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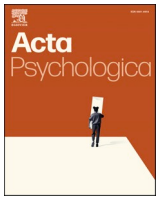

Psychometric properties of the Depression, Anxiety, and Stress Scale (DASS-21) among different Chinese populations: A cross-sectional and longitudinal analysis

I-Hua Chen [a], Chao-Ying Chen [b,m], Xiao-ling Liao [c], Xiu-mei Chen [d], Xia Zheng [e], Yu-Cheng Tsai [f,*], Chung-Ying Lin [g,h,i,j,**], Mark D. Griffiths [k], Amir H. Pakpour [l]

[a] Chinese Academy of Education Big Data, Qufu Normal University, Qufu City, Shandong, China
[b] School of Physical Therapy and Graduate Institute of Rehabilitation Science, College of Medicine, Chang Gung University, Taoyuan, Taiwan
[c] Faculty of Education, Jiangxi Science and Technology Normal University, Nanchang 330031, China
[d] Faculty of Education, Qufu Normal University, Qufu, City, Shandong, China
[e] Mental-Health Education Center, Nanchang University, Nanchang 330000, China
[f] Department of Pediatrics, E-DA Hospital, I-Shou University, Kaohsiung, Taiwan
[g] Institute of Allied Health Sciences, College of Medicine, National Cheng Kung University, Tainan, Taiwan
[h] Department of Public Health, College of Medicine, National Cheng Kung University, Tainan, Taiwan
[i] Biostatistics Consulting Center, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, 701401 Tainan, Taiwan
[j] Department of Occupational Therapy, College of Medicine, National Cheng Kung University, Tainan, Taiwan
[k] International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK
[l] Department of Nursing, School of Health and Welfare, Jönköping University, Jönköping, Sweden
[m] New Taipei City Tucheng Hospital (Chang Gung Medical Foundation), Department of Pediatric Internal Medicine, New Taipei City, Taiwan

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ABSTRACT

Given that there is limited evidence concerning the psychometric properties of DASS-21 when applied to primary school students, the present study undertook a comprehensive exploration of the psychometric evidence supporting the use of the DASS-21 within this demographic. The research comprised three studies. In Study 1, the basic psychometric properties of internal consistency and construct validity were examined. A total of 3138 primary school students from three provinces in mainland China participated. The internal reliability of the overall scale was 0.93, and for all the subscales, it was higher than 0.80. Construct validity was partially supported. Both exploratory and confirmatory factor analyses upheld the factorial validity of the original three-factor structure. While convergent validity was established, the results showed unsatisfactory discriminant validity. The bifactor model showed that DASS-21 raw scores predominantly indicated the general factor, evidenced by the high explained common variance and omega-hierarchical values. However, the contributions from the three specific factors were minimal, with their omega hierarchical values all below 0.15. In Study 2, a longitudinal design was adopted, tracking 1366 primary school students from Southwest China over a three-month interval. The results further confirmed that the DASS-21 exhibited scalar time-invariance. The latent mean analysis showed that there were no statistically significant differences in the latent means of depression, anxiety, and stress between Time 1 and Time 2. In Study 3, which included 364 college students and 483 enterprise workers, the results demonstrated that the DASS-21 had measurement invariance across different populations. The latent mean analysis further confirmed that, in terms of the latent mean of all three subscales, both college students and enterprise workers had significantly higher scores than primary school students. Overall, the findings indicated that the DASS-21 is a suitable tool for screening schoolchildren for general psychological distress, but it is not suitable for discerning distinct negative mood state disorders.

* Corresponding author.
** Correspondence to: C.-Y. Lin, Institute of Allied Health Sciences and Departments of Occupational Therapy and Public Health, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, 1 University Rd, Tainan 701, Taiwan.
E-mail addresses: cxm@sdyu.edu.cn (X.-m. Chen), zhengxia@ncu.edu.cn (X. Zheng), ed104872@edah.org.tw (Y.-C. Tsai), cylin36933@gmail.com (C.-Y. Lin).

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What is the public health significance of this article? The present study comprehensively evaluated the psychometric properties of the DASS-21 among primary school students utilizing a longitudinal design and multiple group comparisons. The study highlights the application of DASS-21 among a population of primary school students should be interpreted as a general mental health illness rather than a specific emotional disorder (e.g., anxiety).

1. Introduction

The COVID-19 pandemic significantly impacted children's mental health worldwide due to drastic changes in their daily lives, including limited social interaction and play (Chen et al., 2021). These changes compounded pre-existing concerns about child mental health (UNICEF, 2021). It is crucial to address these issues as research shows childhood mental health disorders often persist into adulthood (Liu, 2017), and can predict adult psychopathology (Reef et al., 2009) and increased risk of specific personality disorders (Kasen et al., 2001). Therefore, ongoing monitoring of children's mental health is essential to prevent and minimize the duration of such disorders.

For accurate diagnosis of mental health disorders, a reliable and valid screening instrument is crucial. The Depression, Anxiety, and Stress Scale (DASS) by Lovibond and Lovibond (1995), is widely used for this purpose. Initially intended to assess depression and anxiety, it was expanded to include a stress component, reflecting mood states like irritability, tension, and agitation (Lovibond & Lovibond, 1996). A condensed 21-item version (DASS-21) was later developed for faster administration and to cater to younger individuals with shorter attention spans (Mellor et al., 2014).

The psychometric properties of DASS-21 have been well established among different types of populations including patients (Alfonsson et al., 2017; Ng et al., 2007), general adults (Gomez et al., 2014), adolescents (Moore et al., 2016; Patias et al., 2016), college students (Diaz-Godiño et al., 2019; Lee & Kim, 2020), and individuals with specific occupations such as hospital workers (Jiang et al., 2020). However, there are limited data on its applicability in children and adolescents under 14 years of age (Lee et al., 2019), with a recent review indicating little evidence for its use in primary school students (Yeung et al., 2020).

Lovibond et al. (1995) deemed the DASS suitable for children aged 12 years due to expected language proficiency. However, alternative tools designed to assess children's emotional disorders, such as the Children's Depression Inventory (Steele et al., 2006) and Children's Manifest Anxiety Scale (Gerard & Reynolds, 2014), are supported by empirical evidence. In contrast, the DASS-21 lacks comprehensive validation for use with children. The present study sought to address this gap by examining the psychometric properties of the DASS-21 among school-aged children, to provide potential support for the tool's applicability in assessing children's mental health. The study also investigated the unresolved psychometric issues related to using the DASS-21 among this younger demographic, which necessitate additional evaluation.

1.1. Factorial validity of DASS-21 on children and young adolescent populations

The psychometric properties of DASS-21 raise concerns about its ability to distinguish three separate emotional symptoms in younger audiences. Although the scale and subscale reliability appear consistent, research suggests that the original three-factor model is not well-suited for those in early childhood, often revealing only one component (Patrick et al., 2010; Szabó & Lovibond, 2006). Meanwhile, Costa et al. (2020) raised concerns about the validity and misalignment of factor loadings for young children.

Given the findings mentioned above, and in light of concerns about the high intercorrelation between depression and anxiety in children (Lahey et al., 2004; Mineka et al., 1998), it is prudent to approach the DASS-21 with caution when assessing children's emotional disorders. The challenge in differentiating symptoms indicates a potential overlap between generalized anxiety and depression. For primary school students, considering the significant overlap between concepts like depression and anxiety, is it valid to interpret the distinct DASS-21 subscale scores for children and younger adolescents separately? Several studies have done so (e.g., Tang et al., 2021; Zainudeen et al., 2021). However, such an approach might lead to biased interpretations. Furthermore, during the COVID-19 pandemic, some reviews on children's mental health also utilized these specific DASS-21 subscale scores (e.g., Gul & Demirci, 2021; Racine et al., 2021). Given these concerns, the validity of the separate DASS-21 subscale scores merits critical examination.

1.2. Measurement invariance of DASS-21 among children/adolescent population

Equivalence of measure is another concern when applying the DASS-21 to children. Measurement invariance, which is essential for meaningful group comparisons, is uncertain for DASS-21 across different populations (Lu et al., 2018; Mellor et al., 2014). It is crucial, especially when comparing mental health outcomes among different subgroups post-COVID-19 (Vadivel et al., 2021). Currently, there is no evidence supporting the DASS-21's invariance between primary school students and other groups, which calls studies comparing these populations into question (Wang et al., 2020; Wang et al., 2021).

Furthermore, longitudinal invariance, which examines construct measurement over time, is also a concern (Brown, 2014; Newsom, 2015). This property is often assumed in longitudinal studies but is critical for meaningful time comparisons. The observed scores of DASS-21 may vary over time, even if the construct remains unchanged. Studies comparing mental health status at different times during the COVID-19 pandemic should thus be cautious about DASS-21 results (Planchuelo-Gómez et al., 2020; Wang et al., 2020). Insufficient evaluation exists regarding the DASS-21's longitudinal invariance, especially among children or adolescent populations. The current evidence base is narrow, with limited application of advanced psychometric testing methods like confirmatory factor analysis [CFA] (Anghel, 2020; Page et al., 2007).

1.3. Research questions of the present study

Based on the aforementioned concerns, the present study comprehensively evaluated the psychometric evidence supporting the use of the DASS-21 among children. Three distinct studies were conducted. The first study assessed the basic psychometric properties of internal consistency and construct validity using a sample of primary school students. The second study assessed the longitudinal invariance of the DASS-21 among a different group of primary school students. The third study broadened the participant base to include college students and enterprise workers to determine if the DASS-21's properties remained consistent across different age groups. The research questions were: (i) Does the DASS-21 exhibit robust internal consistency and construct validity? (ii) Is the DASS-21 time-invariant in a longitudinal context among primary school students? and (iii) Is the DASS-21's performance consistent across varied age demographics?

2. Study 1

2.1. Method

2.1.1. Participants and procedure

In Study 1, a cross-sectional study was conducted in June 2020 using both convenience and purposive sampling methods. During this time, COVID-19 was relatively well-controlled in mainland China, and most activity restrictions had been relaxed. However, school campuses remained physically closed to ensure the safety of students and staff.

Consequently, all primary school students in the present study attended classes via online platforms. Schools adapted to this situation by leveraging a variety of digital tools and online platforms to maintain educational continuity. This adaptation included the use of video conferencing tools for live lessons, asynchronous learning platforms for assignments and resources, and communication platforms that allowed students and teachers to interact and address any problems. Parents also played a role, often assisting younger students with the technical aspects of online learning.

The schoolchildren participating in the survey were from a western (Sichuan), central (Jiangxi), and eastern (Shandong) province. With the assistance from the principals of the primary schools in these three provinces, a hyperlink was forwarded to the parents who were responsible for helping their children participate. The survey was voluntary and anonymous. The inclusion criteria were: (i) being a student in the third grade or higher in a primary school, and (ii) being able to understand written Chinese. A total of 3138 primary (out of 10,897) school students participated. The participation rate was 28.8 %. There were no instances of missing data, as the online platform did not allow the submission of non-completed surveys. The mean age for the participants was 9.52 years (from 7 to 13 years; $SD = 1.59$). Table 1 shows the cross-distribution by gender and age. Of the participants, 716 were from the sixth grade (22.8 %), 845 from the fifth grade (26.9 %), 772 from the fourth grade (24.6 %), and 805 from the third grade (25.7 %). The gender distribution was almost balanced with females comprising 49.3 % of the sample ($n = 1546$) and males comprising 50.7 % of the sample ($n = 1592$).

Electronic informed consent was obtained from all participants who completed the survey on the online platform. The research was approved by the Ethics Committee of the Institutional Review Board of the Jianxi Psychological Consultant Association (IRB reference number JXSXL-2020-J013).

2.1.2. Measures

In addition to the DASS-21, and the basic demographic variables (i.e., sex and age), the current emotional state of the participants was assessed. More specifically, participants were asked to select one of the following emotions that best matched their current state: 'worry,' 'fear,' 'anxiety,' 'depression,' 'irritability,' 'anger,' and 'peacefulness.' This item was used to test the construct validity of the DASS-21.

Table 1
Frequency distribution of participants by sex and age group.

Study 1: Primary school students ($n = 3138$)							
	7 Years	8 Years	9 Years	10 Years	11 Years	12 Years	13 Years
Boys	229	218	284	336	369	113	43
Girls	202	211	275	396	309	110	43
Chi-square test for homogeneity (p-value): 11.55 (0.07)							
Study 2: Primary school students ($n = 1366$)							
	7 Years	8 Years	9 Years	10 Years	11 Years	12 Years	13 Years
Boys	1	3	59	168	321	141	4
Girls	0	1	73	192	293	108	2
Chi-square test for homogeneity (p-value): 10.83 (0.09)							
Study 3: College student ($n = 364$)							
	17 Years	18 Years	19 Years	20 Years			
Male	25	51	20	7			
Female	42	103	35	20			
Chi-square test for homogeneity (p-value): 1.30 (0.72)							
Study 3: Enterprise workers ($n = 483$)							
	18–25 Years	26–30 Years	31–40 Years	41–50 Years	Above 51 Years		
Male	91	116	87	52	34		
Female	39	35	18	9	2		
Chi-square test for homogeneity (p-value): 14.14 (0.01)							

2.1.2.1. DASS-21.

The participants completed the Chinese version of DASS-21. Like the original DASS-21, the Chinese DASS-21 comprises three seven-item subscales assessing depression, anxiety, and stress. Items are rated on a four-point Likert scale (from 0 to 3), with higher scores indicating higher levels of depression, anxiety, or stress. The DASS-21, translated into many languages, has been widely applied in Chinese-speaking regions (e.g., Chan et al., 2012; Wang et al., 2015). The present study used the simplified Chinese version of the DASS-21 (Chan et al., 2012) because this is the language primarily used by the participants in the present study. In contrast, the version by Wang et al. (2015) is a translation into traditional Chinese, based on Taouk et al. (2001), and features linguistic variations that differ from simplified Chinese. In order to accurately reflect the language used by the target population in the present study—mainland Chinese primary school students— the version by Chan et al. (2012) was deemed to be the most suitable for the present study. To ensure comparability with other studies, the integrity of the item content in the Chan et al. (2012) simplified Chinese version of the DASS-21 was preserved, without making any alterations. However, the response options were reworded to better align with the linguistic proficiency and comprehension levels of children. The original scale options (i.e., "does not apply", "applies somewhat", "definitely applies", and "strongly applies"), were changed to more age-appropriate language (i.e., "does not match", "sometimes matches", "often matches", and "always matches").

2.1.3. Data analysis

McDonald's omega (ω) was first used to evaluate the internal reliability of the DASS-21. Subsequently, construct validity of the scale was assessed by examining factorial validity, convergent validity, and discriminant validity. More specifically, factorial validity was evaluated using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA); convergent validity and discriminant validity were also examined using CFA. Additionally, an analysis of variance (ANOVA) was employed to test the association between participants' current emotional state and the DASS-21, providing another perspective on construct validity. A detailed explanation of these aspects is provided below.

2.1.3.1. Exploratory factor analysis.

In conducting the EFA, the chosen sample size of 300 was guided by Monte Carlo simulation work, which suggests that a valid sample size for achieving factor pattern replicability falls between 300 and 400 participants (Kyriazos, 2018). The EFA comprised the following stages: the identification of factors; the operational definition of each factor, clearly and precisely outlining what each factor represents; the number of items that comprise each factor; the variance explained by each factor; the extent of correlation (or lack thereof) between the identified factors; and the presentation of factorial loadings for each item across all identified factors.

2.1.3.2. Confirmatory factor analysis.

Following the EFA, the next step is to assess the goodness of fit for the identified solution of the factor structure. This is achieved by using a cross-validation procedure to conduct a CFA with the remaining participants ($n = 2838$), which is the total number of participants minus the number used in the EFA. Given that the distribution of responses in terms of psychological distress often violates normal distribution and the Shapiro–Wilk test also confirmed that the DASS-21 data among the participants were not normally distributed (the value of all the items was ranged from 0.23 to 0.71, all $p < 0.01$), the estimation of diagonally weighted least squares (DWLS) was adopted in all CFAs because DWLS is more suitable for dealing non-

normally distributed data (Li, 2016).

In the CFAs, one-factor model, two kinds of two-factor model, three-factor model, and the bifactor model were evaluated in sequence. More specifically, except for the one-factor model and the bifactor model, the aforementioned factor structure was based on two perspectives: the three separate emotional symptoms (i.e., the original three-factor model) proposed by Lovibond et al. (1996) and the tripartite model which indicates depression and anxiety share a common factor (i.e., negative affect factor) developed by Clark and Watson (1991). In the original three-factor model, Items 3, 5, 10, 13, 16, 17, and 21 belonged to the depression factor; Items 2, 4, 7, 9, 15, 19, and 20 belonged to the anxiety factor; and Items 1, 6, 8, 11, 12, 14, and 18 belonged to the stress factor. In the tripartite model, Items 2, 4, 7, and 19 belonged to physiological arousal; Items 3, 10, 16, and 21 belonged to lack of positive affect; and the remaining items belonged to generalized negativity (Duffy et al., 2005; Mineka et al., 1998). Based on the original three-factor model and the tripartite model, scholars have proposed two revised models with the combined factor (i.e., two-factor model) (Duffy et al., 2005; Szabó & Lovibond, 2006). In the first, the model followed the original three-factor model, while the anxiety and stress factor were combined (i.e., depression and the combined factor of anxiety and stress). The other mainly inherited the tripartite model where lack of positive affect and generalized negativity were combined into one factor.

To evaluate the factorial validity in CFAs, model fit criteria including χ^2, comparative fit index (CFI), non-normed fit index (NNFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) were adopted. CFI and NNFI values of 0.95 or higher, RMSEA values of 0.06 or lower, and SRMR values of 0.08 or lower were considered acceptable (Hu & Bentler, 1999). In addition, the difference of the Akaike information criterion (AIC_{higher} - AIC_{lower}, ΔAIC) was also used to determine the best fit model. ΔAIC between 0 and 2 means the two models had the equal fit with the data; ΔAIC higher than 4 indicates that, compared to the model with the lower AIC, the empirical data cannot support the model with the higher AIC (Burnham & Anderson, 2002; Korner-Nievergelt et al., 2015).

Furthermore, using the CFA approach, the composite construct reliability (CCR) and average variance extracted (AVE) were calculated to evaluate the convergent and discriminant validity. The convergent valitidy was supported if CCR > 0.70 and AVE > 0.50 for each construct (Fornell & Larcker, 1981; Hair et al., 2019). The square root of AVE should exceed the correlations between the latent variables making each pair to support discriminant validity (Fornell & Larcker, 1981; Hair et al., 2019).

For the bifactor model, explained common variance (ECV) and omega-hierarchical (OH) were used to justify if the general factor existed. If the general factor of ECV and OH is higher than 0.80, the variance of the total scores can be attributed to a single general factor (Arrindell et al., 2017; Rodriguez et al., 2016).

2.1.3.3. Two-way ANOVA. After the CFAs, two separate two-way ANOVAs were carried out to further evaluate construct validity. A three-way ANOVA (age, sex, and the current emotional state) was ruled out, due to some cell sizes being fewer than three participants. The first ANOVA assessed the effects of age and students' current emotional state, with each student identifying their prevailing emotion. The second ANOVA analyzed the effects of gender and students' current emotional state. For both ANOVAs, if the interaction term was significant, a simple main effect test was subsequently performed.

Logically, the current emotional state selected by participants should significantly correspond to the specific emotional disorders in the DASS-21. For example, participants who identified depression as their main current emotion should have higher scores on the depression subscale compared to those who selected peacefulness. Moreover, evidence of construct validity would be further solidified if the difference in the depression subscale scores between the depression emotion group and the peacefulness group is greater than the difference between those who chose other emotions and the peacefulness group.

2.2. Results

The mean observed score of the DASS-21 was 0.22 ($SD = 0.33$). The descriptive statistics for each item can be found in Table S1 in the appendix. As for the current emotional state, peacefulness was the most frequently reported emotion by primary school students ($n = 2549$, 81.2 %). The McDonald's ω indicated that the overall reliability of the DASS-21 was 0.93, and the reliability of the subscales for depression, anxiety, and stress was 0.84, 0.81, and 0.83, respectively.

2.2.1. Explanatory factor analysis

EFA was conducted using the extraction method of principal axis factoring. Oblimin rotation, a general form of oblique rotation which allows the factors to be correlated, was employed. After confirming the Kaiser-Meyer-Olkin value of 0.94 and the results of Bartlett's Test of Sphericity ($\chi^2 = 3542.98$, $p < 0.01$) — both of which met the prerequisites for conducting an EFA — the scree plot was examined. The results indicated that the curve's slope distinctly plateaued at the three-factor point, often referred to as the 'elbow' (see Fig. 1). This suggests that three factors appear to be the most appropriate choice. Moreover, the sequential chi-square tests demonstrated that a three-factor model was the most parsimonious solution, providing a better model goodness of fit ($\chi^2 = 410.84$, df = 150, $p < 0.01$). When compared to the two-factor model ($\chi^2 = 508.51$, df = 169, $p < 0.01$) and the four-factor model ($\chi^2 = 383.21$, df = 132, $p < 0.01$), the three-factor model showed a significant improvement in fit over the two-factor solution (difference of $\chi^2 = 97.67$, df = 19, $p < 0.01$). However, it did not differ significantly from the four-factor model (difference of $\chi^2 = 27.63$, df = 18, $p = 0.07$). In the three-factor model, the inter-factor correlations were noteworthy. Factor 1 correlated with both Factor 2 and Factor 3 at 0.63, while the correlation between Factor 2 and Factor 3 was 0.59. Collectively, these three factors accounted for 51.4 % of the total variance, with Factors 1 to 3 explaining 25.1 %, 15.3 %, and 11.0 %, respectively.

In the three-factor structure derived from the EFA, Table 2 details the communalities and factor loadings for each item. From this table, it can be seen that Factor 1 predominantly represents depression. Of the seven items in the depression subscale, six have salient loadings on this factor. However, Item 5 did not load on Factor 1 but showed a stronger loading on Factor 2. Factor 2 encompassed items from the stress subscale, all of which displayed salient loadings. Lastly, items in Factor 3 primarily related to anxiety, with items from the anxiety subscale showing strong loadings on it, except for Items 2 and 15, which loaded more significantly on other factors.

Overall, the factor pattern from the EFA aligned well with the original three-factor structure (Lovibond et al., 1996). Importantly, the factor loadings and communalities of the measured variables aligned with recognized criteria: most items displayed factor loadings above 0.50, and communalities predominantly exceeded 0.40 (Sass & Schmitt,

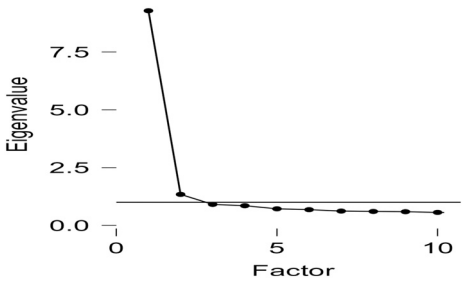

Fig. 1. Scree plot of the explanatory factor analysis.

Table 2
Exploratory factor analysis on the Depression Anxiety Stress Scale-21 (DASS-21) (n = 300).

Subscale	Item	Communalities	Factor 1	Factor 2	Factor 3
Depression	3. Couldn't experience positive feeling	0.32	0.54	0.45	0.23
	5. Difficult to work up the initiative to do things	0.37	0.25	0.59	0.18
	10 Had nothing to look forward to	0.60	0.66	0.44	0.50
	13.Felt down-hearted and blue	0.68	0.79	0.55	0.30
	16.Unable to become enthusiastic	0.44	0.64	0.47	0.23
	17. Not worth much as a person	0.57	0.75	0.38	0.21
	21. Life was meaningless	0.83	0.89	0.38	0.06
Anxiety					
	2. Dryness of my mouth	0.33	0.31	0.58	0.40
	4. Experienced breathing difficulty	0.44	0.43	0.48	0.66
	7. Experienced trembling	0.43	0.56	0.54	0.62
	9. Worried about situations of panic and making a fool of myself	0.58	0.45	0.41	0.63
	15. Feeling of close to panic	0.72	0.84	0.58	0.17
	19. Aware of the action of my heart	0.57	0.44	0.48	0.58
	20. Felt scared without any good reason	0.43	0.55	0.61	0.63
Stress	1. Hard to wind down	0.41	0.30	0.63	0.24
	6. Tended to over-react	0.49	0.46	0.62	0.44
	8. Using a lot of nervous energy	0.53	0.58	0.68	0.16
	11. Getting agitated	0.52	0.46	0.59	−0.10
	12. Difficult to relax	0.64	0.58	0.69	−0.05
	14. Intolerant of anything	0.40	0.32	0.61	−0.06
	18. Felt rather touchy	0.52	0.57	0.69	0.21

Note: A value highlighted in bold indicates that the item has higher factor loadings in the factor to which it belongs compared to other factors.

2010). However, it should be noted that some items exhibited cross-loadings. Traditional practices might suggest modifying or removing such items (Sass & Schmitt, 2010). While this approach is often relevant during scale development, it is not the main focus of the present study. Given the aim was to clarify the factor structure of DASS-21 for the child demographic, it was considered essential to retain all scale items for subsequent psychometric analyses, to facilitate comparisons with other studies. Consequently, the analysis proceeded with all 21 items. However, to elucidate the potential influence of these cross-loadings on the factor structure, results pertaining to CFA, convergent, and discriminant validity—derived from analyses after the exclusion of items with cross-loadings—are presented in the Appendix. For the removal of such items, analysis adhered to the general upper cut-off value of 0.50, as proposed by Howard (2016). Comprehensive details are available in Table S2 of the Appendix.

2.2.2. Confirmatory factor analysis

Following the EFA, CFAs were conducted to assess the goodness of different factor structures to evaluate the factorial validity. The results demonstrated that DASS-21 fitted well with the factor structure of one-factor, two-factor, and three-factor structure among primary school students (see Table 3). The lowest Akaike information criterion (AIC) was 831.94 found in Lovibond et al. (1996)'s original three-factor model. ΔAIC, which represents the difference in AIC values between various factor structures and the original three-factor structure, was employed to identify the best fitting model. The observed values, specifically for the difference between the original three-factor model and other models, consistently exceeded 10, signaling a significantly better data fit for the former. Additionally, the analysis juxtaposed the original three-factor model with a four-factor model, informed by prior EFA outcomes (also see Table 3). Items were categorized according to their factor loadings and allocated to the factor with which they demonstrated the highest affinity. The AIC value discrepancy between these two models was <4, indicating that both models exhibited nearly comparable fits to the data. However, adhering to the rule of parsimony, the three-factor model was favored over the four-factor model.

Moreover, to assess convergent and discriminant validity, the composite construct reliability (CCR) and average variance extracted (AVE) were calculated based on the factor loadings from the best-fitting three-factor structure (see Table 4). The results showed that CCR and AVE of depression, anxiety, and stress subscales were all higher than 0.90 and 0.60 (also see Table 4), respectively, indicating the convergent validity was adequate for the DASS-21. In terms of the discriminant validity, the

Table 3
Model fit among different factor structures.

χ^2 (df)	CFI	NNFI	RMSEA (90 Percent Confidence Interval)	SRMR	AIC
One-factor model					
940.27 (189)	0.997	0.996	0.037 (0.035–0.040)	0.041	1024.27
Two-factor model: Based on Szabó and Lovibond (2006), depression and combined factor (anxiety and stress)					
811.65 (188)	0.997	0.997	0.034 (0.032–0.037)	0.042	897.65
Two-factor model: Based on Duffy et al. (2005), physiological arousal and combined factor (generalized negativity and lack of positive affect)					
896.08 (188)	0.997	0.997	0.036 (0.034–0.039)	0.041	982.08
Three-factor model: Based on the original three-factor model					
741.94 (186)	0.998	0.997	0.032 (0.030–0.035)	0.042	831.94
Three-factor model: Based on tripartite model (physiological arousal, lack of positive affect, and generalized negativity)					
832.15 (186)	0.997	0.997	0.035 (0.033–0.037)	0.039	922.15
Four-factor model: based on EFA results in this present study					
738.42 (183)	0.998	0.997	0.033 (0.030–0.035)	0.038	834.42

CFI = comparative fit index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; AIC = Akaike information criterion; In the four-factor model: Factor 1 comprised items: 3, 7, 10, 11, 12, 13, 15, 16, 17, 19, and 21.Factor 2 comprised items: 1, 2, 5, 8, 9, and 14. Factor 3 comprised items: 18 and 20. Factor 4 comprised items: 4 and 6.

Table 4
The psychometric characteristics of DASS-21 in terms of items, along with composite construct reliability and average variance extracted.

	Study 1: Cross-sectional survey (n = 2838)	
The Depression, Anxiety and Stress Scale-21		
Subscale of Depression	*Mean* (*SD*)	Loadings
3. Couldn't experience positive feeling	0.28 (0.59)	0.78
5. Difficult to work up the initiative to do things	0.30 (0.59)	0.67
10. Had nothing to look forward to	0.14 (0.44)	0.85
13. Felt down-hearted and blue	0.18 (0.46)	0.88
16. Unable to become enthusiastic	0.16 (0.44)	0.85
17. Not worth much as a person	0.11 (0.42)	0.93
21. Life was meaningless	0.10 (0.43)	0.84
Composite construct reliability	0.94	
Average variance extracted	0.69	
Subscale of Anxiety		
2. Dryness of my mouth	0.29 (0.57)	0.69
4. Experienced breathing difficulty	0.08 (0.34)	0.78
7. Experienced trembling	0.10 (0.37)	0.75
9. Worried about situations of panic and making a fool of myself	0.45 (0.67)	0.73
15. Feeling of close to panic	0.14 (0.45)	0.90
19. Aware of the action of my heart	0.09 (0.35)	0.89
20. Felt scared without any good reason	0.18 (0.48)	0.81
Composite construct reliability	0.93	
Average variance extracted	0.64	
Subscale of Stress		
1. Hard to wind down	0.52 (0.70)	0.64
6. Tended to over-react	0.22 (0.50)	0.77
8. Using a lot of nervous energy	0.27 (0.55)	0.80
11. Getting agitated	0.18 (0.45)	0.86
12. Difficult to relax	0.23 (0.52)	0.84
14. Intolerant of anything	0.28 (0.58)	0.73
18. Felt rather touchy	0.37 (0.64)	0.79
Composite construct reliability	0.91	
Average variance extracted	0.60	

correlation between the subfactors was scrutinized. However, since the correlations among the latent variables were very high (i.e., the correlation between depression and anxiety was 0.96, between depression and stress was 0.93, and between anxiety and stress was 0.98), discriminant validity of the scale was not supported.

Moreover, the bifactor model was employed, which is particularly valuable when researchers aim to understand the extent to which a general factor (e.g., psychological distress) accounts for variance across all items, in contrast to specific factors (e.g., depression, anxiety, and stress) that influence only specific subsets of items. The bifactor model further showed that the raw scores of DASS-21 should be treated as univocal indicators of the general factor for primary school students since the explained common variance and omega hierarchical of the general factor was higher than 0.80 (see Table S2). Furthermore, for these child participants, the omega hierarchical of the specific factors were all below 0.15 (also see Table S2), indicating the contribution of three specific factors was negligible.

2.2.3. Two-way ANOVA

The two-way ANOVAs showed interactions between age and current emotional state, as well as between sex and current emotional state, on the entire DASS-21 and its three subscales (with *F*-values ranging from 2.19 to 6.73) (see Tables 5 and 6). Consequently, tests for simple main effects were subsequently conducted (see Table S3 and S4). These simple main effects showed that the effect of the current emotional state on the entire DASS-21 and its three subscales was greater for individuals older than 10 years compared to those younger than 10 years. Additionally, the effect was more pronounced among females than among males.

For the entire scale, the simple effect showed that regardless of being older or younger than 10 years, or being male or female, participants who identified with any of the six negative emotions as their primary current emotion scored significantly higher on the overall DASS-21 compared to those who felt their current emotion was peacefulness (with *F*-values ranging from 35.12 to 84.42). This result indicated that the overall DASS-21 score represented a general negative emotion, thereby supporting its construct validity.

Regarding the subscales, the construct validity of the depression factor was deemed satisfactory. This assertion was substantiated by the observation that, within both age groups (above and below 10 years) and across gender categories (male and female), students who identified with "depression" exhibited the most pronounced discrepancy in scores on the depression subscale compared to those who identified with "peacefulness". This disparity was notably larger than the score differentials observed between other negative emotions and "peacefulness" (see Table S3 and S4).

Conversely, the scores on the anxiety subscale did not unambiguously reflect the corresponding negative emotion, specifically the anxiety factor. This conclusion is drawn from the observation that participants who identified "anxiety" as their prevailing emotion did not register higher scores on the DASS-21 subscale for anxiety relative to other groups (see Table S3 and S4). As such, the anticipated construct validity of the anxiety factor was not unequivocally corroborated, especially for younger participants.

3. Study 2

3.1. Method

3.1.1. Participants and procedure

In the longitudinal follow-up study (referred to as Study 2), the participating children were part of an extensive project monitoring the mental health status of children residing in Southwest China. The study was conducted in two waves with a three-month interval, and ethical approval was obtained from the Ethics Committee of the Institutional Review Board of the Jianxi Psychological Consultant Association (IRB reference number: JXSXL-2020-J013). The first wave of data collection (Time 1) took place in October and November of 2019, followed by the second wave (Time 2) in mid-January 2020. During Time 2, most Chinese provinces had not yet implemented strict COVID-19 preventive measures, except in Wuhan city, as widespread actions occurred later, after February 2020.

A total of 1366 students from grades four to six participated in a longitudinal survey. In the fourth grade, there were 452 students, accounting for 33.1 % of the total sample. Their ages ranged from 7 to 11 years, with a mean age of 9.67 years (SD = 0.59). The gender distribution for this grade comprised 248 females and 204 males. In the fifth grade, there were 487 students, accounting for 35.6 % of the total sample. Their ages ranged from 9 to 12 years, with a mean age of 10.68 years (SD = 0.52). The gender distribution for this grade comprised 245 females and 242 males. Lastly, in the sixth grade, there were 427 students, accounting for 31.3 % of the total sample. Their ages ranged from 9 to 13 years, with a mean age of 11.62 years (SD = 0.62). The gender

Table 5
Two-way ANOVA Results: Effects of age and emotional state on whole scale and three subscales.

Dependent variable	Source of variance	Sum of square	df	*F*-test (*p*-value)	Post-hoc tests following a significant main effect.	Effect size (η^2)
DASS-21	Emotional state	63.62	6	123.02 (<0.01)	The six negative emotions > peacefulness	0.19
	Age group	0.00	1	0.02 (0.89)		0.00
	Emotional state × Age group	1.75	6	3.38 (<0.01) **		0.01
	Residuals	269.27	3124			
Depression	Emotional state	60.52	6	104.37 (<0.01)	Diff. between Dep. and Peace is largest vs. other neg. Emo. with Peace	0.16
	Age group	0.35	1	3.58 (0.06)		0.00
	Emotional state × Age group	2.71	6	4.68 (<0.01)		0.01
	Residuals	301.93	3124			
Anxiety	Emotional state	43.56	6	81.71 (<0.01)	Diff. between Dep. and Peace is largest vs. other neg. Emo. with Peace	0.13
	Age group	0.00	1	0.03 (0.86)		0.00
	Emotional state × Age group	2.71	6	5.09 (<0.01)		0.01
	Residuals	277.56	3124			
Stress	Emotional state	93.95	6	124.18 (<0.01)	Diff. between Dep. and Peace is largest vs. other neg. emo. with Peace	0.19
	Age group	0.27	1	2.09 (0.15)		0.00
	Emotional state × Age group	1.66	6	2.19 (0.04)		0.00
	Residuals	393.94	3124			

Note: Age is categorized into two groups: those above 10 years old and those below 10 years old. This is because using the original age groups would result in some cells having too few individuals.

Table 6
Two-way ANOVA Results: Effects of sex and emotional state on whole scale and three subscales.

Dependent variable	Source of variance	Sum of square	df	*F*-test (*p*-value)	Post-hoc tests following a significant main effect.	Effect size (η^2)
DASS-21	Emotional state	62.59	6	121.21 (<0.01)	The six negative emotions > peacefulness	0.18
	Sex	0.34	1	3.99 (0.05)		0.00
	Emotional state × Sex	2.14	6	4.15 (<0.01)		0.01
	Residuals	268.86	3124			
Depression	Emotional state	56.59	6	97.99 (<0.01)	Diff. between Dep. and Peace is largest vs. other neg. Emo. with Peace	0.15
	Sex	0.52	1	5.43 (0.02)	Female>Male	0.00
	Emotional state × Sex	3.89	6	6.73 (<0.01)		0.01
	Residuals	300.68	3124			
Anxiety	Emotional state	45.82	6	85.35 (<0.01)	Diff. between Dep. and Peace is largest vs. other neg. Emo. with Peace	0.13
	Sex	0.64	1	7.20 (0.01)	Female>Male	0.00
	Emotional state × Sex	1.59	6	2.96 (0.01)		0.01
	Residuals	279.53	3124			
Stress	Emotional state	92.01	6	121.94 (<0.01)	Diff. between Dep. and Peace is largest vs. other neg. Emo. with Peace	0.19
	Sex	0.05	1	0.43 (0.51)		0.00
	Emotional state × Sex	2.99	6	3.97 (<0.01)		0.01
	Residuals	392.84	3124			

distribution for this grade comprised 200 females and 227 males.

3.1.2. Measure

In Study 2, the Simplified Chinese version of the DASS-21 (Chan et al., 2012) was used. Its construct validity was assessed in Study 1. The internal reliability for Study 2 was very good. The overall scale's McDonald's ω was 0.91 at Time 1 and 0.92 at Time 2. For the depression subscale, it was 0.82 at Time 1, and 0.83 at Time 2. For the anxiety subscale, it was 0.76 at Time 1, and 0.77 for Time 2. For the stress subscale, it was 0.77 at Time 1, and 0.81 at Time 2.

3.1.3. Data analysis

In Study 2, the participants' descriptive statistics of the DASS-21, the model fit at two time points, as well as the test-retest reliability are presented first. Subsequently, to evaluate whether the DASS-21 demonstrates time-invariant characteristics among primary school students, the CFA approach was utilized to test the scale's longitudinal invariance over a three-month period. The CFA approach of the examination of the measurement invariance was conducted and the estimation of DWLS was used. Three nested models were compared to examine whether the DASS-21 passed the longitudinal measurement invariance tests. More specifically, the configural model (i.e., baseline model) was compared with the factor-loading constrained model; the factor-loading-

constrained model (a less constrained model) was compared with the factor-loading and item-intercept constrained model (a more constrained model). ΔCFI, ΔRMSEA, and ΔSRMR were used to evaluate whether the DASS-21 has the measurement equivalence across different times and populations. If ΔCFI >-0.01, ΔRMSEA < 0.015, and ΔSRMR < 0.03 (for factor loading) or < 0.01 (for item intercept), the measurement invariance is supported (Chen, 2007).

The study took into consideration that the estimation method, DWLS, requires the computation of both the polychoric correlation matrix (PCM) and asymptotic covariance matrix (ACM). Due to small sample sizes, ACM can exhibit poor performance (Monroe, 2018). To provide a more accurate ACM estimate, the Monte Carlo Markov chain (MCMC) method in the PRELIS program of LISREL was used. This method enabled the conducting of multiple imputations on the DASS-21 for the longitudinal data, even though the attrition rate in the present study was not significant, at only 28 %. Results from Little's Test of Missing Completely at Random (MCAR) test suggested that the data were not missing completely at random (χ^2 = 1706.76, df = 867, p < 0.01). However, the pattern of missing data did not materially deviate from a random pattern, as indicated by the normed χ^2 (χ^2/df) of 1.96, which was <2.0 (Bollen, 1989). Moreover, based on the general approach to assessing differences between imputed values and the original dataset with missing values (Little & Rubin, 2002), it was inferred that the missing data could be considered as missing at random. More specifically, the relationships were analyzed – that is, the correlations between all items of the DASS-21 using the dataset with imputed values. This analysis was then replicated on the original dataset containing the missing values. A Fisher z-transformation was subsequently employed to compare the results and discern differences between the analyses of imputed and original data. The findings showed no significant discrepancies between the pairwise correlations of the imputed and original datasets, with z-values ranging from 0 to 1.89 and no p-values reaching the significance threshold. These results underscore that the missing data were indeed random, and therefore validating the imputation method utilized in the present study.

3.2. Results

In the DASS-21 evaluation, the overall observed scores were lower at Time 2 compared to Time 1 (Time 1: *mean* = 0.50, *SD* = 0.50; Time 2: *mean* = 0.42, *SD* = 0.49). Further analysis of the sub-scales showed decreases across all categories. The depression score decreased from 0.40 (*SD* = 0.53) to 0.34 (*SD* = 0.49), the anxiety score from 0.59 (*SD* = 0.55) to 0.51 (*SD* = 0.50), and the stress score from 0.65 (*SD* = 0.58) to 0.53 (*SD* = 0.53).

3.2.1. Evaluation of the model fit across two time points

In the examination of longitudinal invariance, it was found that both types of three-factor structures demonstrated a better model fit compared to the one-factor and two-factor structures in Study 1. Consequently, these three-factor structures were adopted for further invariance testing in Study 2. Before comparing various nested models, it was ascertained that the model fit for both three-factor models was satisfactory at both time points. In the evaluation of the original three-factor model, the results from Time 1 indicated a χ^2(df) of 505.27 (186), with accompanying fit indices: CFI of 0.995, NNFI of 0.994, RMSEA of 0.035, and SRMR of 0.042. By Time 2, the model yielded a χ^2(df) of 686.97 (186) and the fit indices adjusted slightly, with a CFI of 0.994, NNFI of 0.993, RMSEA of 0.044, and SRMR of 0.046. On the other hand, the tripartite model at Time 1 presented a χ^2(df) of 585.09 (186), a CFI of 0.994, NNFI of 0.993, RMSEA of 0.040, and SRMR of 0.043. At Time 2, the corresponding values were a χ^2(df) of 746.92 (186), CFI of 0.993, NNFI of 0.992, RMSEA of 0.047, and SRMR remaining at 0.046.

3.2.2. Test-retest reliability and time-invariance examination

Intraclass Correlation Coefficients (ICCs) were employed to evaluate the test-retest reliability of the entire scale and the three subscales before examining their time invariance characteristics. For the entire scale, the ICC (2,1) was 0.71. In the original three-factor model, the ICC values for the depression, anxiety, and stress subscales were 0.66, 0.68, and 0.67, respectively. In the tripartite model, the ICC values for physiological arousal, lack of positive affect, and generalized negativity were 0.63, 0.62, and 0.70, respectively. Overall, these results signified acceptable levels of test-retest reliability for the subscales in both models.

Furthermore, Table 7 indicates that the longitudinal invariance test results for the DASS-21 consistently demonstrated satisfactory invariance properties over a three-month span for both factor structure types. Notably, when comparing the nested models, all ΔCFI values exceeded −0.01, while both ΔRMSEA and ΔSRMR remained below 0.010.

3.2.3. Latent mean analysis

Under the premise of a time-invariant property, a latent mean analysis was conducted to determine differences across two distinct time points. The findings indicated that there were no statistically significant differences in the latent means of depression, anxiety, and stress between Time 1 and Time 2.

4. Study 3

4.1. Method

4.1.1. Participants and procedure

In Study 3, to determine whether DASS-21 exhibited measurement invariance across different populations, participants not only from Study 1 but also from two other samples were included: college students and enterprise workers, using convenience sampling for the latter two groups. For the college students, the research team conducted a survey with freshman students at a university in Jiangxi Province. One month after the freshmen enrolled (i.e., October 2020), class teachers asked the students to use their smartphones to respond to the online survey in a classroom setting. A total of 364 college students participated in this study. The average age of the college students was 18.17 years (from 17 to 20 years, *SD* = 0.42), with a gender distribution of 31.9 % male (n = 116) and 68.1 % female (n = 248). The distribution of males and females across different age groups was homogeneous, as shown in Table 1.

Additionally, enterprise workers were surveyed through a partnership between the research team and several Chinese companies and state agencies. Collaborating with these organizations, the research team aimed to evaluate the mental health status of their employees and conducted offline mental health workshops for them in June 2021. As part of the procedure, volunteers attending the workshops were invited to complete an online survey using their smartphones before the workshop began. In total, 483 workers from 32 institutions located in 10 provinces completed the online survey. The average age of these participants was 32.14 years (from 21 to 56 years; *SD* = 10.09), with a gender distribution of 78.7 % male (n = 380) and 21.3 % female (n = 103). Table 1 shows that males were significantly more prevalent than females in the age groups 18–25 years and above 51 years.

Both waves of data collection received approval from the Ethics Committee of the Institutional Review Board of the Jianxi Psychological Consultant Association (IRB reference numbers JXSXL-2021-J99 for the college students and JXSXL-2021-J105 for the enterprise workers).

4.1.2. Measure

In Study 3, the Simplified Chinese version of the DASS-21 (Chan et al., 2012) was used. Reliability was very good for both the college students and enterprise workers. The overall McDonald's ω was 0.88 for college students, and 0.93 for enterprise workers. For the depression subscale, ω was 0.79 for college students and 0.85 for enterprise workers. For the anxiety subscale, ω was 0.63 for college students and 0.83 for enterprise workers. For the stress subscale, ω was 0.76 for college students and 0.83 for enterprise workers.

Table 7
Fit indexes in measurement invariance across different times.

	The original three-factor structure										
Model	χ^2	df	Model comparison	$\Delta\chi^2$	Δdf	*p*-value	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR	ΔSRMR
Mo	2369.02	783				<0.01	0.992		0.039		0.053	
M1	2416.22	801	M1–M0	47.2	18	<0.01	0.992	0	0.038	−0.001	0.055	0.002
M2	2498.25	819	M2–M1	82.03	18	<0.01	0.992	0	0.039	0.001	0.055	0
	Tripartite model structure (physiological arousal, lack of positive affect, and generalized negativity)											
Mo	2503.45	783				<0.01	0.992		0.040		0.053	
M1	2547.8	801	M1–M0	44.35	18	<0.01	0.992	0	0.040	0	0.056	0.003
M2	2629.88	819	M2–M1	82.08	18	<0.01	0.991	−0.001	0.040	0	0.055	−0.001

CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; M0 = baseline model (without invariance); M1 = Loadings constrained as equal; M2 = Loadings and thresholds constrained as equal.

4.1.3. Data analysis

First, the descriptive statistics of the DASS-21 and the model fit for both college students and enterprise workers are presented. Subsequently, using the same approach adopted in Study 2, CFAs were conducted to determine whether the DASS-21 demonstrates invariant properties across these different populations. The analysis compared the configural model, the factor-loading constrained model, and the factor-loading plus item-intercept constrained model using indices such as ΔCFI, ΔRMSEA, and ΔSRMR. Measurement invariance is considered supported if ΔCFI > −0.01, ΔRMSEA <0.015, and ΔSRMR <0.03 (for factor loading) or < 0.01 (for item intercept), following the criteria proposed by Chen (2007).

4.2. Results

The observed score of DASS-21 among enterprise workers (*mean* = 0.77, *SD* = 0.47) was higher than that of primary school students (*mean* = 0.22, *SD* = 0.33), and college students (*mean* = 0.53, *SD* = 0.33) of which all were conducted later in the onset of the COVID-19 pandemic.

4.2.1. Model fit for different samples

In the multi-group CFA, the model for each group was assessed, excluding the primary school students from Study 1, based on two types of factor structures. For the original three-factor model, the results indicated a χ^2(df) of 430.63 (186) for college students and 508.99 (186) for enterprise workers. Except for an unsatisfactory SRMR of 0.092 among college students, other fit indices were satisfactory: CFI values were 0.980 for college students and 0.987 for enterprise workers; NNFI values were 0.977 for college students and 0.986 for enterprise workers; RMSEA was 0.060 for both groups, and the SRMR was 0.056 for enterprise workers. Regarding the tripartite model structure, college students had a χ^2(df) of 445.50 (186), CFI of 0.978, NNFI of 0.976, RMSEA of 0.062, and an SRMR of 0.088. For enterprise workers, the values were χ^2(df) of 435.33 (186), CFI of 0.990, NNFI of 0.989, RMSEA of 0.053, and an SRMR of 0.055.

4.2.2. Measurement invariance across different populations

In Table 8, the invariance test results indicated that the DASS-21 exhibited equivalence across primary school students, college students, and enterprise workers when employing the original three-factor structure. However, it did not achieve this in the tripartite model. More specifically, within the original three-factor model, the smallest ΔCFI was −0.001, the largest ΔRMSEA was 0.005, and the ΔSRMR was 0.016 with factor loading constrained to be equal, and was 0.006 when both factor and item intercepts were constrained to be equal. Importantly, all these variations were within acceptable criteria.

4.2.3. Latent mean analysis

After ensuring measurement consistency across different populations, a latent mean analysis was conducted in the original three-factor model. The findings showed that college students exhibited higher levels of depression, anxiety, and stress compared to primary school students. More specifically, their depression level was higher by a difference of 0.15 ($t = 3.72$, $p < 0.01$) with an effect size of 0.43 (Cohen's *d*). Their anxiety level was higher by a difference of 0.21 ($t = 6.29$, $p < 0.01$) with an effect size of 0.63, and their stress level was higher by a difference of 0.28 ($t = 8.28$, $p < 0.01$) with an effect size of 0.70.

Similarly, enterprise workers registered significantly higher scores on these three latent variables compared to primary school students. The differences in their levels of depression, anxiety, and stress were 0.51 ($t = 13.60$, $p < 0.01$, with an effect size of 1.34), 0.45 ($t = 12.86$, $p < 0.01$, with an effect size of 1.25), and 0.57 ($t = 17.12$, $p < 0.01$, with an effect size of 1.36), respectively.

4.3. Discussion

In the current invesigation, the reliability of the DASS-21 total score was found to be very good to excellent, with the McDonald's ω ranging between 0.88 and 0.93 among participants from the three studies. Additionally, the reliabilities of the DASS-21 subscale scores were predominantly acceptable. Furthermore, results from both EFA and CFA

Table 8
Fit indexes in measurement invariance across primary school students, college students, and enterprise workers.

	The original three-factor structure										
Model	χ^2	df	Model comparison	$\Delta\chi^2$	Δdf	*p*-value	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR	ΔSRMR
Mo	1915.01	558				<0.01	0.995		0.043		0.056	
M1	2048.94	594	M1–M0	133.93	36	<0.01	0.995	0	0.043	0	0.072	0.016
M2	2551.3	630	M2–M1	502.36	36	<0.01	0.994	−0.001	0.048	0.005	0.078	0.006
	Tripartite model structure (physiological arousal, lack of positive affect, and generalized negativity)											
Mo	2058.81	558				<0.01	0.995		0.045		0.055	
M1	2189.50	594	M1–M0	130.69	36	<0.01	0.995	0	0.045	0	0.065	0.010
M2	2772.84	630	M2–M1	583.34	36	<0.01	0.993	−0.002	0.051	0.006	0.076	0.011

CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; M0 = baseline model (without invariance); M1 = Loadings constrained as equal; M2 = Loadings and thresholds constrained as equal.

suggested that the DASS-21 exhibited satisfactory factorial validity. While the original three-factor structure of the DASS-21 best fit the data for primary school students, other factor structures also demonstrated acceptable model fit. The internal reliability of the DASS-21 observed in the present study aligns with findings from previous studies (e.g., Camacho et al., 2016; Diaz-Godiño et al., 2019; Lee & Kim, 2020). This supports the argument that the DASS-21 can be reliably administered to both children and adults.

It is noteworthy that, contrary to most previous studies suggesting the original three-factor structure did not fit well when testing with primary school students (e.g., Costa et al., 2020; Patrick et al., 2010; Szabó & Lovibond, 2006), the three-factor structure appeared to be the best fit for the primary school students in the present study. This might be due to the fact that the present study was conducted during the COVID-19 pandemic, a period when children were predominantly at home. Students at this age are prone to observational learning. Observing adults or older siblings exhibiting signs of stress, anxiety, or depression because of the pandemic might lead them to internalize and demonstrate similar symptoms. Furthermore, the heightened awareness of mental health could play a significant role. More specifically, due to the global reach and impact of the pandemic, there has been increased media coverage and public awareness of mental health issues. Children, even at the primary school age, may have been more exposed to discussions and educational content about depression, anxiety, and stress, making them more attuned to these distinct emotional states. While the present authors could not find other studies that examined the factor structure of DASS-21 among children during the COVID-19 pandemic, some research indicates that children post-earthquake also produced data resulting in a clear three-factor structure for the DASS-21 (Zhang et al., 2016). Based on this, it is posited that the context might be a potential factor underlying the different factor structures found.

The results also demonstrated that the DASS-21 has adequate convergent validity among primary school students. Both the composite construct reliability and average variance extracted for the depression, anxiety, and stress subscales were all higher than 0.90 and 0.60, respectively. This means that DASS-21 is suitable for screening general mental health condition by successfully estimating latent variables of psychological distress (Lee, 2019). However, the discriminant validity was not supported among the children. To further discuss the issue of poor discriminant validity, the bifactor model was used to assess whether the general factor exists. The result showed that the raw scores of DASS-21 should be considered as the single general factor among primary school children. However, the subscales of DASS-21 had poor explained variance among this population. Overall, the findings of the present study match previous studies that the DASS-21 may be used to reflect general rather than specific psychological distress among children.

The main speculated reason underlying this is because of indistinguishable features between depression, anxiety, and stress, especially among children and adolescents who are still in development (Kovacs & Goldston, 1991). For example, depression may coexist alongside other psychological distress such as anxiety and anger in childhood (Hammen & Compas, 1994). Szabó and Lovibond (2006) also found that some nonspecific negative symptoms failed to differentiate depression and anxiety among both adults and children. Importantly, factors of the DASS-21 specific to depression can be identified in different factorial models while anxiety and tension/stress could not be differentiated (Szabó and Lovibond, 2006), which draws the attention to the (as yet) unknown timing when the psychological status is mature enough to differentiate specific mood disorders.

Supporting this, the ANOVA results indicate that primary school children who selected any negative emotion scored higher on the DASS-21 than those who identified with peacefulness as their current emotion. This finding also indicates that the DASS-21 score reflected a general negative emotion as aforementioned (Luciano et al., 2020; Yeung et al., 2020). Moreover, primary school students who chose depression as the current emotional status demonstrated the significantly greatest score of depression, which supports the construct validity of the depression subscale of the DASS-21 in detecting the mood condition. Similar results did not apply to either anxiety or stress subscales, which may again, support the suggestion regarding the lack of capacity in distinguishing specific types of psychological distress among children (such as anxiety and stress). Overall, the DASS-21 may still be an applicable tool used to screen children for general negative emotion as well as depression but not anxiety or stress. However, the cut-off scores of different risk levels of psychological disorders should be interpreted carefully and may need new criteria appropriate for child measurement.

In the past couple of years, the outbreak of COVID-19 has resulted in negative impacts on human emotion and psychological status directly due to the fear of infection (Hasannia et al., 2021; Rajabimajd et al., 2021) or indirectly caused by social restrictions, changing lifestyles, and other factors (Alijanzadeh & Harati, 2021; Ashraf et al., 2021; Hasannia et al., 2021). The DASS-21 is therefore considered as one of the most important tools used in both clinical and research settings to evaluate and monitor individuals' psychological well-being. For this purpose, it is crucial to assure the measurement invariance of DASS-21 so that the influence of COVID-19 can be reflected accurately at different times. The results of the present study showed that the invariance property across time was satisfactory in both the original three-factor model and the tripartite model. Moreover, the invariance measurement across different populations was also supported in the original three-factor model. These results support the contention that the DASS-21 is a suitable tool to evaluate event impact on mental health and to perform between-population comparisons.

The DASS-21 has proven to be a reliable tool with consistent psychometric properties across diverse Chinese populations, including primary school students, college students, and enterprise workers. For health professionals, its strength lies not only in its ability to assess general psychological distress but also in its time-invariant properties. This means that the DASS-21 can reliably track changes or stability in psychological mood states over time, making it invaluable for longitudinal studies or monitoring interventions. Moreover, its demonstrated measurement invariance across different populations suggests that the instrument can be used for comparative studies between distinct groups without concerns of bias. However, while adept at capturing general distress, it may not distinctly differentiate between specific mood states in younger cohorts. Professionals should be cognizant of this when interpreting results. Given the potential for varied factor structures in different situations, it is imperative for health professionals to apply context-specific criteria, ensuring nuanced and accurate mental health evaluations.

Despite the comprehensive evaluation of the psychometric properties of the DASS-21 among children, youth, and adults, there are, several limitations. Firstly, the timing of assessments varied among participants, potentially introducing inconsistencies in data collection. Secondly, while the study included primary education and college-level participants, high school students were not sampled. Therefore, the study was unable to systematically contrast the psychometric attributes of the DASS-21 across all young age groups. Thirdly, the participant pool did not include individuals diagnosed with mental health illnesses, making it difficult to ascertain the scale's clinical diagnostic efficacy within the primary school demographic. Therefore, future research should prioritize evaluating the psychometric traits of the DASS-21 among clinical child populations. Finally, for Study 1, the primary school students' participation involved surveys conducted with the assistance of their parents. It should be noted that this might have led some children to underreport symptoms, given that their parents would likely have seen their responses.

5. Conclusion

In conclusion, the DASS-21 can be viewed as a reliable tool that

reflects general negative mood states among different age groups. The present study's findings also supported the suitable comparisons of DASS-21 score changes over time and differences of DASS-21 scores between populations. Future studies are needed to investigate the psychometric maturity among children so that information can be obtained to facilitate more accurate interpretation of DASS-21.

Transparency and openness

Materials and analysis code for this study are available by emailing the corresponding author. This study was not preregistered.

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CRediT authorship contribution statement

Conceptualization—I-HC, C-YC, Y-CT, C-YL
Data curation—I-HC, X-lL, X-mC, XZ
Formal analysis—I-HC
Funding acquisition—I-HC, Y-CT
Investigation—I-HC, C-YC, C-YL
Methodology—X-lL, XmC, XZ, MDG, AHP
Project administration—I-HC, C-YL
Resources—I-HC, Y-CT, C-YL
Software—I-HC, C-YL, AHP
Supervision—C-YL, MDG, AHP
Validation—MDG, AHP
Visualization—I-HC
Writing (original draft)—I-HC, C-YC
Writing (review and editing)—X-lL, X-mC, XZ, Y-CT, C-YL, MDG, AHP

All authors have reviewed and agreed to their individual contribution(s) before submission.

Declaration of competing interest

None.

Data availability

Data will be made available upon reasonable request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2023.104042.

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