

Impact of Pranayama, Hatha Yoga, and Raja Yoga Meditation on Executive Function and Metacognitive Regulation

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Abstract: The present investigation studies the effects of Pranayama, Hatha yoga and Raja yoga meditation on Executive Function and Metacognitive regulation. A sample of 60 students was selected for the study. They were randomly allotted to one of three yoga groups (pranayama, hatha yoga, raja yoga meditation) of 20 members. The working memory, inhibitory control and metacognitive regulation were measured by WAIS-IV working memory subtest, Stroop test and metacognitive awareness inventory (MAI) respectively. The pre-training test scores were collected following which they were provided yoga training for 30 days. Tests were again conducted at the 10-day point and at the end of training after 30 days. Findings revealed that all the three types of yogic patterns lead to an increase in Executive function and Metacognitive regulation. The length of training also affected the test scores. Longer the training, better were the scores on all three tests. The interaction effect of yoga type and length of training was only significant for metacognitive regulation.

Index terms: Pranayama, hatha yoga, raja yoga meditation, executive function, metacognitive regulation.

I. Introduction:

'Yoga', the connection of the Supreme Being with the living, is an orthodox school of Indian philosophy. In India, yoga is not only a form of physical exercise, but also a spiritual practice and a way of living.

In today's generation, yoga is gaining popularity as a way of achieving a healthy body and a healthy mind. Whether physical or mental, any problem can be solved by practicing yoga. It is not an instant magic miracle, but rather a long-term process, which requires patience and faith. Yoga is a science directed towards healing of problem. It enables the human body to be physically fit and strong, the human mind to be mentally stable, and thus leads to an all-round development of wellbeing. Yoga boosts human cognitive functions like memory, attention, and mental flexibility. With every day practice of yoga, one can control their own thoughts and emotions as well. Yoga actively stimulates the brain and nervous system. It inhibits the activity of sympathetic nervous system and activates the parasympathetic nervous system, which helps in attaining homeostasis, keeping the mind calm, regulating thoughts and increasing awareness.

The science of pranayama deals with experiencing and understanding prana and it's influenced by our life in the essence of controlling breath, hunger and thought. Pranayama is based on breathing techniques. Breathing is the mediator of it. Through the breathing process, we control our prana for a better result in our life. Breathing basically includes three processes: - inhalation, retention, and exhalation. In pranayama we inhale oxygen from air, then retain it for longer period of time, so that more oxygen reach to every cell of the brain, and then exhale carbon dioxide from cells. Breathing connects the function of the mind with the organ of the body. Concentration is an essential part of pranayama. We have to concentrate on the breathing, postures and also our present consciousness. The pranayama process activates parasympathetic nervous system so that one can feel calm, cool and relaxed after a stressful situation. One becomes more aware and can reflectively make any decision; there is no haphazard or any disturbance, so one can only concentrate on their present consciousness. People become more organized, their self-awareness is enhanced and so is the ability to distinguish right from wrong with a clear mind. Every day, we are hard at work, always busy with our exhausting routines. Thus, at the end of the week, we are not only physically tired, but also mentally fatigued. If we practice pranayama daily, then one can achieve mindfulness and feel relaxed. It also will help us in improving our cognitive functioning as we will be better able to tackle our everyday obstacles.

Hatha yoga requires physical force. Hatha loosely translates to "forceful". In western countries, most of the people practice it as physical force of action; it consists of physical postures which require more physical energy, power, balance, flexibility. It helps us to gain a physically fit and balanced body with greater concentration power. In Hatha Yoga, we confront our fears as well as our potentials by balancing attention between the body and the mind. Hatha Yoga is a science that takes into consideration bodily pains, poor posture, faulty breathing and incorrect walking, teaching greater awareness of the body as a whole, without separating it from the mind and influences all the senses. Hatha yoga focuses on the path towards personal wellness and enlightenment through physical, mental, and spiritual means.

Raja means royal; it is a royal form of yoga. It consists of yoga asanas with meditative methods. Raja yoga practitioners perform the yoga with full of concentration. It is the highest form of yoga, which leads to higher consciousness and enlightenment. Raja yoga meditation is a different form of yoga meditation. It empowers self, body and mind. For practicing Raja yoga meditation, one requires contemplation, reflection, concentration and imagination, so that they can reach to the deepest level of inner-self. Raja yoga meditation is a holistic approach that deals with the entire mechanism of human existence. Self-observation, self-initiation, self-realization are the common factors of Raja yoga meditation. During the 20-minute meditation, Raja yoga gives us the right

mental thought. It re-establishes harmony between man and his environment. It makes us aware of all the false identities, which are deep-rooted inside our consciousness. Meditation helps us to concentrate and create inner skills which may have been lost in our past.

Executive function is a higher-order cognitive function that deals with many other forms of cognitive functions. Cognitive flexibility, inhibition control, working memory, self-monitoring, planning, self-initiation, and attention, are all examples of executive functions. Basically, executive functions can be conceptualized as a broad roof where other cognitions shelter in. The concept of executive function was defined in the 1970s. The frontal lobe of our brain, specifically the prefrontal cortex, is responsible for executive functions. According to Delis (2012), “executive function reflects the ability to manage and regulates one’s behaviour in order to achieve desired goal”. Baddeley and Hitch (1974) proposed the model of working memory, which is one of the important process of cognitive function, specially a major form of executive function, with limited capacity to manipulate and store information. Working memory can hold audio, visual and spatial information up to very short period of time, and play a supervisory role in attention, memory, planning and execution. According to Goldman, Rakic and Christen (1994), inhibition is “the ability to reject an automatic tendency in a given situation”. Inhibitory control, also known as response inhibition or attentional inhibition, is another executive function. Inhibitory control means one’s ability to inhibit other stimuli when they are engaging in a particular task. It is the ability to inhibit distracting stimuli.

Metacognitive regulation is a cognitive strategy used most in learning and memory. Self-awareness and self-monitoring are required to use metacognitive strategy in any learning process. Metacognitive strategy tells us how information can be used in the proper manner in the proper situation, so that we can easily learn or memorize what we want to. Regulation of cognition means regulating consciousness/awareness to facilitate one’s cognitive processes. Planning, monitoring and evaluation are required to regulate our metacognition.

II. Research methodology:

1.1. Objectives:

1. To study the impact of the three different kinds of yogic patterns (pranayama, hatha yoga, raja yoga meditation) on executive functions and metacognitive regulation of college students.
2. To determine if the length of training of yoga has any impact in enhancing the executive functions and metacognitive regulation of college students.
3. To determine the interaction effects, if any, between the type of yoga and the length of training on the executive functions and metacognitive regulation of college students.

3.2. Description of the Tools:

- Executive Function (working memory): The Wechsler Adult Intelligence Scale (WAIS) is an IQ test to measure intelligence and cognitive ability of adults. Current version of WAIS was released in 2008 (WASI-IV), and is composed of four index components. For measuring working memory, WAIS-IV working memory subtest was used. This subtest consists of Digit span forward, Digit span backward, sequencing and arithmetic. For scoring the WAIS-IV manual was consulted. Test-retest reliabilities range from 0.70 (7 subscales) to 0.90 (2 subscales). Inter scorer coefficients are very high, all being above 0.90.

- Executive Function (Inhibitory control): For measuring inhibitory control, the Stroop colour and word test by Charles J. Golden and Shawna M. Freshwater of Nova South-Eastern University, was used. This test consists of three pages and each page contains 100 items, presented in 5 columns of 20 items. The word page consists of the words “RED”, “GREEN” and “BLUE”, randomly printed in black ink on white background. The colour page consists of 100 items, all written as XXXX, printed in either red, green, or blue ink. The colour-word page consists of the word from the word page printed in the colour from colour page; the two pages were blended item for item. In no case, does the word and the colour it is printed in, match one another. Golden (1975) reported reliabilities of .86, .82, and .73 for the individual version.

- Metacognitive regulation: For measuring metacognitive regulation Metacognitive Awareness Inventory (MAI) by Gregory Schraw and Rayne Sperling Dennison of Department of Educational Psychology, University of Nebraska at Lincoln, was used. It has 52 items measuring two dimensions: knowledge about cognition and regulation of cognition. Regulation of cognition consists of 5 sub processes (planning, information management, monitoring, debugging strategies and evaluation). Factors are reliable (0.90) and inter correlated $r = 0.54$.

3.3. Sample:

In the present study, 60 students (female) were selected who were new undergraduates in their college. Age of the students varied between 18 to 19 years. All students were enrolled in the stream of humanities and had no previous yoga experience.

3.4. Procedure:

The 60 participants were divided into three different yoga groups each consisting 20 members. First one was the pranayama group, second one was the hatha yoga group and the last one was the raja yoga meditation group. A 30-day yogic training program was provided to each group by yoga experts. Study was conducted at local college. All the three groups practiced for 30 minutes daily, for 30 days. Common pranayama techniques were provided like Anulom-bilom, Ekanashika, Kopalbhati (without blow), Kapalbhati (with blow), Bhramri, and OUM chanting. Hatha yoga training included some basic yogasanas like Padmasana, Bajrasana, Ardhakurmasana, Paschimottasana, Halasana Setubandhasana, Tadasana, Birbhadrasana, and Brikhasana. For the session of raja yoga meditation, basic simple meditative technique was provided, which mainly focused on self-awareness and concentration on

present task. Data were collected initially before giving yoga training and then data collection was repeated after ten days and twenty days of yoga training.

3.5. Statistical analysis:

- Mean and SD were calculated for each group of yoga training (pranayama, hatha yoga, raja yoga meditation) pre-training, after 10 days and after 30 days of training in terms of executive function (working memory, inhibitory control) and metacognitive regulation.
- Two-way analysis of variance (ANOVA) was done for comparing each group of yoga training (pranayama, hatha yoga, and raja yoga meditation), length of training (pre-training, after 10 days of training and after 30 days of training) and their interaction effect in terms of executive function (working memory, inhibitory control) and meta-cognitive regulation.

III. Result:

Table1: Show the mean and SD between the group of yoga training and days of practicing in term of working memory.

Days of Training	Groups of Yoga Training					
	Pranayama		Hatha Yoga		Raja Yoga	
	Mean	SD	Mean	SD	Mean	SD
Pre-training	33.4	4.10	29.95	4.51	35.2	4.82
After 10 days	38.35	5.01	33.45	4.43	39.95	3.95
After 30 days	45.4	4.88	38.75	4.68	46.15	3.88

Table1 reveals that mean values after 30 days of training are higher than 10 days of training and pre-training in the context of pranayama, Hatha yoga and Raja yoga meditation. Thus, it can be said that although all yogic patterns are successful in enhancing working memory, the longer one practices yoga, the better will be the result.

Table 2: Show the mean and SD between the group of yoga training and days of practicing in term of inhibitory control.

Days of Training	Groups of Yoga Training					
	Pranayama		Hatha Yoga		Raja Yoga	
	Mean	SD	Mean	SD	Mean	SD
Pre-training	-8.12	4.32	-9.93	9.48	2.54	5.15
After 10 days	-3.55	4.45	-8.18	8.74	7.61	9.03
After 30 days	-3.28	4.79	-4.52	8.53	9.84	8.40

Table2 reveals that mean values after 30 days of training are higher than 10 days of training and pre-training in context of Pranayama, Hatha yoga and Raja yoga meditation. Thus, all yoga types were successful in improving inhibitory control of the college students. Also, longer the training, better the result.

Table3: Show the mean and SD between the group of yoga training and days of practicing in term of metacognitive regulation.

Days of Practicing	Groups of Yoga Training					
	Pranayama		Hatha Yoga		Raja Yoga	
	Mean	SD	Mean	SD	Mean	SD
Pre-training	4.39	0.31	3.38	0.31	4.18	0.41
After 10 days	4.78	0.23	4.58	0.17	4.71	0.26
After 30 days	4.93	0.12	4.87	0.13	4.93	0.11

Table3 reveals that mean values after 30 days of training are higher than 10 days of training and pre-training in context of Pranayama, Hatha yoga and Raja yoga meditation. Thus, all yoga types enhanced metacognitive regulation, and it improved further with longer training days.

Table4: Show the comparative picture of two-way analysis of variance (ANOVA) in terms of working memory.

Source	Sum of Square	df	Mean of Square	F ratio	Sig
Yoga Types	1353.211	2	676.606	33.512	0.000**
Days of Training	3392.011	2	1696.006	84.002	0.000**
Yoga Types * Days of training	53.922	4	13.481	0.668	0.615

**significant at 0.01 level of significance

Table 4 reveals that there is a significant main effect of yoga types on working memory $F(8,171) = 33.512$ at 0.01 level of significance. There is also a significant main effect of days of training on working memory, $F(8,171) = 84.002$ at 0.01 level of significance. And F ratio of interaction effect is $F(8,171) = 0.668$, which is insignificant.

Table5: show the comparative picture of two-way analysis of variance (ANOVA) In terms of Inhibitory control.

Source	Sum of Square	df	Mean of Square	F ratio	Sig
Yoga Types	7131.244	2	3565.622	70.352	0.000**
Days of Training	870.556	2	435.278	8.588	0.000**
Yoga Types * Days of training	205.083	4	51.271	1.012	0.403

**significant at 0.01 level of significance

Table 5 reveals that there is a significant main effect of yoga types on inhibitory control $F(8,171) = 70.352$. There is also significant main effect of days of training $F(8,171) = 8.588$. But the F-ratio of interaction effect is 1.012, which is insignificant. Thus, both the main effects are significant but the interaction between them isn't.

Table6: Show the comparative picture of two-way analysis of variance (ANOVA) In terms of meta-cognitive regulation.

Source	Sum of Square	Df	Mean of Square	F ratio	Sig
Yoga Types	2.323	2	1.162	18.760	0.000**
Days of Training	19.392	2	9.696	156.580	0.000**
Yoga Types * Days of training	1.389	4	0.347	5.607	0.000**

** Significant at 0.01 level of significance

Table 6 reveals that there is a significant main effect of yoga types on meta-cognitive regulation $F(8,171) = 18.76$. There is also a significant main effect of days of training on meta-cognitive regulation, $F(8,171) = 156.58$. The F-ratio of interaction effect is 5.607, which is significant at 0.01 level. Thus, both the main effects and their interaction effect are significant. This mean not only does the yoga type and days of training affect metacognitive regulation, but their interaction also plays a significant role.

Discussion:

Executive Function is a broad category of cognitive function or cognitive task and it deals with many forms of cognitive task like working memory, inhibitory control, mental flexibility, decision making etc. Different types of yoga training (pranayama, Hatha yoga and Raja yoga meditation) differ significantly in terms of improving working memory and inhibitory control. Current study has shown that all the three types of yoga can increase the power of working memory and inhibitory control of the college students. Each student has the ability to perform executive functions but they differ in this ability. Students may want to increase their level of executive functioning for their benefits through which they can easily accomplish any task. Doing yoga regularly can increase the level of executive function among the students.

Different types of yoga (pranayama, Hatha yoga and Raja yoga meditation) differ significantly in terms of metacognitive regulation but current study has shown that all the three kinds of yogic patterns have the capability to enhance the regulation of metacognition by the students. Metacognitive regulation brings success in academic achievement among students. It enables each learner to monitor the learning processes and to control them.

Another finding revealed by the present study is that the length of training also had an effect on improving the working memory, inhibitory control and metacognitive regulation of the college students. It has been found that the longer the students trained, the showed more positive improvement.

II. Conclusion:

One-month program of yoga promoted cognitive functioning specifically manipulation and maintenance of working Memory and increase inhibition, shorter reaction time and increase concentration. Enhancement of metacognitive regulation is reflected by yoga among students. Pranayama, Hatha yoga and Raja yoga meditation all three are differ significantly in terms of Executive Function and Metacognitive regulation.

III. Implication of this Study:

There are two important cognitive functions behind every human task: the executive function and cognitive regulation. The importance of these two factors is immense especially among students as they are constantly working towards building their careers. Some cognitive factors, responsible for the success of their careers, are memory, planning, organizing, evaluation, attention and concentration. But these cognitive factors are not evenly distributed in all. Those who have less ability to perform cognitive functions are far behind their peers in society. They need to increase their level of cognitive function so that they can compete fairly. Increasing the level of cognitive function, requires a variety of clinical interventions and medications. But it can be enhanced through something besides clinical intervention, like yoga practice. It can be used for the clinical population just as well (yoga use as a clinical intervention need more supported research). The present study has shown that yoga can increase the cognitive function of some normal population students; even if only a small amount. In the same way if one practices yoga more and can make it a habit, it can have many beneficial effects on themselves and the society.

IV. Limitations of the Study:

This study was conducted within a very short period of time, so few areas of interest could not be properly explored. The sample size was quite small and consisted only female college students. The result cannot be generalized to the whole population due to lack of sample size and sample homogeneity. One month of yoga practice alone is not enough to enhance a person's complete cognitive function. Further details analysis by taking a large samples and quantitative research on this area may give better and accurate reason behind these results. Due to certain constraints further, statistical analysis could not be used to compare the yoga types to one another.

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