ORIGINAL ARTICLE
https://doi.org/10.1071/IB25025
Brain Impairment

# Preliminary validation of a 10-item version of the Depression, Anxiety and Stress Scale in a mild traumatic brain injury sample

Deborah L. Snell[A,*], Josh W. Faulkner[B] and R. J. Siegert[C]

For full list of author affiliations and declarations see end of paper

***Correspondence to:**
Deborah L. Snell
Department of Orthopaedic Surgery and Musculoskeletal Medicine, University of Otago, Christchurch, 2 Riccarton Avenue, Christchurch 8011, New Zealand
Email: debbie.snell@otago.ac.nz

**Handling Editor:**
Cynthia Honan

**Received:** 6 March 2025
**Accepted:** 1 October 2025
**Published:** 21 October 2025

**Cite this:** Snell DL *et al.* (2025) Preliminary validation of a 10-item version of the Depression, Anxiety and Stress Scale in a mild traumatic brain injury sample. *Brain Impairment* **26**, IB25025. doi:10.1071/IB25025



## ABSTRACT

**Background.** In this study, we evaluated the psychometric properties of a 10-item version of the Depression, Anxiety and Stress Scale (DASS-10) in a mild traumatic brain injury (mild TBI) sample. **Methods.** Treatment-seeking adults ($n$ = 354; mean age 36.3 years, 62% women) were recruited from outpatient rehabilitation services in New Zealand. Participants completed the DASS-10 on average 11.5 (15.0) weeks after their injury. Dimensionality, reliability, person separation index and differential item functioning of the DASS-10 were examined using Rasch analyses. **Results.** Initial fit to the Rasch model for the 10-item measure was good ($\chi^2$ = 78.6, d.f. = 70, $P$ = 0.22), with high internal consistency (Cronbach's alpha 0.89, person separation index 0.86) and acceptable unidimensionality. There was no evidence of differential item functioning for any of the person factors tested (age, gender, ethnicity, education, mental health history). **Conclusion.** These findings provide preliminary support for the DASS-10 as a psychometrically sound measure of psychological distress for adults seeking treatment following mild TBI. The DASS-10 for mild TBI may be a helpful brief measure to triage mental health needs among persons referred to outpatient services after mild TBI.

**Keywords:** concussion recovery, DASS-10, item response theory, mental health, mild traumatic brain injury, psychological factors, psychological symptoms, psychometrics.

## Introduction

Psychological symptoms after mild traumatic brain injury (mild TBI) impact recovery of functioning, well-being and quality of life (Petchprapai and Winkelman 2007; Silverberg and Iverson 2011; Theadom *et al.* 2017; Voormolen *et al.* 2019). Psychological factors, including pre-injury mental health, are also robust predictors of mild TBI outcomes (Broshek *et al.* 2015; Silverberg *et al.* 2015; Wäljas *et al.* 2015; Ponsford *et al.* 2019; Snell *et al.* 2023). Additionally, acute psychological distress, such as depression and anxiety symptoms, early after mild TBI correlates with post-concussion symptom burden, more so than injury severity or neuropsychological test performance (King 1996; Landre *et al.* 2006; Scheenen *et al.* 2017).

It has been estimated that 12–44% of individuals experience some degree of depression within the first 3 months of mild TBI (Hellewell *et al.* 2020). Similar rates of anxiety symptoms have also been reported (Moore *et al.* 2006; Lamontagne *et al.* 2022). Various tools and questionnaires validated for mild TBI are available to evaluate depression and anxiety following mild TBI; however, such measures can be lengthy, and may place burden on patients and clinicians. One commonly used measure is the Depression, Anxiety and Stress Scale (DASS; Lovibond and Lovibond 1995). Rather than mapping onto diagnostic criteria, the DASS measures the severity of core symptoms of depression, anxiety and stress, offering opportunities to target psychological treatments (Silverberg *et al.* 2020). The DASS has two main versions – a 42-item and a 21-item scale (Lovibond and Lovibond 1995) – which are freely available in the public domain. Both versions have well-established psychometric properties, and have been used extensively across a diverse range of populations and settings (Lovibond and Lovibond 1995; Oei *et al.* 2013;

Wang *et al.* 2016). The measurement properties of the DASS in TBI samples have also been validated in several studies (Ownsworth *et al.* 2008; Dahm *et al.* 2013; Wong *et al.* 2013), including mild TBI (Faulkner *et al.* 2025).

Recently, Halford and Frost (2021) developed and evaluated a 10-item version of the DASS in a clinical and community sample. The clinical sample was made up of 2184 consecutive adult presentations to a clinical psychology clinic in Brisbane, Australia, and the community sample comprised 326 newlywed heterosexual couples who provided normative data. The measure, called the DASS-10, was developed from the DASS-42 scale, and these items are also included in the DASS-21. The DASS-10 showed high internal reliability ($\alpha = 0.89$). It yielded two internally consistent, discriminable, but highly correlated, factors of anxiety-stress and depression. These two factors loaded onto a superordinate psychological distress factor. Furthermore, distress items discriminated between a clinical sample and a community sample, and were sensitive to clinical change. As a result, the authors proposed a single psychological distress score has potential for use as a routine outcome assessment measure, as well as for monitoring progress in clinical settings.

Psychological distress, while vague, tends to be viewed as a state of emotional turmoil characterised by depression and anxiety symptoms, also including somatic symptoms, such as fatigue, sleep disturbance and headaches (Belay *et al.* 2021). The *Diagnostic and Statistical Manual of Mental Disorders*, 5th edition (DSM-5) defines psychological distress as non-specific symptoms ranging from anxiety and depression, and associated functional and somatic impairments (American Psychiatric Association 2013). It is common following specific stresses (Belay *et al.* 2021); for example, an injury such as mild TBI (Silverberg and Mikolić 2023). Accordingly, a brief and validated measure of psychological distress, such as the DASS-10, could be helpful for mild TBI management by highlighting treatment pathways and accommodations. These could include referral for psychological support and tempering expectations in rehabilitation to accommodate psychological factors (Silverberg *et al.* 2020). In addition, individuals with mild TBI often experience post-concussion symptoms, such as fatigue, headache and concentration difficulties, which can make it challenging to complete lengthy self-report questionnaires. Thus, having a psychometrically sound assessment tool that reduces patient burden, while still providing meaningful clinical data, would be particularly useful (Aiyegbusi *et al.* 2022). Additionally, brief screening tools can reduce the cost, time and burden for clinical services (Iragorri and Spackman 2018). With these considerations in mind, the objective of the current study is to conduct a preliminary evaluation of the DASS-10 (Halford and Frost 2021) in a mild TBI sample. We aimed to use Rasch analyses to examine the unidimensionality and item characteristics of the measure.

# Methods

## Design and setting

We recently evaluated the 21-item version of the DASS in a mild TBI sample (Faulkner *et al.* 2025). We used the same dataset in the present study to evaluate the shorter DASS-10 version published by Halford and Frost (2021). The dataset for our DASS studies was described in full in Faulkner *et al.* (2025). We analysed data collected from participants attending outpatient concussion services in New Zealand who were enrolled in two studies examining the role of psychological factors in mild TBI recovery. Both studies used prospective observational methods following participants after mild TBI. In Study 1, participants were recruited from five outpatient mild TBI clinics across both the North ($n = 2$) and South Islands ($n = 3$) of New Zealand between February 2019 and October 2021. The aim of Study 1 was to investigate psychological predictors of mild TBI outcome. In Study 2, participants were recruited from an additional nine mild TBI outpatient clinics in the North Island of New Zealand between March 2020 and September 2020. The aim of Study 2 was to examine the role of psychological flexibility as a mediating factor influencing psychological predictors of mild TBI outcome. All clinics were funded by New Zealand's government-funded injury insurance scheme. Eligibility, recruitment procedures, study assessment timelines and measures were similar across both studies. Eligible and consenting participants ($n = 355$) completed questionnaires using secure web-based platforms: REDCap (Study 1) or Qualtrics (Study 2), by mailed questionnaires ($n = 5$) or by telephone ($n = 1$).

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). All participants provided written consent to participate in each respective study.

## Participants

Eligible participants: (1) were aged $\geq$16 years (study 1) and $\geq$18 years (study 2), (2) sustained a mild TBI confirmed by a medical practitioner at each clinic and in line with World Health Organization Neurotrauma Taskforce criteria (Holm *et al.* 2005), (3) were fluent in English, and (4) had no prior neurological condition, including a past history of moderate-to-severe traumatic brain injury or severe current unstable medical condition (e.g. respiratory illness, cancer). A prior history of mild TBI was not an exclusion criterion. In Study 1, $n = 110$ and in Study 2, $n = 245$ participants' data were available, resulting in a combined sample of $n = 355$ participants. One participant in Study 1 did not complete any DASS items and was excluded from the analyses, resulting in a final sample of $n = 354$ (Table 1).

**Table 1.** Demographic and injury characteristics of the mild TBI sample (*n* = 354)

| Variable | Category | *N* (%) or *M* (s.d.) |
|---|---|---|
| Demographic characteristics | | |
| Gender, *n* (%) | Female | 218 (61.6%) |
| | Male | 135 (38.1%) |
| Age (years), *n* (%)[A] | 17–25 | 94 (26.6%) |
| | 26–31 | 84 (23.7%) |
| | 32–45 | 76 (21.5%) |
| | 46–76 | 100 (28.2%) |
| Ethnicity, *n* (%) | NZ European | 237 (66.9%) |
| | NZ Māori | 42 (11.9%) |
| | Other | 75 (21.2%) |
| Education, *n* (%) | High school or less | 96 (27.1%) |
| | Post high school | 258 (72.9%) |
| Previous concussion history, *n* (%) | Yes | 165 (46.6% |
| Mental health history, *n* (%)] | Yes | 182 (51.9%) |
| Injury characteristics | | |
| Time since injury, mean (s.d.), median | Weeks | 11.5 (15.0), 7.0 |
| Mechanism of injury, *n* (%) | Motor vehicle accident | 63 (17.8%) |
| | Fall | 71 (20.1%) |
| | Assault | 65 (24/0%) |
| | Hit by object | 77 (21.8%) |
| | Other | 58 (16.4%) |
| Other injury sustained, *n* (%)[B] | Yes | 234 (66.1%) |

[A]Age was evenly distributed to test for differential item functioning.
[B]Other injury sustained means other injury sustained at the same time as the concussion injury (e.g. fracture, neck sprain).

## Measure

The DASS is a self-report questionnaire that measures general distress experienced over the previous week, as well as three more specific aspects of distress, namely depression, anxiety and stress symptoms (Lovibond and Lovibond 1995). Individuals respond to a Likert scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). In the present study, participants completed the DASS-21, and DASS-10 items were selected according the Halford and Frost version (Table 2). DASS-10 scores range from 0 to 30, with higher scores indicating greater levels of distress.

## Statistical analyses

Participant characteristics were summarised by descriptive statistics using IBM SPSS (version 29). Rasch analyses were conducted to evaluate psychometric properties of the DASS-10 using RUMM2030 software (Andrich *et al.* 2009). 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 (latent trait) and the item difficulty (Rasch 1993; Bond and Fox 2013). We were specifically interested in differential item functioning (DIF) and unidimensionality of the DASS-10 in our sample.

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-squared fit statistics that demonstrate interaction between the item and a trait should be non-significant ($P > 0.05$). For an excellent fit to the Rasch model, the overall item and person fit residuals would be expected to have a mean of approximately 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 (2002). 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 >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 (Nilsson and Tennant 2011). 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 the latent trait. In analysing the DASS-10 with our mild TBI sample, we followed these steps:

1. Item responses were examined to determine the most appropriate version of the Rasch model. 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 (Masters 1982).
2. Checking overall model fit (item–trait interaction) and individual item fit.
3. Rescoring of any items with disordered thresholds to improve 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. Stepwise removal of individual items if necessary to improve model fit.
5. Testing for unidimensionality (Wainer and Kiely 1987; Smith 2002). 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.

**Table 2.** Depression, Anxiety and Stress Scale (DASS-10) in a mild traumatic brain injury sample ($n$ = 354).[A]

| Item | Mean (s.d.) | Range | Floor, *n* (%) | Ceiling, *n* (%) |
|---|---|---|---|---|
| 1. I couldn't seem to experience any positive feelings at all (D) | 0.83 (0.80) | 0–3 | 136 (38.4) | 13 (3.7) |
| 2. I found it difficult to work up the initiative to do things (D) | 1.36 (0.92) | 0–3 | 65 (18.4) | 45 (12.7) |
| 3. I tended to over-react to situations (S) | 1.29 (0.93) | 0–3 | 74 (20.9) | 43 (12.1) |
| 4. I was worried about situations in which I might make a fool of myself (A) | 0.90 (0.97) | 0–3 | 158 (44.6) | 27 (7.6) |
| 5. I felt that I had nothing to look forward to (D) | 0.72 (0.89) | 0–3 | 185 (52.3) | 18 (5.1) |
| 6. I found it difficult to relax (S) | 1.38 (0.96) | 0–3 | 70 (19.8) | 50 (14.1) |
| 7. I felt down hearted and blue (D) | 1.11 (0.92) | 0–3 | 98 (27.7) | 32 (9.0) |
| 8. I was intolerant of anything that kept me from getting on with what I was doing (S) | 1.14 (0.90) | 0–3 | 92 (26.0) | 30 (8.5) |
| 9. I felt I was close to panic (A) | 0.69 (0.84) | 0–3 | 184 (52.1) | 12 (3.4) |
| 10. I felt scared without any good reason (A) | 0.66 (0.84) | 0–3 | 194 (54.8) | 10 (2.8) |
| DASS-10 total score | 10.09 (6.42) | 0–3 | 11 (3.1) | 2 (0.6) |

How much did the statement apply to you over the past week (0 = Did not apply to me at all, 1 = Applied to me to some degree or some of the time, 2 = Applied to me a considerable degree or good part of the time, 3 = Applied to me very much or most of the time).
[A]Item order differs from DASS-10 version by Halford and Frost (Halford and Frost 2021). Above items appear as they do in DASS-21 (A = anxiety item; D = depression item; S = stress item).

All participants are then compared on the two subtests using the $t$-test and if $>5\%$ of tests are significant multidimensionality is inferred (Smith 2002).

6. Testing for DIF by the person factors (age, gender, education,ethnicity, mental health history). DIF is present when persons at the same level of the latent trait being measured score systematically differently on an item; for example, when younger and older participants with the same overall level of anxiety score differently on an individual anxiety item.
7. Finally, we developed ordinal-to-interval conversion tables for DASS-10 total scores.

## Results

### Participant characteristics

The average age of the cohort ($n = 354$) was 36.3 years (s.d. 14.0), ranging from 17 to 76 years, with more women than men (women 62%). A majority were of New Zealand European ethnicity (67%). Just over half the sample endorsed a prior mental health history (52%). Participants were on average 11.5 weeks post-injury (s.d. 15.0), and the most common injury mechanisms included motor vehicle accidents, assaults and being hit by an object. A summary of participant characteristics is shown in Table 1.

### DASS-10 analyses

The total mean DASS-10 score for the sample was 10.1 (s.d. 6.4), median 9.0, and interquartile scores 5.0, 9.0 and 14.0. Evaluation of internal consistency of the DASS-10 using Cronbach's alpha was suggestive of high internal consistency ($a = 0.89$) based on Cohen's rules (Bland and Altman 1997). Corrected item-total correlations ranged from 0.58 to 0.72. Table 2 shows DASS-10 item characteristics, including floor and ceiling effects.

The overall fit statistics for the initial Rasch analysis of the DASS-10 showed a good fit to the model ($\chi^2$ (70) = 78.63, $P = 0.22$), indicated by a non-significant chi-squared value. The person separation index, a statistic similar to Cronbach's alpha, was 0.86. This reflects the scale's ability to discriminate among groups of persons at different levels of the measured trait. No items showed disordered thresholds or required rescoring (Fig. 1). Unidimensionality testing showed 21 out of 354 $t$-tests (5.93%) were significant. Ideally, this figure should be $<5\%$, but a binomial test gave confidence intervals at 95% of lower (0.04) to upper (0.08). If the lower 95% CI is $<0.05$, unidimensionality can be considered acceptable.

We evaluated DIF on five person factors (age, gender, ethnicity, education, mental health history). There was no evidence of DIF on any of these variables. Finally, Fig. 2 shows the distribution of person ability (latent trait) mapped against the distribution of item location (difficulty) on the Rasch logarithmic scale. This shows floor and ceiling effects also reflected in Table 2. Ordinal to interval conversion for DASS-10 total scores are shown in Table 3.

## Discussion

The objective of this study was to evaluate whether a brief measure of psychological distress, a 10-item version of the DASS, might offer an efficient option for triaging needs for

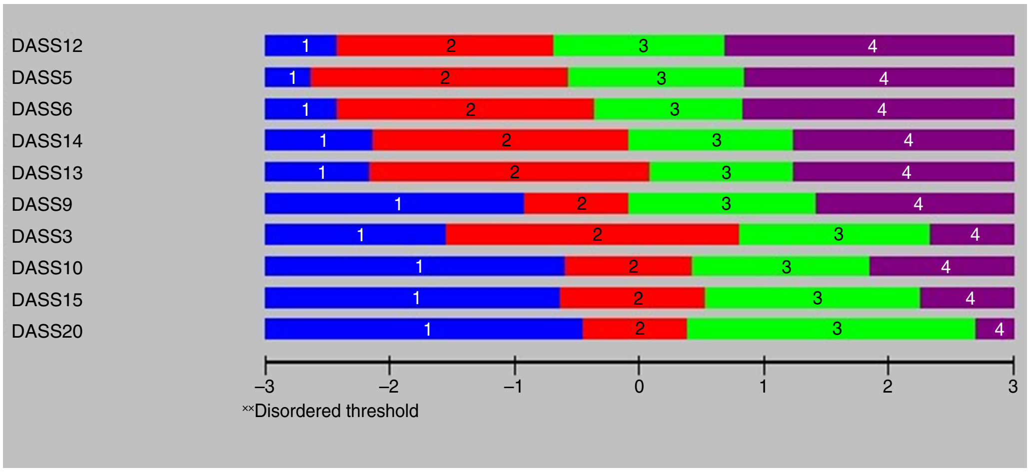


**Fig. 1.** DASS-10 item thresholds with items ranked by location (i.e. difficulty).

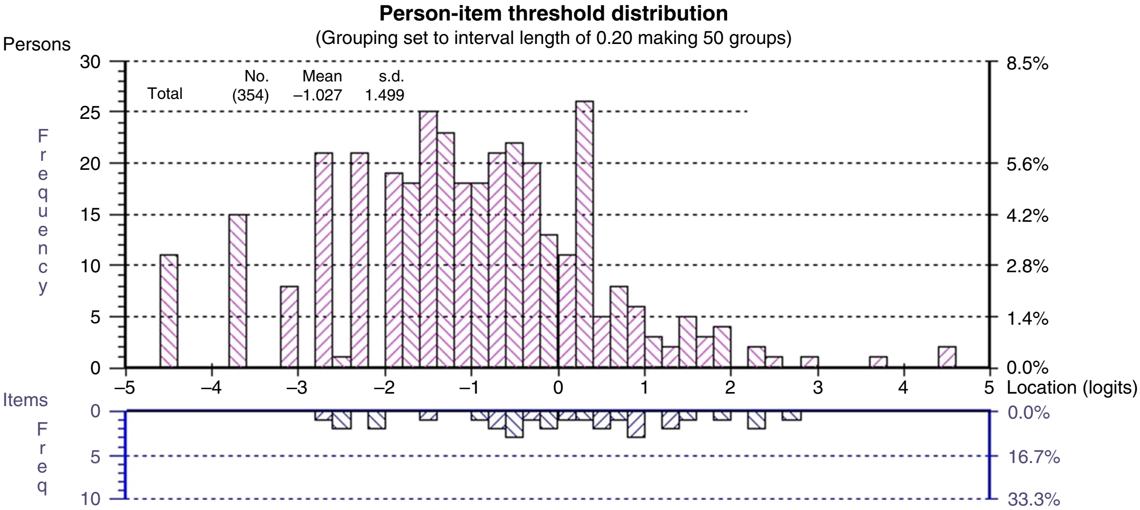


**Fig. 2.** Distribution of item location (difficulty) and person ability (latent variable) on Rasch logarithmic scale.

mental health support among people following mild TBI. We were interested in whether the brief version demonstrated acceptable unidimensionality and reliability in our clinical sample. Initial fit to the Rasch model for the 10-item measure was good, with high internal consistency and acceptable unidimensionality. There was no evidence of DIF for any of the person factors tested (age, gender, ethnicity, education, pre-injury mental health history). These findings suggest the brief DASS-10 for mild TBI may offer a psychological distress score that is easy to calculate, and not burdensome for clinicians and patients.

The only other examination of the 10-item version of the DASS to our knowledge was undertaken by Halford and Frost (2021) in adult psychology treatment-seeking and general community samples. They found a unidimensional superordinate psychological distress factor that discriminated between their clinical and community samples. The clinical sample mean relative to the community sample was higher, as expected (clinical mean 12.9 (s.d. 6.8), community mean 3.0, s.d. (3.2), $P < 0.01$, effect size 1.9). They determined a clinical cut-off for defining a clinical case was a DASS-10 score >7. In our treatment-seeking adult sample of people with mild TBI, we found a mean score of 10.1 (s.d. 6.4). Although these scores seem comparable to those reported by Halford and Frost in their clinical sample, using their cut-off score (DASS-10 >7) for psychological distress among people presenting for treatment after mild TBI may not be reliable. Further research would be required to provide confident cut-off score information for use in mild TBI clinical settings.

## Clinical implications

Strategies to reduce patient burden and improve efficiency, such as use of brief screening and outcome measures, are important considerations in health research and clinical

**Table 3.** Ordinal-to-interval transformation scores for the DASS-10 for mild TBI.

| Raw score | Logit score | Interval score | Raw score | Logit score | Interval score |
|---|---|---|---|---|---|
| 0 | -4.58 | 0 | 16 | 0.20 | 16 |
| 1 | -3.72 | 3 | 17 | 0.36 | 16 |
| 2 | -3.10 | 5 | 18 | 0.53 | 17 |
| 3 | -2.65 | 6 | 19 | 0.70 | 17 |
| 4 | -2.28 | 8 | 20 | 0.87 | 18 |
| 5 | -1.97 | 9 | 21 | 1.05 | 19 |
| 6 | -1.69 | 10 | 22 | 1.25 | 19 |
| 7 | -1.45 | 10 | 23 | 1.46 | 20 |
| 8 | -1.22 | 11 | 24 | 1.68 | 21 |
| 9 | -1.01 | 12 | 25 | 1.94 | 22 |
| 10 | -0.82 | 12 | 26 | 2.22 | 23 |
| 11 | -0.63 | 13 | 27 | 2.57 | 24 |
| 12 | -0.46 | 14 | 28 | 3.00 | 25 |
| 13 | -0.29 | 14 | 29 | 3.61 | 27 |
| 14 | -0.12 | 15 | 30 | 4.47 | 30 |
| 15 | 0.04 | 15 | | | |

assessment (Karran *et al.* 2017). One driver for validating brief screening approaches for psychological factors after mild TBI includes a need to improve identification of such risk factors to enable targeted treatment (Silverberg *et al.* 2020). Identification can direct the most appropriate treatment; for example, a referral to a psychologist. However, decision making for referrals to psychologists appears inconsistent, and this might be because of a lack of systematic evidence-based approaches for triaging psychological risk among people seeking outpatient rehabilitation after mild TBI (Faulkner *et al.* 2025). Using brief measures has the potential to streamline and guide triage assessment, especially when triage is conducted on service entry by non-psychologists. It does not necessarily replace or override decisions for administering full questionnaires, as clinically indicated. By capturing psychological distress, the DASS-10 may offer a means of screening for risk for persistent symptoms and directing treatment referral decisions. However, clinicians may still wish to consider full length questionnaires for treatment planning once a client has been directed to an appropriate treatment pathway (Mikolić *et al.* 2024; Snell *et al.* 2025).

## Limitations

There are limitations to be considered. First, our sample consisted of treatment-seeking adults, and so does not generalise to the wider mild TBI population. We recruited from outpatient rehabilitation services, where patients are referred (most often by family physicians, emergency medicine physicians or disability claim managers) or self-referred because of a slow recovery. This sampling method means participants were in a sub-acute stage (McCrea *et al.* 2009), and likely explains the relatively high symptom burden and incidence of psychiatric comorbidity compared with unselected mild TBI samples (Carroll *et al.* 2014). Participants in our sample, at 11 weeks post-injury, may be more likely to have heightened psychological distress, because their symptoms have persisted and are impacting functioning. Further research examining the utility of a brief measure of distress, such as the DASS-10, among the wider mild TBI population would enhance support for the measure. Finally, other psychometric properties were not examined, such as aspects of validity and sensitivity to change, to determine if the measure could be useful as a tool for monitoring change over time in treatment.

## Conclusions

The findings of this study provide preliminary support for the DASS-10 as a psychometrically sound brief measure of psychological distress among adults seeking treatment following mild TBI. The DASS-10 for mild TBI may be an efficient tool for clinicians to triage psychology needs among persons referred to mild TBI outpatient services, and to direct assessment and treatment needs. Interval score conversions have been included to increase the precision of measurement.

## References


Aiyegbusi OL, Roydhouse J, Rivera SC, Kamudoni P, Schache P, Wilson R, Stephens R, Calvert M (2022) Key considerations to reduce or address respondent burden in patient-reported outcome (PRO) data collection. *Nature Communications* **13**, 6026. doi:10.1038/s41467-022-33826-4

American Psychiatric Association (2013) 'Diagnostic and Statistical Manual of Mental Disorders', 5th edn. (American Psychiatric Association: Arlington, VA)

Andrich D, Sheridan B, Luo G (2009) 'RUMM 2030.' (RUMM Laboratory: Perth, WA, Australia)

Belay A, Guangul M, Asmare W, Mesafint G (2021) Prevalence and Associated Factors of Psychological Distress among Nurses in Public Hospitals, Southwest, Ethiopia: A cross-sectional Study. *Ethiopian Journal of Health Sciences* **31**, 1247–1256. doi:10.4314/ejhs.v31i6.21

Bland J, Altman D (1997) Statistics notes: Cronbach's alpha. *BMJ* **314**, 572. doi:10.1136/bmj.314.7080.572

Bond T, Fox C (2013) 'Applying the Rasch Model: Fundamental Measurement in the Human Sciences.' (Psychology Press: NY)

Broshek D, de Marco A, Freeman J (2015) A review of post-concussion syndrome and psychological factors associated with concussion. *Brain Injury* **29**, 228–237. doi:10.3109/02699052.2014.974674

Carroll L, Cassidy J, Cancelliere C, Côte' P, Hincapie' C, Kristman V, Holm L, Borg J, Nygren-de Boussard C, Hartvigsen J (2014) Systematic Review of the Prognosis After Mild Traumatic Brain Injury in Adults: Cognitive, Psychiatric, and Mortality Outcomes: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. *Archives of Physical Medicine and Rehabilitation* **95**, S152–173. doi:10.1016/j.apmr.2013.08.300

Dahm J, Wong D, Ponsford J (2013) Validity of the Depression Anxiety Stress Scales in assessing depression and anxiety following traumatic brain injury.

*Journal of Affective Disorders* **151**, 392–396. doi:10.1016/j.jad.2013.06.011

Faulkner J, Snell D, Siegert R (2025) Rasch analysis of the depression anxiety Stress scales-21 (DASS-21) in a mild traumatic brain injury sample. *Brain Injury* **39**, 136–144. doi:10.1080/02699052.2024.2411297

Halford W, Frost A (2021) Depression Anxiety Stress Scale-10: A brief measure for routine psychotherapy outcome and progress assessment. *Behaviour Change* **38**, 221–234.

Hellewell S, Beaton C, Welton T, Grieve S (2020) Characterizing the risk of depression following mild traumatic brain injury: a meta-analysis of the literature comparing chronic mTBI to non-mTBI populations. *Frontiers in Neurology* **11**, 350. doi:10.3389/fneur.2020.00350

Holm L, Cassidy J, Carroll L, Borg J (2005) Summary of the WHO Collaborating Centre for Neurotrauma Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine* **37**, 137–141. doi:10.1080/16501970510027321

Iragorri N, Spackman E (2018) Assessing the value of screening tools: reviewing the challenges and opportunities of cost-effectiveness analysis. *Public Health Reviews* **39**, 17. doi:10.1186/s40985-018-0093-8

Karran E, Mcauley J, Traeger A, Hillier S, Grabherr L, Russek L, Moseley G (2017) Can screening instruments accurately determine poor outcome risk in adults with recent onset low back pain? A systematic review and meta-analysis. *BMC Medicine* **15**, 13. doi:10.1186/s12916-016-0774-4

King N (1996) Emotional, neuropsychological, and organic factors: their use in the prediction of persisting postconcussion symptoms after moderate and mild head injuries. *Journal of Neurology, Neurosurgery and Psychiatry* **61**, 75–81. doi:10.1136/jnnp.61.1.75

Lamontagne G, Belleville G, Beaulieu-Bonneau S, Souesme G, Savard J, Sirois M, Giguère M, Tessier D, Le Sage N, Ouellet M (2022) Anxiety symptoms and disorders in the first year after sustaining mild traumatic brain injury. *Rehabilitation Psychology* **67**, 90–99. doi:10.1037/rep0000422

Landre N, Poppe C, Davis N, Schmaus B, Hobbs S (2006) Cognitive functioning and postconcussive symptoms in trauma patients with and without mild TBI. *Archives of Clinical Neuropsychology* **21**, 255–273. doi:10.1016/j.acn.2005.12.007

Lovibond P, Lovibond S (1995) The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy* **33**, 335–343. doi:10.1016/0005-7967(94)00075-u

Masters G (1982) A Rasch model for partial credit scoring. *Psychometrika* **47**, 149–174. doi:10.1007/BF02296272

McCrea M, Iverson G, Mcallister T, Hammeke T, Powell M, Barr W, Kelly J (2009) An integrated review of recovery after mild traumatic brain injury (MTBI): implications for clinical management. *The Clinical Neuropsychologist* **23**, 1368–1390. doi:10.1080/13854040903074652

Mikolić A, Snell D, Theadom A, Faulkner J, Zemek R, Silverberg N (2024) Screening for psychological risk factors to improve management of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation* **39**, E355.

Moore E, Terryberry-Spohr L, Hope D (2006) Mild traumatic brain injury and anxiety sequelae: A review of the literature. *Brain Injury* **20**, 117–132. doi:10.1080/02699050500443558

Nilsson Å, Tennant A (2011) Past and present issues in Rasch analysis: the functional independence measure (FIM™) revisited. *Journal of Rehabilitation Medicine* **43**, 884–891. doi:10.2340/16501977-0871

Oei T, Sawang S, Goh Y, Mukhtar F (2013) Using the Depression Anxiety Stress Scale 21 (DASS-21) across cultures. *International Journal of Psychology* **48**, 1018–1029. doi:10.1080/00207594.2012.755535

Ownsworth T, Little T, Turner B, Hawkes A, Shum D (2008) Assessing emotional status following acquired brain injury: The clinical potential of the depression, anxiety and stress scales. *Brain Injuury* **22**, 858–869. doi:10.1080/02699050802446697

Petchprapai N, Winkelman C (2007) Mild traumatic brain injury: determinants and subsequent quality of life. A review of the literature. *Journal of Neuroscience Nursing* **39**, 260–272.

Ponsford J, Nguyen S, Downing M, Bosch M, Mckenzie J, Turner S, Chau M, Mortimer D, Gruen R, Knott J, Green S (2019) Factors associated with persistent post-concussion symptoms following mild traumatic brain injury in adults. *Journal of Rehabilitation Medicine* **51**, 32–39. doi:10.2340/16501977-2492

Rasch G (1993) 'Probabilistic Models for Some Intelligence and Attainment Tests.' (MESA Press: Chicago, IL, USA)

Scheenen M, Spikman J, de Koning M, van der Horn H, Roks G, Hageman G, van der Naalt J (2017) Patients "at risk" of suffering from persistent complaints after mild traumatic brain injury: the role of coping, mood disorders, and post-traumatic stress. *Journal of Neurotrauma* **34**, 31–37. doi:10.1089/neu.2015.4381

Silverberg N, Iverson G (2011) Etiology of the post-concussion syndrome: physiogenesis and psychogenesis revisited. *NeuroRehabilitation* **29**, 317–329. doi:10.3233/NRE-2011-0708

Silverberg ND, Mikolić A (2023) Management of Psychological Complications Following Mild Traumatic Brain Injury. *Current Neurology and Neuroscience Reports* **23**, 49–58. doi:10.1007/s11910-023-01251-9

Silverberg N, Gardner A, Brubacher J, Panenka W, Li Jun J, Iverson G (2015) Systematic Review of Multivariable Prognostic Models for Mild Traumatic Brain Injury. *Journal of Neurotrauma* **32**, 517–526. doi:10.1089/neu.2014.3600

Silverberg ND, Iaccarino MA, Panenka WJ, Iverson GL, Mcculloch KL, Dams-O'connor K, Reed N, Mccrea M (2020) Management of Concussion and Mild Traumatic Brain Injury: A Synthesis of Practice Guidelines. *Archives of Physical Medicine and Rehabilitation* **101**, 382–393. doi:10.1016/j.apmr.2019.10.179

Smith E (2002) Detecting and evaluating the impact of multi-dimensionality using item fit statistics and principal component analysis of residuals. *Journal of Applied Measurement* **3**, 205–231.

Snell D, Faulkner J, Williman J, Silverberg N, Theadom A, Surgenor L, Hackney J, Siegert R (2023) Fear avoidance and return to work after mild traumatic brain injury. *Brain Injury* **37**, 541–550. doi:10.1080/02699052.2023.2180663

Snell D, Mikolić A, Faulkner J, Theadom A, Silverberg N (2025) Comparative predictive validity of a psychological risk screening tool in adults after mild traumatic brain injury. *Brain Injury* 1–7. doi:10.1080/02699052.2025.2565640

Theadom A, Barker-Collo S, Jones K, Kahan M, Te Ao B, Mcpherson K, Starkey N, Feigin V, the BIONIC4you Research Group (2017) Work limitations 4 years after mild traumatic brain injury: a cohort study. *Archives of Physical Medicine and Rehabilitation* **98**, 1560–1566. doi:10.1016/j.apmr.2017.01.010

Voormolen D, polinder S, von Steinbuechel N, Vos P, Cnossen M, Haagsma J (2019) The association between post-concussion symptoms and health-related quality of life in patients with mild traumatic brain injury. *Injury* **50**, 1068–1074. doi:10.1016/j.injury.2018.12.002

Wainer H, Kiely G (1987) Item clusters and computerized adaptive testing: A case for testlets. *Journal of Educational Measurement* **24**, 184–201.

Wäljas M, Iverson G, Lange R, Hakulinen U, Dastidar P, Huhtala H, Liimatainen S, Hartikainen K, Öhman J (2015) A Prospective Biopsychosocial Study of the Persistent Post-Concussion Symptoms following Mild Traumatic Brain Injury. *Journal of Neurotrauma* **32**, 534–547. doi:10.1089/neu.2014.3339

Wang K, Shi H, Geng F, Zou L, Tan S, Wang Y, Neumann D, Shum D, Chan R (2016) Cross-cultural validation of the Depression Anxiety Stress Scale-21 in China. *Psychological Assessment* **28**, e88–e100. doi:10.1037/pas0000207

Wong D, Dahm J, Ponsford J (2013) Factor structure of the depression anxiety stress scales in individuals with traumatic brain injury. *Brain Injury* **27**, 1377–1382. doi:10.3109/02699052.2013.823662

**Data availability.** Data are available on request.

**Conflicts of interest.** The authors have no disclosures, and no competing financial interests exist.

**Declaration of funding.** This research was supported by grants from the Health Research Council of NZ (ref 18/046 and 20/041).

**Ethics.** The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation, and with the Helsinki Declaration of 1975, as revised in 2008.

**Author affiliations**
[A]Department of Orthopaedic Surgery and Musculoskeletal Medicine, University of Otago, Christchurch, 2 Riccarton Avenue, Christchurch 8011, New Zealand.
[B]Te Herenga Waka - Victoria University of Wellington, PO Box 600, Wellington, New Zealand.
[C]Department of Psychology, Faculty of Health and Environmental Sciences, Auckland University of Technology, Auckland, New Zealand.