EFFICACY OF VEDIC MATHEMATICS AND YOGIC BREATHING IN SCHOOL CHILDREN - A PILOT STUDY

Vasant V Shastri, Alex Hankey, Bhawna Sharma, Sanjib Patra

ABSTRACT

We report an RCT study comparing the Vedic Mathematics and Yogic pranayama practices effects on working memory, math-anxiety and cognitive flexibility in school children.

Methods

Subjects: 40 higher secondary (8^{th}, 9^{th}, 10^{th}) students, residing at hostel, in Sai Angels School, Chikmagalur, Karnataka, India were randomly assigned to Yogic Breathing (YB), Vedic Mathematics (VM) and Jogging (JG) groups. YB, VM and JG groups had 14, 13 and 13 children, respectively.

Inclusion / Exclusion Criteria: School children who study Mathematics in their curriculum and having normal vision or corrected to normal vision are included. Children undergoing any psychiatric treatment; having neurological disorders and colour blindness are excluded.

Intervention: Children in YB and VM groups attended seven days' workshop on Pranayama and Vedic Mathematics respectively. JG went jogging every day.

Assessments: Mathematics Anxiety Rating Scale (MARS-R), STROOP test, Children's Cognitive Assessment Questionnaire (CCAQ) and Digit Span Test were administered pre and post the intervention.

Analysis: SPSS-17 was used to make non-parametric pre-post comparison tests (Wilcoxon) and group comparisons tests (Mann-Whitney).

Results: Math-anxiety decreased most in VM (-11.77±10.47; $p<0.01$). Others: YB (-4.08±4.99; $p<0.05$); JG, (-3.75±16.94). VM improved most in cognitive flexibility and reaction to cognitive stress (+9.77±5; $p<0.001$); YB (+5.38±5.38; $p<0.01$) and JG (+8.58±9.91; $p<0.05$). Changes in self-defeating cognition scores associated with test anxiety and performance lowered most in the YB (-1.77±1.83; $p<0.01$); VM (-1.38±3.2), JG (+0.67±1.44). Digit span scores associated with performance were similar in all three groups.

Discussion: The VM and YB groups showed slight improvement in cognitive skills and slight decrease in math-anxiety compared to the JG group. The study shows, Vedic Mathematics workshop improved mathematical abilities by decreasing the math-anxiety which might have

helped enhance their cognitive skills. The calming effect of the pranayama practices is the probable cause for YM group improvements.

Keywords: Vedic Maths, Math Anxiety, Pranayama, Cognitive Skills, School Children

Introduction

Mathematics learning and cognitive skills are extremely important to qualify for better career options later on in life, but students with math-anxiety have a strong tendency to avoid mathematics (Ashcraft & Jeremy, 2007; Meece et al., 1990). Earlier studies have shown that high math-anxiety, low working memory, and poor maths performance are strongly correlated (Ashcraft & Kirk, 2001; Sherman and Whitter, 2003; Ramirez et al., 2012). Reciprocal relationship between math-anxiety and low self-concept exists (Ahmed et al., 2012). Math-anxiety can also influences the decision making abilities of an individual (Morsanyi et al., 2014) and can also bring immediate physiological changes resulting from stress situations, such as difficulty in breathing, increased heart rate, upset stomach, and light headedness (Plaisance, 2009).

Many methods have been studied and applied to reduce math-anxiety or to improve math performance in school children (Blazer, 2011; Plaisance, 2009; Iossi, 2007). In present study we are interested to see the efficacy of vedic maths (VM) module and yogic breathing module on math-anxiety and related cognitive skills in school children.

Vedic Mathematics:

One possible way may be showing different strategies which involves less number of steps in solving mathematical problems. VM methods are one such alternatives which may inspire students to feel mathematics class as entertaining – joyful sessions of pattern finding in their initial stages. We therefore assume that pleasurable VM algorithms, appropriate to solving particular problems, can be effectively presented by school teachers, and function as teaching aids to handle math-anxiety; also that improvements in cognitive load produced by certain VM techniques may have a positive impact on working memory.

VM is a name given by His Holiness Jagadguru Shankaracharya Bharati Krishna Teerthaji Maharaj (1884-1960), who identified 16 *sūtras* (formulae) and 16 *upasūtras* (sub formulae) at the end of Atharva Veda (Bharati Krsna Tirthaji, 1992).

VM is not a new branch of mathematics but a set of unique approaches to simplification suggesting various thinking patterns to help solve arithmetical, algebraic or geometric calculations common in elementary level maths learning. Certain VM patterns reduce cumbersome-looking calculations in conventional mathematics to simple ones (Karad, 2004). Application of this can be found in digital signal processing where construction of shortest algorithms for multipliers in circuits optimizes chip area (Reddy & Reddy, 2014; Kanheetal,

2012; Thapliyal & Srinivas, 2004; Bathija et al., 2012). The pattern given in the Urdhva Tiryakbhyam sutra has been found the most efficient algorithm, giving minimum delay for multiplication of all types of numbers (Chunduri et al., 2013). Such applications of VM algorithms improve efficiency of machines rather than mental processes, but shortened algorithms for mathematical calculations may impact cognitive processes, eventually affecting math-anxiety and performance. VM methods have not previously been investigated as teaching aids in educational and cognitive research. Here we report results of using a VM module both to develop cognitive skills and manage math-anxiety.

Yogic breathing (YB) **(Pranayama)**

Yoga pranayama is well known to help improve conditions in both clinical and non-clinical situations. Evidence that pranayama reduces stress levels and improves individual wellbeing is strong (Brown & Gerbarg, 2009). Pranayama has also been found to decrease state and trait anxiety levels (Gupta et al., 2006).

Uninostril breathing (left nostril breathing or right nostril breathing) and alternate nostril breathing (Nadishodhana pranayama), can bring positive changes in cognitive tasks (Naveen et al., 1997). They may help sharpen the critical faculty and creativity, and may also bring balance between left and right halves of the brain (Nagendra, 2005). Also Kapalabhati, Bhastrika and Nadishodhana i.e. both fast and slow pranayamas, and Pranava (OM) chanting can be used to reduce stress levels, and to improve cognitive skills particularly working memory (Sharma et al., 2014).

The present study evaluates and compares the effectiveness of VM and YB modules in the management of math-anxiety and cognitive skills.

Methods

Participants: 40 children studying in 8^{th}, 9^{th}, 10^{th} standards, at Sai Angels CBSE school, Chikmagalur, were randomly assigned to: **Yogic Breathing group** (YB – 14 children), **Vedic Mathematics group** (VM – 13 children) and **Jogging group** (JG – 13 children). The design of the study was explained to parents / guardians and signed informed consent obtained.

Design

Three group, pre-post random control design (Figure 1). Randomization was done using random number generator.

Data Extraction

Mathematics Anxiety Rating Scale - MARS-R, CCAQ, Digit span test and STROOP test were given at baseline and after the 7-day workshops were completed.

Interventions

YB group and VM group students attended workshops on Pranayama and Vedic Mathematics respectively (30 mins at 6 am every day for seven days). Those in the Jogging group went for 30 minutes jogging every day at 5.30 am.

Assessment Instruments Used

MARS-R: (Plake & Parker, 1982)

This 24-item instrument is designed to measure anxiety related to involvement in statistics and mathematic courses. The instrument is a revised version of a 98-item scale by Richardson and Suinn (1972). The current version is more focused on situation specific (state) anxiety, general (trait) anxiety, and test anxiety. The instrument comprises two subscales: learning mathematics anxiety (LMA) which pertains to the process of learning of math and statistics; and evaluation mathematic anxiety (EMA) measuring anxiety over tests on maths and statistics. The sum of LMA and EMA is taken as Total mathematics anxiety (TMA).

Scoring: Respondents rate each item on a 5-point scale from “low anxiety” to “high anxiety”. Scores are the sum of the item ratings, and range from 24 to 120 for the total scale.

Stroop: (Gualtieri & Johnson, 2006)

The Stroop test consists of three subtasks measuring cognitive flexibility, creativity, and reaction to cognitive stress. The stimulus material for each of these subtasks is shown on a white sheet of paper that is landscape oriented (A4 letter format, 11.69in×8.26in

[29.70cm×20.99cm]). 100 stimuli for each subtask are distributed evenly in a 10×10 matrix on each sheet of paper with a margin of about 1.97in (5cm) at the top, 0.59in (1.5cm) on the left and on the right, and 1.57in (4cm) at the bottom. The first subtask shows color words in random order (red, blue, yellow, green) printed in black ink (noncapital letters, 0.157in [0.4cm] high). Subtask 2 displays solid color patches of 0.276in×0.787in (0.7cm×2.0cm) in one of these four basic colors. The third subtask contains color words printed in an incongruous ink color (non-capital letters, 0.157in [0.4cm] high), e.g., the word *yellow* printed in red ink.

Children's Cognitive Assessment Questionnaire – CCAQ: (Zatz and Chassin, 1983)

This 40-item instrument measures self-defeating and self-enhancing cognitions associated with test-anxiety. The instrument was originally developed for hypothesis testing on the relationship of cognition to test-anxiety and task performance. The theoretical perspective asserts that self-defeating thoughts inhibit one's performance while self-enhancing thoughts facilitate performance. The CCAQ focuses on negative self-evaluations (NSE) and positive self-evaluations (PSE) as reflecting self-defeating and self-enhancing cognitions respectively. It also assesses self-distracting thoughts (called off-task thoughts; OFFT) and cognitions which focus one's attention to the task (called on-task thoughts; ONT). The four aspects of the CCAQ are used as subscales.

Scoring: Each of 40 items is answered true or false. Total scores for the four subscales are the number of items answered "true" and they range from 0 to 10. Higher scores reflect more thoughts associated with test-anxiety.

Digit span test: (Woods et al., 2011)

This test measures working memory.

For the duration of 14 trials a participant sees a sequence of digits (starting with 3 digits- level 3), presented for one second each, after which the participant is asked to recall the digit sequence and type the answer into a presented textbox. If the response is correct (in digits and presentation order), the participant moves up to the next level (e.g. level 4). If the response is incorrect, the same level is presented a second time. If a consecutive error occurs the participant moves back down to a lower level, starting over.

The first time a participant makes a consecutive error, span is set to the last correctly recalled number of digits (e.g. if participant reaches level 8, but answers incorrectly both times, the span is set to 7).

Data Analysis

The data was analysed using SPSS 17.0. In view of the small size of the groups, non-parametric tests were used: the Mann-Whitney test for inter-group comparisons, and the Wilcoxon test for within group pre-post comparisons.

Results

The three groups, YB, VM and JG, were all measured on the various different questionnaires and tests. Results are as follows:

(a) Math-anxiety rating scale

Vedic Maths group showed significant pre-post differences in TMA (pre 57.85±14.43; post 46.08±14.38; $p<0.01$), LMA (pre 34.69±8; post 29±9.23; $p< 0.05$) and EMA (pre 23.15±7.8; post 17.08±6.22; $p< 0.01$) (Table 1).

Yoga group: we found significant differences in MARS-R in pre-post measures. TMA was significantly lowered (pre 51±14.3; post 46.92±12.63, $p<0.05$). EMA was found to be significantly different between pre-post measures (pre 20.85±7.35; post 17.15±4.38, $p<0.05$), out of two subsets of MARS-R (Table 1). Pre-post differences for the LMA were not significant.

Jogging group: we found no significant differences between pre-post measures (Table 1).

Comparisons of Pre-post differences between the three groups: LMA and TMA differences between yoga and vedic maths groups were significant ($p<0.05$) (Table 1); but could have been due to lower pre values in yoga group. Whereas jogging group was not significantly different in all three parameters from both other groups (Table 1).

(b) Stroop test

VM group showed significant difference in Color score (pre 61.23±7.44; post 66.85±10.64; $p<0.05$) and Color Word (pre 34.15±7.45; post 43.92±9.06; $p< 0.001$). Pre-post differences in means of Word color were not significant (Table 2).

YB showed significant difference in color word test of the Stroop test (pre 35.46±5.98; post 40.85±7.89; $p< 0.005$) (Table 2).

In JG group significance were observed in Word score (pre 86.58±13.27; post 93.5±12.38; $p<0.05$) and color word (pre 31.33±6.4; post 39.92±9.03; $p< 0.05$) (Table 2).

No significant difference was observed between three groups for Stroop test.

(c) Children's Cognitive Assessment Questionnaire- CCAQ

VM group showed highly significant difference in pre-post values of OFFT (pre: 6.08±1.61; post: 2.62±2.66; $p<0.001$) (Table 3).

YB Group: showed significant improvement in lowering NSE (pre: 2.77±2.01; post: 1±1; $p<0.01$) and OFFT (pre: 5.54±2.57; post: 3.38±2.36; $p<0.01$) (Table 3).

JG group also showed significant difference in pre-post values of OFFT (pre: 7.42±2.91; post: 5.92±2.35; $p<0.05$) (Table 3).

Pre-post differences analyses between the three groups suggest that YB and JG were significantly different in NSE (YB: -1.77±1.83; JG: 0.67±1.44; $p<0.05$) (Table 3).

(d) Digit Span test:

All the three groups performed equally in forward and backward digit span tests (Table 4).

Discussion

This paper mainly concerns individual effects of three interventions on Math-anxiety by MARS-R; cognitive flexibility and selective attention by the Stroop test; self-defeating and self-enhancing thoughts by CCAQ; and working memory measured by the Digit span test. We have found that all three interventions influence the various measured parameters, to varying degrees.

Math-anxiety with its two subscales; learning math-anxiety and evaluation math-anxiety, is our primary variable. VM brought the most benefit for math-anxiety levels, followed by Yoga (Figure 2). Jogging did not reduce math-anxiety levels to any significant extent. Why the VM received the most benefit compared to other groups is obvious: it deals directly with numbers and brings confidence to students concerned with mathematics.

The VM group also showed the greatest improvement on the Stroop test (Figure 3). The JG group's initial values were lower than those of the other two groups on Word score, and its final (post) value did not even reach the pre values of the other two groups (Table 2, Figure 3). Therefore, the impact of Jogging on this pre-post measure was confusing, and requires further investigation.

Scores on the CCAQ test measuring self-defeating and self-enhancing thoughts improved most for the yoga group followed by the Vedic maths group (Figure 4). The Jogging group's initial negative evaluation increased, but not significantly (Table 3).

The Digit Span test, which measures working memory and focussed attention, did not show significant change after any intervention, nor between any pair of groups (Figure 5). This result may be due to low sample size and the short intervention period. It needs further investigation.

Overall VM tended to show greater results than the other interventions on all parameters. VM offers different possible strategies of mental calculation in smaller numbers of steps, bringing "a feel-good factor" to solving lengthy problems. Its methods promote pattern recognition in maths, introducing a fun element, possibly by stimulating endorphin release. Improvement in working memory, and reduction in math-anxiety result.

YB practices including repetitive chanting of A, U, M, Om, and generating a humming sound in Shambhavi Mudra, may stimulate the brain, eventually yielding stronger pattern recognition (Subbalakshmi et al., 2005). This may again stimulate the endorphin system. Cognitive flexibility, creativity, and reaction to cognitive stress and math-anxiety all improve slightly.

Yogic breathing brings better changes in CCAQ than other interventions, strengthens the impact of yoga in decreasing stress and improving self-concept and self-esteem (Deshpande et al., 2009), which may lead to greater self-confidence, and result in better performance. This may also lead to reduction in math-anxiety.

The combined effect of these practices may therefore be of value in managing math-anxiety and enhancing cognitive skills. The study brings a new understanding of VM, and may introduce a new domain for its application. It also offers reasons for including VM and Pranayama, individually or together, in the school curriculum.

Strength of the Study: The observed improvements in working memory, math-anxiety, focussed attention, resulting from learning VM are new, as are those produced by practising pranayama.

Limitation: As a pilot study, the sample size was too small to draw any strong conclusions. The intervention of one week is not enough make results conclusive.

Further Research: follow up studies with larger group sizes are called for; also studies investigating mechanisms behind the observed changes.

Conclusion

The VM and YB modules were found useful in decreasing math-anxiety, self-defeating thoughts and improving cognitive flexibility and self-enhancing thoughts in school children. Increasing sample size and intervention time may help generate stronger conclusions, and thus provide the grounds for implementing both techniques in school curricula.

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TABLES

Table 1: Mathematics Anxiety Rating Scale - MARS-R: Mean ± SD

	YB	YB (pre-post Difference)	VM	VM (pre-post Difference)	JG	JG (pre-post Difference)
LMA (pre)	30.15 ± 8.28	**-0.38 ± 3.04***	**34.69 ± 8**	**-5.69 ± 7.08***	34.75 ± 8.41	-2.08 ± 10.83
LMA (post)	29.77 ± 8.53		**29 ± 9.23***		32.67 ± 9.88	
MEA (pre)	**20.85 ± 7.35**	-3.69 ± 5.36	**23.15 ± 7.8**	-6.08 ± 6.24	22.5 ± 6.27	-1.67 ± 8.86
MEA (post)	**17.15 ± 4.38***		**17.08 ± 6.22****		20.83 ± 8.49	
TMA (pre)	**51 ± 14.3**	**-4.08 ± 4.99***	**57.85 ± 14.43**	**-11.77 ± 10.47***	57.25 ± 11.34	-3.75 ± 16.94
TMA (post)	**46.92 ± 12.63***		**46.08 ± 14.38****		53.5 ± 17.68	

Caption: Table 1 shows the pre and post mean ± SD of yoga (YB), vedic maths (VM) and jogging (JG) groups on Mathematics anxiety rating scale- revised (MARS-R). Table also provides the pre-post differences of the three groups as well. Significant differences are shown by *; where *<0.05 and **<0.01.

Table 2: Stroop Test: Mean ± SD

	YB	YB (pre-post Difference)	VM	VM (pre-post Difference)	JG	JG (pre-post Difference)
Word score (pre)	95.15 ± 11.26	4 ± 7.15	97.85 ± 16.34	4.85 ± 9.26	**86.58 ± 13.27**	6.92 ± 8.08
Word score (post)	99.15 ± 15.57		102.69 ± 15.23		**93.5 ± 12.38***	
Color score (pre)	61.69 ± 8.44	3.54 ± 8.58	**61.23 ± 7.44**	5.62 ± 8.14	61.17 ± 6.69	3.67 ± 7.01
Color score(post)	65.23 ± 11.1		**66.85 ± 10.64***		64.83 ± 12.09	
Color word (pre)	**35.46 ± 5.98**	5.38 ± 5.38	**34.15 ± 7.45**	9.77 ± 5	**31.33 ± 6.4**	8.58 ± 9.91
Color word (post)	**40.85 ± 7.89****		**43.92 ± 9.06*****		**39.92 ± 9.03***	

Caption: Table 2 shows the pre and post mean ± SD of yoga (YB), vedic maths (VM) and jogging (JG) groups on Stroop test. Table also provides the pre-post differences of the three groups as well. Significant differences are shown by *; where *<0.05, **<0.01 and ***<0.001

Table 3: Children's Cognitive Assessment Questionnaire – CCAQ: Mean ± SD

	YB	YB (pre-post Difference)	VM	VM (pre-post Difference)	JG	JG (pre-post Difference)
Negative Evaluations (pre)	**2.77 ± 2.01**	**-1.77 ± 1.83***	3.08 ± 3.25	-1.38 ± 3.2	2.83 ± 1.99	**0.67 ± 1.44***
Negative Evaluations (post)	**1 ± 1****		1.69 ± 2.75		3.5 ± 2.58	
Off-task thoughts (pre)	**5.54 ± 2.57**	-2.15 ± 2.15	**6.08 ± 1.61**	-3.46 ± 3.04	**7.42 ± 2.91**	-1.5 ± 2.2
Off-task thoughts (post)	**3.38 ± 2.36****		**2.62 ± 2.66*****		**5.92 ± 2.35***	
Positive Evaluations (pre)	7.77 ± 1.92	0.62 ± 2.33	7.15 ± 2.64	-0.77 ± 3.03	8 ± 2.22	-1 ± 2.09
Positive Evaluations (post)	8.38 ± 1.94		6.38 ± 3.31		7 ± 2.89	
On-task thoughts (pre)	8.15 ± 1.52	-0.08 ± 1.32	6.85 ± 3.05	0.46 ± 2.79	7.5 ± 1.68	0.42 ± 2.35
On-task thoughts (post)	8.08 ± 1.98		7.31 ± 3.07		7.92 ± 1.83	

Caption: Table 3 shows the pre and post mean ± SD of yoga (YB), vedic maths (VM) and jogging (JG) groups on Children's Cognitive Assessment Questionnaire (CCAQ). Table also provides the pre-post differences of the three groups as well. Significant differences are shown by *; where *<0.05, **<0.01 and ***<0.001.

Table 4: Digit Span test: Mean ± SD

	YB	YB (pre-post Difference)	VM	VM (pre-post Difference)	JG	JG (pre-post Difference)
Forward digit span (pre)	6.17 ± 0.58	0.50 ± 0.80	6.75 ± 0.87	0.50 ± 1.00	6.00 ± 0.82	0.40 ± 0.70
Forward digit span (post)	6.67 ± 0.65		7.25 ± 1.22		6.40 ± 0.70	
Backward digit span (pre)	6.75 ± 0.87	0.50 ± 1.17	6.50 ± 1.51	0.75 ± 1.36	6.10 ± 0.88	0.50 ± 0.71
Backward digit span (post)	7.25 ± 0.75		7.25 ± 0.87		6.60 ± 0.70	

Caption: Table 4 shows pre and post mean ± SD of the yoga (YB), vedic maths (VM) and jogging (JG) groups on Digit span test- forward and backward digit span. Table also provides the pre-post differences of the three groups as well.

FIGURES

Figure 1: Study Design

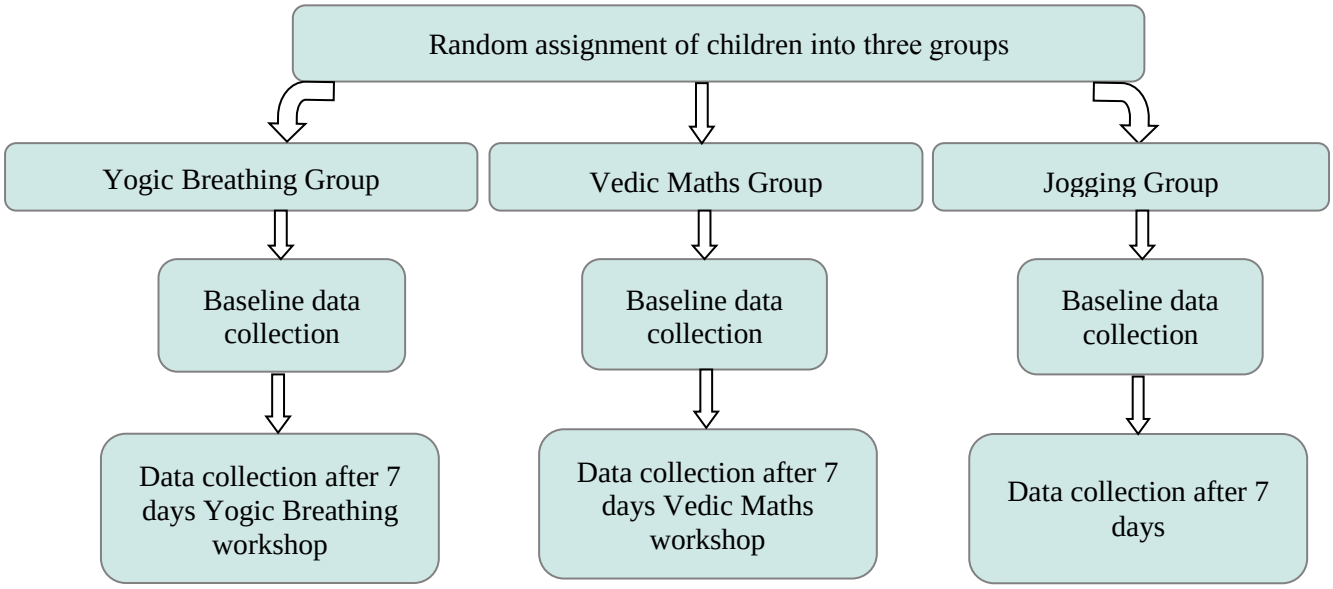
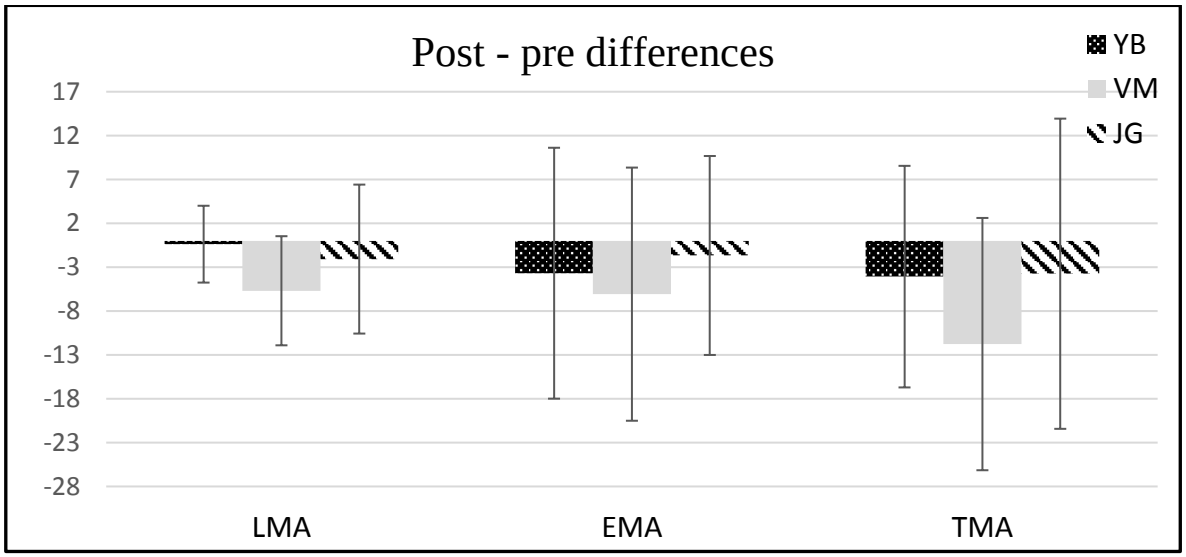


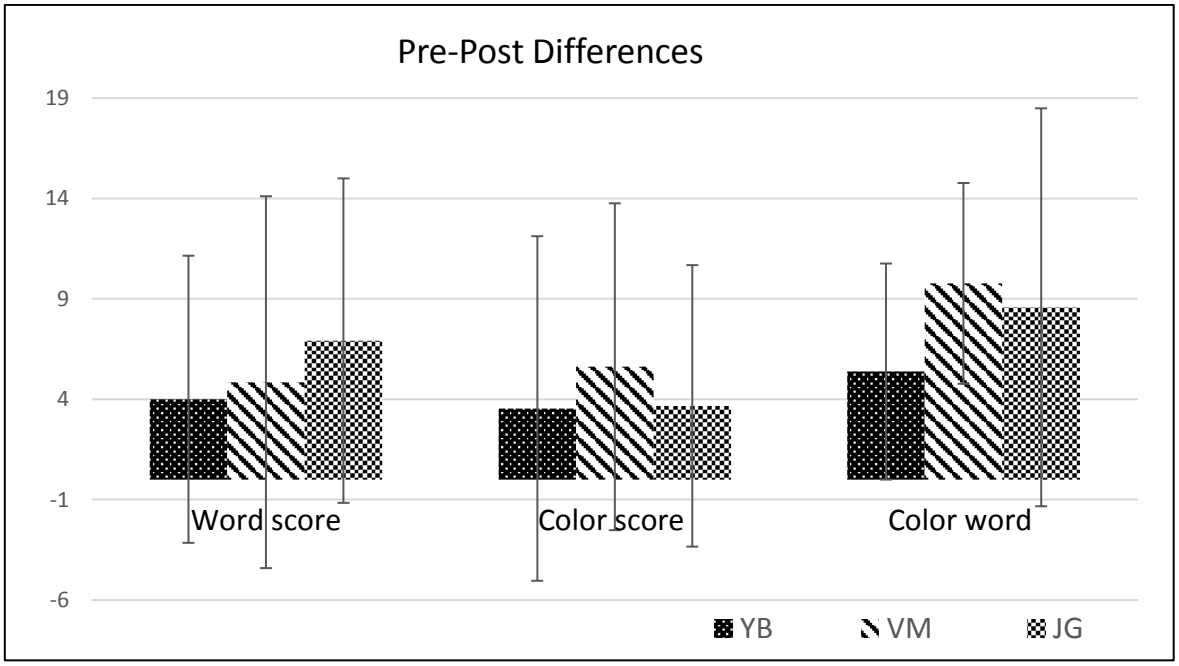
Figure 1 caption: shows the study design. The sample was divided randomly (with the help of random number generator) into three groups: YB, VM and JG. The baseline data was collected and then respective intervention was given for 7 days to the groups. Post data was collected after the intervention.

Figure 2: Comparison of Math-anxiety pre-post differences between YB, VM and JG groups



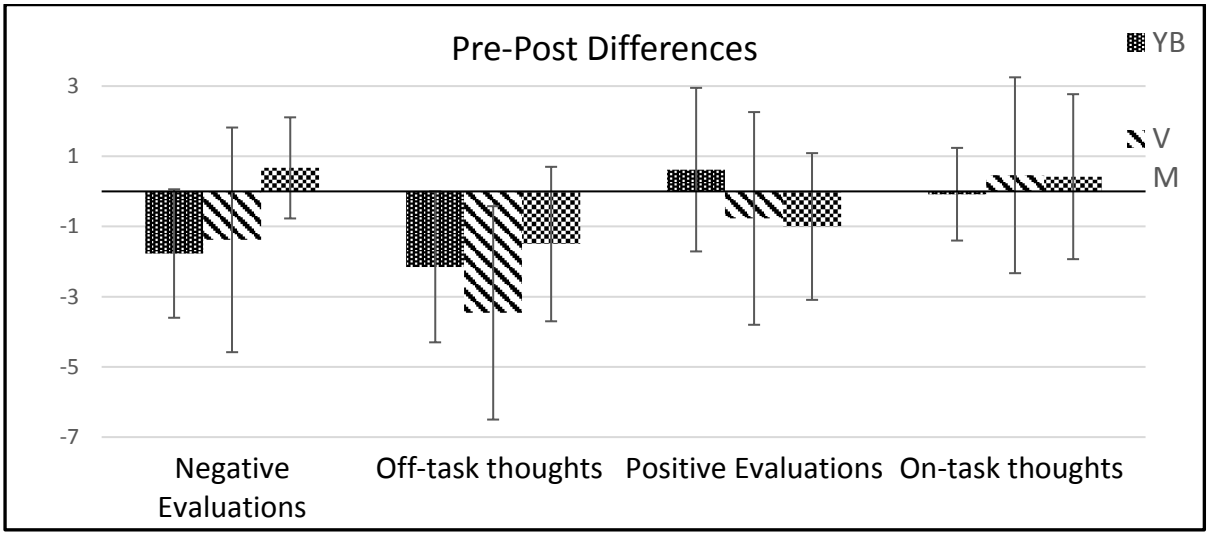
Caption figure 2: Figure 2 shows pre-post differences of all three math-anxiety score: Learning math-anxiety, Evaluation math-anxiety and total math-anxiety, between all three groups i.e., YB, VM and JG. VM group showed greater reduction in math-anxiety, followed by YB group. Standard deviations are shown by error bars.

Figure 3: Comparison of Stroop pre-post differences scores between YB, VM and JG groups



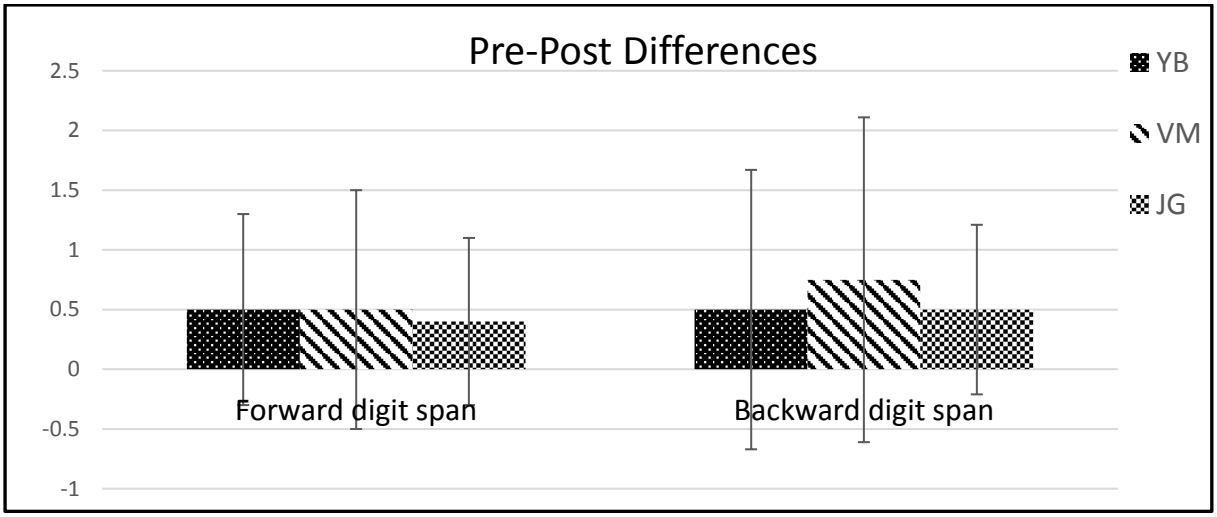
Caption figure 3: Figure 3 shows comparison of pre-post differences of all three parameters of stroop test score: Word score, Color score and Color word score, between all the three groups i.e., YB, VM and JG. VM group showed greater increase in color and color word scores. JG group showed maximum increase in word score. Standard deviations are shown by error bars.

Figure 4: Comparison of CCAQ pre-post differences scores between YB, VM and JG groups



Caption figure 4: Figure 4 compares the pre-post differences of all four parameters of CCAQ, between all the three groups i.e., YB, VM and JG. VM group showed greater reduction in Off-task thoughts, followed by YB group. YB was observed to have greater reduction in negative evaluation and maximum increase in positive evaluations. Standard deviations are shown by error bars.

Figure 5: Comparison of Digit span pre-post differences scores between YB, VM and JG groups



Caption figure 5: Figure 5 shows comparison of digit span pre-post differences: forward and backward span, between all the three groups i.e., YB, VM and JG. Standard deviations are shown by error bars.