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Original Article

Connecting the Dots: Normative Data of Trail Making Test in Medical and Nursing Students of Eastern India — A Cross-Sectional Study

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ABSTRACT

Background and Objectives: The Trail Making Test (TMT) is a widely-used neuropsychological instrument assessing psychomotor speed, attention, and executive function. Normative data for educated young adults in Eastern India are absent from the literature. This study aimed to establish percentile-referenced normative values for TMT-A, TMT-B, and the B–A difference score in MBBS and nursing students, and to examine the influence of age, sex, education, occupation, and religion on performance.

Methods: A cross-sectional observational study was conducted at Calcutta National Medical College and Hospital (CNMC), Kolkata. One hundred and fifty healthy participants (85 males, 65 females; mean age 19.64 ± 1.70 years; mean education 15.36 ± 1.90 years), including MBBS first-year students (n = 130) and Nursing students (n = 18), were recruited. Screening included the Clinical Global Impression–Severity Scale (CGI-S). TMT-A and TMT-B were administered per Spreen and Strauss (1998) standardised guidelines. Descriptive statistics, Shapiro-Wilk normality tests, independent-samples t-tests, Mann–Whitney U tests, Pearson and Spearman correlations, and multiple linear regression were computed using SPSS v16.0. Cohen's d was calculated as a measure of effect size.

Results: Mean TMT-A was 35.22 ± 12.32 s (median 33.0 s; range 12–73 s); mean TMT-B was 81.07 ± 26.77 s (median 76.0 s; range 34–197 s); mean B–A was 45.93 ± 29.59 s. All three distributions were significantly right-skewed and non-normal (Shapiro-Wilk, all $p < 0.001$). No significant differences were found for sex (TMT-A: $p = 0.529$, $d = 0.10$; TMT-B: $p = 0.952$, $d = -0.01$), religion (all $p > 0.50$, all $d < 0.15$), or occupation group — MBBS versus nursing students (TMT-A: $p = 0.487$; TMT-B: $p = 0.509$). Pearson correlation identified significant associations of age and education with TMT-B ($r = 0.260$ and 0.278, both $p = 0.001$); however, these were attenuated and non-significant under Spearman analysis ($\rho = 0.140$, $p = 0.088$ and $\rho = 0.193$, $p = 0.018$ respectively) and disappeared entirely upon sensitivity analysis excluding two older outliers (age > 25 years, $n = 148$; $r = 0.094$, $p = 0.256$). Multiple regression of age and education on TMT-B yielded $R^2 = 0.082$, with neither predictor independently significant.

Conclusion: This study provides the first systematically derived, percentile-referenced normative data for the TMT in educated young adults of Eastern India. Sex, religion, and occupation had no meaningful influence on performance (all effect sizes negligible). Apparent correlations of age and education with TMT-B were fragile and driven by outlier participants; TMT performance in this narrow-age student cohort is essentially uniform across demographic subgroups. A single, non-stratified normative table is appropriate for clinical use in this population.

Keywords: Trail Making Test; normative data; Eastern India; executive function; psychomotor speed; neuropsychological assessment; medical students; nursing students.

INTRODUCTION

The Trail Making Test (TMT), originally developed as part of the United States Army Individual Test Battery (1944),[1] was subsequently incorporated into the Halstead–Reitan Neuropsychological Battery[2, 3] and remains one of the most frequently administered neuropsychological instruments worldwide. It comprises two parts: TMT-A, requiring the participant to connect 25 numbered circles in ascending sequence; and TMT-B, requiring alternation between numbers and letters (1–A–2–B–3–C…). Completion time in seconds is the primary score; errors are corrected in situ without stopping the stopwatch.[4]

TMT-A primarily measures psychomotor speed and visual attention. TMT-B additionally engages prefrontal executive systems; cognitive flexibility, working memory, and set-shifting.[5 6] The B–A difference score, which partially controls for basic processing speed, is a widely used index of executive set-shifting and is sensitive to traumatic brain injury, [7] mild cognitive impairment,[8] schizophrenia,[9] Parkinson's disease,[10] and mood disorders.[11]

TMT performance is significantly influenced by age and education in broad population samples.[12 13] Sex differences have been inconsistently reported but are typically absent in well-powered studies of healthy adults.[14 15] Despite the test's global prominence, normative data from Indian populations remain sparse and regionally skewed. Most published norms originate from North American or European cohorts[16 17] whose direct applicability to Indian patients is questionable given differences in educational systems, linguistic backgrounds, and cultural familiarity with standardised testing.

Within India, the NIMHANS Neuropsychology Battery (2004)[18] does not provide TMT norms stratified for educated young adults in Eastern India. Available Indian normative studies are predominantly from Northern or Southern India.[19 20] Eastern India, comprising West Bengal, Odisha, Jharkhand, and the North-East, represents a distinct sociolinguistic and educational milieu. Furthermore, no study has specifically examined and compared TMT performance across healthcare student subgroups (medical versus nursing students) in this region, despite differences in curriculum structure and cognitive demands.

This study was therefore conducted at CNMC, Kolkata, to: (i) establish normative values (means, standard deviations, and percentiles) for TMT-A, TMT-B, and B–A; (ii) examine the influence of age, sex, education, occupation, and religion on performance with appropriate non-parametric tests and effect-size estimation; (iii) generate B–A reference values as an index of executive set-shifting; and (iv) perform a sensitivity analysis to evaluate the robustness of any observed demographic effects.

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional observational study was conducted in the Department of Psychiatry, Calcutta National Medical College and Hospital (CNMC), Kolkata, West Bengal, India. Data collection was carried out over one month following Institutional Ethics Committee (IEC) approval. The study conformed to the principles of the Declaration of Helsinki and the ICMR National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017).

Participants and Sampling

The target population comprised MBBS first-year students and Nursing students attending CNMC. Purposive sampling was employed, targeting 300 participants; after applying inclusion and exclusion criteria and excluding incomplete records, 150 participants with valid, complete data were retained for analysis. This sample size was sufficient to compute stable percentile norms and to detect moderate bivariate correlations ($r \geq 0.20$) with greater than 80% power ($\alpha = 0.05$, two-tailed).

Inclusion and Exclusion Criteria

Inclusion Criteria

(i) Age ≥ 18 years at the time of enrollment.
(ii) Currently enrolled as an MBBS first-year or BSc Nursing (third-year) student at CNMC.
(iii) Provision of written informed consent before participation.

Exclusion Criteria

(i) CGI-S score > 1, indicating any degree of current psychiatric illness.
(ii) Known neurological illness (epilepsy, stroke, Parkinson's disease, or dementia).
(iii) Upper limb deformity, pain, or dysfunction interfering with fine motor task completion.
(iv) Current use of psychotropic medications.

(v) Failure to complete either TMT part within the maximum allowed time of 300 seconds (5 minutes).

Assessment Tools
(a) Sociodemographic proforma: recorded age, sex, religion, marital status, occupation, and years of completed formal education.
(b) Clinical Global Impression–Severity Scale (CGI-S).[21] A validated 7-point clinician-rated global severity measure (1 = normal, not at all ill; 7 = among the most extremely ill patients). Only participants scoring 1 were enrolled, ensuring a psychiatrically healthy sample.
(c) Trail Making Test (TMT-A and TMT-B):[22] Administered in a quiet, well-lit, standardised environment per Spreen and Strauss (1998) guidelines. Practice trials preceded the formal test (TMT-A: 8 targets; TMT-B: 4 numbers and 4 letters). Errors were corrected by redirecting the participant to the last correctly connected point without pausing the stopwatch. Time in seconds was recorded using a calibrated digital stopwatch. The maximum time allowed per part was 300 seconds.

Statistical Analysis
Data were entered and analysed using IBM SPSS Statistics for Windows, Version 20.0. Descriptive statistics (mean, standard deviation, median, range, skewness, and kurtosis) were computed for all continuous variables. Shapiro-Wilk tests were used to assess normality of TMT-A, TMT-B, and B–A distributions. Percentile norms (P5, P25, P50, P75, P95) were derived for TMT-A, TMT-B, and B–A.

Group comparisons for sex, occupation (MBBS vs Nursing), and religion were performed using independent-samples t-tests, complemented by Mann–Whitney U tests given the non-normal distributions. Effect size was quantified using Cohen's d ($|d| < 0.2$ = negligible; 0.2–0.5 = small; 0.5–0.8 = medium; > 0.8 = large). Both Pearson (r) and Spearman rank (ρ) correlation coefficients were computed to assess relationships between continuous demographic predictors (age, education) and TMT scores. A simultaneous multiple linear regression, with age and years of education as predictors and TMT-B as the dependent variable, was performed to assess the independent contributions. A pre-planned sensitivity analysis was conducted by repeating all correlation analyses after excluding two participants with age > 25 years (who were clear demographic outliers in this student cohort), to evaluate the robustness of any significant correlations. The significance level was set at $p < 0.05$, two-tailed

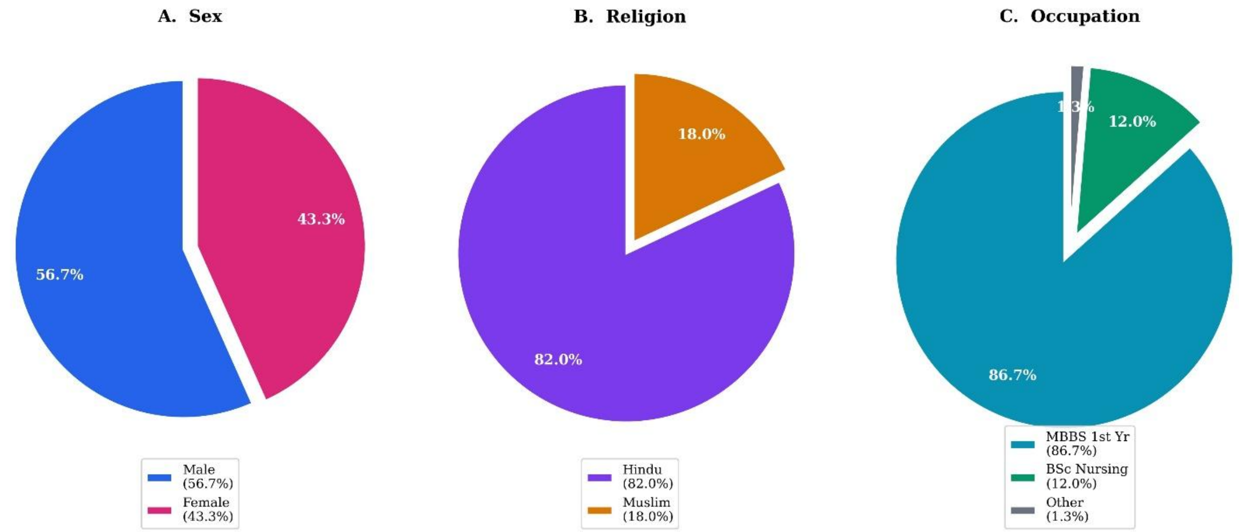
RESULTS
Sociodemographic Characteristics
One hundred and fifty participants (85 males [56.7%]; 65 females [43.3%]) were enrolled. Mean age was 19.64 ± 1.70 years (range 17–31 years; 97.3% aged 18–25 years). Mean years of education was 15.36 ± 1.90 (range 12–26 years). The majority of participants were MBBS first-year students (n = 130, 86.7%), with 18 BSc Nursing third-year students (12.0%) and 2 older postgraduate-level students (1.3%). Most were Hindu (n = 123, 82.0%) and unmarried (n = 149, 99.3%). Full sociodemographic details are provided in Table 1.

Table 1. Sociodemographic profile of the study sample (N = 150).

Variable	**Category**	**n (%)**
Age (years)	Mean ± SD	19.64 ± 1.70
	Range	17–31
Sex	Male	85 (56.7)
	Female	65 (43.3)
Religion	Hindu	123 (82.0)
	Muslim	27 (18.0)
Marital Status	Unmarried	149 (99.3)
	Married	1 (0.7)
Occupation	MBBS (1st Year)	130 (86.7)
	BSc Nursing (3rd Year)	18 (12.0)
	Other (postgraduate)	2 (1.3)
Education (years)	Mean ± SD	15.36 ± 1.90
	Range	12–26

Values are frequency (%) unless otherwise specified. Occupation: 2 'Other' participants were older postgraduate-level students (ages 27 and 31).

Figure 1. Sociodemographic Profile of the Study Sample (N = 150)



Normative Values — TMT-A, TMT-B, and B–A Difference Score

All three distributions were significantly non-normal on Shapiro-Wilk testing (TMT-A: W = 0.938, $p < 0.001$; TMT-B: W = 0.939, $p < 0.001$; B–A: W = 0.957, $p < 0.001$), with positive skewness (TMT-A: 0.948; TMT-B: 1.093; B–A: 0.862), consistent with the right-skewed distributions characteristically observed in timed neuropsychological tasks. The TMT-B/TMT-A ratio had a mean of 2.60 (SD 1.42; median 2.35), indicating that TMT-B required approximately 2.6 times longer to complete than TMT-A.

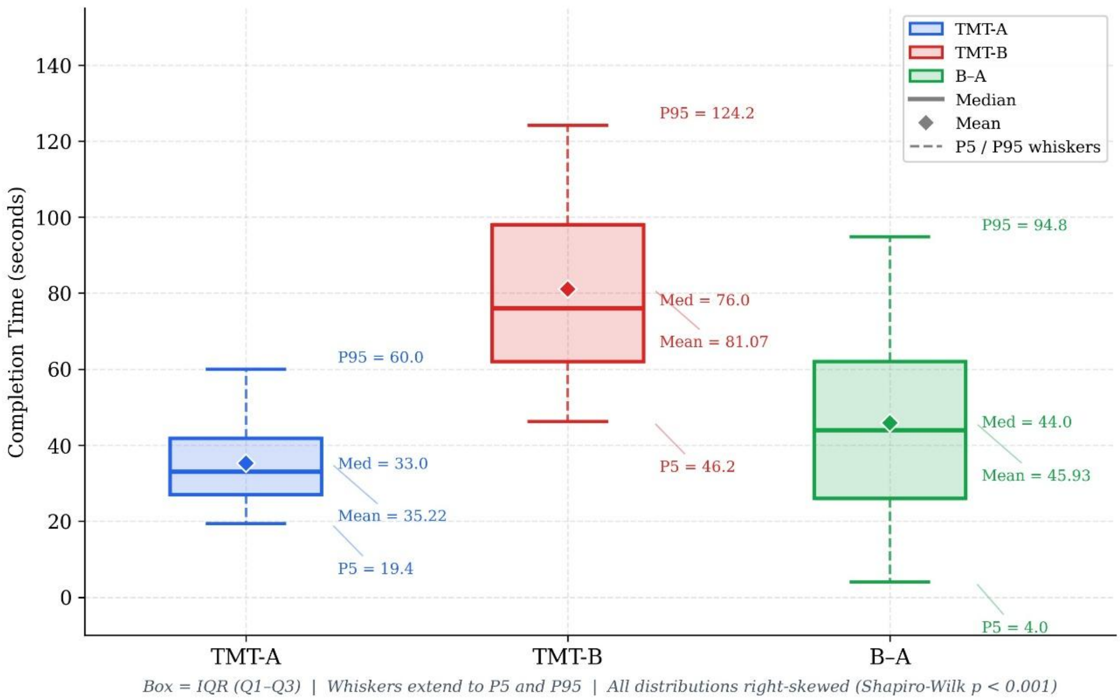
Mean TMT-A was 35.22 ± 12.32 s (median 33.0 s; range 12–73 s). Mean TMT-B was 81.07 ± 26.77 s (median 76.0 s; range 34–197 s). Mean B–A difference score was 45.93 ± 29.59 s (median 44.0 s; range −10 to 157 s); five participants had negative B–A values (TMT-B faster than TMT-A), all of whom had unusually prolonged TMT-A times (50–73 s), suggesting practice-effect or anxiety-related variability on Part A. Full descriptive statistics and percentile distributions for TMT-A, TMT-B, and B–A are shown in Table 2.

Table 2. Descriptive statistics, distributional characteristics, and percentile norms for Trail Making Test Part A (TMT-A), Part B (TMT-B), and B–A difference score.

Statistic	**TMT-A (s)**	**TMT-B (s)**	**B–A (s)**
N valid	150	149	149
Mean ± SD	35.22 ± 12.32	81.07 ± 26.77	45.93 ± 29.59
Median	33.0	76.0	44.0
Range (Min–Max)	12–73	34–197	−10 to 157
Skewness	0.948	1.093	0.862
Kurtosis (excess)	0.716	2.273	1.662
Shapiro-Wilk W (p)	0.938 (<0.001)	0.939 (<0.001)	0.957 (<0.001)
5th percentile	19.4	46.2	4.0
25th percentile (Q1)	27.0	62.0	26.0
50th percentile (Median)	**33.0**	**76.0**	**44.0**
75th percentile (Q3)	41.8	98.0	62.0
95th percentile	60.0	124.2	94.8

s = seconds. B–A = TMT-B minus TMT-A. Five participants had negative B–A values (TMT-B faster than TMT-A), all attributable to unusually slow TMT-A performance. Shapiro-Wilk W confirms significant non-normality for all three variables.

Figure 3. Percentile Distribution of TMT-A, TMT-B, and B–A Scores



Effect of Sex

No statistically significant sex differences were found on TMT-A (males: 35.78 ± 13.47 s; females: 34.49 ± 10.68 s; t = 0.632, p = 0.529), TMT-B (males: 80.95 ± 25.47 s; females: 81.22 ± 28.62 s; t = −0.060, p = 0.952), or B–A (males: 45.18 ± 28.50 s; females: 46.94 ± 31.19 s; t = −0.359, p = 0.720). Cohen's d values were negligible for all three comparisons (TMT-A: d = 0.10; TMT-B: d = −0.01; B–A: d = −0.06). Mann–Whitney U tests confirmed these null findings (all p > 0.88). These results support the use of a single, non-sex-stratified normative reference table. Details are presented in Table 3.

Table 3. Comparison of Trail Making Test scores by sex.

Variable	Male (n=85) Mean ± SD	Female (n=65) Mean ± SD	t	p	Cohen's d
TMT-A (s)	35.78 ± 13.47	34.49 ± 10.68	0.632	0.529	0.10
TMT-B (s)	80.95 ± 25.47	81.22 ± 28.62	−0.060	0.952	−0.01
B–A (s)	45.18 ± 28.50	46.94 ± 31.19	−0.359	0.720	−0.06

s = seconds. Independent-samples t-test; all Mann–Whitney U tests confirmed null results (all p > 0.87). Cohen's d: |d| < 0.20 = negligible effect.

Effect of Occupation Group (MBBS vs Nursing)

No significant differences in TMT-A or TMT-B performance were found between MBBS first-year students (TMT-A: 34.88 ± 12.95 s, n = 130; TMT-B: 80.81 ± 25.96 s, n = 129) and Nursing students (TMT-A: 37.06 ± 6.49 s, n = 18; TMT-B: 76.61 ± 18.84 s, n = 18) (TMT-A: t = −0.698, p = 0.487, d = −0.18; TMT-B: t = 0.662, p = 0.509, d = 0.17). Mann–Whitney U tests corroborated the null results (TMT-A: p = 0.087; TMT-B: p = 0.707). This finding supports the applicability of a unified normative table across both medical and nursing student populations. Results are presented in Table 4.

Table 4. Comparison of Trail Making Test scores by occupation group (MBBS 1st Year vs Nursing 3rd Year).

Variable	MBBS 1st Year (n=130) Mean ± SD	Nursing (n=18) Mean ± SD	t	p	Cohen's d
TMT-A (s)	34.88 ± 12.95	37.06 ± 6.49	−0.698	0.487	−0.18
TMT-B (s)	80.81 ± 25.96	76.61 ± 18.84	0.662	0.509	0.17

s = seconds. Two 'Other' (postgraduate-level) participants were excluded from this comparison. Independent-samples t-test; Mann–Whitney U: TMT-A p = 0.087, TMT-B p = 0.707. Cohen's d: |d| < 0.20 = negligible effect.

Correlations with Age and Education

Both Pearson and Spearman correlation coefficients are presented in Table 5. Pearson correlation indicated significant associations of age ($r = 0.260$, $p = 0.001$) and years of education ($r = 0.278$, $p = 0.001$) with TMT-B, but not TMT-A (age: $r = 0.088$, $p = 0.284$; education: $r = 0.001$, $p = 0.992$). However, Spearman rank correlation — the appropriate non-parametric method given the confirmed non-normality — attenuated the age–TMT-B association to non-significance ($\rho = 0.140$, $p = 0.088$) while retaining a weaker but significant education–TMT-B correlation ($\rho = 0.193$, $p = 0.018$). Pearson correlation of age and education with the B–A score was significant ($r = 0.198$, $p = 0.015$ and $r = 0.251$, $p = 0.002$, respectively), but Spearman ρ was non-significant for age ($\rho = 0.088$, $p = 0.288$) and marginal for education ($\rho = 0.183$, $p = 0.025$).

Critically, age and education were highly collinear in this sample (Pearson $r = 0.792$, $p < 0.001$), and in a simultaneous multiple regression model, neither predictor independently and significantly predicted TMT-B (age: $\beta = 1.658$, $t = 0.815$, $p = 0.416$; education: $\beta = 2.735$, $t = 1.498$, $p = 0.136$; overall $R^2 = 0.082$, adjusted $R^2 = 0.069$), confirming that the univariate correlations cannot be interpreted as independent effects.

A pre-planned sensitivity analysis excluding the two oldest participants (aged > 25 years, n = 148) demonstrated that the Pearson age–TMT-B correlation dropped from $r = 0.260$ ($p = 0.001$) to $r = 0.094$ ($p = 0.256$), and the education–TMT-B correlation from $r = 0.278$ ($p = 0.001$) to $r = 0.148$ ($p = 0.074$), both becoming non-significant. This confirms that the observed Pearson correlations were driven by two demographically atypical participants and are not robust features of the student cohort. TMT-A and TMT-B remained uncorrelated under all analyses (Pearson $r = −0.011$, $p = 0.895$; Spearman $\rho = 0.025$, $p = 0.765$), confirming their construct distinctiveness.

Table 5. Pearson (r) and Spearman rank (ρ) correlation coefficients of Trail Making Test scores with age and years of education (N = 149).

Variable	TMT-A			TMT-B		B–A
	r	p	*r*	P	*r*	p
Age (years) — Pearson	0.088	0.284	0.260	0.001**	0.198	0.015*
Age (years) — Spearman ρ	0.122	0.137	0.140	0.088	0.088	0.288
Education (years) — Pearson	0.001	0.992	0.278	0.001**	0.251	0.002**
Education (years) — Spearman ρ	−0.013	0.880	0.193	0.018*	0.183	0.025*
TMT-A (s) — Pearson	—	—	−0.011	0.895	−0.426	<0.001**

** $p < 0.05$; ** $p < 0.01$ (two-tailed). Age and education were highly collinear (Pearson $r = 0.792$, $p < 0.001$). Sensitivity analysis excluding two participants aged > 25 years (n = 148): age vs TMT-B Pearson $r = 0.094$ ($p = 0.256$), education vs TMT-B Pearson $r = 0.148$ ($p = 0.074$) — both non-significant. Multiple regression (TMT-B ~ Age + Education): $R^2 = 0.082$, adjusted $R^2 = 0.069$; age $\beta = 1.658$ ($p = 0.416$); education $\beta = 2.735$ ($p = 0.136$).*

Effect of Religion

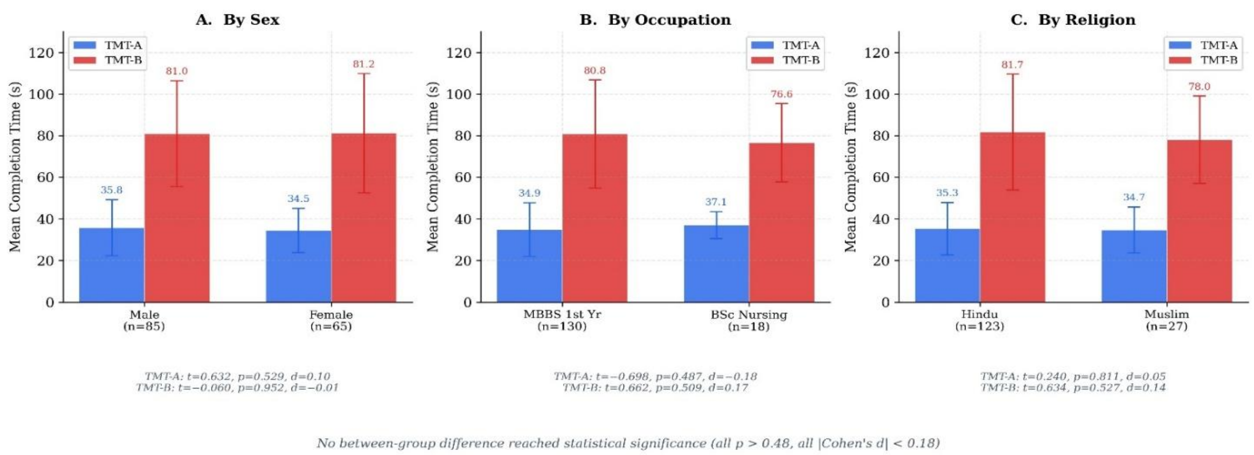
No significant differences were found between Hindu (n = 123) and Muslim (n = 27) participants on any TMT measure: TMT-A (35.33 ± 12.61 vs 34.70 ± 11.07 s; $t = 0.240$, $p = 0.811$, $d = 0.05$); TMT-B (81.71 ± 27.87 vs 78.04 ± 20.99 s; $t = 0.634$, $p = 0.527$, $d = 0.14$); B–A (46.37 ± 30.94 vs 43.85 ± 22.54 s; $t = 0.395$, $p = 0.694$, $d = 0.09$). Mann–Whitney U tests confirmed these null results (all $p > 0.82$). Results are shown in Table 6.

Table 6. Comparison of Trail Making Test scores by religion.

Variable	Hindu (n=123) Mean ± SD	Muslim (n=27) Mean ± SD	t	p	Cohen's d
TMT-A (s)	35.33 ± 12.61	34.70 ± 11.07	0.240	0.811	0.05
TMT-B (s)	81.71 ± 27.87	78.04 ± 20.99	0.634	0.527	0.14
B–A (s)	46.37 ± 30.94	43.85 ± 22.54	0.395	0.694	0.09

s = seconds. Independent-samples t-test; all Mann–Whitney U tests confirmed null results (all $p > 0.82$). Cohen's d: $|d| < 0.20$ = negligible effect. Muslim TMT-B n = 26 (one missing value).

Figure 2. TMT-A and TMT-B Scores Across Demographic Groups (Mean ± SD)



DISCUSSION

This study provides the first systematically derived, percentile-referenced normative data for TMT-A, TMT-B, and the B–A difference score in an educated young adult population of Eastern India, addressing a meaningful gap in the regional neuropsychological literature. The findings are interpretable at multiple levels: normative benchmarks, demographic predictors, and methodological lessons regarding the choice of statistical approach.

The observed normative values , TMT-A mean 35.22 ± 12.32 s, TMT-B mean 81.07 ± 26.77 s, and B–A mean 45.93 ± 29.59 s are moderately higher than Western benchmarks for comparable age and education strata. Tombaugh (2004),[24] in a large Canadian normative dataset, reported TMT-A means of 23–32 s and TMT-B mean of 54–87 s for adults aged 20–29 with more than 12 years of education. The modest elevation observed in the present sample is consistent with prior Indian normative studies and likely reflects cultural unfamiliarity with timed psychometric assessments in formal clinical settings, possible test anxiety among student participants, and differences in pencil-based task formats rather than genuine cognitive inferiority. Jain et al. (2020)[25] reported mean TMT-A of 38–42 s and TMT-B of 90–105 s in a Northern Indian young adult sample,somewhat higher than our findings, possibly reflecting regional educational system differences. The NIMHANS Battery[18] lacks TMT norms for this specific demographic. Among Southern Indian studies,[19] mean TMT-B times of approximately 80–100 s in educated young adults encompass our mean of 81.07 s, suggesting reasonable consistency across urban India after controlling for age and education.

The TMT-B/TMT-A ratio of 2.60 (median 2.35) is within the range of 2.0–3.0 reported in international healthy adult samples,[26, 23] providing a convenient metric for quantifying the additional cognitive burden imposed by the set-shifting demands of Part B over basic visuomotor scanning. The B–A difference score (mean 45.93 s; median 44 s) aligns with Corrigan and Hinkeldey (1987)[30] and Tombaugh (2004)[24] for healthy young adults (approximately 30–50 s), validating its use as a culture-partially-corrected executive index. Five participants exhibited a negative B–A score, all characterised by unusually slow TMT-A times (50–73 s, representing the highest decile of Part A completion times in this sample). This pattern is consistent with Part A-specific anxiety or motor hesitation, producing an artefactually elevated denominator for the ratio calculation. Clinically, a negative B–A score in a young healthy adult should prompt re-administration to confirm the result.

The absence of significant sex differences (all d < 0.10, all p > 0.50) is consistent with the robust majority of the international normative literature.[14 15 27] Drane et al. (2002)[15] and Periáñez et al. (2007)[27] both found no meaningful male–female differences in healthy controls after demographic adjustment. In the present sample, Cohen's d for sex differences ranged from −0.01 to 0.10 ,values that are clinically negligible and far below the threshold of 0.20 typically considered a small effect. A single non-sex-stratified normative table is therefore appropriate and practical for this population.

The occupation comparison of MBBS versus Nursing students is a novel analysis not reported in prior Indian TMT normative studies, and its null result (all p > 0.48; all |d| < 0.18) is clinically meaningful. Despite differences in curriculum, academic year, and occupational trajectory, MBBS first-year and Nursing students demonstrated psychomotor speed and executive function that were effectively equivalent, as measured by the TMT. This supports the use of a unified normative reference across healthcare student subgroups in Eastern India.

The analysis of demographic correlates revealed an important methodological lesson. Pearson correlations suggested significant associations of age and education with TMT-B (r = 0.260 and 0.278, both p = 0.001). However, three converging lines of evidence challenge the robustness and clinical significance of these associations. First, the distributions were confirmed as significantly non-normal (Shapiro-Wilk, all p < 0.001), making the Spearman rank correlation the more appropriate measure; Spearman ρ for age versus TMT-B was 0.140 ($p = 0.088$), which is non-significant. Second, in a simultaneous multiple regression including both predictors, neither age nor education was an independently significant predictor of TMT-B (both $p > 0.13$), with the combined model explaining only 8.2% of variance — a magnitude that is statistically marginal and clinically negligible. Third, a sensitivity analysis excluding the two oldest participants (aged 27 and 31, who were postgraduate-level 'STUDENT' entries and clear demographic outliers in this student cohort) reduced the Pearson age–TMT-B correlation from $r = 0.260$ to $r = 0.094$ ($p = 0.256$, $n = 148$) and education–TMT-B from $r = 0.278$ to $r = 0.148$ ($p = 0.074$), both non-significant. The extreme collinearity of age and education in this sample ($r = 0.792$) further precludes disentangling their independent effects. Taken together, these findings indicate that within this homogeneous young adult student population, age and education have no clinically meaningful or statistically robust influence on TMT performance, and age-stratified or education-stratified norms are not warranted at this stage.

The near-zero intercorrelation of TMT-A and TMT-B ($r = -0.011$, $\rho = 0.025$, both $p > 0.75$) is consistent with neuroimaging evidence of differential cortical recruitment: TMT-A engages predominantly visuospatial parietal networks, while TMT-B recruits bilateral prefrontal and anterior cingulate circuits mediating cognitive control and task-switching.[28, 29] Clinically, this dissociation means both parts must be independently administered and interpreted; a normal TMT-A performance does not predict or ensure a normal TMT-B result. The high TMT-B variance observed in this sample (SD 26.77 s; coefficient of variation 33%) further supports the clinical importance of percentile-referenced rather than mean-referenced interpretation.

Religion had no significant effect on any TMT measure (all $p > 0.50$, all $|d| < 0.15$). Within the English-medium medical educational context of CNMC, Hindu and Muslim students share equivalent exposure to Roman-script number–letter tasks, and no script-familiarity differential is expected. This supports the application of a single normative reference across religious groups in Eastern Indian clinical settings.

LIMITATIONS

The present study has several limitations that should be considered when interpreting the findings. First, purposive sampling from a single urban tertiary-care institution limits the generalisability of the norms to other regions, educational settings, and rural populations. Second, the predominantly narrow and homogeneous age range (18–25 years for 97.3% of participants) precludes age-stratified norms across the adult lifespan and contributes to the attenuation of age effects demonstrated by sensitivity analysis; separate normative studies in middle-aged and older Indian adults are needed. Third, most participants had 14–17 years of education, which limits education-stratified analyses and may account for the absence of robust education effects. Fourth, handedness was not systematically recorded, although it may influence paper-and-pencil task speed and should be documented in future studies. Fifth, the cross-sectional design precludes assessment of practice effects and test-retest reliability. Finally, the absence of a comprehensive concurrent neuropsychological battery limits formal convergent validity analysis of the TMT within this sample.

CONCLUSION

This cross-sectional study provides the first percentile-referenced normative data for TMT-A, TMT-B, and the B–A difference score in an educated young adult population of Eastern India ($N = 150$; mean age 19.64 ± 1.70 years; MBBS and BSc Nursing students). Mean TMT-A was 35.22 ± 12.32 s, TMT-B was 81.07 ± 26.77 s, the B–A difference score was 45.93 ± 29.59 s, and the TMT-B/TMT-A ratio was 2.60. All distributions were significantly right-skewed and non-normal. Sex, religion, and occupation group (MBBS vs nursing students) had no clinically significant influence on performance, supporting a single unified normative table for this population. The apparent effects of age and education on TMT-B did not survive non-parametric analysis, multiple regression, or sensitivity analysis excluding two outlier participants. These locally-derived percentile norms can serve as calibrated clinical benchmarks for neuropsychological evaluation of Eastern Indian young adults and constitute the methodological foundation for larger, multi-centric, age-stratified normative studies across the Eastern Indian states.

DECLARATIONS

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