DOI: 10.7860/JCDR/2014/10727.5080

Original Article

Physiology Section

Study of Effect of Age and Gender Related Differences on Common Paper and Pencil Neurocognitive Tests in Adolescents

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ABSTRACT

Background: Neurocognitive tests are routinely used to assess cognitive domains in the adolescents for assessing cognitive deficits and for therapeutic interventions. Now they are being used to assess their mental abilities in athletics too.

Aim: To study the effect of age and gender differences on routinely used common paper and pencil neuro-cognitive tests in adolescents and present the trends of normative data of Indian adolescent population.

Settings and Design: Present study was conducted as a joint collaboration between Department of Physiology and Jawahar Navodaya school, Puducherry, India.

Materials and Methods: Four hundred and thirty nine adolescents in the age group of 12 to 17 y (M = 250, F= 189) were selected in the present study after meeting the inclusion and exclusion criteria. Subjects were administered commonly used paper and pencil neuropsychological tests in the following order: Two Target Letter Cancellation test, Trail Making test A and B, Ruff Figural Fluency test (RFFT).

Statistical Analysis: We divided the students based on their age into six groups - from age 12–17. Neurocognitive parameters were compared between these age groups using one-way-ANOVA with Bonferroni post-hoc test. Only the p-values for one, two and three year difference were considered. The same analysis was repeated for each gender separately. We compared males and females from the entire sample using unpaired t test. We then repeated the same test to compare males and females in each age group separately. Pearsons correlation was done to find correlation between the neurocognitive test parameters using the entire sample size. Then the correlation was done again after adjusting for age. All the statistical analysis was done using Statistical package for social sciences (SPSS) version 19.

Results: Year wise normative data has been presented for all the age groups from 12 y onwards to 17 y. The results showed a consistent improvement in performance on the tested neuro-psychological tests with increasing age in adolescents. Overall gender comparison showed significantly better RFFT performance in males than females, with a non-significant difference in other tested parameters. However, no such difference was observed when the comparison was made within each age group.

Conclusion: Improvement in the tests as a function of age may represent ongoing neuro-maturational process. Overall gender comparison from 12 to 17 y demonstrates that males performed better on nonverbal fluency task and strategic analysis suggesting difference in cognitive growth patterns but changes are so slow and gradual that no significant difference was observed at each intra-age group gender comparison. Baseline testing should be at least repeated once in two years.

Keywords: Adolescents, Cognition

INTRODUCTION

Neurocognitive tests (NCT) are routinely administered to all the age group both during health and disease to assess various cognitive domains including attention span, concentration and various executive functions [1,2]. These tests can be presented to the subjects using either traditional paper-and-pencil NCT or computerized cognitive assessment tests. While the use of computer assisted cognitive tests is increasing due to its ease of administration and reduced testing time [3], it may not be feasible to administer them easily to adolescent population in various schools in developing countries like India. According to National University of Educational Planning and Administration (NUEPA), 77% of Indian schools are without access to computers [4].

There is paucity of normative data and studies on age and gender differences on these commonly used NCT in Indian adolescent population. In the present study, we have selected those paper and pencil tests which are valid for the age group of 12 to 17 y and are routinely administered as a part of various cognitive test batteries [5]. It consists of two target letter cancellation test (LCT), Trail making A & B (TTA &TTB), Ruff figural fluency test (RFFT). These tests can measure the following cognitive domains: Attention span and concentration, psycho-motor speed and various

Parameters	Overall			Male			Female		
	N	F	p-value	N	F	p-value	N	F	p-value
Height (cm)	421	83.044	<0.001	240	77.408	<0.001	181	19.273	<0.001
Weight (kilogram)	421	90.009	<0.001	240	90.364	<0.001	181	16.325	<0.001
LCT comission	415	2.062	0.069	238	1.376	0.234	177	1.551	0.177
LCT commission	415	1.358	0.239	238	0.963	0.441	177	0.627	0.680
LCT time (seconds)	415	13.967	<0.001	238	10.211	<0.001	177	6.244	<0.001
TTA (seconds)	437	39.847	<0.001	248	21.502	<0.001	189	18.353	<0.001
TTB (seconds)	405	32.792	<0.001	237	20.655	<0.001	168	12.717	<0.001
RFFT Designs	439	103.442	<0.001	250	52.390	<0.001	189	52.676	<0.001
RFFT Rotations	439	6.696	<0.001	250	4.360	0.001	189	2.030	0.076
RFFT Perseverations	439	85.339	<0.001	250	51.391	<0.001	189	31.250	<0.001

[Table/Fig-1a]: Age wise comparison of neurocognitive test, *LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, RFFT –Ruff figural fluency test Analyzed using one way ANOVA, P<0.05 is considered statistically significant*

Parameters	Age (yr)	Mean ± SD				p-value 1 year difference				p-value 2 year difference				p-value 3 year difference		
		Overall	Male	Female		Overall	Male	Female		Overall	Male	Female		Overall	Male	Female
LCT time (seconds)	12	117.71 ± 25.58	119.29 ± 24.83	116.43 ± 26.41	12 vs 13	1.000	1.000	1.000	12 vs 14	1.000	1.000	1.000	12 vs 15	0.117	1.000	0.083
	13	115.56 ± 24.76	114.78 ± 23.62	116.56 ± 26.51	13 vs 14	1.000	0.990	1.000	13 vs 15	0.640	1.000	0.126	13 vs 16	0.030	0.658	0.198
	14	117.80 ± 19.47	123. 17 ± 20.65	111.14 ± 15.83	14 vs 15	0.144	0.937	1.000	14 vs 16	0.004	0.002	1.000	14 vs 17	<0.001	<0.001	0.012
	15	108.47 ± 16.61	114.13 ± 15.75	102.81 ± 15.71	15 vs 16	1.000	1.000	1.000	15 vs 17	0.002	0.002	0.634				
	16	104.85 ± 18.88	106.13 ± 19.73	102.05 ± 16.99	16 vs 17	0.058	0.260	1.000								
	17	94.73 ± 12.80	96.35 ± 13.60	90.95 ± 10.02												
TTA (seconds)	12	45.78 ± 6.23	46.32 ± 6.87	45.33 ± 5.72	12 vs 13	1.000	1.000	1.000	12 vs 14	<0.001	<0.001	0.001	12 vs 15	<0.001	<0.001	<0.001
	13	46.16 ± 6.59	46.05 ± 6.79	46.29 ± 6.43	13 vs 14	<0.001	<0.001	<0.001	13 vs 15	<0.001	<0.001	<0.001	13 vs 16	<0.001	<0.001	<0.001
	14	40.15 ± 4.16	40.10 ± 3.67	40.20 ± 4.70	14 vs 15	1.000	1.000	1.000	14 vs 16	0.418	1.000	0.432	14 vs 17	0.003	0.133	0.125
	15	38.61 ± 4.90	38.26 ± 4.62	38.97 ± 5.23	15 vs 16	1.000	1.000	1.000	15 vs 17	0.728	1.000	1.000				
	16	38.10 ± 6.17	38.65 ± 6.47	36.86 ± 5.35	16 vs 17	1.000	1.000	1.000								
	17	36.77 ± 4.74	36.96 ± 4.54	36.36 ± 5.20												
TTB (seconds)	12	115.95 ± 28.73	113.26 ± 30.10	118.12 ± 27.75	12 vs 13	1.000	1.000	1.000	12 vs 14	1.000	1.000	1.000	12 vs 15	<0.001	<0.001	<0.001
	13	115.64 ± 30.23	118.55 ± 29.38	111.68 ± 31.45	13 vs 14	1.000	1.000	1.000	13 vs 15	0.001	0.001	0.001	13 vs 16	<0.001	<0.001	0.007
	14	112.10 ± 33.16	115.74 ± 31.85	107.54 ± 34.77	14 vs 15	<0.001	<0.001	0.006	14 vs 16	0.001	0.001	0.041	14 vs 17	<0.001	<0.001	0.001
	15	82.72 ± 21.78	83.32 ± 20.77	82.03 ± 23.21	15 vs 16	1.000	1.000	1.000	15 vs 17	1.000	1.000	1.000				
	16	87.61 ± 21.80	89.34 ± 23.79	83.55 ± 15.97	16 vs 17	0.136	0.172	1.000								
	17	75.77 ± 19.53	75.80 ± 20.37	75.70 ± 17.79												

[Table/Fig-1b]: Agewise comparison of neurocognitive tests, LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, Analyzed using one way ANOVA with bonferroni post hoc test., P<0.05 is considered statistically significant

Parameters	Age (yr)	Mean ± SD				p- value 1 year difference				p- value 2 year difference				p- value 3 year difference		
		Overall	Male	Female		Overall	Male	Female		Overall	Male	Female		Overall	Male	Female
RFFT Designs	12	11.91 ± 2.85	11.35 ± 3.10	12.36 ± 2.57	12 vs 13	1.000	0.248	1.000	12 vs 14	<0.001	<0.001	<0.001	12 vs 15	<0.001	<0.001	<0.001
	13	12.44 ± 3.21	13.24 ± 2.84	11.47 ± 3.41	13 vs 14	<0.001	<0.001	<0.001	13 vs 15	<0.001	<0.001	<0.001	13 vs 16	<0.001	<0.001	<0.001
	14	17.29 ± 2.87	17.24 ± 2.58	17.34 ± 3.22	14 vs 15	<0.001	0.082	0.017	14 vs 16	<0.001	0.003	0.007	14 vs 17	<0.001	<0.001	0.057
	15	19.64 ± 3.23	19.44 ± 3.16	19.84 ± 3.34	15 vs 16	1.000	1.000	1.000	15 vs 17	1.000	1.000	1.000				
	16	20.10 ± 4.02	19.98 ± 4.41	20.38 ± 3.01	16 vs 17	1.000	1.000	1.000								
	17	20.40 ± 3.39	20.73 ± 3.53	19.72 ± 3.03												
RFFT Rotations	12	5.89 ± 2.25	5.82 ± 2.04	5.95 ± 2.44	12 vs 13	1.000	1.000	1.000	12 vs 14	1.000	1.000	1.000	12 vs 15	1.000	1.000	1.000
	13	5.63 ± 2.12	5.68 ± 2.29	5.56 ± 1.93	13 vs 14	1.000	1.000	1.000	13 vs 15	1.000	1.000	1.000	13 vs 16	0.000	0.002	0.285
	14	5.92 ± 2.48	6.12 ± 2.61	5.69 ± 2.32	14 vs 15	1.000	1.000	1.000	14 vs 16	0.001	0.037	0.449	14 vs 17	0.189	1.000	1.000
	15	6.02 ± 2.98	6.47 ± 3.12	5.53 ± 2.81	15 vs 16	0.004	0.357	0.276	15 vs 17	0.442	1.000	0.869				
	16	7.55 ± 2.91	7.73 ± 2.89	7.14 ± 2.99	16 vs 17	1.000	1.000	1.000								
	17	6.91 ± 1.81	6.98 ± 1.74	6.76 ± 1.96												
RFFT Perseverations	12	22.05 ± 4.05	22.50 ± 4.34	21.69 ± 3.80	12 vs 13	1.000	1.000	1.000	12 vs 14	<0.001	<0.001	<0.001	12 vs 15	0.001	0.001	0.001
	13	21.79 ± 4.24	21.07 ± 4.01	22.65 ± 4.40	13 vs 14	<0.001	<0.001	<0.001	13 vs 15	<0.001	<0.001	<0.001	13 vs 16	0.001	0.001	0.001
	14	16.67 ± 3.93	16.37 ± 3.73	17.03 ± 4.17	14 vs 15	0.026	0.305	0.489	14 vs 16	<0.001	<0.001	0.001	14 vs 17	0.001	0.001	0.052
	15	14.42 ± 4.35	14.09 ± 3.80	14.78 ± 4.91	15 vs 16	0.001	0.018	0.393	15 vs 17	0.261	0.728	1.000				
	16	11.33 ± 4.56	11.00 ± 4.75	12.10 ± 4.11	16 vs 17	0.717	1.000	1.000								
	17	12.73 ± 4.31	12.25 ± 4.32	13.72 ± 4.20												

[Table/Fig-1c]: Agewise comparison of neurocognitive tests, RFFT – Ruff figural fluency test, Analyzed using one way ANOVAwith bonferroni post hoc test P<0.05 is considered statistically significant

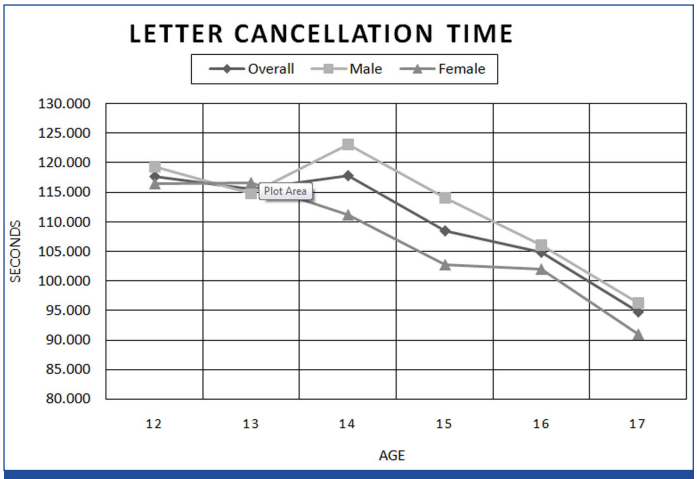
executive functions including non-verbal fluency, manipulation of verbal memory, auditory short term retentive capacity and attention shifting strategy. It is necessary to develop reference normative data for the commonly used paper and pencil tests for the baseline neuropsychological testing of adolescents in Indian setup which can be later used for comparisons for evaluating the clinical significance of therapeutic interventions, identifying cognitive deficits and track mental health status of the students and athletes over time. The primary hypothesis is that there will be age and gender differences on these paper and pencil neurocognitive tests. Therefore, present study has been conceived.

MATERIALS AND METHODS

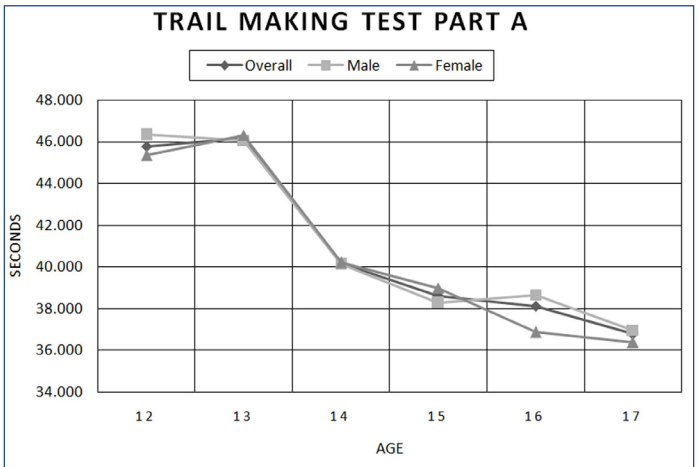
Present study is a part of larger Randomized controlled trial no CTRI/2013/08/003897 which has been approved by JIPMER scientific advisory committee and JIPMER institute ethics committee for human studies. The study represents the part of the cross sectional data of the baseline parameters recorded. It was done by the Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education & Research (JIPMER), Pondicherry, India in collaboration with a residential school Jawahar Navodaya Vidyalaya, Pondicherry, India. After explaining the study to the participants, written informed assent from the participants and written consent from the local guardian or parents was obtained.

PARTICIPANTS

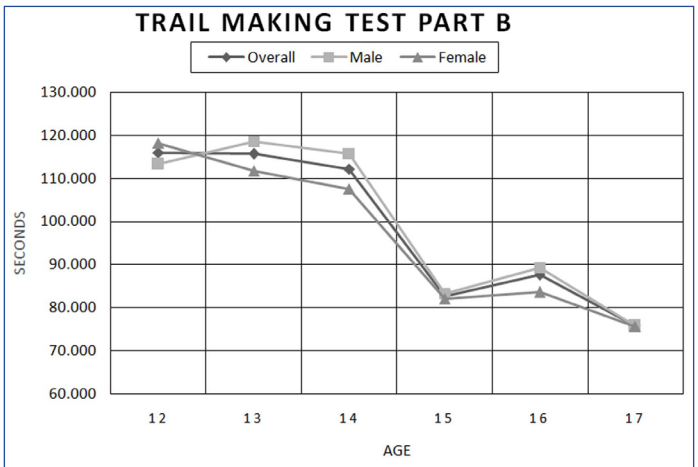
Volunteer students in the age group of 12 to 17 y (M =250, F= 189) studying in Jawahar Navodaya Vidyalaya, Pondicherry from VIIth grade to XIIth grade were included in the present study. Participants with history of previous or current neurological disorder, alcohol abuse, epilepsy or mental retardation were excluded from the study. Participants' age was recorded from the date of birth specified in the



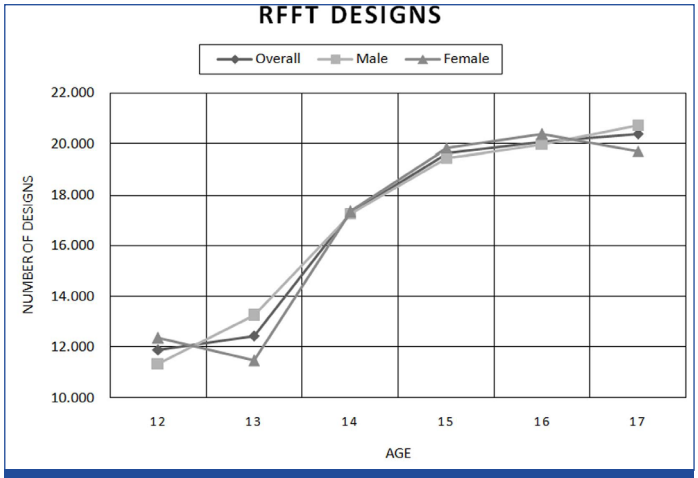
[Table/Fig-2]: Agewise trend in letter cancellation time



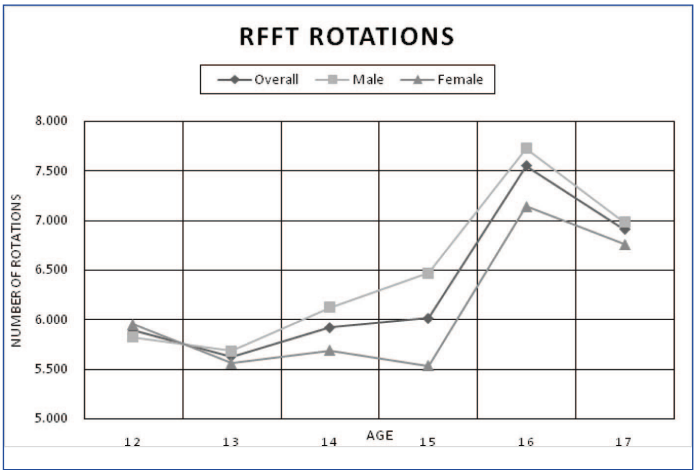
[Table/Fig-3]: Agewise trend in trail making test part A completion time



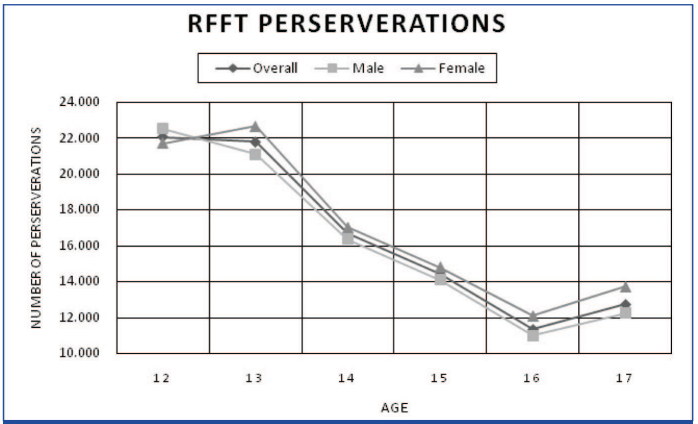
[Table/Fig-4]: Agewise trend in trail making test part B completion time



[Table/Fig-5]: Agewise trend in Ruff Figural Fluency Test designs



[Table/Fig-6]: Agewise comparison in Ruff figural fluency test rotations



[Table/Fig-7]: Agewise comparison in Ruff figural fluency test perseverations

school records. All the students belonged to lower socio-economic group and were full time school residents. Subjects were asked to report to the school examination room at 9 AM two hours after having light breakfast. All the tests were conducted by an expert trained in administering NCT in the isolated room maintained at 25 ± 2 ° Celsius.

Previous studies have shown that the greatest improvement in NCT scores occurs between the first and second administrations of a neurocognitive test [3,6]. Therefore, one practice session was given to all the subjects and then these tests were administered to all the study subjects within 72 h of the practice session. In order to facilitate replication, only those paper and pencil tests which are frequently documented in the neuro-psychological literature batteries [5] were chosen for the present study and then administered to the subjects in the following order:

a. **Two Target Letter Cancellation Test (LCT):** Paper and pencil Cancellation tests are frequently used to assess a person's ability for visual scanning, response speed and sustained attention for an identifiable target in which they are instructed to either cancel or circle all such target items in an array [7]. In the present study, subject was presented with six 52 character rows of letters of English alphabet and was instructed to cancel out randomly placed letters 'E' and 'C'. The score was the time taken (in seconds) by the subject to actually perform this task. In addition, the numbers of different errors (omissions and commissions) done by the subject were also counted [8].

b. **Trail Making Test A and B (TTA & TTB):** Trail making test has been extensively used in the neuropsychological research for the assessment of psychomotor speed, complex attention, and executive functions. It consists of two parts: Part A: assesses visuo-motor speed, visual scanning and sustained attention. The subject is instructed to draw a straight line to

Parameters	Gender	N	Mean ± SD	p-value
Age (yr)	Female	189	14.16 ± 1.69	0.001
	Male	250	14.71 ± 1.73	
Height (cm)	Female	181	1.51 ± 0.08	<0.001
	Male	240	1.56 ± 0.12	
Weight (Kilogram)	Female	181	44.38 ± 7.24	<0.001
	Male	240	47.67 ± 10.03	
LCT omission	Female	177	1.20 ± 1.69	0.181
	Male	238	1.01 ± 1.27	
LCT commission	Female	177	0.20 ± 0.49	0.353
	Male	238	0.16 ± 0.46	
LCT time (seconds)	Female	177	108.40 ± 22.12	0.208
	Male	238	111.14 ± 21.72	
TTA (seconds)	Female	189	41.35 ± 6.64	0.349
	Male	248	40.75 ± 6.68	
TTB (seconds)	Female	168	99.67 ± 31.29	0.528
	Male	237	97.69 ± 30.98	
RFFT Designs	Female	189	16.25 ± 4.77	0.020
	Male	250	17.34 ± 4.82	
RFFT Rotations	Female	189	6.00 ± 2.45	0.025
	Male	250	6.54 ± 2.55	
RFFT Perseverations	Female	189	17.71 ± 5.73	0.001
	Male	250	15.78 ± 5.96	

[Table/Fig-8]: Comparison of neurocognitive tests between male and female., LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, RFFT – Ruff figural fluency test, Analyzed using unpaired t test, P<0.05 is considered statistically significant

connect 25 consecutive circles. The score is the time taken (in seconds) by the subject to complete the task. Part B: In addition to above, it measures subjects' ability to shift strategy, response set, planning, and flexibility and hence, is a sensitive measure of executive function as well. In this test the subject was instructed to connect 25 numbered and lettered circles by alternating between the two sequences. The score was the total time taken (in seconds) by the subject to complete the task [9,10].

c. **Ruff figural fluency test:** This test evaluates non-verbal fluency of the subject, which is an indirect measure of subject's ability to form a strategy to complete a given task. The subject was presented with a sheet of paper on which similar 40 boxes with each containing five dot patterns similar to dice arrangement were presented to the subject. The objective was to draw dissimilar patterns in these boxes by joining dots present in these boxes within duration of five minutes. The score was based on total number of dissimilar unique patterns generated, rotations of these patterns and number of perseverations. This test also measures strategic analysis of the subject which is a sensitive measure of executive function [11].

Entire assessment took nearly 25-30 min and no break was given to the participants. The data was recorded and statistically analysed.

STATISTICAL ANALYSIS

All the statistical analysis were done using Statistical package for social sciences (SPSS) version 19.We divided the students based on their age into six groups - from age 12 – 17. Neurocognitive parameters were compared between these age groups using one-way-ANOVA with Bonferroni post-hoc test. Only the p-values for one, two and three year difference were considered. The same analysis was repeated for each gender separately. We compared males and females from the entire sample using unpaired t-test. We then repeated the test to compare males and females in each age group. Pearsons correlation was done to find correlation between the neurocognitive test parameters using the entire sample size. Then the correlation was done again after adjusting for age.

RESULTS

[Table/Fig-1a] demonstrates that except for LCT Commission and Omission, all other neurocognitive tests differ significantly between different age groups and this holds true for subjects of both the genders. To further evaluate these differences, Post-Hoc analysis was done and [Table/Fig-1b&c] show that there was no significant difference in neurocognitive tests between the successive age groups (one year difference), however, there was trend of increasing number of tests becoming significantly different in all age groups when analysis was done over successive two and three years period.

[Table/Fig-2-4] shows that the time taken to complete the tasks in LCT, TTA and TTB decreases with age. [Table/Fig-5-7] shows that there was continuous increase in the number of RFFT Patterns and Rotations and progressive decline in RFFT Perseverations as a function of age.

[Table/Fig-8] shows that when overall gender comparison was done there was significant difference between males and females in RFFT patterns, rotations and perseverations. However, [Table/Fig-9a & b] show that within each age group, there was no such significant difference between the males and females except for significantly better LCT time at age 14 & 15 y in females (p=0.005 and p=0.012 respectively) and RFFT patterns at the age 13 y in males (p= 0.016).

[Table/Fig-10a] shows that in all the age groups from 12 to 17 y, there was significant correlation in all the cognitive tests.

To further evaluate data, age adjusted correlation was done as given in [Table/Fig-10b]. Its findings show that there was reduction in the values of all the NCT correlations. Only the correlation between RFFT patterns and perseverations remained significant. This signifies that in adolescents age plays very important role in determining the neurocognition of the subjects.

DISCUSSION

One objective of our study was to determine whether age affects neurocognitive test performance in the adolescents. Our results demonstrate that there was significant improvement in all the administered paper and pencil tests in this study as a function of age from age 12 y to 17 y. Age adjusted correlation also demonstrated that age was an important determinant of cognitive functions in the adolescents. Since we selected only healthy adolescents, perseverative errors were very low in all the age groups and that may have resulted in significant negative correlation between RFFT patterns and perseverations. Our findings corroborate with previous studies which have also found similar age related improvement in neuropsychological tests among high school and adult athletes [3,12]. Previous MRI study also suggests that frontal and parietal neural networks change over the adolescent age range and positively correlated with age. In another study, Hunt and Ferrara observed similar age-related differences among high school students (ages 13–18 y) on Trail making Test B. They suggested that these changes demonstrate continuous improvement in the processing speed of cognitive functions in adolescents thereby, causing observable differences in various age groups. These studies further suggest that improvements in cognition with age represents continuously ongoing brain development and underlying neuro maturational processes during adolescent and early adulthood [3].

Since the difference in NCT results became significantly different in subjects of both genders when compared for every successive two and three years of age groups, our study suggests that there should be retesting of baseline of adolescents every two years and preferably, every year as subtle changes due to cognitive growth

Parameters	Gender	12			13			14		
		N	Mean ± SD	p-value	N	Mean ± SD	p-value	N	Mean ± SD	p-value
Height (cm)	F	41	1.44 ± 0.08	0.006	32	1.48 ± 0.07	0.630	33	1.52 ± 0.06	0.120
	M	33	1.39 ± 0.07		41	1.48 ± 0.08		34	1.55 ± 0.09	
Weight (kilogram)	F	41	38.93 ± 7.59	0.006	32	41.75 ± 5.67	0.171	33	43.58 ± 3.79	0.448
	M	33	34.97 ± 3.10		41	39.93 ± 5.51		34	44.47 ± 5.61	
LCT omission	F	42	0.83 ± 1.19	0.524	32	0.88 ± 1.18	0.350	29	1.83 ± 2.48	0.103
	M	34	0.68 ± 0.88		41	1.12 ± 1.05		36	1.06 ± 1.17	
LCT commission	F	42	0.24 ± 0.48	0.397	32	0.25 ± 0.44	0.871	29	0.24 ± 0.58	0.532
	M	34	0.15 ± 0.44		41	0.27 ± 0.50		36	0.17 ± 0.38	
LCT time (seconds)	F	42	116.43 ± 26.41	0.631	32	116.56 ± 26.51	0.763	29	111.14 ± 15.83	0.012
	M	34	119.29 ± 24.83		41	114.78 ± 23.62		36	123.17 ± 20.65	
TTA (seconds)	F	42	45.33 ± 5.72	0.495	34	46.29 ± 6.43	0.874	35	40.20 ± 4.70	0.921
	M	34	46.32 ± 6.87		41	46.05 ± 6.79		39	40.10 ± 3.67	
TTB (seconds)	F	42	118.12±27.75	0.468	28	111.68 ± 31.45	0.365	28	107.54 ± 34.77	0.333
	M	34	113.26 ± 30.10		38	118.55 ± 29.38		35	115.74 ± 31.85	
RFFT Designs	F	42	12.36 ± 2.57	0.127	34	11.47 ± 3.41	0.016	35	17.34 ± 3.22	0.882
	M	34	11.35 ± 3.10		41	13.24 ± 2.84		41	17.24 ± 2.58	
RFFT Rotations	F	42	5.95 ± 2.44	0.806	34	5.56 ± 1.93	0.802	35	5.69 ± 2.32	0.447
	M	34	5.82 ± 2.04		41	5.68 ± 2.29		41	6.12 ± 2.61	
RFFT Perseverations	F	42	21.69 ± 3.80	0.389	34	22.65 ± 4.40	0.110	35	17.03 ± 4.17	0.467
	M	34	22.50 ± 4.34		41	21.07 ± 4.01		41	16.37 ± 3.73	

[Table/Fig-9a]: Agewise comparison of neurocognitive tests between male and female., F-female, M- male, LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, RFFT – Ruff figural fluency test, Analyzed using unpaired t test, P<0.05 is considered statistically significant

Parameters	Gender	15			16			17		
		N	Mean ± SD	p-value	N	Mean ± SD	p-value	N	Mean ± SD	p-value
Height (cm)	F	32	1.55 ± 0.06	0.036	19	1.60 ± 0.07	0.037	24	1.54 ± 0.07	0.001
	M	34	1.58 ± 0.08		48	1.64 ± 0.07		50	1.67 ± 0.07	
Weight (kilogram)	F	32	48.53 ± 6.70	0.457	19	50.21 ± 6.01	0.001	24	48.17 ± 5.26	0.001
	M	34	47.26 ± 7.02		48	57.77 ± 6.15		50	55.16 ± 6.76	
LCT omission	F	32	1.38 ± 2.01	0.892	21	1.33 ± 1.46	0.233	21	1.19 ± 1.40	0.468
	M	32	1.44 ± 1.64		46	0.91 ± 1.26		49	0.92 ± 1.44	
LCT commission	F	32	0.16 ± 0.37	0.236	21	0.24 ± 0.77	0.822	21	0.05 ± 0.22	0.463
	M	32	0.06 ± 0.25		46	0.20 ± 0.69		49	0.10 ± 0.31	
LCT time (seconds)	F	32	102.81 ± 15.71	0.005	21	102.05 ± 16.99	0.416	21	90.95 ± 10.02	0.107
	M	32	114.13 ± 15.75		46	106.13 ± 19.73		49	96.35 ± 13.60	
TTA (seconds)	F	32	38.97 ± 5.23	0.564	21	36.86 ± 5.35	0.271	25	36.36 ± 5.20	0.605
	M	34	38.26 ± 4.62		48	38.65 ± 6.47		52	36.96 ± 4.54	
TTB (seconds)	F	30	82.03 ± 23.21	0.815	20	83.55 ± 15.97	0.323	20	75.70 ± 17.79	0.985
	M	34	83.32 ± 20.77		47	89.34 ± 23.79		49	75.80 ± 20.37	
RFFT Designs	F	32	19.84 ± 3.34	0.617	21	20.38 ± 3.01	0.705	25	19.72 ± 3.03	0.223
	M	34	19.44 ± 3.16		48	19.98 ± 4.41		52	20.73 ± 3.53	
RFFT Rotations	F	32	5.53 ± 2.81	0.204	21	7.14 ± 2.99	0.446	25	6.76 ± 1.96	0.619
	M	34	6.47 ± 3.12		48	7.73 ± 2.89		52	6.98 ± 1.74	
RFFT Perseverations	F	32	14.78 ± 4.91	0.522	21	12.10 ± 4.11	0.363	25	13.72 ± 4.20	0.162
	M	34	14.09 ± 3.80		48	11.00 ± 4.75		52	12.25 ± 4.32	

[Table/Fig-9b]: Agewise comparison of neurocognitive tests between male and female, F-female, M- male, LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, RFFT – Ruff figural fluency test, Analyzed using unpaired t test, P<0.05 is considered statistically significant

may lead to erroneous significant results when measured later in healthy and diseased conditions.

Another objective of the study was to study the gender differences in NCT in the subjects. Our study demonstrates that when overall comparison between male and female subjects was done, males performed better than females only on RFFT. Our study demonstrates that males are better than females in the domains of nonverbal fluency and strategic analysis. However, when age wise gender comparison was done, this significance was not observed. Also, [Table/Fig-2-7] demonstrate that there were differences in the age wise pattern of neuro-cognitive tests in both genders which increased after 15 y of age. This may have resulted due to small differences in the trend of cognitive tests between males and females which were insignificant at each age interval, but overall represented different cognitive growth patterns in both the genders. We speculate that with larger sample size, perhaps these small changes might have become statistically significant.

Our results are similar to previous fMRI study which reported continuous change in frontal and parietal neural networks involved in executive functions over the adolescent age range (12 to 17 y) and that these changes were further influenced by gender [13]. Similar significant gender differences in the cognitive abilities of adults have

		TTA	TTB	RFFT Designs	RFFT Perseverations
LCT time	r- value	.121	.320	-.185	.169
	p-value	0.014	<0.001	<0.001	0.001
	N	414	398	415	415
TTA	r- value		.275	-.438	.421
	p-value		<0.001	<0.001	<0.001
	N		404	437	437
TTB	r- value			-.352	.296
	p-value			<0.001	<0.001
	N			405	405
RFFT Designs	r- value				-.868
	p-value				<0.001
	N				439

[Table/Fig-10a]: Correlation between the neurocognitive tests, LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, RFFT – Ruff figural fluency test Analyzed using Pearson's correlation, P<0.05 is considered statistically significant

		TTA	TTB	RFFT Designs	RFFT Perseverations
LCT time	r- value	-.068	.153	.072	-.071
	p-value	0.189	0.003	0.161	0.166
	df	377	377	377	377
TTA	r- value		.027	-.113	.102
	p-value		0.595	0.028	0.047
	df		377	377	377
TTB	r- value			-.038	-.033
	p-value			.459	0.522
	df			377	377
RFFT Designs	r- value				-.754
	p-value				<0.001
	df				377

[Table/Fig-10b]: Correlation between neurocognitive test after adjusting for group, LCT – Letter cancellation test, TTA - Trail making test part A, TTB – Trail making test part B, RFFT – Ruff figural fluency test, Correlation after adjusting for age, P<0.05 is considered statistically significant

been reported earlier even in adults. They found that adult females were better than males on verbal recall and perceptual speed tasks whereas, males were better on spatial tasks [14].

LIMITATIONS OF THE STUDY

Pre Test Intelligence Quotient (IQ) test could not be attempted in this study. During the study, menstrual history of female subjects was not taken. Future studies should be done on larger sample size and more expanded neuropsychological test batteries so that better intragroup gender comparisons could be made.

CONCLUSION

To conclude, we have presented normative data of commonly used paper and pencil tests which can be used as a reference in future studies on adolescents. Our study demonstrates that there was significant positive correlation between age and cognitive functions in the adolescent subjects of both genders in the age group of 2 to 17 y. Also, overall improvement in the executive function of nonverbal fluency and strategic analysis was better in males than females suggesting different cognitive growth patterns. We suggest that baseline of neuropsychological tests should be repeated at least once in two years.

DECLARATION FROM THE AUTHORS

The findings discussed in this research article are a part of the larger Randomized controlled trial no CTRI/2013/08/003897. In the present study we have discussed only the baseline changes in cognitive parameters of the adolescents as it is not possible to explain all the findings in one manuscript.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Jul 30, 2014**
Date of Peer Review: **Aug 18, 2014**
Date of Acceptance: **Aug 29, 2014**
Date of Publishing: **Nov 20, 2014**
Last Updated Date: **Apr 01, 2015**