RESEARCH ARTICLE

Validity and reliability of the Generalized Anxiety Disorder-7 (GAD-7) among university students of Bangladesh

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Abstract

This study investigated the reliability and factorial validity of General Anxiety Disorder-7 (GAD-7) in the context of university students in Bangladesh. The research aimed to assess whether the original one-dimensional model or a model containing both somatic and cognitive-emotional factors is appropriate. A repeated cross-sectional survey design based on convenience sampling was used to collect data from 677 university students. The factor structure of the GAD-7 was assessed by exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), and its convergent validity was determined by investigating its correlations with Patient Health Questionnaire-9 (PHQ-9) and Patient Health Questionnaire Anxiety-Depression Scale (PHQ-ADS). Results showed excellent reliability of GAD-7 as measured by Cronbach's α. CFA suggested that a modified one-factor model is appropriate for the sample. This model provided high values of comparative fit index (CFI), goodness of fit index (GFI), and Tucker Lewis Index (TLI), low value of standardized root mean square residual (SRMR) and a non-significant root mean square error of approximation (RMSEA). Correlation between GAD-7 and PHQ-9 was 0.751 and 0.934 between GAD-7 and PHQ-ADS. Overall, the study provided support for modified unidimensional structure for GAD-7 and showed high internal consistency along with good convergent validity.

Introduction

Generalized Anxiety Disorder (GAD) belongs to a group of mental health conditions collectively known as anxiety disorders, which also includes panic disorder, phobias, social anxiety disorder, Obsessive-Compulsive Disorder (OCD) and Post-Traumatic Stress Disorder (PTSD) [1]. GAD reflects the fundamental characteristics of all emotional disorders and is used to diagnose subsequent occurrence of any other anxiety disorders [2, 3]. The definition of GAD emerged from the third edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-III) where it was characterized as a residual diagnosis and only attributed to patients who did not meet diagnostic criteria for any other anxiety disorders [3–5]. After undergoing

several substantial revisions, GAD was characterized as an independent anxiety disorder with diagnostic description. In the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), GAD has been stated to include both psychological symptoms such as persistent worrying and overthinking, difficulty handling uncertainty, restlessness, indecisiveness, etc. as well as physiological symptoms such as fatigue, sleeplessness, muscle tension, nervousness, nausea, irritability, etc. [6, 7]. Findings from general population surveys of approximately 150000 adults in 26 countries indicated that DSM-5 GAD had a combined lifetime prevalence of 3.7%, 12-month prevalence of 1.8%, and 30-day prevalence of 0.8% [8].

Among South Asian countries, as of 2017, the prevalence and severity of anxiety disorder is the highest in Bangladesh. 4.4% of the Bangladeshi population is estimated to have this disorder and it contributes to 4% of the total years lived with disability (YLD) [9, 10]. Specifically, a study estimated prevalence of GAD to be around 37.3% among individuals of Bangladesh aged between 13 to 63 years [11]. The prevalence of symptoms of anxiety was particularly high in case of university students [12, 13]. A recent study conducted by Faisal et al. (2021) indicated that approximately 40% of Bangladeshi students suffered from symptoms of moderate to severe GAD, a rate which is higher than those reported in the studies conducted on general people [14, 15]. University students go through significant changes in their emotional (e.g., loneliness, personal autonomy) and physical environment (e.g., transition from college to university) [16]. They also deal with the pressure of competition for good grades, carefully plan for future career, participate in extracurricular activities and are more involved in family matters as an adult [17]. Therefore, it is not unexpected for students to be more vulnerable to symptoms of anxiety disorders.

Despite high prevalence and potentially severe consequences including decreased quality of life, multiple somatic complaints, maladaptive personality traits, and increased mortality due to suicide, cardiovascular, and cerebrovascular causes, GAD has been largely ignored as a mental health condition [18–21]. One important barrier to effective treatment has been inaccurate or no assessment. People who suffer from anxiety disorders are often under-diagnosed and/or treated inadequately [17]. To overcome the hurdles, there is a need for a reliable, valid, and relatively brief screening tool for anxiety disorders, particularly for university students. The seven-item Generalized Anxiety Disorder scale (GAD-7) was developed with the purpose of screening for, and assessing the severity of GAD symptoms in both clinical and research contexts [22]. Conducted on a large primary care sample, the first validation study of GAD-7 found good reliability, as well as criterion, construct, factorial, and procedural validity. Subsequently, the psychometric properties of GAD-7 have been evaluated in different sample of patients, including other primary care samples [23, 24], psychiatric patients [25–27], people with addiction [28], pregnant woman [29, 30], and outpatients [29–31]. GAD-7 has also shown strong psychometric properties in different populations, such as general adults [32], elderly [33, 34] as well as people from different culture and countries [35–39]. In academic setting, validation was performed among Korean university students [40], Portuguese college students [41] and Saudi university male students [42]. In the context of Bangladesh, GAD-7 has been widely used in various studies as a screening tool for anxiety symptoms among adults and university students [11–13]. Moreover, Faisal et al. (2021) explored the psychometric properties of the Bengali version of the GAD-7; however, the main focus of the paper was to assess the impact of the COVID-19 pandemic on anxiety, depressive symptoms and mental health status of university students [14]. Thus, a detailed assessment of factorial validity of GAD-7 focusing on Bangladeshi students has not been carried out yet.

Regardless of adequate internal consistency and moderate to strong correlation with other comorbid disorders (depression, worry, etc.), findings regarding the factor structure of GAD-7 have not been consistent [43, 44]. Some studies showed a unidimensional factor structure [37, 41, 45–47]; which aligns with the result of the original validation study. Contrastingly, others

indicated a two-dimensional factor structure [25, 27]. Given the lack of consensus regarding the factor structure of GAD-7 in different contexts, a comprehensive validation study for Bangladeshi university students may be beneficial for an easy and cost-effective screening of anxiety disorders in this population.

Against this backdrop, we conducted this study with the objective of investigating the reliability and factorial validity of GAD-7 in the context of university students in Bangladesh. To this effect, the research mainly aimed to assess whether the original one-dimensional model or a model containing both somatic and cognitive-emotional factors is appropriate for both public and private university students. We further examined the convergent validity of GAD-7 with other relevant measures of mental health conditions, namely Patient Health Questionnaire-9 (PHQ-9) and Patient Health Questionnaire Anxiety-Depression Scale (PHQ-ADS). Finally, we examined the mean GAD-7 score of the students across different demographic and socioeconomic correlates. We expect that the study will contribute to the growing body of literature pertaining to validation studies assessing symptoms of anxiety disorders in university students.

Methods

Procedure and sampling

A repeated cross-sectional survey design was used to collect responses among the university students of Bangladesh. Data was collected in two waves: July 18-July 31, 2020 and February 10-February 22, 2021; the survey Administration software Google Form [48]. Snowball sampling strategy was utilized to capture both public and private university students. To be eligible for the study, the participants had to meet the following criteria: (a) be willing to participate in the study; (b) be enrolled in any public or private university in Bangladesh; (c) have internet access; and (d) be able to read, write, and comprehend the English questionnaire.

Bangladesh has roughly 1.3 million students currently pursuing higher education in 47 public and 107 private universities [49, 50]. Considering this population, we calculated the sample size based on the formula:

$$n = \frac{z^2 p(1-p)}{e^2}$$

where, n is the sample size, z is the selected critical value of the desired confidence level, p is the estimated proportion of an attribute that is present in the population, and e is the desired level of precision. Using 5% margin of error, 99% confidence level, and 50% response distribution, the sample size was estimated to be 666.

The questionnaire was circulated among two public and three private university students. Students from these universities were most likely to have access to a suitable internet connection and also use English as a mode of learning. Therefore, it was convenient for us to reach them through social media platforms while keeping the questionnaire in its original form. The questionnaire (Google Form link) was initially shared with faculty members of those selected universities, and they were asked to distribute the questionnaire in their respective classrooms either via e-mail or through any course material sharing platform that they were using for communication. We also asked the faculty members to encourage the students to pass on the survey link among their classmates to ensure maximum data collection. The final collection of data had a sample of 677 participants studying at different levels of university.

Description of GAD-7

In order to assess the presence and severity of GAD, a self-administered seven-item instrument GAD-7 is used as a screening tool [22, 23, 51]. Its items describe the prominent

diagnostic features of the original DSM-IV diagnostic criteria for generalized anxiety disorder [52]. In the assessment, participants are asked how often during the last two weeks they have encountered anxiety symptoms like feeling nervous, trouble relaxing etc. Response options for each item range from 0 to 3 on a 4-point Likert-scale (0 = not at all, 1 = several days, 2 = more than half the days and 3 = nearly every day). Adding the scores of all seven items provide the GAD-7 total score ranging from 0 to 21. Several validation studies have detected cut-points of ≥5, ≥10 and ≥15 based on receiver operating characteristics analysis for GAD-7, standing for mild, moderate and severe anxiety levels, respectively [52].

PHQ-9 and PHQ-ADS scales were also used to test for convergent validity of GAD-7. The PHQ-9 assesses the frequency and severity of symptoms of depression using nine 4-point Likert-scaled items ranging from 0 (not at all) to 3 (nearly every day) [53]. A total score ranging from 0 to 27 is obtained by summing across all items. The total score can be categorized at a cutoff of 10 to differentiate between minimal/mild versus moderate/severe depression. On the other hand, the PHQ-ADS is a composite measure that assess the overall burden of anxiety and depressive symptoms (mental distress) while combining the sum of the PHQ-9 and GAD-7 scores [54]. Thus, the scale can range from 0 to 48, with higher scores indicating higher levels of depression and anxiety symptomatology. Cut points of 10, 20, and 30 on the PHQ-ADS can be considered as thresholds of mild, moderate, and severe distress symptoms, respectively.

Statistical analysis

Characteristics of the items were examined by exploring item mean score, item-intercorrelations and corrected item-total correlations. Internal consistency and reliability were assessed by using Cronbach's α.

To analyze construct validity of GAD-7, maximum likelihood Exploratory Factor Analysis (EFA) was performed. For applicability purpose, Bartlett Test of Sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were assessed prior to executing Principal Component Factoring (PCF). The number of factors to be retained by PCF was evaluated by (i) using eigenvalue of more than 1, (ii) visually inspecting the scree plot, (iii) considering the items which had factor loading of at least 0.40 per factor and (iv) were interpretable [55].

Based on the results from the EFA, confirmatory factor analysis (CFA) was performed with structural equation model (SEM). CFA is a multivariate procedure used to validate the factor structure of a set of observed variables [56].To determine the areas of misfit in the model suggested by EFA, modification indices were inspected. Next, the original model and the modified model were compared using several model fit indices and their criteria, including (i) the chi-square (χ^2) and its degrees of freedom (df), (ii) root mean square error of approximation (RMSEA) and its 90% confidence interval, (iii) comparative fit index (CFI), (iv) goodness of fit index (GFI), (v) Tucker Lewis Index (TLI) and (vi) standardized root mean square residual (SRMR) (Table 3). RMSEA values of less than or equal to 0.05 represents close fit, while values between 0.05 to 0.08 are considered acceptable fit [57, 58]. Likewise, based on previous studies, GFI values greater than 0.9 indicate good fit [59]. CFI [59] and TLI [60] are incremental fit indices and values of greater than or equal to 0.95 of these indices indicate very good fit [60], while values of 0.90 or above are considered acceptable fit. Additionally, SRMR values up to 0.05 indicate close-fit, whereas values between 0.05 to 0.10 suggest acceptable fit [60].

To assess convergent validity of the GAD-7, the associations between GAD-7 and PHQ-9 and PHQ-ADS were examined using Pearson's correlation (r) and its significance. Relationship between GAD-7 score and socio-demographic variables was also studied using t-test and analysis of variance. Data cleaning, validation, and all statistical analysis were performed using Stata/IC 16.1 (StataCorp, College Station, TX, USA).

Ethical considerations

Ethical permission for data collection was taken from respective faculty and department heads of the universities where the questionnaire was distributed. Before responding anonymously to the online survey, all participants voluntarily gave their informed consent to participate in the study. In the consent form, participants were provided with information concerning the purpose, procedure and nature of the study, the option to take part as well as the right to revoke their data at any point of the study. The research is approved by the Department of Economics, East West University and procedures of this study complied with the provisions of the Declaration of Helsinki (1989) regarding research on human participants.

Results

Distribution of socio-demographic variables

Among the 677 participants included in the study, 51.40% were male and 48.60% were female. The mean age of the participants was 21.11 years. Almost two-third of the sample (65.19%) were made up of public university students and 45.64% of the students were studying in first year. The distribution of the main socio-demographic characteristics is presented in Table 1.

Item characteristics and reliability

Item characteristics are summarized in Table 2. The mean (SD) value of GAD-7 scale is 9.87 (6.05) and mean value of the items ranges from 1.04 to 1.65. Corrected item-total correlations (i.e. correlation between an item and the scale that is formed by all other items) are found to be between 0.587 to 0.784 indicating maximum performance tests [61, 62].

The reliability coefficient Cronbach's α for the overall GAD-7 scale is 0.895, which is greater than the recommended value of 0.80 suggesting excellent reliability [63]. Besides, there is no alpha for any of the items which is greater than the overall alpha, suggesting excellent reliability even if an item is deleted (Column VI, Table 2). All intercorrelation between GAD-7 items were significant at $p<0.01$ (S1 Table).

Construct validity

Construct validity of GAD-7 was tested with exploratory and confirmatory factor analysis. Applicability of factor analysis was tested using KMO and Bartlett Test of Sphericity. The KMO coefficient is 0.915 which surpasses the recommended value of 0.6, while Bartlett Test of Sphericity is found statistically significant (χ^2 = 2425.95, df = 21, p<0.01), indicating a factor analysis can be conducted in this case [64]. As a first step, we conducted an exploratory factor analysis to investigate the factor structure of GAD-7. Only one factor was extracted based on eigenvalue and scree plot inspection which alone accounts for 61.40% of the total variance of GAD-7 (S2 Table and Fig 1). All the items of GAD-7 had statistically significant loadings with values greater than 0.5 (Table 2). Therefore, all seven items of the measure are important to interpret.

Based on the result of EFA, a one-factor model was analyzed for the CFA. The results do not confirm adequate fit criteria for the initial one-factor model (χ^2 = 61.43, df = 14; p-value<0.01; CFI = 0.980; GFI = 0.975; TLI = 0.971; RMSEA = 0.071 (90% CI, 0.053–0.089, $p<0.05$); SRMR = 0.028) (Table 3). While CFI, GFI and TLI have values greater than the recommended threshold (0.950) and SRMR is indicates close fit (<0.05), the chi-square value is significant at $p<0.01$ suggesting poor fit of the model. Besides, chi-square provides inflated value when sample size is large and does not work well when in cases where sample size is small, and the underlying distribution may be non-normal [65]. Moreover, the RMSEA value

Table 1. Socio-demographic variables.

Variables	Categories	*n*	% in the sample
Gender	Male	348	51.40
	Female	329	48.60
Age[a]	18–22 years	550	81.24
	23–27 years	127	18.76
Marital Status	Married	8	1.19
	Single	661	97.93
	Others	6	0.89
Type of University	Public University	440	65.19
	Private University	235	34.81
Level of Education	First year	309	45.64
	Second year	98	14.48
	Third year	131	19.35
	Fourth year	95	14.03
	Masters	44	6.50
Principal Source of Income	Government Service Holder	189	27.92
	Agricultural wage labor	35	5.17
	Organized Trade/Business	173	25.55
	Pension/ Rent	87	12.85
	Private Service Holder	181	26.74
	Others	12	1.77
Student employment	Yes	102	15.07
	No	575	84.93
Family monthly income	<25,000 BDT	154	22.75
	25,000–54,999 BDT	250	36.93
	55,000–99,999 BDT	174	25.70
	> = 1,00,000 BDT	99	14.62
Family Size	< = 4 members	340	50.22
	>4 members	337	49.78
Joint Family	Yes	141	20.83
	No	536	79.17
Domestic violence in family	Yes	96	14.18
	No	581	85.82
Whether the student is the victim of domestic violence	Yes	65	67.71
	No	31	32.29
Majority of time spent	Alone	191	28.21
	With family	409	60.41
	With friends	66	9.75
	With pets	11	1.62

[a] Mean (SD): Age, 21.11 (0.064), CI (20.99–21.24).

BDT = Bangladeshi Taka.

is above the recommended upper limit of 0.05 and is statistically significant. Therefore, as a next step, we tested whether GAD-7 fits the two-factor structure (cognitive and somatic) for our sample. The cognitive factor comprises of item 1, 2, 3 and 7 whereas the somatic factor comprises of items 4, 5 and 6. While the two-factor model performed better in all fit indices compared to the one-factor model (Table 3), the covariance between the two factors was

Table 2. Characteristics of items and total GAD-7 scale.

GAD-7 Items	I Mean (95% CI)	II SD	III Item Total Correlation [a]	IV Corrected Item-Total Correlation [b]	V Factor Loadings	VI Cronbach's α
1. Feeling nervous, anxious or on edge?	1.42 (1.34–1.50)	1.08	0.807	0.729	0.814	0.875
2. Not being able to stop or control worrying?	1.53 (1.44–1.61)	1.15	0.842	0.771	0.848	0.870
3. Worrying too much about different things?	1.65 (1.57–1.73)	1.12	0.850	0.784	0.857	0.868
4. Trouble relaxing?	1.30 (1.23–1.38)	1.09	0.756	0.661	0.754	0.883
5. Being so restless that it is hard to sit still?	1.04 (0.96–1.12)	1.07	0.697	0.587	0.686	0.891
6. Becoming easily annoyed or irritable?	1.38 (1.30–1.47)	1.09	0.755	0.660	0.753	0.883
7. Feeling afraid as if something awful might happen?	1.55 (1.46–1.63)	1.15	0.767	0.669	0.762	0.882
GAD-7 Total Score	9.87 (9.41–10.33)	6.05	___	___	___	0.895

[a] Correlation between the item and the total score from the scale when the item itself is included in the total.

[b] Correlation between the item and the total score from the scale when the item itself is not included in the total.

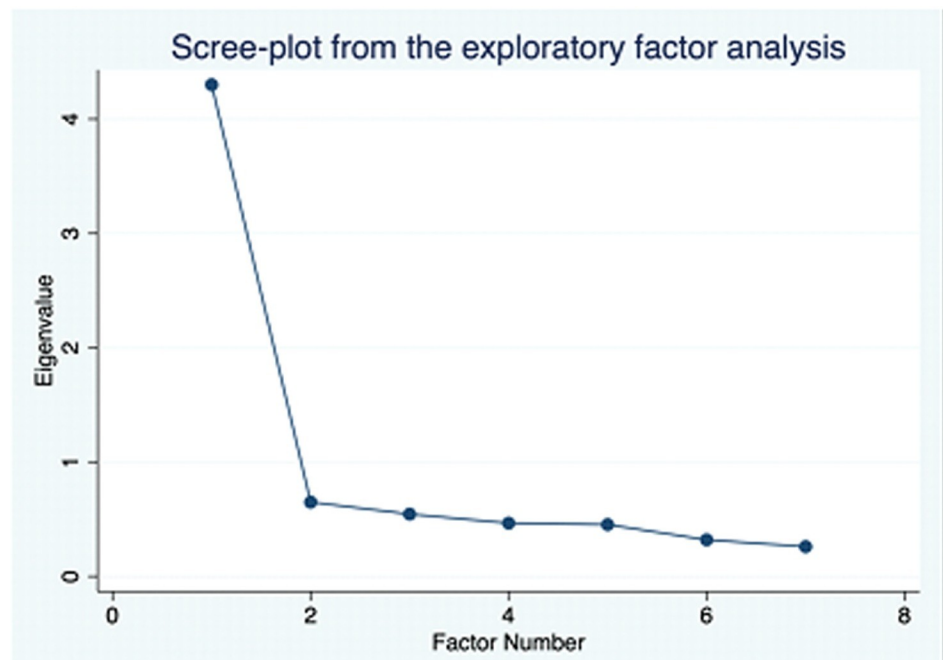CI = Confidence Interval; SD = Standard Deviation.

Fig 1. Scree-plot of GAD-7.

Table 3. Goodness of fit indices for the GAD-7 -item factor models (*n* = 677).

Model	k	χ^2	df	CFI	GFI	TLI	RMSEA (90% CI)	SRMR
One-factor model	7	61.431**	14	0.980	0.975	0.971	0.071*(0.053–0.089)	0.028
Two-factor model	7	44.721	13	0.987	0.982	0.978	0.060 (0.041–0.080)	0.021
Modified one-factor model	7	26.105	11	0.994	0.989	0.988	0.045(0.023–0.068)	0.017

*$p<0.05$,

** $p<0.01$.

k = number of items; df = degrees of freedom; CFI = comparative fit index; GFI = goodness of fit index; TLI = Tucker-Lewis index; RMSEA = root mean squared error of approximation; SRMR = standardized root mean residual; CI = Confidence Interval.

extremely high (0.931). In cases where two factors are highly overlapping, because of parsimony concerns, it is customary to inspect modification indices to decide whether a modified one-factor structure provides a reasonable fit [65]. Based on examination of modification indices, the error terms of item-1 and item-2, item-4 and item-5 and item-5 and item-6 were allowed to covary to improve the goodness of fit of the model. The modified model then provided a non-significant chi-square, higher values of CFI, GFI and TLI (0.986, 0.981 and 0.978, respectively) and lower value of SRMR (0.024) as well as a non-significant RMSEA with a lower value (0.061). All factor loadings and error covariances are statistically significant ($p<0.01$), suggesting that the indicator variables are significantly related to their respective factor. Confirmatory factor analysis path diagram is represented in Fig 2 and the fit indices are shown in Table 3.

GAD-7 scores across socio-demographic characteristics

Table 4 shows the mean score of GAD-7 index across different socio-demographic variables. From the table, it is observed that female students have higher mean GAD-7 scores compared to males. In counter to private university students, mean GAD-7 score for public university students was also significantly higher. Moreover, mean GAD-7 scores are significantly different among students enrolled in different educational levels in university
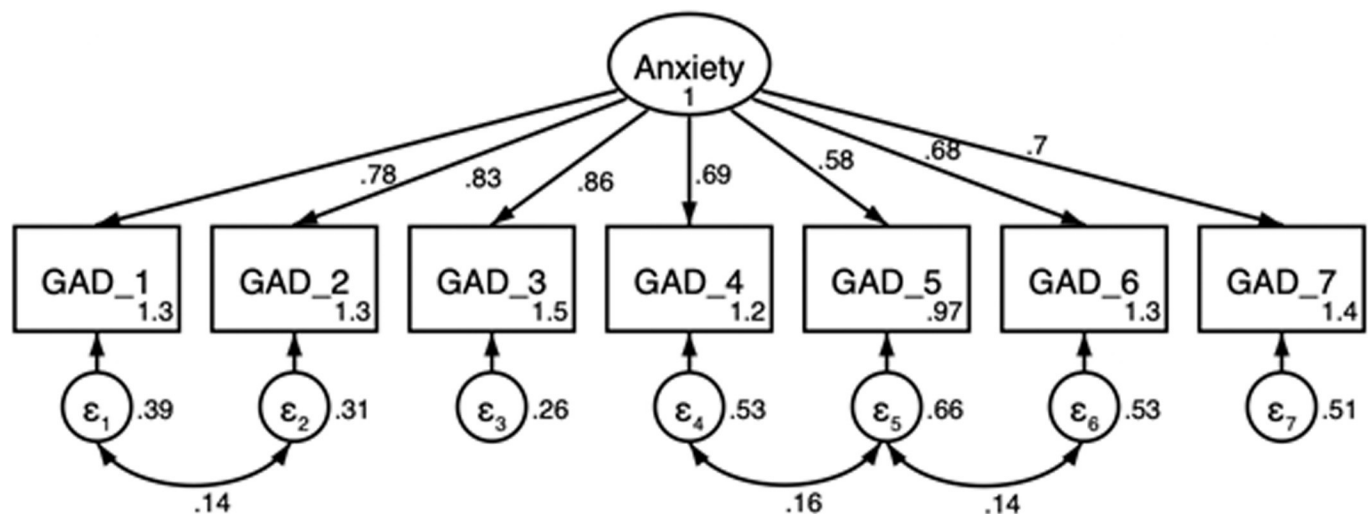

Fig 2. Confirmatory factor analysis path diagram for modified one-factor model of GAD-7 factors.

Table 4. Association of GAD-7 scores with socio-demographic characteristics (*n* = 677).

Variables	Categories	GAD-7 Mean Score (SD)	*t/F*	*p*-value
Gender	Male	8.73 (5.91)	5.133	<0.01**
	Female	11.08 (5.98)		
Age	18–22 years	9.83 (5.89)	-0.333	0.739
	23–27 years	10.03 (6.75)		
Marital Status	Married	10.25 (6.65)	0.48	0.62
	Single	9.88 (6.03)		
	Others	7.5 (7.42)		
Type of University	Public University	10.46 (6.15)	-3.559	<0.01**
	Private University	8.74 (5.73)		
Level of Education	First year	8.94 (5.74)	5.03	<0.01**
	Second year	9.69 (5.76)		
	Third year	11.60 (6.22)		
	Fourth year	10.68 (6.45)		
	Masters	9.86 (6.36)		
Principal Source of Income	Government Service Holder	9.60 (5.93)	1.92	0.088
	Agricultural wage labour	9.43 (6.25)		
	Organized Trade/Business	8.97 (5.79)		
	Pension/ Rent	10.43 (6.33)		
	Private Service Holder	10.81 (6.22)		
	Others	10.17 (5.22)		
Student employment	Yes	9.20 (5.68)	1.22	0.223
	No	9.99 (6.12)		
Family monthly income	<25,000 BDT	9.31 (5.89)	0.86	0.463
	25,000–54,999 BDT	9.88 (5.89)		
	55,000–99,999 BDT	10.38 (5.96)		
	> = 1,00,000 BDT	9.84 (6.85)		
Family Size	< = 4 members	10.06 (6.01)	-0.815	0.416
	>4 members	9.68 (6.12)		
Joint Family	Yes	8.67 (5.93)	2.601	<0.05*
	No	10.18 (6.05)		
Domestic violence in family	Yes	11.48 (5.92)	-2.825	<0.01**
	No	9.60 (6.04)		
Majority of time spent	Alone	12.39 (5.67)	17.81	<0.01**
	With family	8.65 (5.82)		
	With friends	10.11 (6.60)		
	With pets	10.09 (4.81)		

[a] Group differences were performed using *t*-test and analysis of variance.

*$p<0.05$,

** $p<0.01$.

SD = Standard Deviation, BDT = Bangladeshi Taka.

ranging from first year to fourth year, where higher levels students had higher average GAD-7 scores. Furthermore, students who faced domestic violence in the family and spent time alone reported significantly higher mean GAD-7 scores. Of note, there was no difference in mean GAD-7 scores among students with different age group, family income and family size.

Convergent validity

Pearson correlation coefficients were calculated to examine convergent validity of the GAD-7 with other measures (PHQ-9 and PHQ-ADS). Scores on GAD-7 scale were highly and positively correlated with the scores of PHQ-9 and PHQ-ADS. Correlation between GAD-7 and PHQ-9 is 0.751 and between GAD-7 and PHQ-ADS is 0.934. Both correlations are statistically significant ($p<0.01$) (S1 Table).

Discussion

GAD-7 has been used to detect symptoms of anxiety disorders in various settings and across diverse populations, beyond its original application in primary-care settings. Therefore, evaluating the psychometric properties of the scale is necessary. Furthermore, the paucity of studies conducted on vulnerable groups such as university students also necessitates a contribution to the existing gap in the literature. In this context, our study examined the psychometric properties of the GAD-7 with a sample of university students in Bangladesh, using EFA and CFA.

In the present study, internal consistency of the scale was excellent, reflected by the overall Cronbach's α of 0.895. The original validation study conducted on adult patients in primary care clinics in USA reported a Cronbach's α score of 0.92 [22]. Other clinical and non-clinical studies conducted in Korea, Portugal, United States, Iran, Germany and, Peru have similarly found excellent Cronbach's α coefficient [30, 40, 41, 46, 47, 66] which show good internal consistency of GAD-7 scale across different populations. Specifically, surveys conducted on university students of Korea and college students of Portugal found on Cronbach's α coefficient to be 0.91 and 0.88 respectively, revealing excellent internal consistency. [40, 41]. In Bangladesh, Faisal et al. (2021) found good internal consistency of GAD-7 (Cronbach's α = 0.87) in a study on university students [14]. We tested the convergent validity of GAD-7 with two other scales, PHQ-9 and PHQ-ADS. Correlation of GAD-7 with both PHQ-9 and PHQ-ADS were strong, with the coefficients statistically significant and greater than 0.75, suggesting good convergent validity. Studies have found comorbidity of GAD with depressive disorders [67, 68] and it has been identified as a predictor of mood disorders [69]. Hettema (2008) noted that GAD has undergone a series of revisions in its diagnostic criteria that has moved it, nosologically, away from its original affiliation with panic disorder (PD) and closer to major depressive disorder (MDD). Accordingly, he found a strong overlap between GAD and MDD based upon familial/genetic, childhood environment, personality trait, and demographic data. Schoevers et al. (2005) studied 2,173 community-living elderly persons and found that GAD often coexists with depression. Therefore, relationship between scales measuring symptoms of anxiety and depression is not unexpected. The study on Korean university students has also found good convergent validity of GAD-7 with PHQ-9, with a correlation coefficient of 0.68 [40]. The study conducted on Portuguese college students found strong correlation (r>0.8) of GAD-7 with HADS-A and HADS-D scale (Hospital Anxiety and Depression Scale) [41]. Other studies have also found strong evidence of convergence validity of GAD-7 with similar psychometric instruments in different settings [25, 47]. All these results signify the usefulness of GAD-7 scale as a screening tool for anxiety disorder among university students in different countries.

The unidimensional model proposed by EFA showed a marginal fit to our context. Hence, the original model was amended using the examination of modification indices. Dependency between the error terms of item-1 ('Feeling nervous, anxious or on edge') and 2 ('Not being able to stop or control worrying'), 4 ('Trouble relaxing') and 5 ('Being so restless that it is hard to sit still') and 5 and 6 ('Becoming easily annoyed or irritable') upgraded the fitness of the model. Our modified one-factor model was partially similar to that for Korean university

students [40] and for Portuguese college students [41]. While these studies found that there is covariance between error terms of item 4 and item 5 as well as item 5 and item 6, error terms of item 1 and item 2 were not found to covary. Lowe et al. (2008) and Kertz et al. (2013) have also confirmed the modified one-factor structure of the GAD-7 scale in samples of general population and patients enrolled in a partial hospital program, respectively [27, 47]. However, a study on Saudi university male students found support for the original one-factor structure of GAD-7 [42], whereas the two-factor structure of GAD-7 was supported by some other studies [25, 70]. In consistence with results from most of the studies conducted on samples of students, the unidimensional structure of GAD-7 also fits well in our study. [40, 41].

Aside from the issues discussed above, the mean scores obtained from GAD-7 across different socio-demographic characteristics were in line with existing literature on the university students around the globe [71–73]. In terms of gender, higher GAD-7 scores were associated with female students. Such finding is not unexpected as according to several studies, gender difference in incidence of psychological disorders is pervasive [31, 74, 75], including university students in Dhaka, Bangladesh [76]. In case of level of education, we observe that students enrolled in higher level of their undergraduate study have significantly higher GAD-7 scores. Advanced undergraduate students often face tougher courses as well as rigid grading compared to previous years which results in a gradual increase in anxiety [77–79]. Additionally, factors such as failure in love affairs, lack of self-confidence and familial problems might contribute to increasing anxiety [80]. The results obtained from our sample also show that the GAD-7 scores are significantly higher for students from public universities. As public university students in Bangladesh mostly come from a lower socio-economic background compared to private university students, they have an additional pressure of finding jobs just after or even during their study as well as maintain good grades. As a result, fear of delayed completion of degree and uncertainty of jobs can be additional contributing factors to the high score. Our results also indicate that students who witnessed domestic violence in the family suffer more from anxiety compared to those who did not [30, 81]. Also, students who spent most of their time with family members, friends or pets, rather than on their own were significantly less anxious [81].

The GAD-7 scale is short and easily administrable and can be used effortlessly in counselling settings of academic institutions as a primary screening measure of anxiety. Hence, the validation of GAD-7 in the context of university students of Bangladesh could make a crucial contribution to the identification and treatment of mental health issues of university students.

Several limitations need to be acknowledged while interpreting the results of this study. First, the data is collected only from a relatively homogeneous sample of university students of Bangladesh in terms of socioeconomic and demographic factors. As a result, the findings should not be generalized in diverse samples. Secondly, data collection was completely web-based which can lead to participation bias and reporting bias [82]. Lastly, future research also needs to explore the sensitivity and specificity of the GAD-7 in academic settings.

This study addressed a major gap in the literature by being the first to evaluate the psychometric properties of GAD-7 in university students of Bangladesh, who are more prone to experiencing heightened anxiety. The study adds to the growing evidence of GAD-7 as a concise, simply administered self-reported questionnaire. The results also provide support for a modified unidimensional structure of GAD-7 and show high internal consistency as well as good convergent validity for the sample of university students. Such successful validation of GAD-7 scale in the context of university students of Bangladesh will allow early diagnosis and treatment of the patients, thus helping the policy makers and public health authorities to take necessary and timely interventions to deal with such disorders.

Supporting information

S1 Table. Pearson's correlation coefficients (r) between GAD-7 items and with other questionnaires, (*n* = 677).
(DOCX)

S2 Table. Eigenvalue, percentage of variance, and cumulative percentage of variance for the factors derived from EFA for PHQ-9 items.
(DOCX)

S3 Table. Distribution of GAD-7 items.
(DOCX)

S1 Dataset.
(DTA)

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