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Research Paper

Psychometric properties of the 10-item Connor-Davidson Resilience Scale (CD-RISC-10) in male military personnel with and without PTSD

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ABSTRACT

Background: The 10-item Connor-Davidson Resilience Scale (CD-RISC-10) is a scale widely used to assess resilience among various clinical and nonclinical populations. Measurement invariance of a scale is essential for group comparison. However, to our knowledge, the psychometric properties, including the measurement invariance, validity and reliability, of the CD-RISC-10 in male military personnel with posttraumatic stress disorder (PTSD) are unknown. The current study aimed to determine the measurement invariance of the CD-RISC-10 and its validity and reliability in male military personnel with and without PTSD.

Methods: A total of 8089 male military personnel were enrolled in the study, 370 of whom were screened as having PTSD based on the screening criteria of a Posttraumatic Stress Disorder Checklist-Civilian score ≥38 and 7719 of whom did not have PTSD. Confirmatory factor analysis (CFA) was conducted to evaluate whether the scale had a single factor and to determine the measurement invariance in PTSD and non-PTSD samples.

Results: The results showed that the CD-RISC-10 had satisfactory and reliable internal consistency and criterion-related validity among the PTSD ($\alpha = 0.91$; $r = -0.54, -0.44, -0.55$, $P<0.01$) and non-PTSD ($\alpha = 0.94$, $r = -0.61, -0.49, -0.56$, $P<0.01$) groups. The unidimensional structure of the CD-RISC-10 was verified by CFA in the PTSD and non-PTSD groups. Moreover, the scalar invariance of the CD-RISC-10 was established across PTSD and non-PTSD groups($\triangle$CFI = -0.002, $\triangle$TLI = 0.001, $\triangle$RMSEA =-0.001).

Conclusions: The findings indicate that the CD-RISC-10 is an effective instrument for assessing psychological resilience across PTSD and non-PTSD male military personnel.

1. Instruction

Military personnel are usually faced with stressful and potentially traumatic combat and war-related events during deployment. They are also confronted with noncombat stressors such as prolonged absence from home, relationship tension, and problems adapting to barrack residence. All of the above factors may increase the risks of mental health disorders, such as posttraumatic stress disorder (PTSD), in military personnel (Gates, 2012). It is often suggested that psychological resilience plays an important role in the maintenance and/or enhancement of their mental health and functioning under these circumstances.

In the field of psychology, resilience is characterized as "processes or patterns of positive adaptation and development in the context of significant threats to an individual's life or function" (Steven M. Southwick, 2014). It helps individuals actively adapt to serious adversities, recover from aftereffects of stressors and maintain mental health (van der Meulen et al., 2020a; Joseph Ssenyonga, 2013). Recently, researchers have explored the buffering effect of resilience against PTSD. The theory of resilience emphasizes the consideration of protective, positive rather than pathological or negative factors in trauma research. Higher resilience has been associated with a lower risk of developing PTSD after being exposed to trauma because resilient individuals tend to view potentially stressful situations as meaningful, renew their commitment to their values and life goals after experiencing stressful situations, believe that they have some control over their stressors (appraising stressors as changeable), and view changes as normal aspects of life (Quan et al., 2017). Therefore, resilience is often regarded as a protective factor against the development of PTSD in trauma-exposed individuals (Anu Asnaani, 2015).

In recent years, psychological resilience has gained widespread attention in the military because of the shift from a focus on treating pathology after it arises to developing and reinforcing positive skills and

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resources that contribute to resilience (van der Meulen et al., 2020b). Studies have shown that veterans with PTSD score significantly lower on a measure of resilience, and that resilience predicts better health and fewer symptoms in military personnel exposed to a range of stressors (Whealin et al., 2013). Consequently, resilience may be an effective predictor of PTSD in military personnel.

According to the close relationship between resilience and PTSD, the degree of resilience, if measured accurately, may predict the development and treatment outcomes of PTSD following trauma exposure. To date, several self-report scales have been developed to assess resilience. The Connor-Davidson Resilience Scale (CD-RISC), which has good reliability and validity, is the most widely used tool to quantify the level of self-perceived resilience (Davidson, 2003). The primary goals of CD-RISC development were to design a valid and reliable measure to measure resilience that facilitated assessment of the malleability of resilience in response to pharmacologic treatment in clinical patients as well as to establish baseline values for resilience in the general population and clinical populations (Davidson, 2003). Currently, it has been widely used in different populations ranging from patients with psychological and physiological diseases to healthy children, adolescents, and adults (Hyeonseok S. Jeong, 2015; Suky Martinez, 2021; Zeng Jie Ye, 2017; Wang et al., 2020).

The 10-item Connor-Davidson Resilience Scale (CD-RISC-10) is a short version of the CD-RISC that has also demonstrates a high reliability and validity (Chang Cheng, 2020; Yunier Broche-P Erez, 2022). Because of its shorter length, the CD-RISC-10 is more convenient for use than the CD-RISC. S. Yao and colleagues evaluated the psychometric properties of the CD-RISC-10 in Chinese undergraduates and depressed patients (Chang Cheng, 2020), and the results showed that the CD-RISC-10 exhibited measurement invariance in depressed and healthy subjects. However, studies on the psychometric properties of the CD-RISC-10 in army members with and without PTSD are quite rare. Previous studies have uncovered that resilience is associated with lower self-reported and clinician-rated PTSD severity in smoking-withdrawal populations (Asnaani et al., 2015). However, few studies have investigated the relationship between PTSD and resilience among military personnel. In addition, the measurement invariance, reliability and validity of the Chinese version of the CD-RISC-10 have not been widely and deeply examined in military personnel or in the PTSD population. Therefore, it is critical to compare the resilience of military personnel with and without PTSD on the basis of the measurement invariance of the CD-RISC-10. In the current study, we aimed to examine the measurement invariance, reliability and validity of the Chinese version of the CD-RISC-10 and explore differences between male military personnel with and without PTSD.

In terms of the criterion validity of the CD-RISC-10 in the PTSD population, we selected perceived stress, insomnia, anxiety, depression and posttraumatic growth, which are all closely and directly related to psychological resilience, as the criteria of resilience in the current study. Resilience involves a positive adaptation after stressful situations. A resilient person has the capacity to successfully adapt to change, resist the negative impact of stressors and avoid substantial dysfunction (Babi et al., 2020). However, insomnia may develop in vulnerable individuals in response to stress (Drake et al., 2014). Anxiety and depression are often associated with stress and insomnia. Therefore, we confidently regard stress, insomnia, anxiety and depression as negative indicators of resilience. In addition, previous studies have shown that resilience correlates positively with posttraumatic growth (PTG) (Adjorlolo et al., 2022). Therefore, we regard PTG as a positive indicator of resilience in our study.

Against this background, the first aim of the present study was to evaluate the measurement invariance of the CD-RISC-10 in military personnel with and without PTSD. The instrument's configural, metric, scalar, and strict invariance were examined using multiple-group confirmatory factor analysis (CFA). The second aim was to evaluate the reliability and validity of the CD-RISC-10 in separate PTSD and non-PTSD groups. The third aim was to compare psychological resilience between military personnel with and without PTSD.

We hypothesized (1) that the CD-RISC-10 would demonstrate measurement (at least scalar) invariance in military personnel with and without PTSD, (2) that the CD-RISC-10 scores would be negatively correlated with severity of perceived stress, insomnia, anxiety and depression and positively correlated with PTG, indicating the good validity and reliability of the CD-RISC-10, and (3) that the level of psychological resilience in military personnel with PTSD would be lower than that in military personnel without PTSD.

2. Method

2.1. Participants

PTSD sample. The inclusion criteria of PTSD sample were as follows: the Posttraumatic Stress Disorder Checklist-Civilian score (PCL-C)$\geq$38, no diagnosed other psychological disorder, no psychiatric medication was initiated. Special Note: PTSD sample in this study mainly refers to military personnel with PTSD symptoms, not clinical PTSD patients.

Non-PTSD sample. The inclusion criteria of Non-PTSD sample were as follows: the Posttraumatic Stress Disorder Checklist-Civilian score (PCL-C) $<$ 38, no diagnosed other psychological disorder, no psychiatric medication was initiated.

A cluster sampling method was used to enroll a total of 8609 army military personnel in Xinjiang Uygur Autonomous Region in the study. All of them enforced the China-India border confrontation task. Because there are very few female military personnel on duty, this study only included male military personnel. They were recruited from May to December 2021. They provided written informed consent before completing the study questionnaires. This study was approved by the Medical Ethics Committee of the Army Medical University (No. 2020–019–02). Finally, a total of 8089 male army military personnel were enrolled in the study, including 370 PTSD sample and 7719 non-PTSD sample.

2.2. Measures

10-item Connor-Davidson Resilience Scale (CD-RISC-10). The 25-item CD-RISC is used to assess resilience, specifically the ability to cope with adversity (Connor, 2003), and the Chinese version of the 25-item CD-RISC was adapted by a two-stage process of translation and back translation, and its reliability and validity in the Chinese population have been well documented(Ye et al., 2017).The CD-RISC-10 was extracted from the original CD-RISC(Campbell-Sills and Stein, 2007). Item responses range from 0 ("not true at all") to 4 ("true nearly all of the time"). The overall score ranges from 0 to 40, with higher scores reflecting a greater ability to cope with adversity.

Perceived Stress Scale (PSS). The original version of the Perceived Stress Scale was designed to measure the degree to which situations in one's life are appraised as stressful (Cohen et al., 1983). Participants respond to these items using a Likert scale from 0 (not at all) to 4 (always) regarding perceived stress in the last month. Total scores range from 0 to 56, with higher scores representing a stronger intensity of perceived stress.

Insomnia Severity Index (ISI). The ISI assesses the nature, severity, and impact of insomnia during the previous 2 weeks. Its seven items address (1) difficulty falling asleep, (2) difficulty staying asleep, (3) problems with waking up too early, (4) sleep dissatisfaction, (5) interference of sleep problems with daytime functioning, (6) noticeability of sleep difficulties to others, and (7) level of distress caused by sleep difficulties. Each item is rated using a 5-point Likert scale ranging from 0 (none) to 4 (very severe). Total scores range from 0 to 28, and higher scores indicate greater insomnia severity (Morin et al., 2011).

Posttraumatic Growth Inventory (PTGI). Tedeschi and Calhoun (1996) (Tedeschi, 1996) developed the original version of the PTGI. It is

mainly used to assess positive outcomes in individuals who experienced negative events. It includes 21 indicators encompassing five growth domains: (1) appreciation of life, (2) new possibilities, (3) personal strength, (4) relating to others, and (5) spiritual change. Respondents are instructed to indicate the degree of their perceived growth on a 6-point Likert scale ranging from 0 (no change) to 5 (very large change). Total scores range from 0 to 105, and a higher score indicates greater posttraumatic growth.

Posttraumatic Stress Disorder Checklist-Civilian version (PCL-C). This scale is used to measure the severity of PTSD symptoms in the last month (Weathers et al., 1993). It consists of 17 items that assess 3 dimensions: intrusion (items 1–5), avoidance and numbing (items 6–12), and hyperarousal (items 13–17). Each item is scored on a 5-point Likert scale, ranging from 1 (not at all) to 5 (extremely). Total scores range from 17 to 85, and higher scores indicate higher severity of PTSD.

Hospital Anxiety and Depression Scale (HADS). The HADS was developed to screen for anxiety and depression in hospital patients. The tool includes 14 items, 7 related to anxiety (HADS-A) and 7 related to depression (HADS-D). Each item is scored on a 4-point Likert scale with values ranging from 0 to 3. Scores $\geq$8 on either of the two subscales should be regarded as a possible case, and scores$\geq$11 should be regarded as a definite case (Zigmond and Snaith, 1983).

2.3. Analytical procedures and statistical methods

Measurement invariance is the premise of group comparison. There are four levels of measurement invariance. The first and lowest level is configural invariance, which implies that the same indicators can be used in all groups to measure the same underlying latent construct. However, even if configural invariance is supported by the data, this still does not allow us to make any meaningful comparisons. The next level is metric invariance, which implies that the factor loadings of the items measuring the latent variable are the same across groups. However, even if metric invariance is present, the model still does not allow the comparison of means with confidence. Meaningful comparisons of means require a higher level of invariance, scalar invariance (MEREDITH, 1993), which implies that not only the factor loadings but also the item intercepts are equal across groups. The last and highest level is strict invariance, which indicates that measurement errors are also equivalent across groups. However, since strict invariance does not have direct consequences for the comparability of structural parameters across groups, most applied studies refrain from its evaluation (Heinz Leitgob and van de Schoot, 2022).

2.3.1. Analytical procedures

First, to determine what estimation method to use for the CFA, the normality of data distribution was assessed for the CD-RISC-10 items of the two samples (PTSD sample, non-PTSD sample). Second, CFA of the single-factor model of the SD-RISC-10 was carried out on the two samples. Third, multiple-group CFA was used to test whether the CD-RISC-10 had cross-group measurement invariance. Following previous research (Bowen and Masa, 2015), validation of measurement invariance includes the following four steps: (1) configural invariance, which was confirmed by factor equivalence between groups. In this study, configural invariance was mainly used to evaluate whether the composition of latent variables was the same between the PTSD group and non-PTSD group. (2) Metric invariance, which was confirmed by factor loading equivalence across different groups. In the metric invariance analysis, the factor loadings were constrained to be equivalent for the tested groups to determine whether items represented the same concepts in both groups. (3) Scalar invariance, which was confirmed by equal intercepts of the observed variables across groups. Scalar invariance was considered to be present when the fit of the scalar and metric models did not differ. (4) Strict invariance, which was confirmed by equivalent error variance across groups. The four models are nested within each other. The next step was tested only when the requirements of the previous step were met (MEREDITH, 1993).

2.3.2. Statistical methods and software

First, the Kolmogorov–Smirnov (K-S) test was used to test the normality of score distributions of CD-RISC-10 items in the two samples. Second, the comparative fit index (CFI) and Tucker–Lewis index (TLI), which are increasing fit indices, and the root mean square error of approximation (RMSEA) and standard root mean square residual (SRMR), which are absolute fit indices, were used for CFA to evaluate the degree of fit between the factor model and the data. The following values indicate that the model fit is acceptable: CFI and TLI$\geq$0.90, SRMR$\leq$0.05 and RMSEA$\leq$0.08. In view of the susceptibility of the chi-square test to sample size, the cross-group equivalence of the CD-RISC-10 was evaluated using ΔCFI, ΔTLI and ΔRMSEA with the tolerable criterion of ΔCFI$<$ 0.010, ΔTLI $<$ 0.010, and ΔRMSEA $<$ 0.015 (Browne, 1992). Third, descriptive analyses were conducted by in SPSS (version 23.0). CFA and cross-group equivalence tests were conducted using Amos 21.0 software. All statistical tests were two-tailed (P<0.05).

Considering the strong connection between resilience and PTSD mentioned above, the criterion-related validity in each group was evaluated by an analysis of the correlation between CD-RISC-10 scores and scores on other scales used in the PTSD group, including the PSS, ISI, PTGI, and HADS.

3. Results

3.1. Sample characteristic

The demographic characteristics of the participants are summarized in Table 1.

3.2. Internal consistency reliability of scales in different groups

The internal consistency reliability of scales in different groups are listed in Table 2.

Cronbach's alpha coefficient is a mostly used method to assess the reliability of a scale. A Cronbach's alpha value of 0.70 or higher demonstrate good consistence (Aksoy et al., 2023).

3.3. Item characteristics and descriptive statistics

Item characteristic analysis, including the means, SD, Cronbach's α, corrected item-total score correlations and factor loadings, was conducted in the PTSD group and non-PTSD group. In the PTSD group, 370 participants' total scores on the CD-RISC-10 ranged from 0 to 40 (mean = 24.85; SD = 7.54), while those of the 7719 participants in the non-PTSD group ranged from 0 to 40 (mean = 32.36; SD = 7.20). The Cronbach's α coefficients of each item of the CD-RISC-10 in military

Table 1
Demographic variables.

	N(%)
Total	8089 (100%)
PTSD sample	370 (4.57%)
Age, mean (SD)	23.67 (4.29)
Sex, male	370 (100%)
Education	
middle school education	116 (31.35%)
High school education	181 (48.92%)
college education	73 (19.73%)
Non-PTSD sample	7719 (95.43%)
Age, mean (SD)	23.57 (3.77)
Sex, male	7719 (100%)
Education	
middle school education	3188 (41.30%)
High school education	3497 (45.30%)
college education	1034 (13.40%)

Table 2
Cronbach's alpha coefficients of scales in different groups.

	Cronbach's alpha coefficient
10-item Connor-Davidson Resilience Scale	
PTSD sample	0.91
Non-PTSD sample	0.94
Total	0.94
Perceived Stress Scale	
PTSD sample	0.74
Non-PTSD sample	0.83
Total	0.84
Insomnia Severity Index	
PTSD sample	0.88
Non-PTSD sample	0.89
Total sample	0.90
Posttraumatic Growth Inventory	
PTSD sample	0.95
Non-PTSD sample	0.97
Total sample	0.97
Posttraumatic Stress Disorder Checklist-Civilian version	
PTSD sample	0.81
Non-PTSD sample	0.90
Total sample	0.95
Anxiety subscale of HADS	
PTSD sample	0.76
Non-PTSD sample	0.76
Total sample	0.79
Depression subscale of HADS	
PTSD sample	0.76
Non-PTSD sample	0.78
Total sample	0.78

personnel with and without PTSD were all above 0.90, which indicates good internal consistency. The corrected item-total score correlations in these groups ranged from 0.54 to 0.82, and all of them were greater than 0.4, which showed that these items had good homogeneity with the scale (Alamer, 2022). The item loadings of the CD-RISC-10 in the two samples are reported in Table 1; these ranged from 0.61 to 0.86, and all were greater than 0.45. Thus, all items loaded significantly on the latent factor (see Table 3).

Table 3
Means, SDs, Cronbach's α values, corrected item-total score correlations (R_{tt}) and factor loadings (Loading) of the CD-RISC-10 items in military personnel with and without PTSD.

Item	Mean±SD	α	R_{tt}	Loading
PTSD group (n = 370)				
CD1	2.60±0.92	0.90	0.65	0.72
CD2	2.54±0.93	0.90	0.63	0.71
CD3	2.52±0.98	0.90	0.66	0.74
CD4	2.68±0.99	0.90	0.71	0.77
CD5	2.38±1.15	0.91	0.54	0.61
CD6	2.51±1.04	0.90	0.75	0.81
CD7	2.07±1.08	0.90	0.68	0.75
CD8	2.55±1.03	0.90	0.71	0.78
CD9	2.61±1.01	0.90	0.74	0.80
CD10	2.41±1.00	0.90	0.69	0.76
Total score	24.85±7.54	0.91		
Non-PTSD group(n = 7719)				
CD1	3.25±0.87	0.93	0.71	0.77
CD2	3.19±0.87	0.93	0.77	0.82
CD3	3.24±0.86	0.93	0.79	0.84
CD4	3.35±0.80	0.94	0.78	0.83
CD5	3.08±1.15	0.93	0.58	0.64
CD6	3.24±0.88	0.93	0.82	0.86
CD7	3.06±0.95	0.93	0.78	0.83
CD8	3.33±0.87	0.93	0.77	0.82
CD9	3.37±0.80	0.93	0.80	0.85
CD10	3.25±0.89	0.93	0.78	0.83
Total score	32.36±7.20	0.94		

Note. SD = standard deviation; CD-RISC-10 = 10-item Connor-Davidson Resilience Scale; PTSD = posttraumatic stress disorder.

3.4. Structural validity

The results of the CFA of the single-factor model of the CD-RISC-10 are presented in Table 4. Examination of the single-factor model in the two samples was determined according to the fit of the models based on the guidelines provided by Inês A. Trindade (2022): for a sample larger than 250, acceptable fit may be determined based on a combination of values of 1) Comparative Fit Index (CFI)≥0.92, Tucker–Lewis Index (TLI)>0.90, and Root Mean Square Error of Approximation (RMSEA)≤ 0.07, or 2) CFI≥0.92, Tucker–Lewis Index (TLI)>0.90, and a Standardized Root Mean Square Residual (SRMR) ≤0.08. Hence, the CD-RISC-10 showed good structural validity in the two samples.

3.5. Measurement invariance

PTSD group vs. non-PTSD group. The assessment of configural invariance with multiple-group CFA aimed to test the structural equivalence of the scale and revealed equivalent patterns of latent variables in the PTSD and non-PTSD groups. Fit indices (CFI = 0.973, TLI = 0.965, RMSEA = 0.065) for the configural invariance model demonstrated the presence of configural invariance. Thus, subsequent testing was performed. The metric and scalar invariance models yielded satisfactory fit indices (△CFI = −0.001, △TLI = 0.002, △RMSEA =−0.002 and △CFI = −0.002, △TLI = 0.001, △RMSEA =−0.001, respectively). The fit indices for the strict invariance model were △CFI = −0.017, △TLI = −0.012, and △RMSEA =0.01, which implied that only △RMSEA was satisfactory, while the indices of absolute △CFI and △TLI were greater than 0.01 (see Table 5). Thus, these results support the hypothesis of measurement invariance of the CD-RISC-10, at least scalar invariance, across PTSD and non-PTSD samples.

3.6. Comparison of CD-RISC-10 in male military personnel with and without PTSD

The independent-sample t-test revealed that CD-RISC-10 total scores in the PTSD group were significantly lower than those in the non-PTSD group (t = 19.54, P<0.001) (see Table 6), suggesting that the level of psychological resilience in military personnel with PTSD was much lower than that in military personnel without PTSD.

3.7. Internal consistency and criterion-related validity

The Cronbach's α values of the CD-RISC-10 were 0.91 and 0.94 for the PTSD and non-PTSD samples, respectively (see Table 3). In addition, the Cronbach's α values of the criterion-related scales (see Table 2) ranged from 0.74 to 0.97, which showed acceptable internal consistency for most scales used in the present study. Therefore, these results indicated satisfactory internal consistency of the CD-RISC-10 and the criterion-related scales.

Regarding the criterion-related validity, there were strong negative

Table 4
Assessment of model fit from single-factor confirmatory factor analysis (CFA) in the two groups.

Model	χ^2	df	CFI	TLI	SRMR	RMSEA (90% CIs)
PTSD group	166.25***	35	0.93	0.91	0.0439	0.101 (0.086–0.116)
Non-PTSD group	1962.94***	35	0.97	0.96	0.0258	0.084 (0.081–0.088)

Note. χ^2 = chi-square goodness of fit; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; 90% CIs = 90% confidence intervals of the RMSEA.

Table 5
Results of multigroup analysis of the CD-RISC-10 in military personnel with and without PTSD.

Model	χ^2	*df*	CFI	TLI	RMSEA (90% CIs)	Comparison	△CFI	△TLI	△RMSEA	Invariance
1. Configural	329.123***	68	0.973	0.965	0.065 (0.058–0.072)					Yes
2. Metric	350.655***	77	0.972	0.967	0.063 (0.056–0.069)	2 vs. 1	−0.001	0.002	−0.002	Yes
3. Scalar	383.221***	86	0.970	0.968	0.062 (0.055–0.068)	3 vs. 2	−0.002	0.001	−0.001	Yes
4. Strict	553.874***	96	0.953	0.956	0.072 (0.067–0.078)	4 vs. 3	−0.017	−0.012	0.01	No

Note. χ^2 = chi-square goodness of fit; *df* = degrees of freedom; CFI = comparative fit index; TLI = Tucker−Lewis index; RMSEA = root mean square error of approximation; 90% CIs = 90% confidence intervals of the RMSEA; △RMSEA = RMSEA difference.

Table 6
Comparison of CD-RISC-10 scores in male military personnel with and without PTSD.

Group	M±SD	Mean value difference	*t*	*P*
PTSD	24.85±7.54	7.50	19.54	<0.001
Non-PTSD	32.36±7.20			

correlations between CD-RISC-10 scores and CPSS, ISI, anxiety, and depression scores ($P<0.01$) as well as strong positive correlations between CD-RISC-10 scores and PTGI scores ($P<0.01$) in both PTSD and non-PTSD samples (see Table 7). In summary, all these results suggest that the CD-RISC-10 has favorable and reliable internal consistency and criterion-related validity in both PTSD and non-PTSD samples.

4. Discussion

In the present study, a cross-group empirical factor analysis was used to investigate the measurement invariance of the CD-RISC-10 between the PTSD and non-PTSD groups. The results supported the configural, metric, and scalar invariance of the CD-RISC-10 across PTSD and non-PTSD groups. Thus, the CD-RISC-10 had good measurement invariance across different groups. Further independent-sample t-tests analysis revealed that the CD-RISC-10 total scores were significantly lower in male military personnel with PTSD than in male military personnel without PTSD. In addition, our findings also confirmed the excellent reliability and validity of the CD-RISC-10 in PTSD and non-PTSD samples.

Table 7
Means, SDs, Cronbach's α values, and correlation coefficients of CD-RISC-10 scores with CPSS, ISI, PTGI, PCL-C and HADS subscale scores in military personnel with and without PTSD.

Variable	Mean ± SD	α	*r*	Mean ± SD	α	*r*
Sample	PTSD group (*n* = 370)			Non-PTSD group (*n* = 7719)		
CD-RISC-10 score	24.85 ±7.54	0.91		32.36±7.20	0.94	
CPSS score	42.78 ±7.02	0.74	−0.54**	30.31±8.96	0.83	−0.61**
ISI score	10.16 ±5.60	0.88	−0.26**	3.17±3.87	0.89	−0.36**
PTGI score	45.24 ±21.75	0.95	0.41**	58.69 ±26.28	0.97	0.52**
Anxiety score	7.80 ±3.53	0.76	−0.44**	2.78±2.65	0.76	−0.49**
Depression score	7.94 ±3.91	0.76	−0.55**	2.77±2.95	0.75	−0.56**

Note. SD = standard deviation; CPSS =Chinese version of the Perceived Stress Scale; ISI = Insomnia Severity Index; PTGI = Posttraumatic Growth Inventory; PCL-C = PTSD Checklist-civilian version; HADS = Hospital Anxiety and Depression Scale. *r* = Pearson's correlation coefficient between CD-RISC-10 scores and CPSS, ISI, PTGI, and PCL-C scores; * *, $P<0.01$.

4.1. Structural validity

Confirmatory factor analysis is a structural equation modeling (SEM) (Bollen, 1989) technique used to evaluate the goodness of fit of a model of the measurement structure of a scale. The findings of our study support a single-factor model of the CD-RISC-10 in the two samples. That is, the one-factor structure of the CD-RISC-10 was stable among PTSD patients and healthy male military personnel. This is consistent with previous research (Chang Cheng, 2020; Zeng Jie Ye, 2017). The stable structural validity of the CD-RISC-10 enabled us to use it as a baseline model for the measurement invariance analysis.

4.2. Measurement invariance

The measurement invariance of the CD-RISC-10 was evaluated before group comparisons in the present study. The results supported the configural, metric and scalar invariance of the scale between the PTSD and non-PTSD groups. The results of this study did not support strict invariance, which indicated that the same items of the scale have different error variances between the PTSD and non-PTSD groups, most applied studies in the literature refrain from its evaluation since strict invariance does not have any direct consequences for the comparability of structural parameters across groups (Heinz Leitgob and van de Schoot, 2022). Overall, these results of measurement invariance of the CD-RISC-10 across PTSD and non-PTSD support our hypothesis.

On this basis, we explored the differences in CD-RISC-10 scores between PTSD and non-PTSD samples. The CD-RISC-10 scores of the PTSD group were significantly lower than those of the non-PTSD group, which was consistent with previous research (Joseph Ssenyonga, 2013). In summary, the measurement invariance of the CD-RISC-10 in this study revealed that intergroup differences were real differences (i.e., not measurement artifacts). The comparisons of CD-RISC-10 scores among the two samples were therefore meaningful.

4.3. Internal consistency and criterion-related validity

In regard to the internal consistency of the CD-RISC-10, our findings showed that the Cronbach's α coefficients were 0.91 and 0.94 in the PTSD group and non-PTSD group, respectively. This reflects the satisfactory internal consistency of the CD-RISC-10 and is consistent with prior studies (Race Ethnicity, 2018). Therefore, the CD-RISC-10 can be used to compare the psychological resilience between PTSD and non-PTSD samples.

Our findings of criterion-related validity support the strong positive correlation between psychological resilience and posttraumatic growth. This result is also in line with a cohort study in which survivors of an earthquake who had high resilience were more likely to report posttraumatic growth (Chen et al., 2022). Similarly, another study revealed that greater PTG was associated with greater cognitive functioning and quality of life (Greenberg et al., 2021), which suggests that PTG may be a positive factor of psychological resilience.

In addition, independent and negative correlations of psychological resilience with perceived stress, insomnia, depression, and anxiety were also found in the current study. This indicates that psychological resilience has a strong negative correlation with major mental illnesses. As

per our knowledge, stress, insomnia, depression and anxiety have been identified as four major psychological morbidities during the COVID-19 pandemic (Mahmud et al., 2021). This is logical because resilience is known to protect against mental illnesses such as depression, anxiety and PTSD, as demonstrated by empirical research (Park and Bae, 2022). Our findings are in line with prior studies that identified negative relationships of depression, stress, and anxiety with resilience (Chen et al., 2022; Dhungana et al., 2022; Peng et al., 2022). In terms of the relationship between psychological resilience and insomnia, our results support the outcome of a previous study that found that bipolar disorder patients with insomnia had lower levels of resilience, particularly regarding in the ability to plan for the future, formulate clear goals, and organize their own time, goals and routines (Palagini et al., 2022). Overall, stress, insomnia, anxiety and depression are risk factors for mental illnesses and reduce resilience among PTSD patients and non-PTSD individuals. Conversely, relieving anxiety, depression, stress and insomnia might effectively improve psychological resilience. In conclusion, the satisfactory criterion-related validity observed in the current study indicates that the CD-RISC-10 should be a valuable measurement tool for measuring resilience of both PTSD and non-PTSD military personnel.

4.4. Limitations

Several limitations should be noted of this study. First, this study had a cross-sectional design and did not consider changes in PTSD symptoms over time. Studies that employ longitudinal designs are needed in the future to determine the measurement invariance of the CD-RISC-10 in different stages of PTSD. Second, the PTSD subjects in the present study were determined according to the screening criteria of PCL-C scores$\geq$38, and further medical diagnosis was not made. In addition, we have not considering the potential impact of other psychological disorders. The comorbidities of PTSD, such as depression, were not assessed in the PTSD group. Previous studies have shown that PTSD and major depressive disorder usually co-occur (Nichter et al., 2020). Future studies should screen for PTSD using more scientific criteria and should assess PTSD with a wide range of comorbidities.

5. Conclusion

In conclusion, our study showed good measurement invariance of the CD-RISC-10 between PTSD and non-PTSD groups, which indicates that the comparisons of CD-RISC-10 scores between these groups are meaningful. The satisfactory internal consistency and criterion-related validity of the CD-RISC-10 verified that it is a valid measure of resilience. These efforts broadens the psychometric and measurement properties of CD-RISC-10 in male military personnel with and without PTSD.

Author statement

Yan X. F. contributed to data curation, formal analysis, funding acquisition, writing-original draft and writing-review & editing. Li M. contributed to conceptualization, investigation and project administration. Wang X. J. and Xu C. both contributed to methodology and software. Peng L. and Xu Y. Y. both contributed to supervision, validation. Liu P. contributed to data curation.

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Declaration of Competing Interest

The authors declare no potential conflicts of interest with respect to the funding, authorship or publication of this paper.

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