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IMPROVED PERFORMANCE IN THE TOWER OF LONDON TEST FOLLOWING YOGA

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Abstract : Twenty girls between 10 and 13 years of age, studying at a residential school were randomly assigned to two groups. One group practiced yoga for one hour fifteen minutes per day, 7 days a week, while the other group was given physical training for the same time. Time for planning and for execution and the number of moves required to complete the Tower of London task were assessed for both groups at the beginning and end of a month. These three assessments were separately tested in increasingly complex tasks requiring 2-moves, 4-moves and 5-moves. The pre-post data were compared using the Wilcoxon paired signed ranks test. The yoga group showed a significant reduction in planning time for both 2-moves and 4-moves tasks (53.9 and 59.1 percent respectively), execution time in both 4-moves and 5-moves tasks (63.7 and 60.3 percent respectively), and in the number of moves in the 4-moves tasks (20.9 percent). The physical training group showed no change. Hence yoga training for a month reduced the planning and execution time in simple (2-moves) as well as complex tasks (4, 5-moves) and facilitated reaching the target with a smaller number of moves in a complex task (4-moves).

Key words: Tower of London yoga physical training planning execution

INTRODUCTION

Studies on patients with various forms of brain damage have indicated that the ability to plan and sequence behaviour in an orderly manner depends partly on the functioning of the pre-frontal cortex (1). The Tower of London test was developed to investigate planning abilities in patients with frontal lobe damage (2), though the test is now used to study planning ability in normal persons (3). In addition to planning strategy, the frontal association areas are needed for the execution of complex functions such as delayed response motor tasks and for changing strategies when required to do so (4).

The practice of yoga has been shown to facilitate mental functions such as visuospatial memory (5), and attention and concentration (6). The effect of yoga training

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has not been studied on planning. The present study aimed at assessing the performance in the Tower of London test, following yoga training. The study also aimed at assessing whether one or both of the two main components of yoga (i.e., increased physical activity and instructions to relax), would influence performance in this test, by comparing two groups, one of which practiced yoga, while the other had physical training, which consisted of increased physical activity without instructions to relax.

METHOD

Subjects

The subjects were 20 girls, whose ages ranged between 10–13 years, who were selected at random from a total of 34 girls of the same age range studying in a residential school.

Design

The 20 subjects were randomly assigned to two groups using a standard random number table (7). One group was given training in yoga, which included physical activity, instructions to relax, and awareness of physical and other sensations. The comparison group was given physical training, so that this group would also have a comparable amount of physical activity as the yoga group, but without instructions about relaxation and awareness. Physical training and Yoga were practiced by the respective groups as one hour fifteen minutes per day, for 7 days a week. Both groups were assessed at the beginning and end of a month, during which they carried on their respective practices.

Assessment

The Tower of London test requires the subjects to move an array of colored beads mounted on three vertical rods, to match a particular goal arrangement (2). For each subject increasingly complex goals were set, so that a subject had to complete three tasks, the first requiring 2 moves to reach the goal, the second 4 moves, and the third, 5 moves. Subjects were assessed based on planning time, execution time, and number of moves.

Yoga

The yoga training included physical postures (asanas), voluntarily regulated breathing (pranayama), internal cleansing practices (kriyas), meditation, devotional songs (bhajans) and relaxation techniques.

Physical training

Physical training consisted of standing and sitting exercises, jogging, bending forward, backward, and side ways, and lifting dumbbells.

Analysis

Post-pre comparisons of the data were made using Wilcoxon paired signed ranks test, for each group separately.

RESULTS

The group mean values (± SEM) of planning time, execution time, and number of moves, for both groups on Day 1 and Day 30 are given in Table I.

TABLE I: Effect of yoga on Tower of London test as compared to that of physical training.

		Yoga group		*Physical training group*	
		Day 1 (mean±SEM)	*Day 30 (mean±SEM)*	*Day 1 (mean±SEM)*	*Day 30 (mean±SEM)*
Planning time (in seconds)	2 moves	24.1±1.2	11.1±0.7*	19.3±0.9	16.8±0.9
	4 moves	47.4±2.1	19.4±0.9**	27.4±1.1	23.3±0.9
	5 moves	35.0±1.6	32.1±1.7	25.1±1.2	22.9±1.1
Execution time (in seconds)	2 moves	20.3±1.2	17.5±1.3	17.6±0.9	28.9±1.8
	4 moves	66.5±2.2	24.1±0.8*	51.9±1.7	40.8±1.5
	5 moves	94.0±2.5	37.3±1.3***	48.2±1.5	66.5±2.2
Number of moves taken to complete the task	2 moves	7.4±0.4	8.5±0.8	7.8±0.6	9.4±0.7
	4 moves	17.2±0.9	13.6±0.5**	18.1±0.8	16.0±1.0
	5 moves	22.8±0.9	20.2±0.7	21.8±1.0	21.6±0.6

*P<.02, **P<.01, ***P<.001, Wilcoxon paired signed ranks test, comparing the Day 1 values with the Day 30.

The yoga group showed a significant decrease in planning time for both 2-moves ($T = 3$, since $T_{.o2(2),\ 10} = 5$, hence $p<0.02$) and 4-moves ($T = 1$, since $T_{.01(2),\ 10} = 3$, hence $p<0.01$); in execution time for both 4-moves ($T = 3$, hence $p<0.02$) and 5-moves ($T = 0$, since $T_{.001(2),\ 10} = 0$, hence $p = 0.001$), and in the number of moves in the 4-moves task ($T = 1$, hence $p<0.01$). The physical training group showed no change.

DISCUSSION

Different aspects of planning, based on the Tower of London test changed following a month of yoga practice. For example, yoga brought about maximum improvement in execution time. The planning time also improved significantly, but in this respect the physical training group was already better at Day 1 than the yoga group. The latter fact limits the validity of the finding, although the improvement in yoga group is statistically significant. Finally, the number of moves made to complete the task remained essentially unchanged in both groups. If inspite of no appreciable effect on number of moves, the execution time improved dramatically after yoga, it means that yoga improved alertness, as a result of which a wrong move was quickly perceived to be so and a fresh move made without much delay. The possible mechanisms underlying these changes are described below.

Early studies correlated poor performance in the Tower of London task with frontal lobe damage (2). More recently it has been shown, using single photon emission computerized tomography (SPECT) that the level of regional cerebral blood flow increased in the left pre-frontal cortex during the Tower of London task in normal persons (3). The improvement in the performance of the Tower of London task in the present study, following a month of yoga training suggests that yoga practice improves frontal lobe function.

A position emission tomography study of regional cerebral metabolic responses

showed that ratios of frontal versus occipital responses were significantly higher during meditation in eight meditators (8). A functional magnetic resonance imaging study (9), also showed that the dorsolateral prefrontal cortex is among other regions which are activated during mediation.

Hence meditation practice appears to involve the frontal regions. The present study suggests that practice of meditation and other components of yoga for a month improves planning, which is a frontal lobe function. This improvement may be related in some way to the fact that meditation increases frontal lobe activity evidenced by an increase in regional cerebral blood flow.

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