Article

Cognitive Flexibility Through the Path of Yoga

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Abstract

Cognitive flexibility plays a crucial role in an individual's ability to adapt to the ever-changing situations and is associated with effective problem-solving and decision-making. Given the wide range of the impact of Yoga on physiological and psychological aspects of health, the purpose of the study was to examine the impact of Yoga-based practices (YBP) on cognitive flexibility among school students. The performance in digit letter substitution test (DLST) was assessed with 80 school students of fifth-grade and 78 students of ninth-grade immediately before and after participating in a single Yoga class and a control session of equal duration. The intervention comprised of YBP focusing on *pranayama* and relaxation meditation. Data were analysed using mixed-method ANOVA by comparing effect sizes between the two conditions supplemented by a within-group analysis. Most outcome measures exhibited a pattern of worsening in the control group over time, whereas changes in the Yoga group over time were either consistent or showed slight improvements. The findings suggest, at a preliminary level, that YBP are effective in improving students' cognitive flexibility as well as their academic school readiness. This information is important to consider as it aims at developing students' executive functions, thereby impacting their future.

Keywords

Yoga, cognitive flexibility, executive function, school students, cognitive performance, learning

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Introduction

Picture the following scenario:

> A student reaches the school and has a well-designed schedule for the day. As per the schedule, he/she has to solve quantitative problems, read literature, understand science and attempt experiments, answer quizzes, participate in co-curricular and extra-curricular activities such as music, debates, arts, sports, and interact with faculty and friends. In a nutshell, he/she has multiple tasks to do with changing set-up in a day's time.

The daily life too is full of changes and requires frequent shifts between cognitive tasks. Cognitive flexibility is defined as the ability of an individual to adapt one's own mental (cognitive) strategies as per the requirement to face new and unexpected situations in the environment (Cañas et al., 2003). It has also been referred to as shifting, attention switching, or task switching, and an ability to disengage from distractions of a prior task and focus on pertinent information in an upcoming task (Monsell, 2003). It is one of the executive functions denoting the high-level cognitive processes that facilitate new ways of behaving, and optimise one's approach towards unfamiliar circumstances.

The above-mentioned higher-order cognitive processes have emerged as crucial predictors of preacademic skills (Shaul & Schwartz, 2014) and learning and academic performance at school age (Jacobson et al., 2011; St Clair-Thompson & Gathercole, 2006). Therefore, cognitive flexibility plays a vital role in the learning in classroom setting as well for students to move easily between courses. Students exhibiting effective cognitive flexibility are likely to handle transitions easily, can move seamlessly between courses and tasks, and may successfully apply learning in one domain to problem-solving in another context. Among university students also, enhanced cognitive flexibility has been found to be associated with attention regulation, experiences of flow, and mindfulness (Moore, 2013), reduced anxiety, greater motivation and success in training programmes (Timarová & Salaets, 2011), and positive attribution of group work (Myers et al., 2009). Notably, cognitive flexibility is critical in overcoming cognitive inertia (Laureiro-Martínez & Brusoni, 2018) for decision-makers in organisations, and for the positive attitude of employees towards organisational change (Chung et al., 2012).

Further, previous research has discussed that executive functions including cognitive flexibility improve through the early school years and adolescence and more gradually during adolescence (Davidson et al., 2006; Huizinga & Van der Molen, 2007, see Romine & Reynolds, 2005, for meta-analysis and Best & Miller, 2010, for a review on executive functions). As a result, it is essential to look for ways to enhance cognitive flexibility right from a young age. Although, there are some studies on training cognitive flexibility in early and middle childhood (Cepeda et al., 2001; Kray et al., 2008; Zinke et al., 2012). However, few programmes have incorporated mind–body approaches such as Yoga and meditation, which are known to be effective self-regulatory practices.

Yoga is a holistic system of mind–body practices for mental and physical health comprising of multiple components such as physical postures for strength and flexibility, breathing exercises for effective respiratory functioning, relaxation

techniques for managing mental and physiological tension and stress, and meditation/mindfulness practices for enhancing mind–body awareness, attention and emotion regulation skills (Felver et al., 2015). There has been an increase in research exploring the benefits of Yoga-based interventions in education contexts and school settings (e.g., Khalsa et al., 2012).

In spite of the perceived importance of cognitive flexibility, the research employing YBP as an intervention is limited (e.g., Nejad et al., 2019). This study examines the potential of YBP to enhance cognitive flexibility among school students. Conducted with two different groups of school students, the study employed a pre–post experiment design and contributes towards the emerging research on mind-body interventions, their impact on higher cognitive functions, and their efficacy and applicability in school environment.

This article is structured in five sections. After the introduction, the next section presents the nature and importance of cognitive flexibility. The third section provides a primer on Yoga, and the hypothesised relationship between YBP and cognitive flexibility. The fourth section presents the research design, details of the sample, method, and research findings. The fifth section discusses the implications of the findings and scope for the future research.

Cognitive Flexibility: Nature and Its Importance

Considering that change is a constant, everyday life gives rise to numerous novel challenges and situations unlike the ones encountered before. This requires executive processing accompanied by a wide range of behaviours. This kind of processing is particularly instrumental when individuals make a plan for the future, voluntarily switch or shift from one task to another, or refrain from a temptation. Put differently, flexibility allows one to lead independent, purposeful life (Gilbert & Burgess, 2008). Frontal lobes of the brain have been posited to support these processes but, the current level of understanding is limited in nature (Monsell, 1996). However, cognitive neuroscience has made progress pertaining to the nature of these processes, and their underlying brain mechanisms.

As discussed, cognitive flexibility is an individual's ability to adapt the cognitive strategies to manage unexpected situations arising in the environment (Cañas et al., 2003). This definition comprises three important aspects: an ability involving a process of learning, adapting cognitive processing strategies with respect to problems and an element of uncertainty, and that adaptation occurs gradually post performing a task for some time (Cañas et al., 2006).

Cognitive flexibility depends on two factors, namely attention and knowledge (Cañas et al., 2006). As the situations keep on changing from time to time, there is a realisation that the response needs to be altered. To come up with a response that caters to the new situation, higher-level attention is needed. This enhanced attention helps in keeping away distractions that might hinder progress and allows mental resources to work on the new response and halt the automated (old) response. Cognitive flexibility is reflected in the knowledge an individual has in order to gauge the environmental signals and act accordingly. This knowledge is

enhanced by learning from previous experiences in similar situations. However, it undergoes revisions and modifications depending upon the requirements of a new task or situation.

The Cognitive Flexibility Theory (Spiro & Jehng, 1990) suggests that cognitive flexible people are able to draw a representation of a task from multiple viewpoints and this enables them to effectively interpret situational changes in the environment. Such individuals are dynamic in their approach to quickly restructure the knowledge, thereby formulating and adapting their responses appropriately with the evolving situational demands.

Importance of Cognitive Flexibility for the Students

Cognitive flexibility facilitates quick switching to alternative thoughts while facing problems and not getting hindered by them (Toraman et al., 2020). Martin et al. (1998) mention that the sense of competence is an underlying component in the concept of cognitive flexibility. Importantly, cognitive flexibility is positively associated with communication self-efficacy, assertiveness, responsiveness (Martin & Anderson, 1998), multi-tasking (Ionescu, 2012), problem-solving and creativity (Lin, Tsai et al., 2014; Ritter et al., 2012), inclination to collaborate, and leadership (Reiter-Palmon, 2003).

Moreover, cognitive flexibility can lead to positive thinking, and consequently, if thoughts become positive, feelings, behaviours and attitudes transform positively (Bilgin, 2009; Önen & Koçak, 2015). A resulting effect of enhancing cognitive flexibility would be that students will have more positive attitudes towards studying, specifically to study actively and forming the habit to study. Cognitive flexibility encompasses switching between modes of thought and considering multiple concepts at any given time, which is essential for learning, language development (Deák, 2003), arithmetical skills (Bull & Scerif, 2001), and academic achievement (Magalhães et al., 2020).

In light of the above discussion, in a classroom, some students are able to move comfortably between courses; however, some have difficult, i.e., they feel stuck or focus on one assignment or problem. This reflects their levels of cognitive flexibility. There can be a difference in abilities, but teachers can help create a classroom where all students improve their cognitive flexibility. Based on the performance on a dynamic task, it has been found that participants who performed better differed mainly in their capacity to adapt their strategies to arising conditions of the tasks, and not in the range of strategies or the ability to implement a strategy (Reder & Schunn, 1999).

Training

In the literature, many ways to improve executive and cognitive functions have been discussed, which include pharmacological, neurological, cognitive, cognitive-behavioural, metacognitive, aerobic and Yoga interventions (Ahmed &

Mohamed, 2011; Van der Straten et al., 2018). For instance, it has been reported that the direct electrical stimulation of the brain by the skull impacts working memory (Meiron & Lavidor, 2013). Other forms of trainings comprise computer-based training programmes for enhancing memory and reasoning (Bergman Nutley, 2011; Holmes et al., 2009), task-switching computer-based training (Karbach & Kray, 2009), traditional martial arts (Lakes & Hoyt, 2004), and aerobics (Kamijo et al., 2011). In the current times, there is a growing emphasis on non-pharmacological methods to improve cognitive and executive functions, which includes aerobic exercises, Yoga, mindfulness (e.g., Manjunath & Telles, 2001; Nejad et al., 2019; Zou et al., 2020). Yoga through its underlying components aims to achieve total health and physical and mental purification through mind and body practices. In a study examining the impact of Yoga exercises on executive functions, Gothe et al. (2013) showed better performance on executive functions post-Yoga than before training.

Yoga: A Brief Overview

The term Yoga originates from the Sanskrit word, which means 'to yoke'. However, it has stood for a multitude of meanings (join, union, renunciation, a means to liberation). Traditionally, it represents a mechanism that aims to bring an individual to the highest state of consciousness, that is, self-realisation. Although there are different branches of Yoga, namely: *Raja Yoga*, *Jnana Yoga*, *Hatha Yoga*, *Karma Yoga*, *Bhakti Yoga*, *Mantra Yoga* and *Tantra Yoga*, with a focus on particular competencies, at its core, the objective of Yoga is self-transformation (Feuerstein, 2013). It offers a way to effective self-regulation and better management of emotions by gaining an awareness of one's emotions and behaviours.

Yoga represents an ancient contemplative practice with its history dating back to over 3500 years in India. It aims to attenuate suffering and aid optimal physical and mental thriving (Cope, 1999; Feuerstein, 2011). Sage Patanjali gave an 'eight-limbed' structure to the yogic path and led to Yoga attain its classical form, known as Ashtanga Yoga (Feuerstein, 2011). This Classical Yoga based on its eight-fold path represents a comprehensive and an integrative system to cultivate morality, ethics, compassion, awareness, and self-transcendence.

Ashtanga Yoga comprises of the following eight practices: *Yama* (moral codes or ethics with respect to others), *Niyama* (self-purification or ethics with respect to self), *Asana* (postures and physical exercises), *Pranayama* (breath regulation), *Pratyahara* (sensory withdrawal), *Dharana* (concentration), *Dhyana* (meditation, effortless attention), and *Samadhi* (self-transcendence).

Yamas and *niyamas* lie at the foundation of the yogic path. These are the practices to harmonise an individual's social interactions as well as one's inner self and set the tone for quieting one's mind, regulate emotions, engage in helpful behaviours (Corner, 2009). *Asanas*, that is, the postures aim at physical control of the body to prepare for controlling the mind in meditation for elongated durations of time (Feuerstein, 2011). *Pranayamas* are specific breath control techniques to allow the breath or the life force to flow freely. *Pranayama* helps an individual in

down-regulating arousal and increasing one's awareness of the interaction between the body and the mind (Sovik, 2000). The next four limbs comprising *pratyahara, dharana, dhyana and Samadhi* aim to bring the mind under control from the various distractions and fluctuations (Gard et al., 2014). The emphasis here is to bring back the attention from the outside world towards the inner self by fixing attention and sustained concentration (Feuerstein, 2013). This consequently helps an individual to attain self-transcendence.

Neurological Impact of Yoga-based Practices

Existing research indicates the down-regulating effect of Yoga on both the sympathetic nervous system (SNS) and the hypothalamic–pituitary–adrenal (HPA) axis as a response to stress (Ross & Thomas, 2010). Activation of the SNS and activation of HPA are among the stress-reactive systems of the body (Herman, et al., 2011). Prolonged activation of the HPA system has been found to have detrimental effects on brain function (Sapolsky, 1992). HPA activation accompanied by higher cortisol concentrations can result in cognitive deficits (Franz et al., 2011).

Research evidence supports the immediate psychological effects of Yoga that include reduced anxiety (Kirkwood et al., 2005), depression (Uebelacker et al., 2010), stress (Chong et al., 2011), as well as enhanced well-being (Oken et al., 2006). Moreover, it has been suggested that Yoga facilitates cultivation of effective stress management and cause a shift toward parasympathetic nervous system dominance (Innes et al., 2005), which may impact cognitive performance.

Further, researchers on Yoga in the medicine and public health domains have assessed the benefits of Yoga in school settings (Eggleston, 2015). It was reported that Yoga improved psychological well-being, physical health (weight control), calmness and enhanced attention, and completing assigned tasks successfully.

Pranayama

The neurocognitive effects of Yoga breathing, that is, *pranayama* have been discussed in a narrative review. Authors of the study reported a positive impact of *pranayama* on neurocognitive abilities where studies included assessed performance on spatial and verbal memory tasks, auditory and visual reaction time, substitution and cancellation tasks (Saoji et al., 2019). In another study, therapeutic breathing exercises were introduced to improve academic performance and the self-regulatory behaviour. Based on a case study and a school-wide *pranayama* programme, involving two breathing exercises: deep breathing, and alternate nostril breathing, both of which showed improved academic performance and positive behavioural outcomes (Gupta et al., 2014). A study encompassing bellows breath, that is, an increased depth of breathing, found reduced auditory and visual reaction time among healthy schoolboys (Bhavanani & Udupa, 2003).

Similarly, high-frequency Yoga breathing was reported to improve the performance scores in an attention-based cancellation task post an immediate practice across different age groups (Telles et al., 2008).

Yoga and Cognitive Flexibility

Although research examining immediate effects of Yoga on cognitive flexibility are limited, studies have looked into its impact on broader executive functions. For instance, prior studies on Yoga including *asanas*, *pranayama*, meditation, and guided relaxation showed improvements in delayed recall of spatial information and verbal memory (Manjunath & Telles, 2004), a decrease in planning and execution time (Manjunath & Telles, 2001) among adults. School children also showed an improvement in cognitive performance as a result of three months of Yoga (Chaya et al., 2012). Further, the Yogic lifestyle brings about a positive impact on the planning ability and executive skills of school students (Rangan et al., 2008). Additionally, Yoga has been found to be an effective process for improving various cognitive functions of attention, concentration, attention span, processing speed, attention alternation ability in healthy young subjects (Prakash et al., 2010).

The high amount of competition and scarce opportunities available have made proactive adaptation with respect to uncertainty a norm. For instance, in the setting of an education institute, students are required to study and excel in a variety of skills and subjects over a period of time (day, week, month or year). And, this requires the ability to switch effectively from one task to another. Cognitive flexibility is the ability to switch between two distinct concepts and think about multiple concepts simultaneously (Scott, 1962). A cognitive flexible student would be in a better position to shift his frame of reference in accordance to the session that is happening, thereby appreciating what is taught and effectively absorbing the knowledge.

However, attention, which is an important factor that affects cognitive flexibility, tends to reduce with the passage of time and efforts expended. With every class that a student attends the level of attention reduces for the subsequent ones. Here, an intervention that can refresh and restart the minds of the students and boost up the attention levels would prove to be significant as YBP can calm and regulate the mind, centre attention and sharpen concentration.

The above-discussed neurological research focused on Yoga, *pranayama* and executive functions led us to the current hypothesis that a short YBP intervention involving 20 minutes of *pranayama* and relaxation meditation exercise could improve cognitive flexibility significantly. Despite an increase in the prevalence of Yoga exercise, research focusing on the relationship between Yoga and cognition is limited. As a result, in this study, we examined that cognitive flexibility can be improved as an immediate effect of Yoga and *pranayama* practice. We introduced Yoga as an intervention and hypothesised that it will be a key instrument in improving the cognitive flexibility of students as compared to their prior levels.

Research Method

Sample and Design

Participants included fifth- and ninth-grade students enrolled in a reputed school in the western part of India. Participants in the study were 80 students of fifth-grade and 78 students of ninth-grade comprising both boys and girls. In line with the developmental perspective, while there are some cognitive abilities that develop early in the childhood, the complete range of executive functions reach their potential till early adulthood (Davidson et al., 2006). And, early individual differences in cognitive abilities likely influence the successive (later in life) differences in learning skills (Wass, 2015). Since students of today represent the future managers and business leaders, facilitating their holistic growth including cognitive functions via trainings and subsequent assessment would be a step in the positive direction.

The study used a pre–post experiment design with control and experiment groups. The students of both fifth- and ninth-grade belonged to two sections. Of the 80 students of fifth-grade, students of one section served as the experiment group (n = 47) while the students of the other section represented the control group (n = 33). Similarly, of the 78 students of ninth-grade, one section served as the experiment group (n = 42) and the other section denoted the control group (n = 36). The participants in the experiment group were introduced to the YBP in one of their sessions. The participants in the control group were untreated and were instructed to disengage from other activities and pay attention to the task. This study was conducted as part of a school-based project of the first author. Permission to conduct the study was taken from the school authority: the Principal and respective teachers. The intervention training was rendered by the Yoga teacher employed at the school.

Instrument and Practice

Yoga-based Protocol. The intervention involved a short 20-minute Yoga-based protocol consisting of a mix of loosening-up exercises, warm-up exercises, *pranayama*, and relaxation. Loosening-up exercises included shaking the body and tapping the body from top to bottom and on-the-spot running constituted the warm-up exercise component. *Pranayama* element of the protocol comprised of four breathing exercises, namely: *dirgha pranayama* (slow, relaxed, complete breathing), *kapalabhati* (forceful exhalation), *anulom-vilom* (alternate nostril breathing) and *bhramari* (exhalation with the sound similar to that of a wasp). Finally, the protocol concluded with relaxation meditation comprising of observing deep breaths, rubbing the palms, and massaging the face.

Substitution Tests. The digit letter substitution test (DLST) was developed from Digit Symbol Substitution Test (DSST) (Natu & Agarwal, 1995) and is one of the subtests from the Wechsler Intelligence Scales (Wechsler, 1955). In the current

study, it was used to assess cognitive flexibility of the participants. The DLST is a worksheet consisting of 8 rows × 12 columns array of random digits 1–9. There is a supporting key, which gives the numbers 1 to 9, each paired with a different letter and the test items printed beneath the key. The objective is to substitute the digits with their respective letters.

Substitution tests are known to be extensively used in neuropsychology (Lezak, 1995). Substitution tests are fundamentally speed-dependent tasks that require a participant to match specific symbols, digits, or letters to other signs within a stipulated time period. It is important to note that substitution tests are sensitive to brain dysfunction in a nonspecific way as their performance is based on many different processes. The responses obtained in substitution tests are determined by neuropsychological processes, which comprise visual scanning, mental flexibility, sustained attention, psychomotor speed, and speed of information processing (Van der Elst et al., 2006; Van Hoof et al., 1998).

Procedure. Participants were instructed to choose their own strategy for the DLST whether they prefer to attempt horizontally, vertically, or selecting a particular digit randomly in the array one at a time. They were then instructed to substitute as many target digits as they can in the specified time of 90 seconds. Subsequently, they were asked to start the test, where time was kept on a smartphone's stopwatch. Net score obtained by a participant was calculated by deducting the number of wrong substitutions from the total number of substitutions attempted. To keep the scoring process unbiased, it was done by a person who was unaware of when the assessment was made ('before' or 'after' the intervention period).

Two questions (Questions 1 and 2) comprising of two different substitutions were used as part of the test. Data (scores) was collected for both the questions before (pre) the intervention and after (post) the intervention to measure the impact of the intervention on cognitive flexibility of the participants.

Data Analysis. To ascertain increase/decrease/no change, simple difference and percentage change were performed. Visual representation of the performance results in the form of graphs was also done. Mixed-design analyses of variance (ANOVA) were performed on the pre- and post-scores of Questions 1 and 2 for Fifth-Grade and Ninth-Grade, comparing the evolution of experimental and control groups over two points in time and examining the group × time interaction. Additionally, we undertook within-group analysis for each group to test the impact of intervention on Questions 1 and 2 for Fifth-Grade and Ninth-Grade via repeated measures ANOVA. For all analyses, effect size estimates are reported as partial eta squared.

Results and Findings

Fifth-Grade: Questions 1 and 2

Of the 47 students in the experiment group, 46 students completed Question 1 (both pre- and post-assessments) and 43 students completed Question 2 (both

pre- and post-assessments). And, of the 33 students in the control group, 29 students completed both Questions 1 and 2 (both pre- and post-assessments).

The positive impact of the YBP on cognitive flexibility is evident from the results presented in Tables 1 and 2. It can be seen from Table 1 that for the control group, there was a decrease in the performance of the students on the DLST by 12% in Question 1 and by 3% in Question 2 from its previous level.

We can also see that the performance of the students with respect to the DLST in the experiment group (YBP) increased from its former level. Table 2 provides that for Question 1, the performance of the students on cognitive flexibility increased by 13% (approximately) and similarly for Question 2, it increased by 6% from its prior level.

There was a significant group × time interaction effect for Question 1, $F_{1, 73} = 10.071$, $p = .002$, $\eta_p^2 = 0.12$, indicating an increase for the experiment participants as compared to the control group. The results of within-group analysis revealed significant positive change in the experimental group from the baseline to post intervention for Question 1 ($F_{1, 45} = 5.488$, $p = .024$, $\eta_p^2 = 0.11$). For the control group, a significant decrease was found in the performance on Question 1 ($F_{1, 28} = 5.081$, $p = .032$, $\eta_p^2 = 0.15$)

A non-significant group × time interaction effect (p-value > .05) $F_{1, 70} = 3.437$, $p = .068$, $\eta_p^2 = .05$ was found for Question 2; however, it indicated a trend towards significance at p < .10. Within-group analysis reported similar results for the experiment group (non-significant as p-value > .05) on Question 2 ($F_{1, 42} = 3.209$, $p = .08$, $\eta_p^2 = 0.07$), but significant (increase) at $p < .10$. However, a non-significant change performance on Question 2 ($F_{1, 28} = .906$, $p = .349$, $\eta_p^2 = 0.03$) was found for the control group from pre to post study.

Table 1. Fifth-Grade: Control Group

Control Group	Mean	Difference	% Increase\Decrease\No Change
Question 1_Pre	10.00	–1.21	(–) 12.10% (decrease)
Question 1_Post	8.79		
Question 2_Pre	24.79	–0.65	(–) 2.62% (decrease)
Question 2_Post	24.14		

Source: The authors.

Table 2. Fifth-Grade: YBP Group

YBP Group	Mean	Difference	% Increase\Decrease\No Change
Question 1_Pre	8.59	1.08	12.57% (increase)
Question 1_Post	9.67		
Question 2_Pre	22.72	1.42	6.25% (increase)
Question 2_Post	24.14		

Source: The authors.

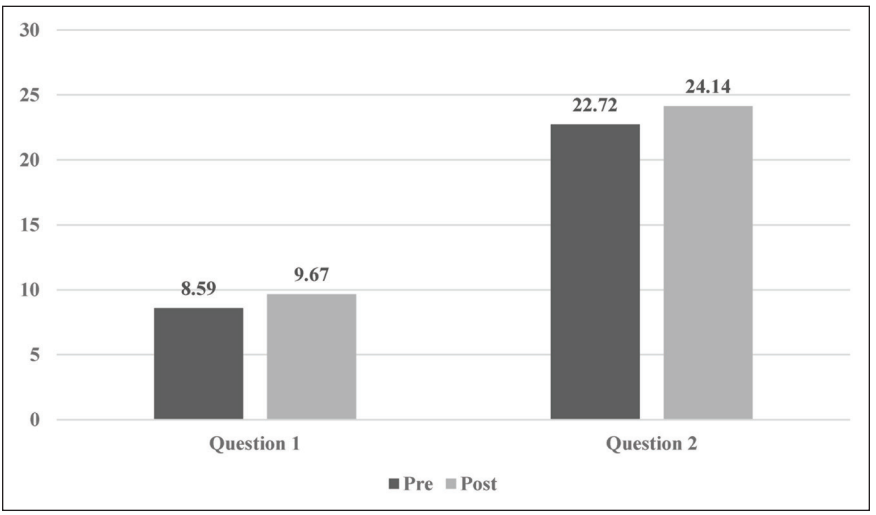

Figure 1. Graphs Representing Performance of Fifth-Grade: YBP Group
Source: The authors.

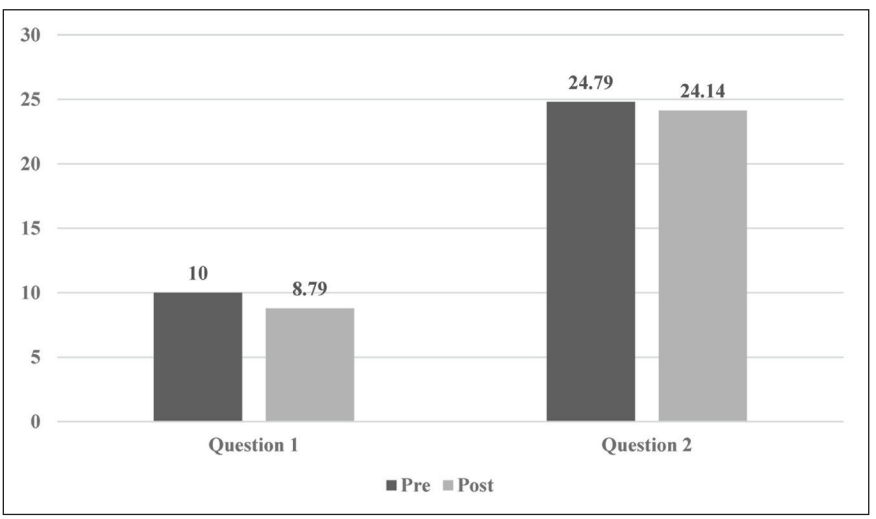

Figure 2. Graphs Representing Performance of Fifth-Grade: Control Group
Source: The authors.

Ninth-Grade: Questions 1 and 2

Of the 42 students in the experiment group, 41 students completed Question 1 (both pre- and post-assessments) and 39 students completed Question 2 (both pre- and post-assessments). And, of the 36 students in the control group, 32 students

completed Question 1 (both pre- and post-assessments) and 17 students completed Question 2 (both pre- and post-assessments).

The positive impact of the YBP on cognitive flexibility is evident from the results presented in Tables 3 and 4. It can be seen from Table 3 that for the control group, there was a decrease in the performance of the students on the DLST by 10% in Question 1 and by 65% in Question 2 from its previous level.

We can also see that the performance of the students with respect to the DLST in the experiment group (YBP) increased from its former level. Table 4 provides that for Question 1, the performance of the students on cognitive flexibility increased by 8% (approximately) and similarly for Question 2, it increased by 4% (approximately) from its prior level.

There was a significant group × time interaction effect for Question 1, $F_{1, 71} = 5.340$, $p = .024$, $\eta_p^2 = 0.07$, indicating an increase for the experiment participants as compared to the control group. The results of within-group analysis revealed non-significant change in the experimental group from the baseline to post intervention for Question 1 ($F_{1, 40} = 1.519$, $p = .225$, $\eta_p^2 = 0.04$). For the control group, a significant decrease was found in the performance on Question 1 ($F_{1, 31} = 8.241$, $p = .007$, $\eta_p^2 = 0.21$).

A significant group × time interaction effect $F_{1, 54} = 135.043$, $p < .001$, $\eta_p^2 = 0.71$ was found for Question 2 indicating an increase for the experiment participants as compared to the control group. The results of within-group analysis revealed non-significant change in the experimental group from the baseline to post intervention for Question 2 ($F_{1, 38} = 1.728$, $p = .196$, $\eta_p^2 = 0.04$). For the control group, a significant decline was found in the performance on Question 2 ($F_{1, 16} = 145.945$, $p < .001$, $\eta_p^2 = 0.90$).

Table 3. Results of ANOVA Analyses for Fifth-Grade

Fifth-Grade	Control Group		Within-group ANOVA	YBP Group		Within-group ANOVA	Mixed-design ANOVA
	Pre	Post	Significance	Pre	Post	Significance	Significance
Question 1	10.00	8.79	Significant →	8.59	9.67	Significant →	Significant
Question 2	24.79	24.14	Non-significant change	22.72	24.14	Significant at $p < .10$	Significant at $p < .10$

Source: The authors.

Table 4. Ninth-Grade: Control Group

Control Group	Mean	Difference	% Increase\Decrease\No Change
Question 1_Pre	9.84	–0.96	(–) 9.75% (decrease)
Question 1_Post	8.88		
Question 2_Pre	39.59	–25.71	(–) 64.94% (decrease)
Question 2_Post	13.88		

Source: The authors.

Table 5. Ninth-Grade:YBP Group

YBP Group	Mean	Difference	% Increase\Decrease\No Change
Question 1_Pre	8.78	0.73	8.31% (increase)
Question 1_Post	9.51		
Question 2_Pre	43.97	1.65	3.75% (increase)
Question 2_Post	45.62		

Source: The authors.

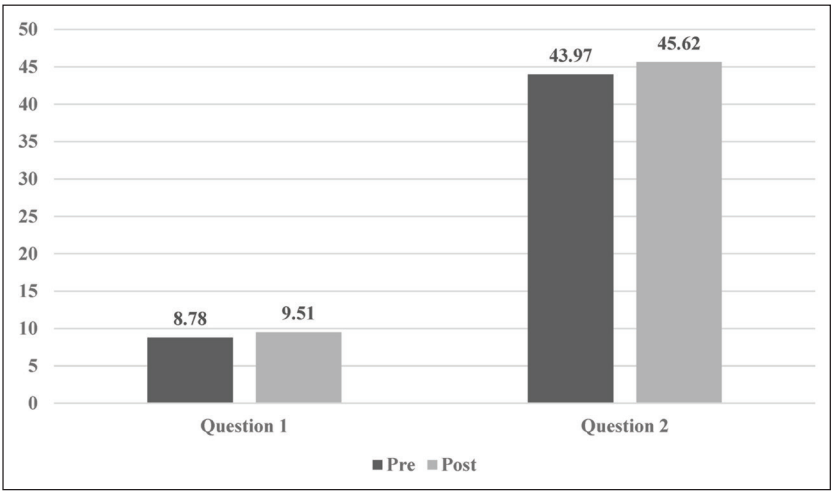

Figure 3. Graphs Representing Performance of Ninth-Grade:YBP Group

Source: The authors.

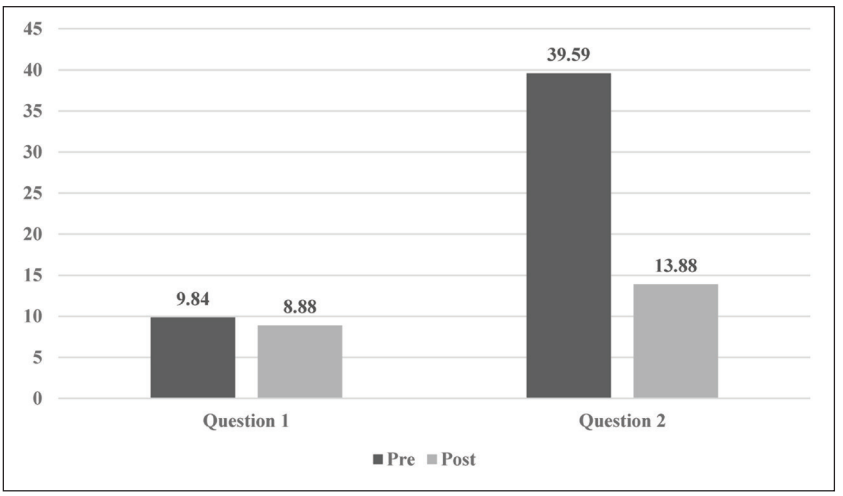

Figure 4. Graphs Representing Performance of Ninth-Grade: Control Group

Source: The authors.

Table 6. Results of ANOVA Analyses for Ninth-Grade

Ninth-Grade	Control Group		Within-group ANOVA Significance	YBP Group		Within-group ANOVA Significance	Mixed-design ANOVA Significance
	Pre	Post		Pre	Post		
Question 1	9.84	8.88	Significant →	8.78	9.51	Non-significant change	Significant
Question 2	39.59	13.88	Significant →	43.97	45.62	Non-significant change	Significant

Source: The authors.

Discussion

This study aimed to examine the effectiveness of YBP intervention on students' cognitive flexibility. The results of the study, based on two different groups of students, revealed that compared to the control group, the performance of YBP group on the tests assessing cognitive flexibility either remained consistent or slightly improved. In other words, the positive impact of YBP on executive function of cognitive flexibility was found. The findings of the present study on the effectiveness of Yoga on executive functions (e.g., working memory, attention) are in line with the previous studies (Avery et al., 2018; Badavi & Zinaali, 2019; Purohit & Pradhan, 2017). Yoga breathing techniques influence the brain cortex area that is associated with memory, attention, and executive functions (Gray et al., 2002). Additionally, high levels of stress at a young age can be detrimental to brain development and can adversely affect attention, learning, executive functioning and working memory, thereby impacting academic performance (Hedges & Woon, 2011). Yogic breathing regulates the autonomic functions via sympathetic-parasympathetic tone to manage stress (Pramanik et al., 2010), thereby maintaining effective cognitive functioning.

Further, flexibility is regarded as a cornerstone of human cognition and intelligent behaviour (Deák, 2003; Jordan & Morton, 2008) and has been found to be crucial for intelligence and creativity (Guilford, 1962). Creativity is essential for an individual whether it is one's education or the work one pursues. It is defined as the ability to generate new ideas that are useful (Sternberg & Lubart, 1996). It involves practising flexibility of perspectives to combine a variety of concepts in different ways and go beyond the existing paths (Benedek et al., 2012). This suggests the positive influence and the role of executive processes of cognitive flexibility on creativity (Pan & Yu, 2018). This association has further been supported by empirical research both in adults (Gilhooly et al., 2007; Pan & Yu, 2018) and children (Krumm et al., 2018). By highlighting the role of YBP in enhancing cognitive flexibility, the current study offers evidence on the efficacy of mind-body intervention in building creativity.

Schools are given the vital responsibility to prepare students for life. In doing so, schools provide an ecosystem comprising of social life of a real world, and a working environment for study and learning strategies under its roof. The strategies that are inculcated at schools have long-term bearing and increase the efficiency

in work life later. Therefore, schools should aim to nurture effective learning and studying strategies (Derry & Murphy, 1986; Önen & Koçak, 2015). Contemplative research, specifically studies that utilise Yoga interventions in school-based settings, is still emerging. This research contributes to a body of work suggesting that contemplative practices may be beneficial for school students by enhancing: psychosocial well-being (Felver et al., 2015), working habits, cooperative behaviour, and academic performance (Benson et al., 2000), and restful alertness, emotional intelligence, and performance (Rosaen & Benn, 2006).

Strengths of the study include its pre–post experiment design with the use of effective measures of cognitive flexibility. The limitations of the study include sample, that is, it was conducted on students belonging to one school and the impact of other school activities could not be ruled out. Future research can aim to study the effect of a similar intervention on a larger sample and long-term practice. Also, empirically studying the mechanism through which YBP impacts cognitive flexibility would be an interesting research question.

Conclusion

It is known that learning requires re-learning and repeated knowledge. The starting of the learning happens primarily in school. The students in the schools have to study about 14 subjects till they reach tenth-grade. The specialisation happens in various streams (science, commerce, arts) after ten years of schooling. Although, students have some likes and dislikes, yet studying all the subjects is deemed beneficial for them to decide their stream of interest. Consequently, to excel in the school studies, a student needs higher cognitive flexibility. It is important to note that cognitive flexibility is a crucial aspect of all stages of life. For instance, graduating from school to university calls for greater self-driven responsibility and accountability of time, resources, and novelty exploration. Similarly, as one begins the management endeavour in the organisation, managing multiple roles and tasks, decision-making and problem-solving become the norm. Therefore, given the rising level of complexity with progression in life and the need to adapt to changing situations and respond effectively, cognitive flexibility is crucial.

This study indicates that the cognitive flexibility of a student can be improved through the practice of YBP. The cognitive flexibility of the students saw an immediate rise after a small 20-minute *pranayama* and relaxation meditation session in this study, which may be a useful tool for the students. The effect of YBP on cognitive flexibility seen in the present study may have potential implications on learning, classroom behaviour and handling unfamiliar circumstances. When students practice the art of keeping their minds calm from a young stage of their lives, it would be easier for them to control their minds in the future.

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