

Level of cognitive flexibility among yoga and non-yoga university students: a cross-sectional study

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Abstract:

The ability to adapt to new situations, shift between thoughts, or tackle different problems using a variety of strategies is known as cognitive flexibility. It is essential for effectively solving problems and strengthening student's ability to communicate and interact in healthier ways. Several studies provide further evidence of the benefits of yoga on cognitive flexibility. Two hundred normal healthy university students ages ranged between 18 and 25 years (male: female = 1: 1) were participated in the study. There were two groups: (i) the students practicing yoga regularly (n = 100) and (ii) the students naïve to yoga (n = 100). Signed informed consent from all the participants were obtained prior to the investigation. The present research was a cross-sectional study with one-time assessment. A standardized cognitive flexibility inventory was administered to assess the level of cognitive flexibility of the participants. To compare the data of yoga and non-yoga group, independent *t*-test was performed using SPSS, version 24.0. Females in yoga and yoga naïve group showed a higher cognitive flexibility as compared to male participants of the respective groups, although there were no statistically significant changes found. The outcomes of the present study showed a significant higher score ($p < 0.001$) of cognitive flexibility in yoga group in comparison to yoga naïve group. Female participants showed higher scores of cognitive flexibility in comparison to male participants (overall). Based on the present findings, it can be concluded that different aspects of yoga practice may be applied as an intervention to enhance cognitive flexibility in students.

Key words: Yoga, Cognitive flexibility, University Students.

Introduction:

The ability to easily switch between two distinct viewpoints and to think about many concepts at once has been termed to as cognitive or mental flexibility (Scott, 1962). Cognitive flexibility is essential for maintaining students' ability to communicate and interact in a healthier style (Stevens, 2009) and for successfully addressing issues because it is defined as the capacity to change viewpoints, adapt to

changing situation, or tackle various problems using a variety of approaches (Martin et al., 2003). Particularly, cognitive flexibility is a fundamental ability for dealing pressure in challenging and unfavorable situations (Diamond, 2021).

Three key elements comprise cognitive flexibility: self-efficacy, willingness to adjust to changing scenarios, and an

understanding of many alternative approaches in stressful situations (Wolff et al., 2017). It is closely linked with interpersonal skills (Smith and Davis, 2022) and ability to solve problems (Bedel and Ulubey, 2015). According to research studies, those who engage in such behaviors show more self-confidence, understanding, and focus (Çelikkaleli, 2014). They are able to develop innovative methods of coping and switch out negative thoughts with positive ones (Arslan and Türk, 2022). In this way, it significantly impacts various aspects of daily life and learning processes.

Students encounter a turning point in college that impacts their lives, preferences, and choice in various domains. Social and educational interactions are significant and students may face a variety of difficulties, such as adjusting to a new setting or handling relationships with another person. When faced with these difficulties, it is essential to use practical strategies and keep a positive perspective on possible solutions (Güvenç, 2019). Students in universities may have high levels of cognitive flexibility and critical thinking abilities, which allow them to solve problems in various capacities and adapt to change with comfort (Serpın Eşiyok, 2016).

Cognitive flexibility is integral to healthy cognitive functioning and emotional well-being. It is related with the ability to manage and adapt to life's challenges, making it a cornerstone for mental health (Kashdan and Rottenberg, 2010). A lack of mental flexibility which is also known as mental rigidity, is a characteristic of various mental disorders (Kashdan and Rottenberg, 2010). Conversely, enhancing cognitive flexibility through mindfulness training has been shown to reduce mental rigidity and improve overall mental health (Greenberg, Reiner, & Meiran, 2012). This enhancement is believed to stem from the role of attentional processes in

mindfulness practice, which promotes an open and adaptive mindset (Moore and Malinowski, 2009). Individuals with higher cognitive flexibility are better able to cope with stress and adapt to emotional challenges.

During and after COVID-19, many students faced low level of happiness and disturbed mental state. So, there is a big need to examine the possible role of yoga in developing different aspects of cognitive flexibility as yoga therapy is a well-known and commonly used complementary and alternative intervention to enhance different aspects of cognitive and emotional ability. The present investigation aimed to compare the level of cognitive flexibility of yoga and non-yoga practitioners' university students.

Literature review:

Based on recent studies, yoga might improve cognitive performance. A 6-session of yoga intervention has been associated with higher mindfulness scores and improvement in the working memory measures for manipulation and maintenance (Brunner, Abramovitch and Etherton, 2017). Engaging in yoga postures improves physical health and mental well-being, indirectly supporting cognitive functions. An 8-week *hatha yoga* intervention enhanced executive functions, including working memory and mental set shifting, in older adults, suggesting that yoga postures contribute to overall cognitive flexibility by promoting physical and mental well-being as well (Gothe, Kramer, & McAuley, 2014).

In an investigation, newly admitted substance abusers following an in-patient rehabilitation program were asked to rate the effectiveness of a yoga-based intervention as a supplement to physical activity to enhance cognitive skills. 96 male participants (ages ranged between 16 and 40 years) were part of this

randomized, matched design. In addition to receiving regular rehabilitation care, subjects in the yoga or physical activity group received daily training under observation for a period of 12 weeks. Based on the outcomes, cognitive functions are improved by the addition of yoga or exercise-related therapies (Gaihre and Rajesh, 2018). Another study examined at how the yoga program improved nursing students' levels of happiness, feelings of worth, and depression symptoms. The study included 54 nursing students, involving 27 participants in each of the experimental and control groups. For 8 weeks, the study participants received a twice-weekly yoga education that included 25 fundamental postures. Everyone who attended were also given yoga manuals so that they could practice on their own. The control group followed everyday schedule and did not engage in yoga. After the yoga program, the experimental group's average scores for happiness and self-esteem were significantly greater than those of the control group (Suvarnarong et al., 2014).

Regular meditation practice also enhances cognitive flexibility by improving attention and reducing cognitive interference. Several studies support this relationship. Moore and Malinowski (2009) found that Buddhist meditators exhibited superior attentional performance and cognitive flexibility compared to non-meditators, with significant correlations between mindfulness scores and test outcomes. Hartkamp and Thornton (2017) observed positive improvements in subjective measures of mindfulness, positive functioning, and well-being following a 6-day intensive *Vipassana* (mindfulness) retreat, despite no significant changes in cognitive performance beyond practice-related improvements. Breathing exercises and relaxation techniques increase mental clarity and reduce stress, contributing to better cognitive flexibility. Pandey and

Dagar (2022) found significant improvements in cognitive flexibility among school students following yoga-based practices focusing on *pranayama* and relaxation.

Several other studies provide further evidence of the benefits of yoga on cognitive flexibility. A 40-minute daily yoga intervention significantly enhanced cognitive flexibility and selective attention among adolescent students (Tripathi and Vajpeyi, 2017). Nejad, Mojtabaie, & Mirhashemi (2019) demonstrated that yoga training was more effective than emotion regulation training in enhancing cognitive flexibility among high school students. Ciganovic and Sharma (2023) reported significant improvements in cognitive flexibility, internal locus of control, and emotional regulation in employees working in IT sectors following a 12-week yoga program.

The evidence strongly supports that yoga practices, including meditation, *pranayama*, and *asanas*, enhance cognitive flexibility. These practices improve attention, reduce stress, and promote mental clarity and well-being, collectively contributing to better cognitive flexibility.

Based on the available literature, the following hypotheses were formed:

There would be significant difference in cognitive flexibility between yoga and non-yoga practitioners' university students.

There would be gender differences in the level of cognitive flexibility in university students.

Research Methods

Participants

Two hundred normal healthy university students ages ranged between 18 and 25 years (male: female = 1: 1) were participated in the study. There were two groups: (i) the students practicing yoga

regularly (n = 100) and (ii) the students naïve to yoga (n = 100). Participants were selected from Patanjali group of institutions, Haridwar located in the northern region of India. Participants having at least one year of yoga experience (for yoga group) and those who were willing to follow the study conditions were included for this investigation. Participants with a diagnosed illness and those who were taking alcohol or any drug were excluded. Prior to the study, signed informed consent from all the subjects were obtained. The study was approved by the Research Degree Committee of T. M. Bhagalpur University, Bihar. Demographic data (about personal information, health, socio-economic status and the experience of yoga etc.) were taken from all the participants before administration of the psychometrics.

Design of the study

The present study was a cross-sectional study with one-time assessment. Standardized psychometric test was administered after familiarizing the participants with the testing procedure and the study protocol.

Measures

A reliable and valid psychometric tool ‘Cognitive flexibility inventory (CFI)’ was used to measure the level of cognitive flexibility of the university students (Dennis and Vander Wal, 2010). The inventory was administered which have composed of 20 self-report items with 7-points Likert scale. When evaluated in two

stages (test-retest), Dennis and Vander Wal (2010) observed a two-factor structure (control and alternatives) and adequate internal consistency. The scale's Cronbach's alpha is .90 for time 1 and .91 for time 2. Based on Shareh, Farmani, & Soltani (2014), the scale's psychometric properties are satisfactory.

Scoring

Standard scoring procedure was followed as mentioned in the manual (Dennis and Vander Wal, 2010). Each statement was rated by the participant from 1 (Strongly disagree) to 7 (Strongly agree).

Data analysis

To compare the raw data of yoga and non-yoga group, data analysis (unpaired or independent sample *t*-test) was done using Statistical Package for the Social Sciences, Version 24.0.

Results:

Detailed results have been reported in Table 1-6 below.

Within group comparisons

Gender-wise changes in cognitive flexibility in yoga group

Females in yoga group showed a higher cognitive flexibility as compared to male participants. The mean and standard deviation (S.D.) between males and females showed changes in cognitive flexibility in yoga group are presented in Table 1.

Table 1. The mean, S.D. and t-value between males and females within yoga group

Yoga group (n=100)		t-value	95%CI		P Value
Males (n=50)	Females (n=50)		Lower limit	Upper limit	
106.60 ± 13.79	107.74 ± 15.01	0.395	-40.581	6.860	0.693

Gender-wise changes in cognitive flexibility in yoga naïve group

Females in yoga naïve group also showed higher scores of cognitive flexibility, although did not showed statistical significant changes. The mean and

standard deviation of changes in cognitive flexibility in yoga naïve group are presented in Table 2.

Table 2: The mean, S.D. and t-value between males and females within yoga naïve group

Yoga naïve group (n=100)		t-value	95%CI		P Value
Males (n=50)	Females (n=50)		Lower limit	Upper limit	
96.86 ± 16.790	101.06 ± 16.412	1.265	-2.389	10.789	.209

Between group comparisons

Overall changes in cognitive flexibility

There were two hundred students who were participated in the present study. The outcomes of the present investigation showed a significant higher scores of

cognitive flexibility in yoga group in comparison to yoga naïve participants. The mean and standard deviation between the two groups are presented in Table 3.

Table 3: Showing the mean, S.D. and t-value between yoga and yoga naïve participants.

Groups (Overall)		t-value	95%CI		P value
Yoga (n=100)	Non-yoga (n=100)		Lower limit	Upper limit	
107.17±14.35	98.96±16.65***	3.735	3.875	12.545	<0.001

Level of significance: ***p<0.001, Independent sample t-test.

Overall Gender-wise changes in cognitive flexibility

The female participants in the present study showed higher scores of cognitive flexibility in comparison to male participants. The mean and standard

deviation between males and females (overall) showed changes in cognitive flexibility are presented in Table 4.

Table 4. The mean, S.D. and t-value between overall males and females

M (n=100)	F (n=100)	t-value	95% CI		P value
			Lower limit	Upper limit	
101.73 ± 16.05	104.40 ± 16.01	1.178	-1.800	7.140	0.240

Changes in cognitive flexibility in male participants

Yoga group’s male participants showed a significant higher scores of cognitive

flexibility in comparison to yoga naïve male participants. The mean and standard

deviation between the two groups are presented in Table 5.

Table 5: The mean, S.D. and t-value between yoga and yoga naïve male participants

Groups (Male)		t-value	95%CI		P value
Yoga (n=50)	Non-yoga (n=50)		Lower limit	Upper limit	
106.60±13.79	96.86±16.79	3.17	3.643	15.837	0.002**

Level of significance: **p<0.01, Independent sample t-test.

Changes in cognitive flexibility in female participants

Yoga group’s female participants showed a significant higher scores of cognitive flexibility when the scores were compared

with yoga naïve female participants. The mean and standard deviation between the two groups are presented in Table 6.

Table 6: The mean, S.D. and t-value between yoga and yoga naïve female participants

Groups (Female)		t-value	95%CI		P value
Yoga (n=50)	Non-yoga (n=50)		Lower limit	Upper limit	
107.74±15.01	101.06±16.41	2.124	0.437	12.923	0.036*

Level of significance: *p<0.05, Independent sample t-test.

Discussion and conclusion:

Gender-wise and overall changes in cognitive flexibility in yoga and yoga naïve group were reported. Females in yoga and yoga naïve group showed a higher cognitive flexibility as compared to male participants of the respective groups, although there were no statistically significant changes found. The outcome of the present investigation showed a significant higher score (p<0.001) of cognitive flexibility in yoga group in comparison to yoga naïve participants.

In the present study, female participants showed higher scores of cognitive flexibility in comparison to male participants (overall). Yoga group’s male participants showed a significant higher score (p<0.01) of cognitive flexibility in

comparison to yoga naïve male participants. Yoga group’s female participants showed a significant higher score (p<0.05) of cognitive flexibility when the scores were compared with yoga naïve female participants.

Yoga practices, including *asanas* (physical postures), *pranayama* (breath regulation), and meditation, have been shown to enhance cognitive flexibility through various physiological and psychological mechanisms. *Pranayama* and meditation help balance the autonomic nervous system by increasing parasympathetic activity and reducing sympathetic arousal. This balance promotes a state of relaxation and mental clarity, enhancing cognitive functions such as flexibility and problem-solving (Zou et al., 2020).

Meditation practices, such as mindfulness on regular basis improve attention and reduce cognitive interference. Enhanced attentional control allows for better task-switching and adaptation to new information. Studies have shown that mindfulness meditation leads to better performance on tasks requiring cognitive flexibility (Moore and Malinowski, 2009). Yoga improves emotional regulation through practices that focus on awareness and acceptance of emotions. This improved emotional regulation reduces the impact of stress and anxiety on cognitive processes, allowing for greater cognitive flexibility (Garland, Gaylord & Park, 2011).

Regular yoga practice reduces cortisol levels, a hormone associated with stress. Lower cortisol levels are linked to improved cognitive performance, including enhanced flexibility in thinking and problem-solving. This reduction in stress hormones supports better executive function and mental agility (Carei et al., 2010). Regular yoga practices also encourage cognitive reappraisal, a form of emotion regulation where individuals reinterpret stressful situations in a more positive light. This skill enhances cognitive flexibility by allowing individuals to view problems from

multiple perspectives and find creative solutions (Zou et al., 2020).

Studies could be carried out with larger and more diverse sample sizes from different educational institutions and locations to improve the study's generalization. In order to examine how cognitive flexibility changes with age, longitudinal research can be conducted. It is possible to develop educational programs or interventions that promote cognitive flexibility and innovative thinking abilities, and exploratory studies can be used to analyze their results. It is also possible to look at how such behaviors affect different age groups.

Based on the present findings, educational institutions may design inclusive education programs to develop cognitive flexibility and creative thinking skills. For students who wish to enhance different aspects of their cognitive abilities, educational institutions may offer guidance and counseling services. This might encourage teachers to include strategies for enhancing these skills in their planning of lessons and teaching methods (Karakuş, 2024). The present study definitely provides valuable insights for researchers and stakeholders in higher education and help different organization in making policies.

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