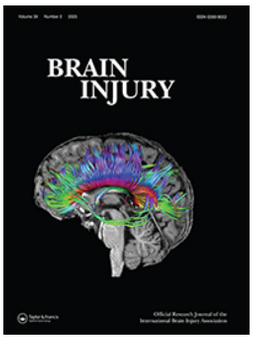

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Rasch analysis of the depression anxiety stress scales-21 (DASS-21) in a mild traumatic brain injury sample

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ABSTRACT

Objective: In this study, we evaluated the psychometric properties of the Depression Anxiety Stress Scales 21 items (DASS-21) in a mild traumatic brain injury (mTBI) sample.

Method: Treatment-seeking adults ($n = 347$) were recruited from outpatient rehabilitation services in New Zealand. Dimensionality, reliability, person separation index, and differential item functioning (DIF) of the DASS-21 were examined using Rasch analysis.

Results: Initial analysis of the complete 21-item DASS showed poor overall fit due to problems with individual items. Fit to the Rasch model was excellent when treated as three composite scores. The stress subscale demonstrated adequate model fit, dimensionality and good reliability. For anxiety, fit was not good, reliability was unsatisfactory and DIF was evident on one item. When this item was removed, fit to the model was still inadequate as was reliability. DIF was also evident for depression, but when this item was removed, fit to the model was adequate.

Conclusion: The DASS-21 is a psychometrically sound measure of distress and stress for adults seeking treatment following mTBI. Ordinal to interval score conversion tables are provided to increase the precision of measurement. When assessing depression in a mTBI population, a 6-item depression subscale is recommended. Caution is advised in using the DASS-21 anxiety subscale alone.

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Mild traumatic brain injury; mental health; DASS-21; psychometrics; Rasch

Psychological difficulties following mild traumatic brain injury (mTBI) are common (1). It has been estimated that 12–44% of individuals experience some degree of depression within the first three months of this injury (2–4). Similar rates of anxiety disorders have also been reported (5,6). The causes of psychological difficulties after mTBI are multifaceted, complex, and likely inter-related (1,7,8). Pre-injury psychological vulnerabilities, such as a preexisting psychological disorder, can persist following an mTBI or even be exacerbated (9). Psychological difficulties may also be a direct consequence of the injury itself. There is evidence to suggest that neurobiological/pathophysiological changes associated with mTBI may be directly related to psychological symptoms (10–12). For example, dysfunction in the dorsolateral prefrontal cortex, insular cortex, thalamus, and striatum has been observed following mTBI (13–15); these brain regions have also been associated with depressive symptomology. In addition, post-concussion symptoms that occur following mTBI can also precipitate psychosocial distress, further contributing to psychological difficulties after mTBI (8).

Psychological difficulties after mTBI can have a profound influence. Not only can psychological symptoms negatively impact well-being, quality of life and daily functioning (16–18), but they can also delay recovery (7). There is now substantial scientific evidence that psychological factors are robust predictors of mTBI outcomes (1,19–21). In a systematic review of prognostic models of mTBI outcomes, pre-injury mental health was identified as the best prognostic indicator of mTBI outcomes (19). Acute psychological distress after mTBI has also been found to consistently correlate with post-concussion symptoms, more so than mTBI severity or neuropsychological test performance (22–24). Moreover, early psychological distress predicts post-concussion symptom severity over time (25,26). Consequently, the assessment and identification of psychological difficulties in the management and treatment of mTBI is imperative.

Self-report questionnaires are often used as a clinical tool to assess psychological difficulties in clinical services. A common tool is the Depression Anxiety Stress Scale (DASS (27)). Rather than mapping onto diagnostic criteria, the DASS measures the severity of core symptoms of depression, anxiety, and stress. Respondents use a 4-point severity-frequency scale to rate the extent to which each statement applied to them over the preceding week, ranging from 0 ('did not apply') to 3 ("applied very much or most of the time). The DASS has two versions, a 42-item, and a 21-item scale (27), which are freely available in the public domain. Both versions have well-established psychometric properties in the general population (28), and the DASS has been used extensively across a diverse range of populations and settings (27–29).

The DASS-21 has been used extensively in the traumatic brain injury (TBI) population, including mTBI (30–33).

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Several studies have demonstrated that the instrument has good psychometric properties, construct validity, and can accurately predict the diagnosis of depression and anxiety when compared with a more comprehensive structured interview (34–37). Although these findings are promising, the current TBI literature has not recognized the limitations within the DASS. Specifically, this instrument was developed primarily on the basis of classical test theory (CTT), which has several shortcomings, such as its focus on total test scores rather than first ensuring individual items are all measuring the latent construct concerned (38). Furthermore, with CTT methods, the statistical properties of the measure are dependent on the sample and characteristics of the cohort used. Regarding this, it is noteworthy that at present, the evidence pertaining to the DASS-21 in TBI has focused on samples with mixed TBI severities (35,36) or more severe injuries (37). To the best of our knowledge, we are unaware of any research that has evaluated the DASS-21 exclusively in mTBI samples. Rasch analysis offers several distinct advantages (39,40). Briefly, using the Rasch model a number of attributes are tested including appropriate stochastic ordering of items, appropriate ordering of response options in polytomous items and testing local independence assumptions, including unidimensionality. Another advantage of Rasch analysis for clinical measures is the opportunity, within the same analytical framework, to identify item bias or Differential Item Functioning (DIF). This is where responding to an item systematically differs according to a personal or demographic characteristic *for people at the same level of the latent trait* being measured, for example, if males or females with similar overall levels of anxiety responded differently (e.g. higher or lower) to an item on an anxiety questionnaire in a systematic way. In this study, we aim to complete a Rasch analysis of the DASS-21 in a mTBI sample. We will also examine each DASS item for possible DIF or bias with respect to person factors namely age, gender, ethnicity and education.

Method

Design and setting

This is a secondary analysis of data collected from participants attending outpatient concussion services in New Zealand who were enrolled in two separate studies that aimed to examine the role of psychological factors in mTBI recovery (41,42). Eligibility, recruitment procedures, study assessment timelines, and measures were similar across both studies, enabling the merging of datasets for the analyses. In study 1, participants were recruited from five outpatient clinics providing rehabilitation services for mTBI across both the North ($n = 2$) and South Islands ($n = 3$) of New Zealand between February 2019 and October 2022. In study 2, participants were recruited from an additional nine outpatient clinics providing rehabilitation services for mTBI in the North Island of New Zealand between March 2020 and September 2020. All clinics were funded by New Zealand's government-funded injury insurance scheme. Eligible and consenting participants completed questionnaires using REDCap or Qualtrics secure web-based platforms either in person or by e-mail link ($n = 341$), by mailed questionnaires ($n = 5$) or by telephone ($n = 1$). Data collection continued during the COVID-19 pandemic and during periods of restriction and lockdown in New Zealand, data were collected remotely.

Ethical approvals for the studies were received from New Zealand's National Health and Disability Ethics Committee (study 1: ref 18/CEN/79) and the Auckland University of Technology Ethics Committee (study 2: ref 20/32).

Participants

Eligible potential participants were approached by a clinician from the outpatient clinic and invited to participate. Eligibility criteria for participants for both studies were: 1) aged 16-years or older (study 1) and 18-years or older (study 2), 2) sustained an mTBI according to World Health Organization Neurotrauma Taskforce criteria (43), 3) were fluent in English, and 4) had no prior neurological condition or severe unstable medical condition (e.g., respiratory illness and cancer), including a past history of moderate-to-severe traumatic brain injury. In study 1, $n = 154$ and in study 2, $n = 193$ participants' data were included, resulting in a combined sample of $n = 347$ participants. A summary of the demographic and injury characteristics of the sample is presented in Table 1.

Measure

The DASS-21 is a 21-item self-report questionnaire that measures general distress experienced over the past week, plus three more specific aspects of distress, namely stress, anxiety and depression (27). The 21-item statements are all responded to on a Likert scale ranging from 0 (*did not apply to me at all*) to 3 (*applied to me very much or most of the*

Table 1. Demographic and injury characteristics of mTBI sample ($n = 347$).

		Number (%)
Demographic Characteristics		
Gender	Male	214 (62%)
	Female	132 (38%)
Age*	17 - 25	91 (26.2%)
	26 - 31	83 (23.9%)
	32 - 47	87 (25.1%)
	48 - 76	86 (24.8%)
Ethnicity	NZ European	231 (66.6%)
	NZ Māori	42 (12.1%)
	Other	74 (21.3%)
Education	High school or less	93 (27%)
	Post high school	254 (73%)
Previous Concussion History		
	Yes	163 (47%)
	No	184 (53%)
Mental Health History		
	Yes	180 (52%)
	No	167 (48%)
Injury Characteristics		
	Time Since Injury	11.27 (14.81)
Mechanism of Injury		
	Motor Vehicle Accident	62 (18%)
	Fall	70 (20%)
	Assault	83 (24%)
	Hit by Object	76 (22%)
	Other	56 (16%)
Other Injury Sustained		
	Yes	229 (66%)

*Age was divided in to these four bands to test for DIF according to age.

time). Total scores can range from 0 to 63 with higher scores reflecting greater distress. Each of the three subscales comprises seven items.

Psychometric analysis

Rasch analysis was completed using RUMM2030 software (44). Rasch analysis is based on the assumption that the probability of choosing a specific response option is represented by a logistic function of the difference of the person ability and the item difficulty (45,46). The Likelihood-ratio test was performed initially to determine the most suitable type of Rasch model (i.e., Rating Scale or Partial Credit). The Rating Scale Model assumes distances between item response thresholds are the same across all items, whereas the Partial Credit Model (PCM) allows more flexibility. If the Likelihood-ratio test is significant, then it rejects the Rating Scale model and the Partial Credit is appropriate. The Rasch PCM discrimination parameters are fixed and are all equal across all item thresholds.

Rasch analyses were conducted initially for the total 21-item DASS and then separately for each of the three seven-item subscales (stress, anxiety, and depression). Rasch analysis is completed in an iterative fashion until satisfactory overall and individual item fit to the model and evidence of unidimensionality is obtained. Overall and individual item chi-square fit statistics that demonstrate interaction between the item and a trait should be non-significant ($p > 0.05$). However, the overall item-trait interaction χ^2 and p-values generated by RUMM2030 software may be misleading in larger samples (47), and Hagell and Westergren (48) suggested that estimation of type I errors is only accurate if $n < 500$. Consequently, we tested each of the best fitting models obtained using the full sample on a randomly selected subsample of $n = 250$ (49). In addition, we calculated a second fit statistic for each analysis – the Root Mean Square of Approximation (RMSEA) – which is less influenced by sample size with a +RMSEA <0.2 reflecting good fit to the Rasch model (40).

For an excellent fit to the Rasch model, the overall item and person fit residuals would be expected to have a mean around 0.00 and a standard deviation equal to approximately 1.00. Individual items should have fit residuals ranging between −2.50 and + 2.50. Unidimensionality is tested using the method developed by Smith (50). This method uses a principal components analysis of the residuals to create two subtests and then compares each participant on both subtests using the t-test. If more than 5% of participants are significantly different on the two subtests, then unidimensionality cannot be concluded.

Local dependency between items is examined by inspection of the correlations among item residuals and can be corrected by combining highly correlated items into a testlet or super-item (51,52). When the basic criteria for fit to the Rasch model are met, the person-item threshold distribution of a final solution is investigated to establish how well the range of item difficulties cover the range of individual abilities on a latent trait. Finally, ordinal-to-interval transformation scores are calculated for users to transform ordinal data to an interval-level scale.

In analyzing the DASS-21 with a mTBI sample we followed these steps:

(1) Examining the item responses to determine the most appropriate version of the Rasch model. The Rating Scale Model (53) assumes the distances between item response category thresholds are all the same whereas the unrestricted Partial Credit Model (54) assumes these can vary within and across items. The appropriate model is identified by the Likelihood Ratio Test. If this test is significant ($p < 0.05$) then the Partial Credit Model must be used.
(2) Checking overall model fit (item-trait interaction) and individual item fit.
(3) Rescoring of items with disordered thresholds to see if this improves overall fit. A disordered threshold occurs when persons higher in the latent trait measured do not consistently endorse higher response options (i.e. 0, 1, 2, 3) for an item.
(4) Resolving local dependency through creation of super-items or testlets. These are composite items formed by summing small numbers of items. Local dependency occurs when responding on an item is influenced by another item independently of the latent variable concerned. It is identified when the residuals of two items are highly correlated.
(5) Removal of individual items where necessary to improve model fit.
(6) Testing for unidimensionality (50). This is done by inspecting loadings on the first principal component of the residuals after the 'Rasch factor' has been removed and then creating two subtests based on the highest positive and negative loading items. All participants are then compared on the two subtests using the t-test, and if more than 5% of tests are significant multidimensionality is inferred.
(7) Testing for Differential Item Functioning (DIF) by the person factors (age, gender, education and ethnicity). DIF is present when persons at the same level of the latent variable being measured score systematically differently on an item – e.g., when younger and older participants with the same overall level of anxiety score differently on an individual anxiety item.
(8) After satisfactory fit was achieved, unidimensionality confirmed and all DIF accounted for, we developed ordinal-to-interval conversion tables.

Results

Table 2 presents the results of the overall fit statistics for each of the Rasch analyses of the DASS-21 and its three subscales. The suitability of the Partial Credit Model for Rasch analysis was confirmed by the significant Likelihood-ratio test ($\chi^2(105) = 236.194$, $p < 0.001$).

Initial examination of the 21-item DASS total score

The initial analysis of the complete 21-item DASS showed poor overall fit as shown by a large and significant chi-square value (see Table 2, Analysis 1), large RMSEA and evidence of multidimensionality. Item 2 (*'I was aware of dryness of my mouth'*) showed large and significant positive misfit with a fit residual of 6.02 (acceptable item fit is

Table 2. Results of Rasch analysis of DASS-21 and subscales.

Analysis	Items	χ^2 /df, p	RMSEA	PSI	Uni-D	DIF
1	21	240.74/105, 0.00	0.06	0.91	10.09% No	Age (item #2)
2	3 Super-items	9.136/15, 0.87	0.04	0.83	0.29% Yes	No DIF
3	7 stress	46.03/35, 0.10	0.02	0.83	4.32% Yes	No DIF
4	7 anxiety	74.25/35, 0.0001	0.06	0.67	2.31% Yes	Age (item #2)
5	6 anxiety	47.39/30, 0.02	0.04	0.64	1.73% Yes	No DIF
6	7 depression	91.08/35, 0.00	0.07	0.85	3.46% Yes	No DIF
7	6 depression	34.38/30, 0.26	0.02	0.86	2.88% Yes	No DIF

usually taken as ranging between −2.50 and +2.50). Positive misfit typically reflects an item in which scores bear little or no logical relationship to the total score. Items 13 (*'I felt down-hearted and blue'*) and 21 (*'I felt that life was meaningless'*) both showed significant negative misfit (−2.50 and −2.72, respectively). Negative misfit is generally considered less of a problem than positive misfit and frequently reflects redundant items that contribute minimal additional information. At the same time, inspection of Figure 1 shows that all 21 items had orderly thresholds and no rescoring was required. The PSI (0.91) was high, reflecting very good internal consistency and the ability to accurately distinguish people from at least three distinct levels of the latent trait. However, there was also evidence of multi-dimensionality with 10% of t-tests significant.

Examination of the 21-item DASS total score with three super-items

Given the results of analysis 1, there was limited scope for improving fit by reordering thresholds and/or removing misfitting items. Consequently, we attempted to improve model fit by treating the three seven-item subscales (stress, anxiety and depression), as super-items (also known as 'testlets'). Table 2, Analysis 2, shows excellent fit for this analysis with a small, non-significant chi square, no evidence of multi-dimensionality and PSI = 0.83. In light of this excellent fit to the Rasch model, we then proceeded to testing each subscale individually for good fit.

Examination of each subscale

The seven stress items demonstrated good fit with a small, non-significant chi square, unidimensionality and good reliability (PSI = 0.83) (see Table 2, Analysis 3). There was no DIF on the seven stress items for any of the four person factors (age, gender, education and ethnicity). In regards to the anxiety subscale, inspection of Table 2 (Analysis 4) shows that while unidimensionality was achieved, overall fit was poor with a larger, significant chi-square value and a PSI of 0.67 which is below the minimum acceptable value of 0.70. Moreover, item 2 (*'I was aware of dryness in my mouth'*) showed DIF for the person factor Age. Inspection of the item characteristic curve (ICC) for Item 2 in Figure 2, shows that

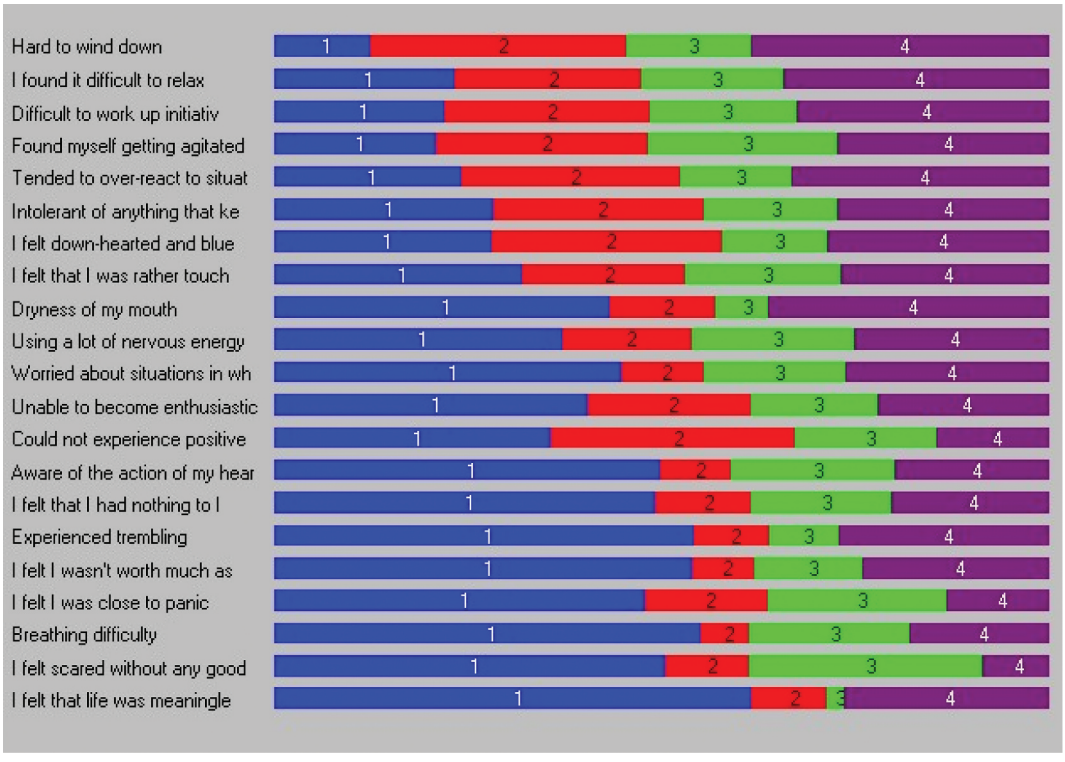

Figure 1. DASS-21item response thresholds ranked according to location (i.e, difficulty).

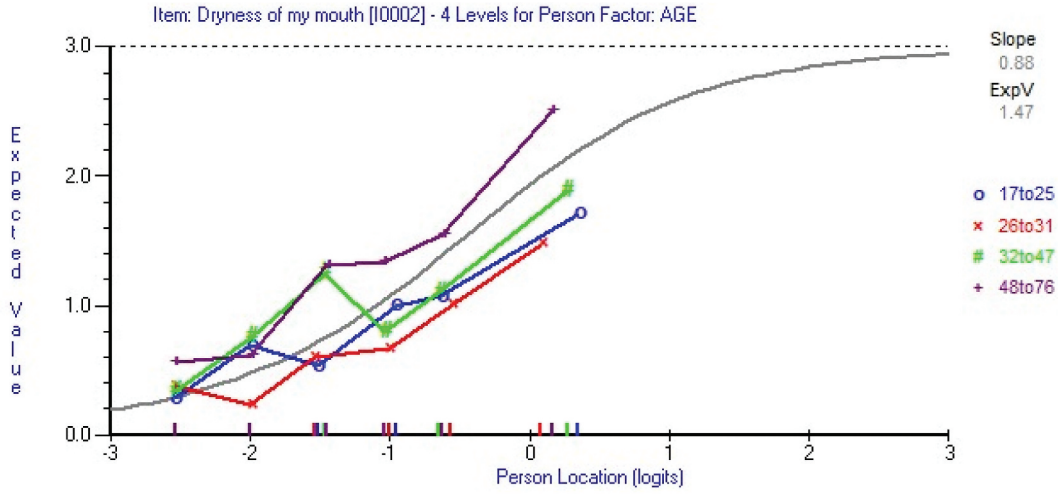

Figure 2. Item characteristic curve for item 2 showing DIF for person factor AGE.

people in the oldest age group consistently score higher than expected on this item when compared with younger people who are otherwise at the same overall level of anxiety. We repeated the analysis after removing Item 2 and this resulted in a smaller chi-square value although still significant (see Table 2, Analysis 5). While the six-item solution was unidimensional and demonstrated no DIF for age, gender, ethnicity or education, the PSI remained low at 0.64. Examination of the frequency distribution of Anxiety subscale total raw scores showed marked positive skewness with 87% of the 347 participants scoring ≤10 on this scale, where scores can range from 0 to 21.

Initial examination of the depression subscale showed poor fit with a significant chi-square value and large RMSEA (0.07) although the PSI was high at 0.85, there was no evidence of multi-dimensionality and there was no DIF observed for any person factor (see Table 2, Analysis 6). One item (Item 5 – *'I found it difficult to work up the initiative to do things'*) demonstrated significant misfit with a fit residual of 4.14 and was deleted from this analysis. This resulted in a small and non-significant chi-square, low RMSEA, PSI = 0.85, unidimensionality and no DIF (see Table 2, Analysis 7).

Ordinal to interval conversion

Overall, the results allowed for the creation ordinal-to-interval conversion tables for the DASS-21 items (using three super items) as a measure of overall distress (see Table 3), as well as for the original stress (see Table 4) and 6-item depression subscales (see Table 5). This is because the results supported the retention of the original response format and content of the overall measure, and each subscale, as no re-ordering of item response thresholds was necessary. These interval scores allow for a more precise assessment of psychological distress, stress and depression in those who have experienced mTBI. Each table allows conversion of the summed ordinal score to interval scores for the total scale, as well as for the stress and 6-item depression subscales. These can be applied without modification to the original scale and response format, assuming scoring options remain the same.

Discussion

The objective of this study was to evaluate a measure of psychological distress in individuals who have experienced an mTBI using Rasch Analysis. The DASS-21 is a commonly used screening tool for psychological distress in TBI; however, its evaluation beyond classical test theory, particularly in those with mTBI, is limited. Advanced measurement approaches, such as the Rasch model, can overcome limitations of classical test theory approaches, such as an inability to control for the difficulty level of scale items, ordering of ordinal response categories, and testing for bias across demographic factors (55). Additionally, Rasch analysis allows for the ability to transform ordinal scores into interval data to increase the precision of measurement. This is advantageous as individual items may explain different information about the construct, and therefore cannot necessarily be treated as equally contributing to the total summed score (55).

Our first step was to conduct a Rasch Analysis of all of the DASS-21 items. Fit to the Rasch model for the entire measure was excellent when we treated the three subscales as 'super items.' These findings provide evidence that the DASS-21 is a psychometrically sound measure of psychological distress for adults seeking treatment following mTBI. Enhancing the psychometric properties further, ordinal-to-interval conversion tables were created with no modifications to the original content and response format required. Psychological distress is common in individuals following mTBI and contributes to persistent symptoms and prolonged recovery (1,4,5,19,20). Consequently, the assessment of psychological distress is an important part of mTBI rehabilitation and is stipulated in treatment consensus guidelines (56). Our study validates the use of the DASS-21 as a tool that can be used for this purpose. It can be used to aid clinicians in their identification of psychological distress and support clinical decision-making for those who may require more specialized mental health assessment and treatment.

We then conducted Rasch analysis for each of the three subscales of the DASS-21. The stress subscale demonstrated adequate model fit, dimensionality and good reliability. However, this was

Table 3. Ordinal-to-interval transformation scores for the DASS-21Total score.

Raw Score	Logit Score	Interval Score	Raw Score	Logit Score	Interval Score
0	−3.06	0	40	0.273	34
1	−2.455	6	41	0.301	35
2	−2.056	10	42	0.331	35
3	−1.793	13	43	0.361	35
4	−1.593	15	44	0.394	36
5	−1.429	17	45	0.427	36
6	−1.289	18	46	0.463	36
7	−1.167	20	47	0.5	37
8	−1.06	21	48	0.541	37
9	−0.963	22	33	0.088	33
10	−0.876	23	34	0.114	33
11	−0.797	23	35	0.14	33
12	−0.724	24	36	0.165	33
13	−0.658	25	37	0.192	34
14	−0.596	26	38	0.218	34
15	−0.539	26	39	0.245	34
16	−0.486	27	40	0.273	34
17	−0.436	27	41	0.301	35
18	−0.39	28	42	0.331	35
19	−0.346	28	43	0.361	35
20	−0.306	29	44	0.394	36
21	−0.267	29	45	0.427	36
22	−0.231	29	46	0.463	36
23	−0.196	30	47	0.5	37
24	−0.163	30	48	0.541	37
25	−0.132	30	49	0.585	38
26	−0.102	31	50	0.632	38
27	−0.072	31	51	0.684	39
28	−0.044	31	52	0.742	39
29	−0.017	31	53	0.806	40
30	0.01	32	54	0.879	41
31	0.036	32	55	0.962	42
32	0.062	32	56	1.058	43
33	0.088	33	57	1.172	44
34	0.114	33	58	1.307	45
35	0.14	33	59	1.473	47
36	0.165	33	60	1.683	49
37	0.192	34	61	1.963	52
38	0.218	34	62	2.386	56
39	0.245	34	63	3.027	63

Table 4. Ordinal-to-interval transformation scores for the DASS-21 stress subscale.

Raw Score	Logit Score	Interval Score	Raw Score	Logit Score	Interval Score
0	−4.276	0	11	0.177	11
1	−3.376	2	12	0.423	12
2	−2.713	4	13	0.672	12
3	−2.224	5	14	0.929	13
4	−1.821	6	15	1.198	14
5	−1.469	7	16	1.486	14
6	−1.151	8	17	1.804	15
7	−0.858	9	18	2.168	16
8	−0.584	9	19	2.613	17
9	−0.323	10	20	3.23	19
10	−0.071	11	21	4.082	21

Table 5. Ordinal-to-interval transformation scores for the DASS-21 depression 6-item subscale.

Raw Score	Logit Score	Interval Score	Raw Score	Logit Score	Interval Score
0	−5.146	0	10	0.569	13
1	−4.067	2	11	0.904	13
2	−3.196	4	12	1.237	14
3	−2.494	6	13	1.576	15
4	−1.893	7	14	1.934	16
5	−1.374	8	15	2.331	17
6	−0.917	9	16	2.804	18
7	−0.507	10	17	3.446	19
8	−0.129	11	18	4.316	21
9	0.227	12			

Depression scale is based on six items summed after removing Item # 5.

not the case for the anxiety subscale. The original seven items demonstrated poor model fit. Moreover, the following item: *'I was aware of dryness in my mouth'* showed differential item functioning (DIF). DIF occurs when groups have different probabilities of endorsing a given item when controlling for overall scale scores. Specifically, people in the oldest age group consistently scored higher than expected on this item, when compared with younger people who had the same overall level of anxiety. Dryness of the mouth is common among older adults and can be a consequence of medication use, changes in body chemistry, nutrition or long-term health problems (57). This finding suggests that this item is impacting on the ability to accurately measure anxiety in individuals with mTBI. However, even when this item was removed, fit to the model was inadequate. While the six-item solution was unidimensional and demonstrated no DIF the PSI remained low, with marked positive skewness. That is, the majority of participants (87%) scored less than 10 on this scale. In addition to the aforementioned item ('I was aware of dryness in my mouth'), the anxiety subscale has additional questions that are heavily weighted to specific physiological sensations (i.e., *'I experienced breathing difficulty,' 'I experienced trembling', 'I was aware of the action of my heart in the absence of physical exertion'*). Endorsement of these items may also be influenced by factors not related to anxiety, impacting the validity of the measure to identify anxiety specifically. As a result of these findings, conversion of ordinal to interval scores was not indicated for this subscale. We consequently, advise caution when using this subscale alone in research and clinical practice to assess anxiety in mTBI. We recommend that if this subscale were to be used, this would be supplemented with additional measures of anxiety. The Hospital Anxiety and Depression Scale (HADS) (58) and Generalised Anxiety Disorder Scale (GAD-7) (59) have been validated in TBI samples and may be appropriate other measures to use.

Finally, in regards to the depression subscale, initial analysis of the seven-item subscale showed poor fit to the Rasch model. The following item: *'I found it difficult to work up the initiative to do things,'* demonstrated significant misfit. When this item was removed, the remaining items showed adequate fit, unidimensionality and no DIF. Consequently, our ordinal-to-interval conversion tables reflect this and we recommend the removal of this item when using this subscale and our table of scores, to measure symptoms of depression in those following mTBI. At present, we can only speculate why this item had significant misfit and further evaluation of this item in individuals with mTBI is needed. One possibility, however, lies in the use of word 'initiative.' This word is not commonly used in everyday dialectic. For example, using the CELEX lemma frequency ratings (60), initiative would be classified as a low-frequency word (with a frequency ratings of less than 70). Consequently, individuals with mTBI, who are not commonly exposed to this word, may struggle to comprehend this word as being an accurate representation of their current state. The incidence of mTBI is well known to be over-represented in certain groups, i.e., those with lower education attainment, younger age, and cultural groups. It is important that tools used for this population are suitable and our findings suggest that this item within the DASS-21 may not be.

The results of this study do need to be considered within the context of its limitations. First, our sample consisted of those who are seeking treatment for their mTBI and is therefore not generalizable to the wider mTBI context. Participants in our sample are more likely to have heightened psychological distress because their symptoms are persisting, impacting functioning and treatment is therefore required. Participants were on average 11 weeks post injury and consequently these findings are reflective of a prolonged period after mTBI. Our samples were also skewed in specific characteristics including a higher proportion of males, a greater level of educational attainment, and predominately New Zealand European ethnicity. Further research is needed using more representative sampling approaches such as through the community or primary care. In this study, we did not repeat the administration of the DASS-21. As a result, any changes to the psychometric properties of this measures over the course of mTBI recovery cannot be inferred. Finally, given the results of this study, an additional further avenue of future research is to examine the psychometric properties of the full DASS-42 in mTBI. These investigations may reveal that a larger number of items are needed to overcome the shortcomings of the DASS-21 in measuring anxiety.

In conclusion, the DASS-21 is a psychometrically sound measure of psychological distress, and the stress subscale is a sound measure of stress for adults seeking treatment following mTBI. The stress and 6-item depression subscales demonstrated adequate model fit and dimensionality. Ordinal-to-interval conversion tables have been created to research and clinical use to increase the precision of these measurements. However, caution is advised in using the anxiety subscale, and we recommend supplementation with other validated measures of anxiety if using the DASS-21 to screen for anxiety in adults following mTBI.

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