3	68.2	62.9
Age (years), mean (*SD*)	80.0 (5.5)	79.6 (5.3)	81.7 (5.8)
Education (years), mean (*SD*)	14.1 (3.4)	14.2 (3.3)	13.2 (3.5)
BIMC total errors, median (range)	1 (0–11)	1.7 (1.9)	3.0 (2.6)
FCSRT-IR free recall score, mean (*SD*)	30.8 (6.4)	31.9 (5.6)	24.8 (7.1)
FCSRT-IR total recall score, mean (*SD*)	47.6 (2.2)	47.7 (2.2)	47.1 (2.1)
LM I total score, mean (*SD*)	20.8 (6.7)	21.5 (6.6)	17.2 (6.3)
Verbal IQ, mean (*SD*)	109.8 (16.4)	110.3 (16.2)	104.7 (17.1)
BAI, mean (*SD*)[a]	4.2 (5.6)	4.1 (5.4)	4.3 (6.3)
GDS, mean (*SD*)	2.2 (2.1)	2.1 (2.1)	2.6 (2.3)
PSS-13, mean (*SD*)[b]	17.1 (7.6)	16.9 (7.5)	18.2 (7.8)
Positive factor (coping), mean (*SD*)	18.1 (5.4)	18.2 (5.3)	17.0 (5.9)
Negative factor (distress), mean (*SD*)†	7.2 (4.4)	7.2 (4.3)	7.3 (4.6)
PANAS-X positive affect[c]	21.0 (8.0)	21.2 (8.1)	19.2 (7.9)
PANAS-X negative affect[c]	7.7 (6.4)	7.3 (6.2)	8.1 (6.9)

Range of possible scores for demographic data: BIMC = 0–33, FCSRT-IR = 0–48 (for both free and total recall), LM I = 0–50, GDS = 0–15, and BAI = 0–63.
BIMC, Blessed Information-Memory-Concentration; LM I, Logical Memory I; FCSRT-IR, Free and Cued Selective Reminding Test-Immediate Recall; BAI, Beck Anxiety Inventory; GDS, Geriatric Depression Scale; PSS, Perceived Stress Scale; PANAS, Positive Affect and Negative Affect Schedule; MCI, mild cognitive impaired.
[a]BAI available for $n = 229$.
[b]Question 12 in PSS-14 is excluded from analysis.
[c]PANAS data available for $n = 699$.

Table 2 Exploratory factor analysis for all versions of PSS: loadings of the two-factor models

	Items	PSS-14		PSS-13		PSS-10		PSS-4	
		Positive (coping)	Negative (distress)	Positive (coping)	Negative (distress)	Positive (coping)	Negative (distress)	Positive (coping)	Negative (distress)
	In the last month, how often have you been/felt								
1	Upset by something happening unexpectedly?	0.027	**0.629**	0.049	**0.628**	0.137	**0.626**		
2	Unable to control the important things in your life?	0.166	**0.746**	0.188	**0.755**	0.288	**0.757**	0.284	**0.736**
3	Nervous and stressed?	0.076	**0.701**	0.102	**0.702**	0.210	**0.697**		
4	Dealt successfully with day-to-day problems and annoyances?	**0.605**	−0.149	**0.597**	−0.123				
5	Effectively coping with important changes that were occurring in your life?	**0.739**	−0.016	**0.741**	0.018				
6	Confident about your ability to handle your personal problems?	**0.769**	0.116	**0.768**	0.156	**0.721**	0.156	**0.726**	0.213
7	Things were going your way?	**0.639**	0.367	**0.651**	0.397	**0.730**	0.383	**0.780**	**0.418**
8	Could not cope with all the things that you had to do?	0.122	**0.627**	0.148	**0.626**	0.217	**0.630**		
9	Dealt successfully with irritating life hassles?	**0.710**	0.099	**0.715**	0.132	**0.679**	0.130		
10	You were on top of things?	**0.685**	0.298	**0.694**	0.332	**0.761**	0.316		
11	Angered because of things that were outside your control?	0.047	**0.668**	0.073	**0.667**	0.160	**0.673**		
12	Thinking about things that you have to accomplish?	−0.322	0.358						
13	Able to control the way you spend your time?	**0.692**	0.131	**0.685**	0.172				
14	Difficulties were piling up so high that you could not overcome them?	0.155	**0.659**	0.182	**0.658**	0.269	**0.663**	0.268	**0.678**

Extraction method used was principal axis factoring. The rotation method was oblimin. Factor loadings of more than 0.4 are in bold.
PSS, Perceived Stress Scale.

Table 3 Confirmatory factor analyses for different models

	MODEL	χ^2	*df*	*p*-value	*CFI*	*RMSEA*	*SRMR*
PSS-13	One-factor model	1736	65	<0.001	0.569	0.182	0.167
	Two-factor model	424	64	<0.001	0.905	0.086	0.075
PSS-10	One-factor model	876	35	<0.001	0.627	0.202	0.136
	Two-factor model	158	34	<0.001	0.952	0.069	0.048
PSS-4	One-factor model	165	2	<0.001	0.73	0.327	0.10
	Two-factor model			Convergence not achieved			

df, degree of freedom; PSS, Perceived Stress Scale; CFI, comparative fit index; RMSEA, root mean squared error of approximation; SRMR, standardized root mean squared residual.

Internal consistency reliability analysis

Internal consistency reliability coefficients, using Cronbach's alpha, for the negative subscale of PSS-13, PSS-10, and PSS-4 were 0.83, 0.83, and 0.67, respectively. The Cronbach's alpha values of the positive subscale of PSS-13, PSS-10, and PSS-4 were 0.86, 0.81, and 0.71, respectively. Finally, the Cronbach's alpha values of the full scale for PSS-13, PSS-10, and PSS-4 were 0.83, 0.82, and 0.66, respectively. On the basis of Kline's criterion (2000), reliability coefficients of more than 0.7 confirm internal consistency. Therefore, our results indicate that PSS-13 and PSS-10 pass the Kline's criterion for internal consistency, but PSS-4 does not.

Mild cognitive impaired population

We also repeated the analysis on a subset of subjects with MCI. Only the two-factor model for PSS-13 showed good model fits, and models for PSS-10 and PSS-4 showed unsatisfactory fit (see Tables S-3, S-4, and S-5).

Concurrent and divergent validity

Scores on the positive and negative subscales were computed by averaging the corresponding items for PSS; higher scores on negative and positive subscales indicate higher levels of perceived distress and coping ability, respectively. The overall PSS score was computed by adding the negative subscale scores and the reverse of the positive subscale scores. Higher overall scores indicate higher levels of stress. In order to provide additional support for the predictive validity of the PSS, we investigated the correlation between the 13-item PSS (total stress score) and the two negative factor (NF) and positive factor (PF) with other demographic and neuropsychological measures (Table 4).

Women reported a significantly higher total stress score than men ($t=-3.2$, $p=0.007$); there was a similar trend for NF with women reporting more distress than men ($t=-3.9$, $p=0.018$). The PF did not demonstrate a gender difference ($t=1.3$, $p=0.22$). Furthermore, total PSS was associated with age ($r_s=0.12$, $p=0.005$). Analysis of PSS factors showed that there is a reverse correlation between PF and age ($r_s=-0.18$, $p<0.001$), but there is no association between NF and age ($r_s=-0.03$, $p=0.44$). As the total years of education increased, total stress score decreased ($r_s=-0.08$, $p=0.02$).

Total stress score was negatively correlated with the free recall score from the FCSRT-IR ($r_s=-0.08$, $p=0.02$) and logical memory ($r_s=-0.09$, $p=0.014$); PF was positively correlated with FCSRT-IR free recall ($r_s=0.10$, $p=0.004$) and logical memory ($r_s=0.14$, $p<0.001$), but there was no association between NF and FCSRT-IR free recall ($r_s<0.001$, $p=0.99$) or logical memory ($r_s=0.0.4$, $p=0.29$).

Depression was positively associated with total stress score ($r_s=0.39$, $p<0.001$); it was positively correlated with the NF ($r_s=0.32$, $p<0.001$) and inversely associated with the PF ($r_s=-0.32$, $p<0.001$). In addition, anxiety was positively associated with total stress score ($r_s=0.29$, $p<0.001$), negatively associated with the PF ($r_s=-0.18$, $p<0.001$), and positively associated with the NF ($r_s=0.35$, $p<0.001$).

As external validators, we also compared the association between coping, distress, and the total score for the 13-item version with PANAS scores. Higher levels of stress were associated with lower scores of PANAS PA ($r_s=-0.39$, $p<0.001$) and higher scores of PANAS negative affect ($r_s=0.46$, $p<0.001$). The NF (PA: $r_s=-0.19$, $p<0.001$; NA: $r_s=0.59$, $p<0.001$) and the PF (PA: $r_s=0.42$, $p<0.001$; NA: $r_s=-0.23$, $p<0.001$) also correlated with PANAS-X NA and PANAS-X PA.

There was some support for divergent validity, as well, as correlations between PSS and the SF-36 bodily pain measure—which was not intended to measure perceived stress—were low (PSS: $r_s=0.18$, $p<0.001$; PF: $r_s=0.14$, $p<0.001$; NF: $r_s=-0.17$, $p<0.001$).

Table 4 Correlations of subscale scores on PSS (13 items)[a]

	Coping	Distress[a]	Total stress
Age	−0.18[b]	−0.03	0.12[b]
Education (years)	0.18[b]	0.04	−0.10[c]
FCSRT-IR free recall	0.10[c]	0.00	−0.08[c]
FCSRT-IR total recall	−0.04	−0.02	−0.04
Logical Memory I	0.14[b]	0.04	−0.09[c]
BIMC	−0.13[b]	0.05	0.12[b]
Beck anxiety score[d]	−0.18[b]	0.35[b]	0.29[b]
GDS score	−0.32[b]	0.33[b]	0.39[b]
PANAS-X positive affect	0.43[b]	−0.20	−0.41[b]
PANAS-X negative affect	−0.22[b]	0.57[b]	0.44[b]

PSS, Perceived Stress Scale; FCSRT-IR, Free and Cued Selective Reminding Test-Immediate Recall; BIMC, Blessed Information-Memory-Concentration; GDS, Geriatric Depression Scale; PANAS, Positive Affect and Negative Affect Schedule.
[a]Question 12 in PSS-14 is excluded from analysis.
[b]Correlation is significant at the 0.01 level.
[c]Correlation is significant at the 0.05 level.
[d]Beck anxiety score available for $n=249$.

Discussion

In this study, we explored the factor structure and internal consistency reliability of the three versions of PSS and validity of PSS-13 in a community-based sample of adults over the age of 70 years. The results confirmed a two-factor structure for PSS-10 and PSS-13 and also demonstrated the internal consistency and concurrent validity for PSS and its corresponding subscales.

In accordance with other studies testing PSS in younger populations (Golden-Kreutz *et al.*, 2004; Ramirez and Hernandez, 2007; Sharp *et al.*, 2007; Leung *et al.*, 2010; Andreou *et al.*, 2011), our findings support a two-factor structure of the 13-item and 10-item versions of PSS and that the two-factor models provided optimal approximations of the data of this scale. For

PSS-14, item 12 loaded highly on both factors, indicating that this item was not a good measure for either of the subscale factors. This item also failed to load on the two factors in the previous studies (Martin *et al*., 1995; Mitchell *et al*., 2008; Leung *et al*., 2010; Andreou *et al*., 2011). This suggests that future community-based studies of older adults may wish to exclude item 12 when calculating the total score or subscale scores. Similar to other studies (Cohen *et al*., 1983; Cohen and Williamson, 1988; Glaser *et al*., 1999), the internal consistency reliability analysis of PSS-13 and PSS-10 showed satisfactory alpha coefficients for the full range and the two subscales.

In our study, women had significantly higher PSS scores, which is consistent with previous studies (Wong *et al*., 2004; Remor, 2006; Andreou *et al*., 2011). Women showed significantly higher scores in the NF and lower scores in the PF than men.

The total PSS score and its subscales correlated with depression, anxiety, and affect in the anticipated directions, which are indicative of the concurrent validity of the PSS. In our sample, depression was associated with higher total PSS scores, higher distress, and lower coping. This is consistent with previous findings showing correlations between depression and PSS (Hewitt *et al*., 1992; Candrian *et al*., 2008; Dennis *et al*., 2008; Elavsky and Gold, 2009; Leung *et al*., 2010; Lee *et al*., 2013). In addition, consistent with earlier findings (Brajenovic-Milic *et al*., 2010; Chen *et al*., 2012), we showed that there is a significant correlation between anxiety and PSS. Finally, in line with previous studies (Golden-Kreutz *et al*., 2004), we showed that there is a reverse correlation between the PA of PANAS scale and PSS and a direct association between NA and PSS score.

Although we studied a sample of older adults free of dementia, we included participants with MCI. The results showed that the free recall score from FCSRT-IR is positively correlated with coping and negatively correlated with total stress score. Stress may have a negative influence on memory. Alternatively, poor memory may be associated with increased stress. Analysis of validity in MCI population on a subset of subjects with MCI showed reliable fit only for the two-factor model of PSS-13. In addition, only PSS-13 and PSS-10 passed the criteria for internal consistency reliability. This suggests that among the three versions of PSS, PSS-13 is the best choice for assessing stress in MCI population.

In our two-factor model for PSS, all the positively worded items loaded together, and all the negatively worded items loaded together. Other studies have shown that positive wording *versus* negative wording of similar items influences the outcome (Wouters *et al*., 2012). This difference in wording may be an important drive for the two-factor structure. But because the correlation of the two factors is relatively weak ($r_s = -0.28$), we suggest that there may be other differences between the constructs.

Although previous studies of PSS showed strong correlation between NF(distress)and PF(coping) in younger populations (Leung *et al*., 2010; Andreou *et al*., 2011), in our study these factors are weakly correlated ($r_s = -0.28$) and should be considered as correlated but somewhat independent factors. In addition, PF and NF show different correlations with other variables (i.e., memory domain). Therefore, we suggest using these factors as separate indicators of stress in future studies of older adults.

The strength of this study is our utilization of a large systematic community sample of participants over the age of 70 years. There are a few limitations for this study. A participation bias may be operative in these findings because individuals with more stress might not elect to participate in research studies. Furthermore, because we excluded participants with dementia and severe psychiatric symptomatology, the results should not be extended to these populations. In addition, the average level of education in our population was 14.1 and higher than general population, which might limit generalizability of the findings. Finally, although we assessed internal consistency reliability of the PSS in our sample, we did not assess test–retest reliability.

Conclusion

The PSS revealed satisfactory psychometric properties in nondemented older adults, and therefore, its 13-item (PSS-14 excluding item 12) and 10-item versions are acceptable for use in older adults.

Conflict of interest

None declared.

Key points

- PSS-13 (PSS-14 excluding item 12) and PSS-10 are acceptable for use in older adults.
- Among 3 versions of PSS, PSS-13 is the best choice for assessing stress in MCI population.
- The weak correlation between positive and negative factors, and different correlations with other variables indicate that these factors are somewhat independent and should be used as separate indicators of stress.

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Author contributions

Study concept and design was made by Lipton, Katz, Zimmerman, and Sliwinski. Katz was responsible for the data acquisition. Ezzati, Jiang, Katz, Zimmerman, Sliwinski, and Lipton performed the data analysis and interpretation. Ezzati and Jiang prepared the initial manuscript. Ezzati, Jiang, Katz, Zimmerman, Sliwinski, and Lipton carried out the critical revision of manuscript for important intellectual content. All authors contributed to and approved the final manuscript.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web-site:

Table S1. Exploratory Factor Analysis for All Versions of PSS: Loadings of the 2-Factor Models for the First Half of Data in the Split-Half Analysis

Table S2. Confirmatory Factor Analyses for Different Models in Split-Half Analysis

Table S3. Exploratory Factor Analysis for All Versions of PSS: Loadings of the 2-Factor Models in MCI Population (N=124)

Table S4. Confirmatory Factor Analyses for Different Models in MCI Population (N=124)

Table S5. Reliability coefficients (Cronbach's alpha) in MCI population (N=124)

