

Validation of the Tablet-based Brief Assessment of Cognition (BAC App) for Schizophrenia

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INTRODUCTION

Computerized tests benefit from automated scoring procedures and standardized administrator instructions. These methods can reduce the potential for rater error. However, especially in patients with severe mental illnesses and neurologic disorders, the equivalency of traditional and tablet-based tests cannot be assumed.

The Brief Assessment of Cognition in Schizophrenia (BACS) is a pen-and-paper cognitive assessment tool that has been used in hundreds of research studies and clinical trials, and has normative data available for generating age- and gender-corrected standardized scores. A tablet-based version of the BACS called the BAC App has been developed.

This study compared performance on the BACS and the BAC App in patients with schizophrenia and healthy controls. Test equivalency was assessed, and the applicability of paper-based normative data was evaluated.

METHODS

- Participants included 48 patients (23 female) with Schizophrenia and 50 healthy controls (25 female) recruited from three academic sites including University of California - San Diego, the University of Miami - Miller School of Medicine, and the University of South Carolina. Detailed demographic information is displayed in Table 1.
- All participants were screened for alcohol and substance abuse using modules J and K of the MINI International Neuropsychiatric Interview. Any subject meeting criteria for current alcohol or substance abuse was excluded.
- In order to ensure adequate sampling to support validation of the BAC across age and gender demographics, enrollment was stratified to ensure balanced representation of men and women in each of 6 age groups: 18-29, 30-39, 40-49, 50-59, 60-69, 70+.
- All subjects completed the BAC App and the paper BAC assessment at a single visit, with order of administration counterbalanced across subjects. For subtests with multiple forms (Verbal Memory, Tower of London, Symbol Coding), alternate versions were utilized during administration of the tablet and paper-based tests.

Table 1: Comparison of patients with Schizophrenia to healthy controls

Parameter	Healthy controls (n=50)	Patients with Schizophrenia (n=48)	p
Age	48.26 ± 14.52	46.04 ± 13.18	0.430
Education	15.12 ± 2.55	12.63 ± 1.65	<0.001
Maternal Education	13.43 ± 2.64	12.47 ± 3.51	0.145
Sex (% male)	50%	52%	0.843
Race (% white)	79%	74%	0.533

All table entries are mean ± SD or %. Continuous variables were compared by independent t-test and the categorical variable were compared by Fischer's exact test. All p-values are non-significant ($\alpha=0.05$) except for Education ($p<0.001$), and then remove the last 2 columns of the table.

RESULTS

In both groups, the distributions of standardized composite scores for the tablet-based BAC App and the pen-and-paper BACS were indistinguishable, and the between-methods mean differences were not statistically significant.

Table 2: Pearson correlations for BAC measures in paper and app forms in healthy controls

Paper BAC	BAC App					
	VM	DS	VF	SC	TM	TL
Verbal memory	0.78**	0.56**	0.52**	0.46**	0.11	0.58**
Digit sequencing	0.56**	0.80**	0.49**	0.33*	0.24	0.33*
Verbal fluency	0.47**	0.52**	0.93**	0.41**	0.25	0.46**
Symbol coding	0.49**	0.41**	0.57**	0.72**	0.48**	0.49**
Token motor task	0.21	0.29*	0.48**	0.48**	0.43**	0.36*
Tower of London	0.51**	0.36*	0.31*	0.26	0.01	0.61**

BAC measures: VM=Verbal memory; DS=Digit sequencing; VF=Verbal fluency; SC=Symbol coding; TM=Token motor task, TL=Tower of London, * $p<0.05$; ** $p<0.01$

Table 3: Pearson correlations for BAC measures in paper and app forms in Schizophrenia patients

Paper BAC	BAC App					
	VM	DS	VF	SC	TM	TL
Verbal memory	0.81**	0.39**	0.48**	0.55**	0.60**	0.41**
Digit sequencing	0.43**	0.83**	0.57**	0.43**	0.39**	0.46**
Verbal fluency	0.48**	0.66**	0.78**	0.42**	0.46**	0.48**
Symbol coding	0.36*	0.49**	0.37*	0.74**	0.68**	0.46**
Token motor task	0.28*	0.36**	0.29	0.47**	0.47**	0.32*
Tower of London	0.36*	0.37**	0.39**	0.37**	0.43**	0.74**

BAC measures: VM=Verbal memory; DS=Digit sequencing; VF=Verbal fluency; SC=Symbol coding; TM=Token motor task, TL=Tower of London, * $p<0.05$; ** $p<0.01$

RESULTS

Figure 1a: Histogram of BAC app and paper BAC composite scores in healthy controls

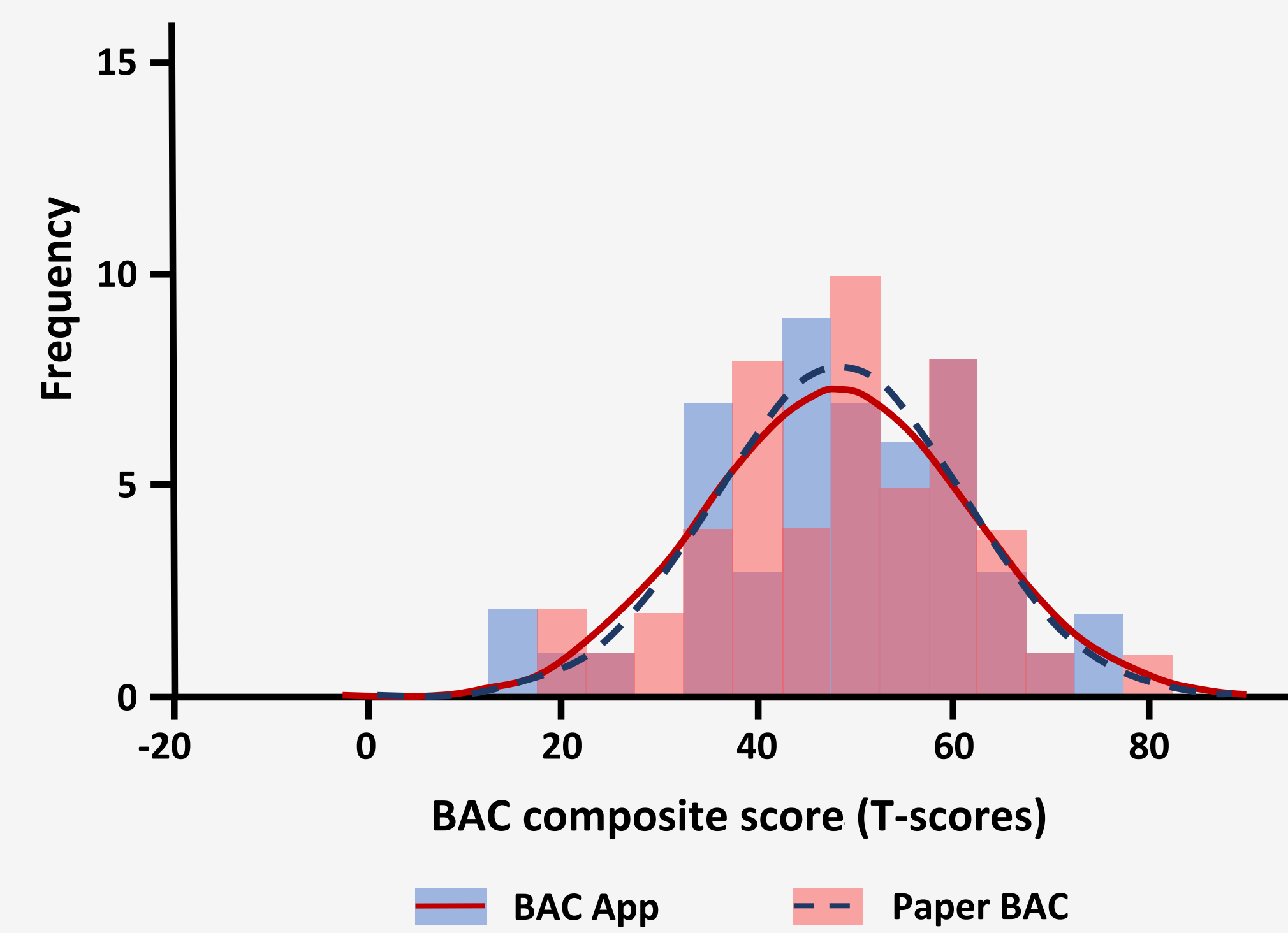


Figure 1b: Histogram of BAC app and paper BAC composite scores in patients

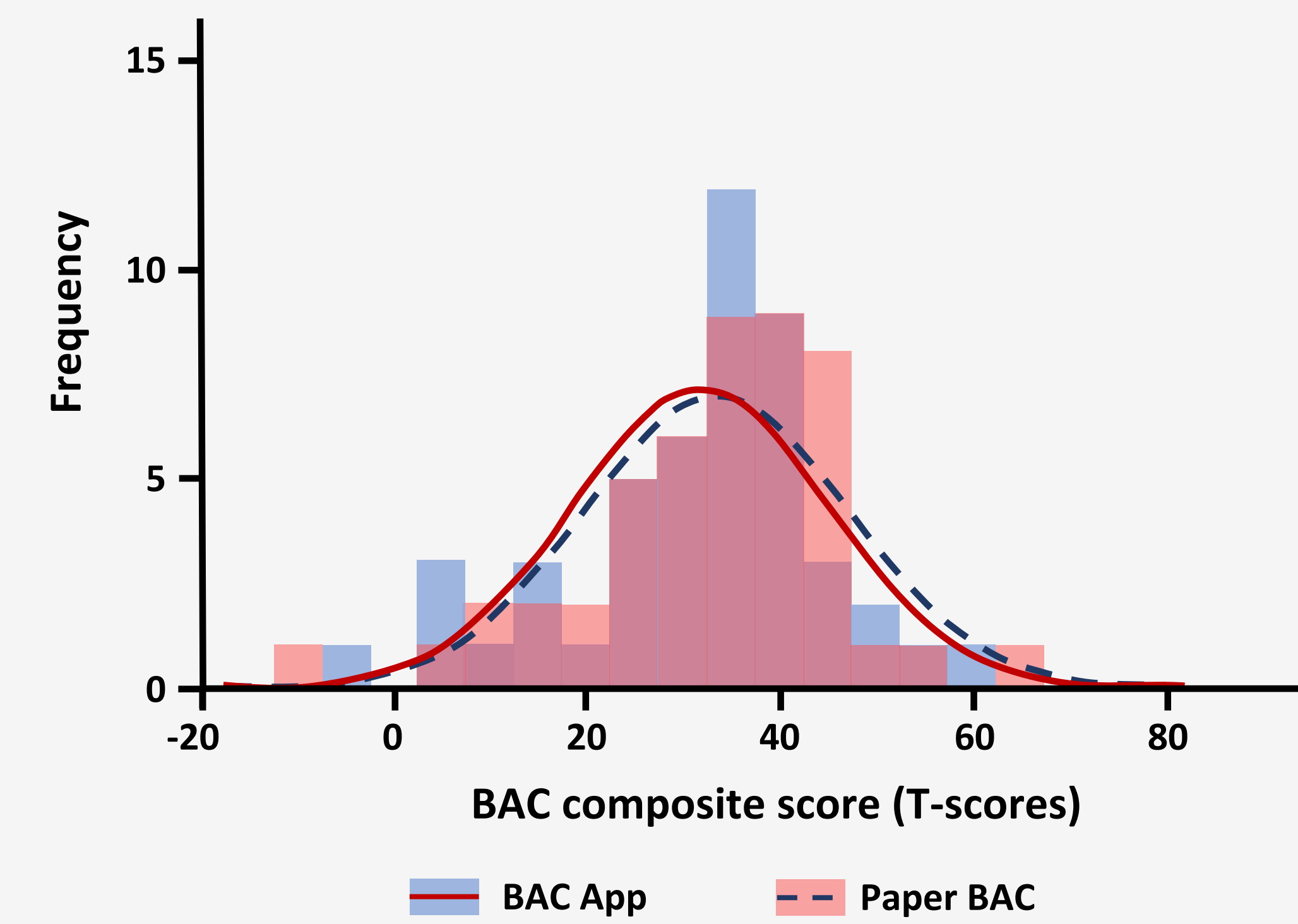


Figure 1c: Histogram of BAC app composite scores for patients and healthy controls

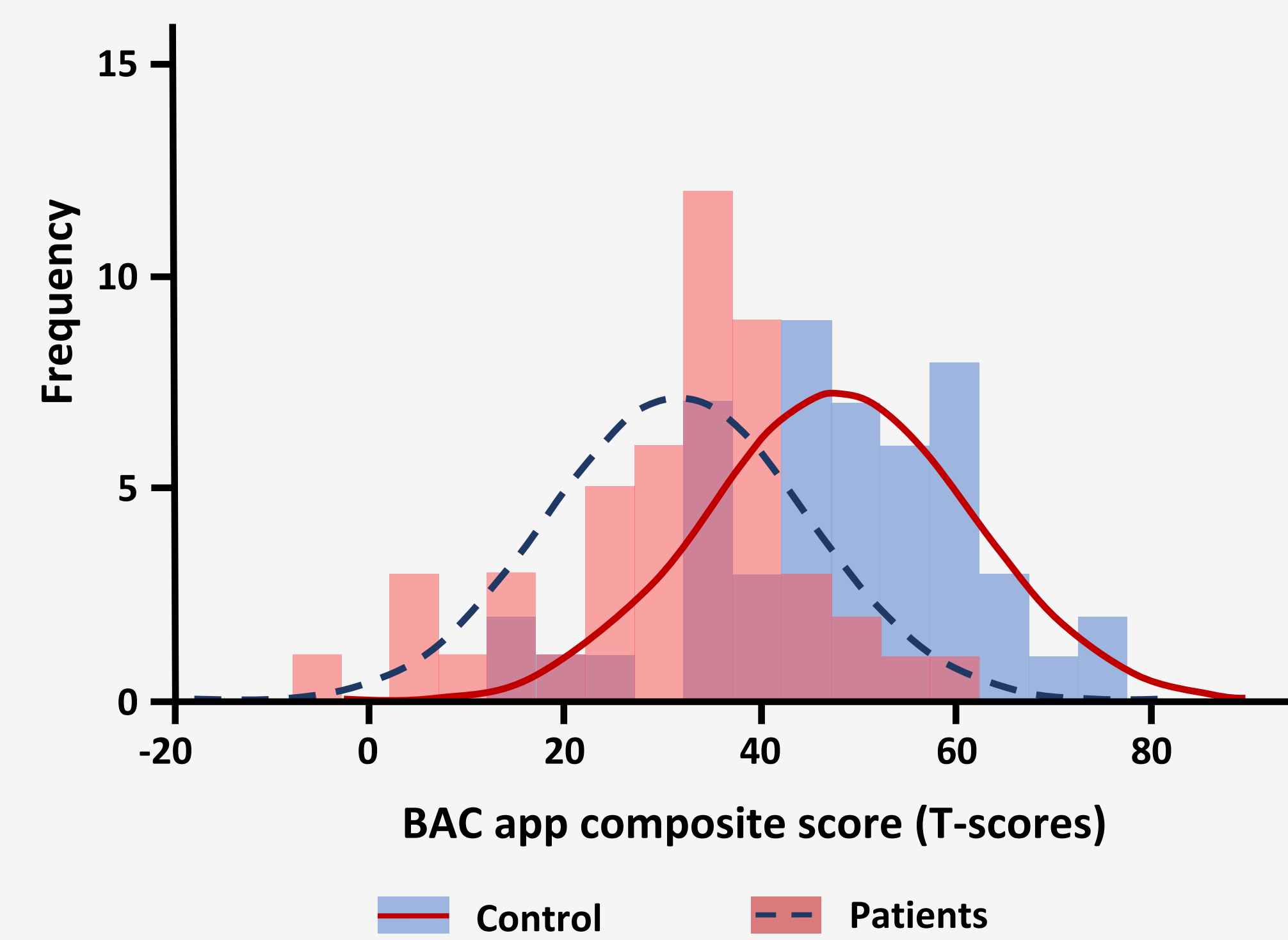


Figure 1d: Histogram of paper BAC composite scores for patients and healthy controls

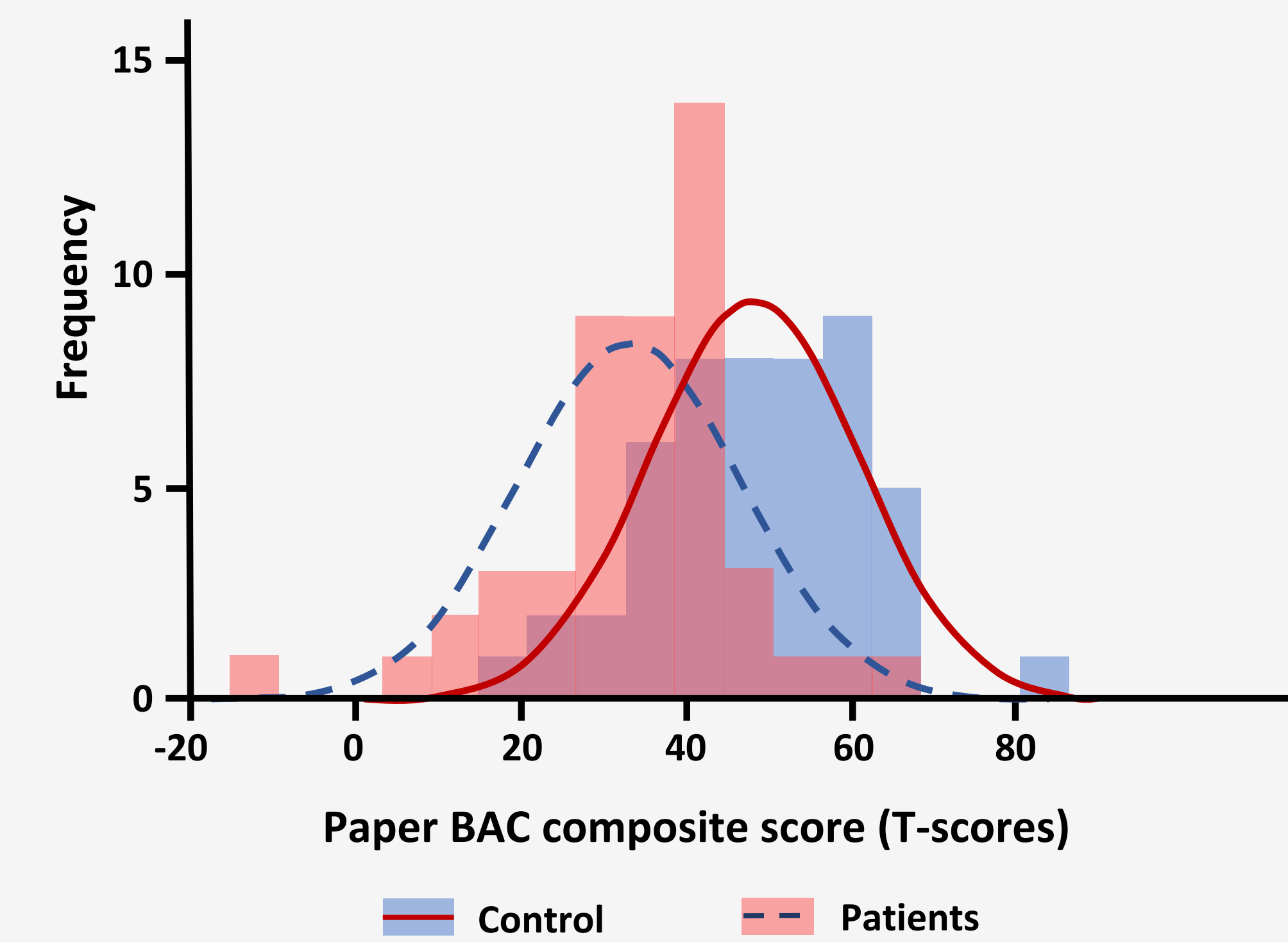
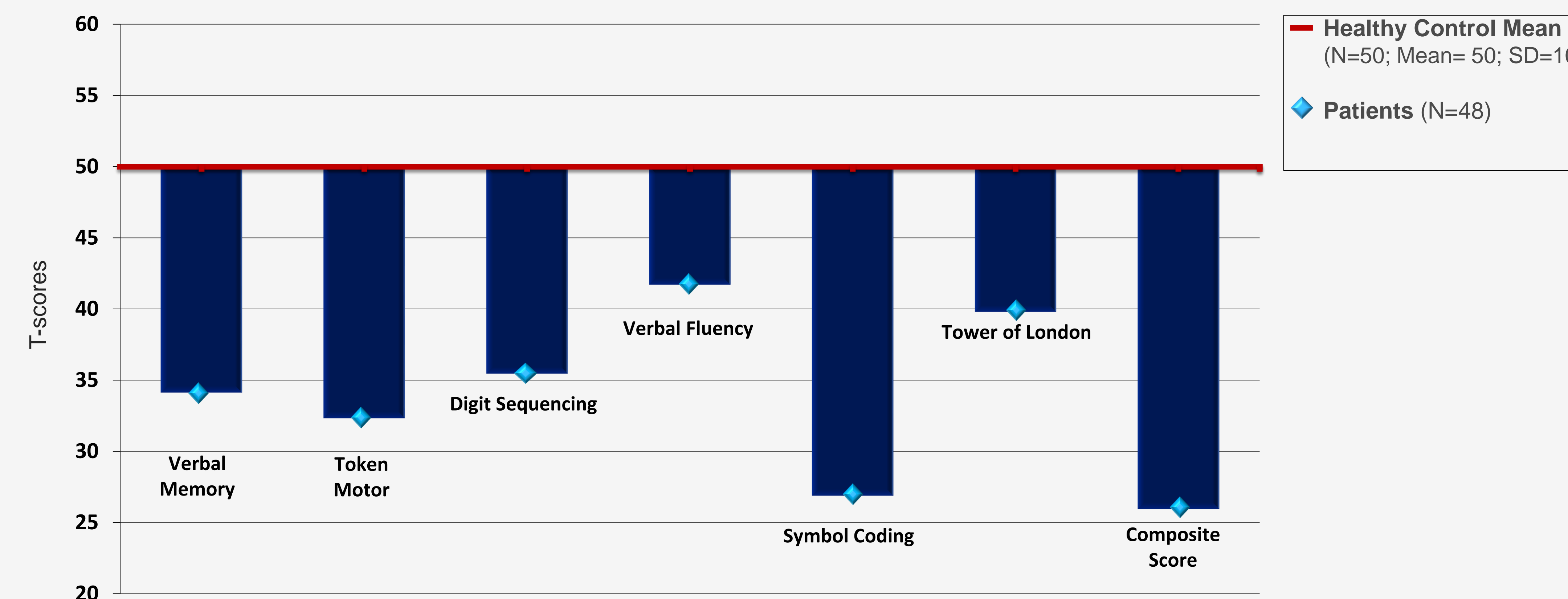


Figure 4: Performance of patients with Schizophrenia on the BAC App subtests and composite score standardized to healthy controls



- Discrimination between patients and controls was similarly robust with the BAC App ($d=1.34$) and the traditional BACS ($d=1.24$).
- The between-methods correlations for individual measures in patients were $r>0.70$ except Token Motor ($r=0.43$) and Tower of London ($r=0.61$). (Table3)
- Performance between the test methods was not significantly different on any tests except the Token Motor Test, which demonstrated increased variability during tablet-based administration, and the Symbol Coding task (Figures 2 and 3)
- A modified BAC App composite, removing the Token Motor Task and applying a +10-point correction to the BAC App Symbol Coding, improved the between-methods correlation of composite scores to $r=.88$ ($df=48$; $P<.001$) in healthy controls and $r=.89$ ($df=46$; $P<.001$) in patients, consistent with the test-retest reliability of each measure. (Figure 5).

Figure 2: Mean performance of BAC app and paper BAC in healthy controls

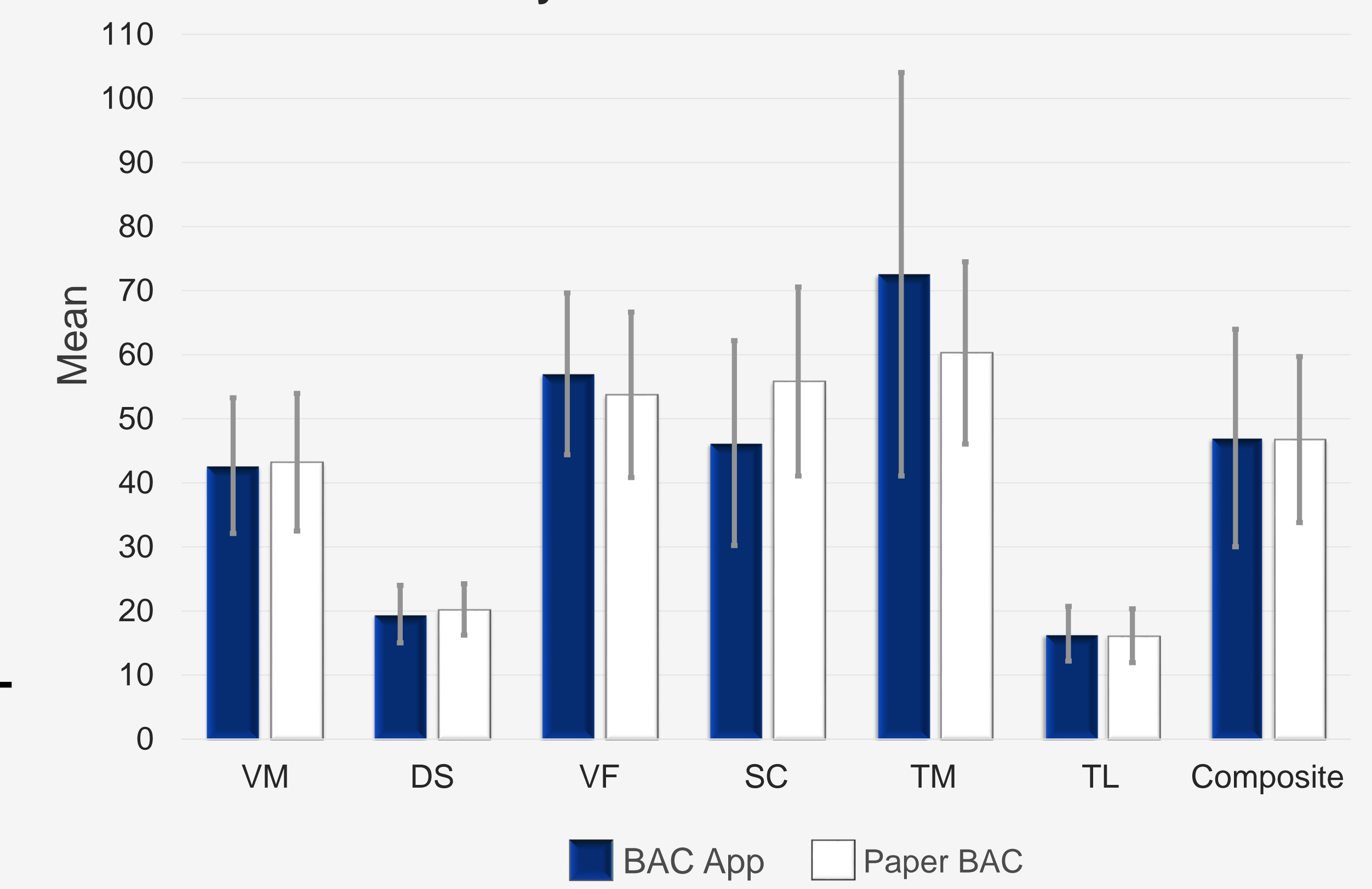


Figure 3: Mean performance of BAC app and paper BAC in patients with Schizophrenia

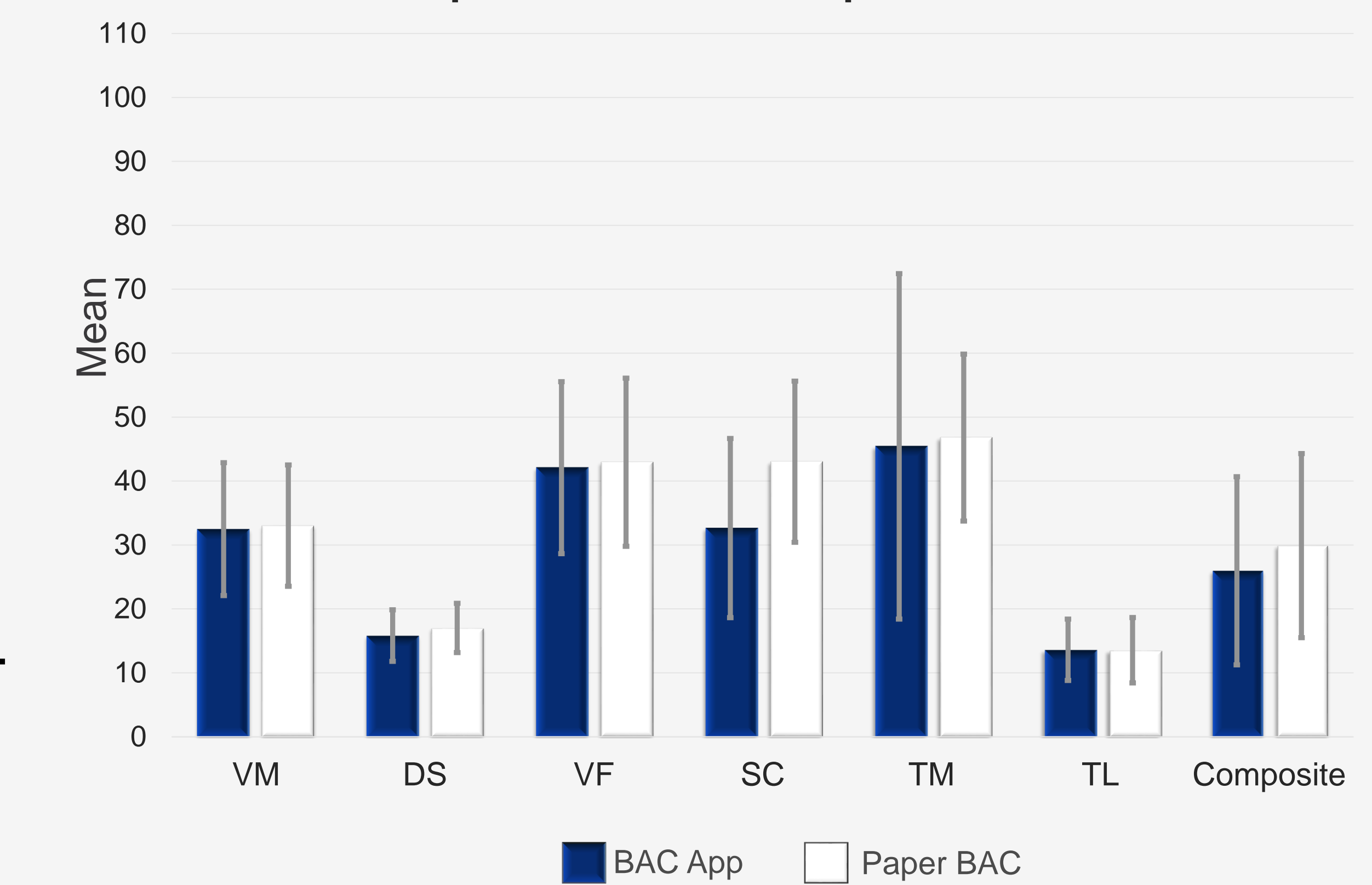
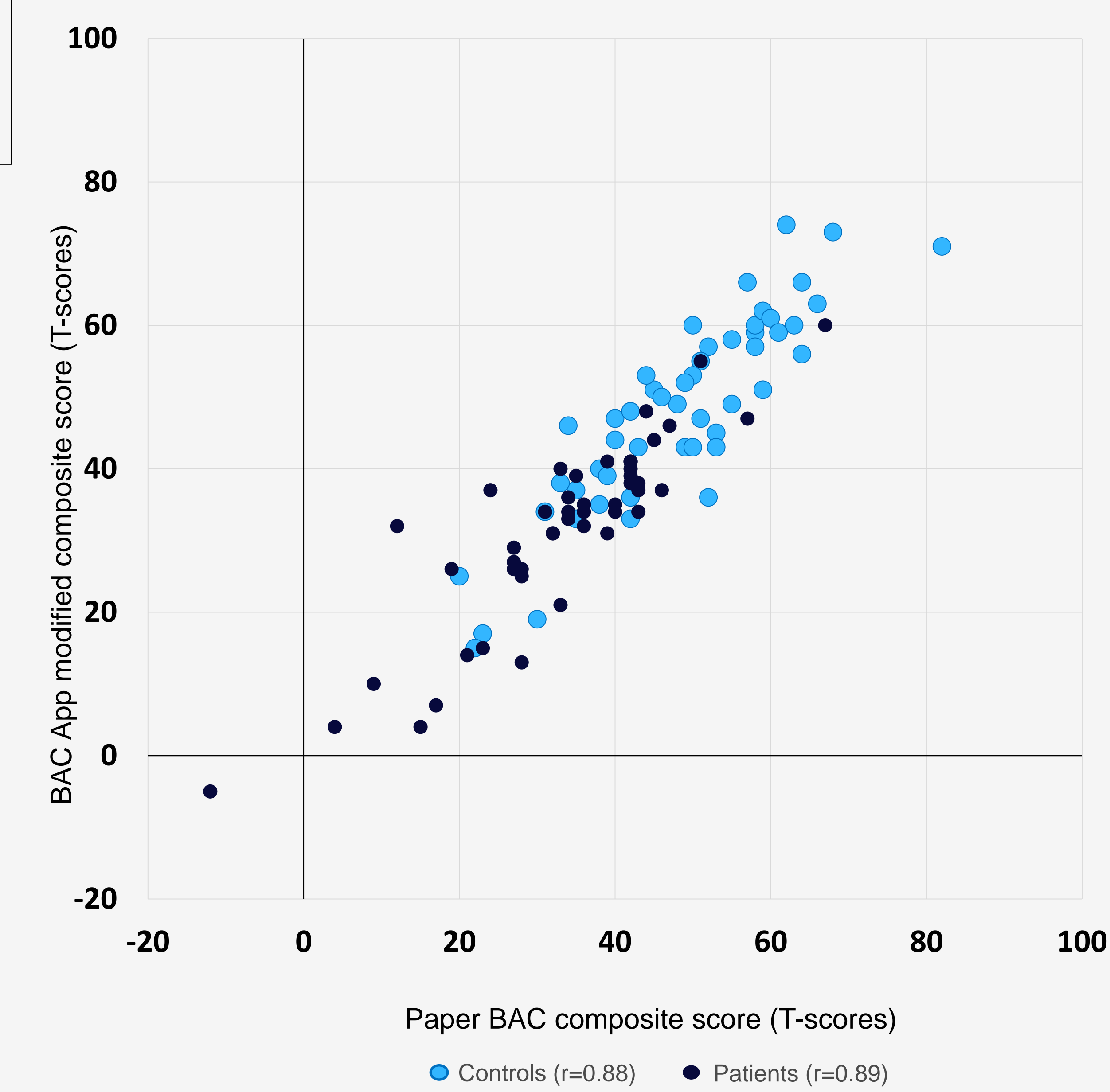


Figure 5: Scatterplot of BAC App and Paper BAC for patients and controls



CONCLUSIONS

The tablet-based BAC App generates results consistent with the traditional pen-and-paper BACS. These data support the notion that the BAC App can now be used in clinical trials and clinical practice.

DISCLOSURES

Dr. Richard Keefe currently or in the past 12 months has received investigator-initiated research funding support from the National Institute of Mental Health. He currently or in the past 12 months has received honoraria, served as a consultant or advisory board member for Abbvie, Akelia, Avanzir, Avinuro/ChemRx, Biogen, Boehringer-Ingelheim, CoMentis, FORUM, GW Pharmaceuticals, Janssen, Lundbeck, Merck, Minerva Neurosciences, Inc., Mitsubishi, Neuraltstem, Novartis, NY State Office of Mental Health, Otsuka, Pfizer, Reviva, Roche, Sanofi/Aventis, Sunovion, Takeda, University of Moscow, and the University of Texas South West Medical Center. Dr. Keefe receives royalties from the BACS testing battery, the MATRICS Battery (BACS Symbol Coding) and the Virtual Reality Functional Capacity Assessment Tool (VRFCAT). He is also a shareholder in NeuroCog Trials, Inc. and Sengenix. Alexandra S. Atkins, Vicki Davis, Tina Tseng, and Adam Vaughan are employees of NeuroCog Trials. Phillip Harvey receives royalties for the BACS and the BAC App.