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Comparison Of Cognitive Abilities Of Yoga And Non-Yoga Secondary And Senior Secondary School Students

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Abstract
Aim: This study aimed to investigate the effects of three distinct physical activity interventions on cognitive abilities. A post-test research design was employed to compare the cognitive performance of 94 participants divided into three groups: Hatha Yoga (n=30), Walking (n=32), and Control (n=32) in the age range of 14 to 18 years, 67 males and 27 females. All the three groups participated in their respective interventions for 35 minutes per day, 5 days a week for 5 weeks.
Measurement tool: A standardized cognitive assessment test (CAT) was administered to all the participants post-intervention. Descriptive statistics and ANOVA were utilized to analyze differences in cognitive abilities (awareness, memory, understanding, reasoning ability, problem-solving ability, and total overall score) among the groups. Levene's test was conducted to assess the homogeneity of variances.
Conclusion: Hatha Yoga participants outperformed the Control group ($p < 0.01$) in terms of memory and overall cognitive ability. However, there were no notable differences in awareness, understanding, or problem-solving skills among the three groups.
Statistical analysis revealed significant group differences in memory and total score, but the effects were moderate in size. The other cognitive factors showed minimal or no differences between the groups. The findings of this study will contribute to a better understanding of the potential benefits of physical activity interventions on cognitive function and provide valuable insights for policymakers and healthcare professionals.

Key words: Hatha Yoga, Cognitive abilities, ANOVA

I. Introduction:

The cognitive abilities of students are crucial for their academic success and overall development. In recent years, there has been growing interest in understanding how different activities, such as yoga, can influence cognitive functions. Yoga, an ancient practice that combines physical postures, breathing exercises, and meditation, has been widely adopted in schools as a means to enhance students' mental and physical well-being. This study aims to compare the cognitive abilities of secondary and senior secondary school students who practice yoga with those who do walking and general sports, drawing on research studies conducted over the past six years.

Several studies have highlighted the positive impact of yoga on cognitive functions. For instance, a scoping review by Hart et al. (2022) found substantial evidence supporting the use of school-based yoga programs to improve executive function, working memory, attention, and academic performance in neurotypical youth populations. Similarly, a randomized controlled trial by Khalsa et al. (2012) demonstrated that secondary school students participating in yoga sessions showed significant improvements in mood, anxiety, and resilience compared to those in regular physical education classes.

Further research by Noggle et al. (2014), reported that yoga practice led to better emotional regulation and cognitive performance among adolescents. Additionally, a study by Telles et al. (2019) found that yoga practitioners exhibited improved attention and working memory compared to non-practitioners. In contrast, students who do not engage in yoga may not experience these cognitive benefits. Traditional physical education programs, while beneficial for physical health, may not provide the same level of mental and emotional support as yoga. The comparison of three different forms of physical activities on the basis of a self-reported cognitive tool underscores the potential of this research study as a holistic approach and a better version to study the cognitive abilities and overall well-being in school settings.

Research question: Does yoga practice have a significant impact on the cognitive abilities of secondary and senior secondary school students?

Objectives of the study: The study on the comparison of cognitive abilities between yoga and non-yoga secondary and senior secondary school students typically aims to achieve the following objectives:

1. **Assess Cognitive Performance**: To evaluate and compare the cognitive abilities, awareness, memory, understanding, reasoning ability and problem solving, of students who practice yoga regularly with those who do not.

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2. **Analyze overall Cognitive Performance**: To determine if there is a significant difference in overall cognitive performance between yoga practitioners and non-practitioners.
3. **Physical Fitness and Health**: To compare the health-related physical fitness levels (body mass index) of students engaged in yoga versus those participating in other forms of physical exercise or none at all.

Hypotheses:

- **Null Hypothesis (H_0):** There is no significant difference in cognitive factors across the three groups (H_0: $\mu1 = \mu2 = \mu3$).
- **Alternative Hypothesis (H_1):** There is a significant difference in at least one cognitive factor across the three groups (H_1: $\mu1 \neq \mu2 \neq \mu3$).

Significance of the study: These objectives help in understanding the potential benefits of incorporating yoga into the school curriculum and its impact on students' cognitive and overall development.

II. **Methodology**: A post-test research design was used in the present study, where data was collected after the implementation of three different types of physical activity interventions to three independent groups. It's particularly useful because the goal was to measure and compare the impact or outcomes of the three programs.

Sample Size: N = 94

Groups:

- **Hatha Yoga Group:** 30 participants
- **Walking Group:** 32 participants
- **Control Group:** 32 participants

Variables:

- **Independent Variable:** Group (Hatha Yoga, Walking, Control)
- **Dependent Variables:** Cognitive abilities (e.g., awareness, memory, understanding, reasoning ability, problem-solving ability, total overall score)

Study Design:

1. **Recruitment:**
   - Recruitment of secondary and senior secondary school students of Delhi, NCR from comparable socioeconomic backgrounds.
   - Equal distribution of age, gender, and body mass index (BMI) across the groups.
2. **Randomization:**
   - Randomly assigned participants to the Hatha Yoga, Walking, or Control group.
3. **Intervention:**
   - **Hatha Yoga Group:** Participants engaged in regular Hatha Yoga sessions (35 minutes per day, 5 days a week for 5 weeks at moderate intensity).
   - **Walking Group:** Participants engage in regular walking sessions (35 minutes per day, 5 days a week for 5 weeks at moderate intensity).
   - **Control Group:** Participants played a sport of their own choice for 35 minutes a day each day for 5 weeks.
4. **Intervention Period:**
   - Conducted the interventions for 35 minutes per day, 5 days a week for 5 weeks.
5. **Post-Test only:**
   - Cognitive ability test-CAT (a standardized cognitive assessment test by Ms. Madhu Gupta and Ms. Bindiya Lakhani) was administered to all participants after the intervention.
6. **Data Analysis:**
   - Descriptive statistics, ANOVA, Levene's test of homogeneity of variances was used to analyze differences in cognitive abilities between the groups.
   - Effect sizes were calculated to assess the magnitude of the differences.

Ethical Considerations:

- Informed consents were obtained from the participants or their legal guardians.
- The safety and well-being of participants during the intervention was ensured.
- Confidentiality of participant data was maintained.

Additional Considerations:

- Demographic data (age, gender, socioeconomic status) was collected ad reported to control for potential confounding factors.
- A standardized protocol for the yoga (content validity of 0.83) and walking interventions (content validity of 0.90) was used to ensure consistency.

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III.Results and discussion:

Table-1: Demographics of the three groups (N=94)

Variable		Group Hatha Yoga Group	Walking Group	Control Group
Age	Mean	16.00	16.19	16.06
	Standard Deviation	1.23	1.23	1.22
	Valid N	30	32	32
Body_Mass_Index	Mean	20.60	20.84	20.66
	Standard Deviation	1.57	1.32	1.41
	Valid N	30	32	32
Gender	Number of Males	19	19	21
	Number of Females	11	13	11
	Total	94		
Soci_economic_status	Number of Upper Middle Class	10	9	12
	Number of Middle Class	13	15	12
	Number of Lower Middle Class	7	8	8

Table-1 shows the demographic variables of the sample (N=94). The sample consisted of 94 participants (30 in the Hatha Yoga group, 32 in the Walking group, and 32 in the Control group). The mean age of participants was 16.00 years (SD = 1.23). The majority of participants were male (n = 67, 71.3%), with 27 females (28.7%). The average body mass index (BMI) was 20.60 (SD = 1.57). Socioeconomic status was distributed as follows: 31 participants (33%) were upper middle class, 40 (42.6%) were middle class, and 23 (24.5%) were lower middle class.

Table-2: Descriptive statistics of awareness and memory (N=94)

Factor		Awareness				Memory			
		Hatha Yoga Group	Walking Group	Control Group	Total	Hatha Yoga Group	Walking Group	Control Group	Total
N		30	32	32	94	30	32	32	94
Mean		5.49	5.47	5.46	5.48	5.47	5.47	5.41	5.45
Std. Deviation		0.07	0.06	0.05	0.06	0.05	0.06	0.07	0.06
Std. Error		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
95% Confidence Interval for Mean	Lower Bound	5.46	5.45	5.44	5.46	5.45	5.45	5.39	5.44
	Upper Bound	5.52	5.49	5.48	5.49	5.49	5.49	5.44	5.46
Minimum		5.35	5.36	5.38	5.35	5.38	5.36	5.32	5.32
Maximum		5.65	5.60	5.58	5.65	5.56	5.58	5.58	5.58

Table-2 shows that the sample consisted of 94 participants (30 in the Hatha Yoga group, 32 in the Walking group, and 32 in the Control group). The mean scores for awareness and memory were similar across all three groups, with no significant differences observed, but this needs to be ascertained upon the application of ANOVA (a parametric test) and Tukey's HSD post-hoc test if the data meets the assumptions.

Awareness:
- Hatha Yoga group: M = 5.49, SD = 0.07
- Walking group: M = 5.47, SD = 0.06
- Control group: M = 5.46, SD = 0.05

Memory:
- Hatha Yoga group: M = 5.47, SD = 0.05
- Walking group: M = 5.47, SD = 0.06
- Control group: M = 5.41, SD = 0.07

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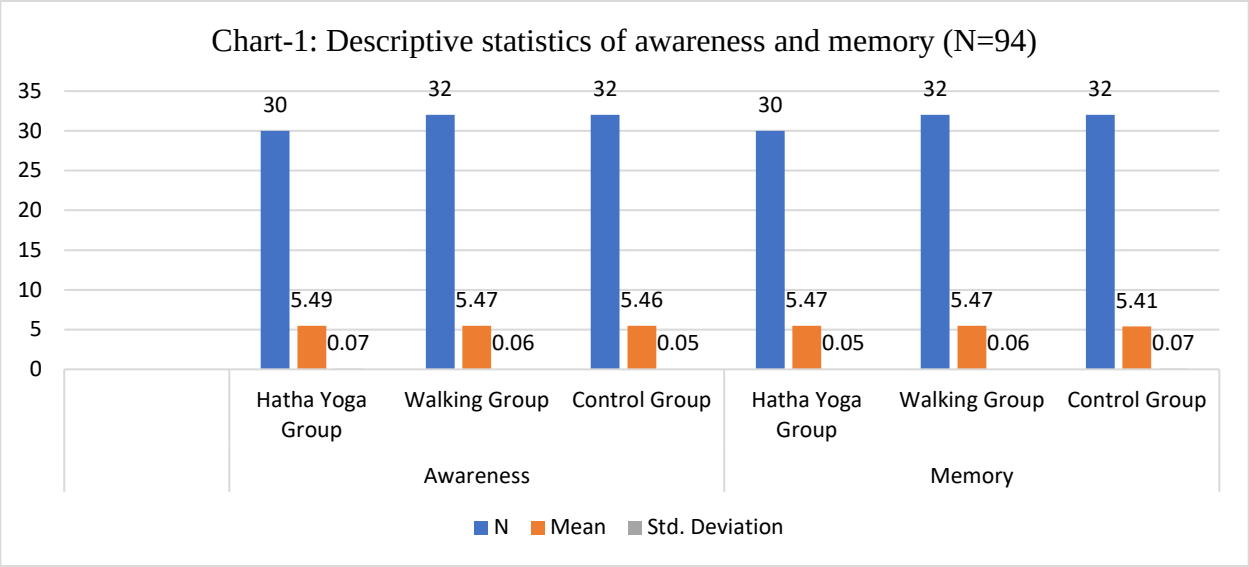

Table-3: Descriptive statistics of understanding and reasoning ability (N=94)

Factor		Understanding				Reasoning_ability			
		Hatha Yoga Group	Walking Group	Control Group	Total	Hatha Yoga Group	Walking Group	Control Group	Total
N		30	32	32	94	30	32	32	94
Mean		4.37	4.37	4.37	4.37	5.47	5.47	5.43	5.46
Std. Deviation		0.03	0.04	0.03	0.03	0.06	0.05	0.07	0.06
Std. Error		0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
95% Confidence Interval for Mean	Lower Bound	4.36	4.36	4.36	4.36	5.45	5.45	5.41	5.45
	Upper Bound	4.38	4.38	4.38	4.38	5.49	5.49	5.46	5.47
Minimum		4.31	4.29	4.31	4.29	5.36	5.36	5.32	5.32
Maximum		4.44	4.44	4.44	4.44	5.58	5.58	5.58	5.58

Table-3 shows that the sample consisted of 94 participants (30 in the Hatha Yoga group, 32 in the Walking group, and 32 in the Control group). The mean scores for understanding and reasoning ability were similar across all three groups, with no significant differences observed, but this needs to be ascertained upon the application of ANOVA (a parametric test) and Tukey's HSD post-hoc test if the data meets the assumptions.

Understanding:

- Hatha Yoga group: M = 4.37, SD = 0.03
- Walking group: M = 4.37, SD = 0.04
- Control group: M = 4.37, SD = 0.03

Reasoning Ability:

- Hatha Yoga group: M = 5.47, SD = 0.06
- Walking group: M = 5.47, SD = 0.05
- Control group: M = 5.43, SD = 0.07

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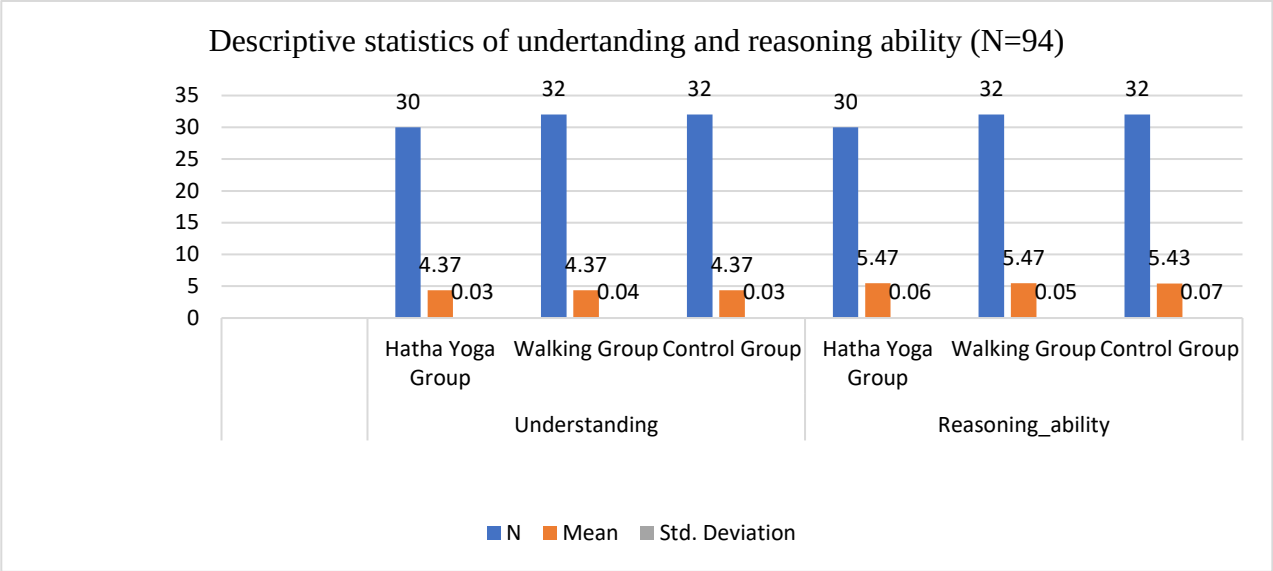

Table-4: Descriptive statistics of problem-solving ability and Total score of all the 5 cognitive ability sub scales (N=94)

Factor		Problem_solving_ability				Total_overall_score			
		Hatha Yoga Group	Walking Group	Control Group	Total	Hatha Yoga Group	Walking Group	Control Group	Total
N		30	32	32	94	30	32	32	94
Mean		5.49	5.50	5.48	5.49	26.30	26.28	26.16	26.24
Std. Deviation		0.06	0.04	0.05	0.05	0.12	0.09	0.16	0.14
Std. Error		0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.01
95% Confidence Interval for Mean	Lower Bound	5.47	5.48	5.46	5.48	26.25	26.25	26.10	26.21
	Upper Bound	5.52	5.52	5.50	5.50	26.34	26.31	26.21	26.27
Minimum		5.38	5.41	5.38	5.38	26.02	26.06	25.89	25.89
Maximum		5.58	5.58	5.56	5.58	26.50	26.42	26.53	26.53

Table-4 shows that the sample consisted of 94 participants (30 in the Hatha Yoga group, 32 in the Walking group, and 32 in the Control group). The mean scores for problem-solving ability and the total overall score were similar across all three groups, with no significant differences observed. As per norms, the overall score across all the three groups lies in the "average" cognitive category. It needs to be ascertained upon the application of ANOVA (a parametric test) and Tukey's HSD post-hoc test if the data meets the assumptions.

Problem-Solving Ability:
- Hatha Yoga group: M = 5.49, SD = 0.06
- Walking group: M = 5.50, SD = 0.04
- Control group: M = 5.48, SD = 0.05

Total Overall Score:
- Hatha Yoga group: M = 26.30, SD = 0.12
- Walking group: M = 26.28, SD = 0.09
- Control group: M = 26.16, SD = 0.16

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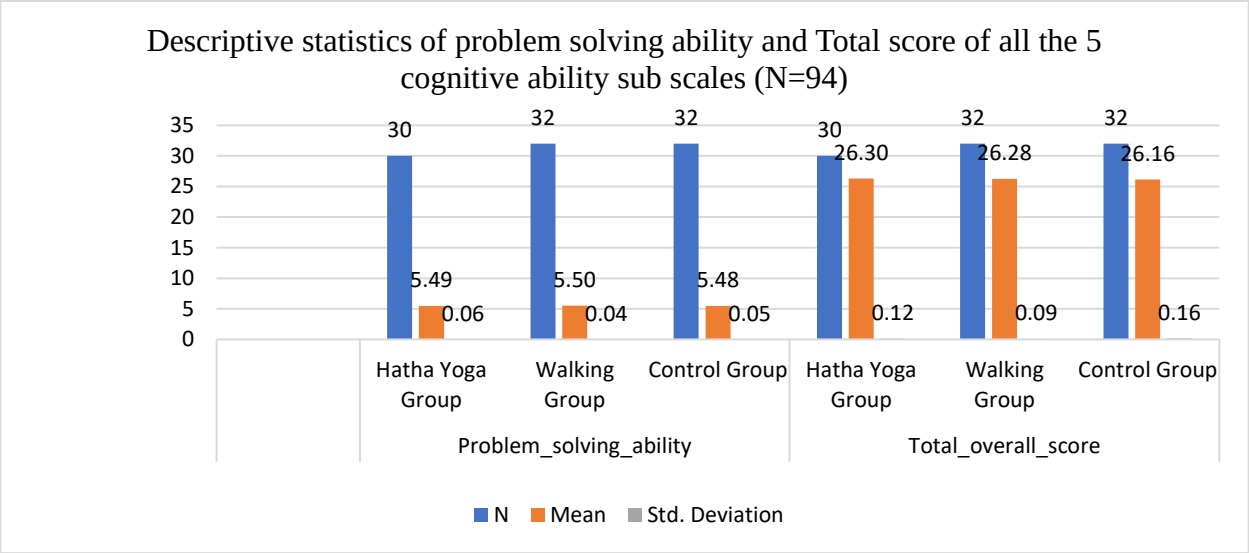

Table-5: Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Awareness	Based on Mean	0.58	2.00	91.00	0.56
Memory	Based on Mean	2.33	2.00	91.00	0.10
Understanding	Based on Mean	0.48	2.00	91.00	0.62
Reasoning_ability	Based on Mean	1.34	2.00	91.00	0.27
Problem_solving_ability	Based on Mean	2.81	2.00	91.00	0.07
Total_overall_score	Based on Mean	5.06	2.00	91.00	0.01

Table-5 shows Levene's test of homogeneity of variances that was conducted to assess the assumption of equal variances across the three groups (Hatha Yoga, Walking, and Control). The results indicated that the assumption of homogeneity of variances was met for all cognitive factors except for the Total_overall_score (Levene's statistic = 5.063, df = 2, 91, p = 0.008). We can proceed with the next statistics.

Table-6: ANOVA Results

		Sum of Squares	df	Mean Square	F	Sig.
Awareness	Between Groups	0.01	2.00	0.00	1.27	0.29
	Within Groups	0.35	91.00	0.00		
	Total	0.36	93.00			
Memory	Between Groups	0.07	2.00	0.03	10.10	0.00
	Within Groups	0.31	91.00	0.00		
	Total	0.38	93.00			
Understanding	Between Groups	0.00	2.00	0.00	0.11	0.90
	Within Groups	0.10	91.00	0.00		
	Total	0.10	93.00			
Reasoning_ability	Between Groups	0.03	2.00	0.02	4.61	0.01
	Within Groups	0.31	91.00	0.00		
	Total	0.34	93.00			
Problem_solving_ability	Between Groups	0.01	2.00	0.00	1.48	0.23
	Within Groups	0.23	91.00	0.00		
	Total	0.23	93.00			
Total_overall_score	Between Groups	0.38	2.00	0.19	11.44	0.00
	Within Groups	1.51	91.00	0.02		
	Total	1.89	93.00			

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The objective of the study was to examine whether there were significant differences in cognitive factors (awareness, memory, understanding, reasoning ability, problem-solving ability, and total overall score) across the three groups (Hatha Yoga, Walking, and Control), one-way ANOVAs were conducted.

Awareness:
- $F(2, 91) = 1.27$, $p = 0.29$

Memory:
- $F(2, 91) = 10.10$, $p = 0.00$

Understanding:
- $F(2, 91) = 0.11$, $p = 0.90$

Reasoning Ability:
- $F(2, 91) = 4.61$, $p = 0.01$

Problem-Solving Ability:
- $F(2, 91) = 1.48$, $p = 0.23$

Total Overall Score:
- $F(2, 91) = 11.44$, $p = 0.00$

Table-6 shows that there were significant differences in memory and total overall scores across the three groups. However, there were no significant differences in awareness, understanding, reasoning ability, or problem-solving ability. Since ANOVA is significant, the one-way ANOVA was re-run with Tukey HSD as the post-hoc test**.** The focus was to look at the multiple comparisons table to see which groups differ significantly.

Table-7: Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Awareness	Hatha Yoga Group	Walking Group	0.02	0.02	0.58	-0.02	0.05
		Control Group	0.02	0.02	0.26	-0.01	0.06
	Walking Group	Hatha Yoga Group	-0.02	0.02	0.58	-0.05	0.02
		Control Group	0.01	0.02	0.83	-0.03	0.05
	Control Group	Hatha Yoga Group	-0.02	0.02	0.26	-0.06	0.01
		Walking Group	-0.01	0.02	0.83	-0.05	0.03
Memory	Hatha Yoga Group	Walking Group	0.00	0.01	0.97	-0.03	0.04
		Control Group	.05915*	0.01	0.00	0.02	0.09
	Walking Group	Hatha Yoga Group	0.00	0.01	0.97	-0.04	0.03
		Control Group	.05563*	0.01	0.00	0.02	0.09
	Control Group	Hatha Yoga Group	-.05915*	0.01	0.00	-0.09	-0.02
		Walking Group	-.05563*	0.01	0.00	-0.09	-0.02
Understanding	Hatha Yoga Group	Walking Group	0.00	0.01	0.95	-0.02	0.02
		Control Group	0.00	0.01	0.89	-0.02	0.02
	Walking Group	Hatha Yoga Group	0.00	0.01	0.95	-0.02	0.02
		Control Group	0.00	0.01	0.99	-0.02	0.02
	Control Group	Hatha Yoga Group	0.00	0.01	0.89	-0.02	0.02
		Walking Group	0.00	0.01	0.99	-0.02	0.02
Reasoning_ability	Hatha Yoga Group	Walking Group	0.00	0.01	0.99	-0.03	0.04
		Control Group	.03981*	0.01	0.02	0.00	0.08
	Walking Group	Hatha Yoga Group	0.00	0.01	0.99	-0.04	0.03
		Control Group	.03750*	0.01	0.03	0.00	0.07
	Control Group	Hatha Yoga Group	-.03981*	0.01	0.02	-0.08	0.00
		Walking Group	-.03750*	0.01	0.03	-0.07	0.00

Problem_solving_ability	Hatha Yoga Group	Walking Group	-0.01	0.01	0.91	-0.04	0.02
		Control Group	0.02	0.01	0.45	-0.01	0.05
	Walking Group	Hatha Yoga Group	0.01	0.01	0.91	-0.02	0.04
		Control Group	0.02	0.01	0.23	-0.01	0.05
	Control Group	Hatha Yoga Group	-0.02	0.01	0.45	-0.05	0.01
		Walking Group	-0.02	0.01	0.23	-0.05	0.01
Total_overall_score	Hatha Yoga Group	Walking Group	0.02	0.03	0.83	-0.06	0.10
		Control Group	.14302*	0.03	0.00	0.06	0.22
	Walking Group	Hatha Yoga Group	-0.02	0.03	0.83	-0.10	0.06
		Control Group	.12406*	0.03	0.00	0.05	0.20
	Control Group	Hatha Yoga Group	-.14302*	0.03	0.00	-0.22	-0.06
		Walking Group	-.12406*	0.03	0.00	-0.20	-0.05

*. The mean difference is significant at the 0.05 level.

Table-7 shows the Post Hoc Comparisons (Tukey HSD). To identify which specific groups differed significantly on the cognitive factors, post hoc comparisons were conducted using the Tukey HSD test.
Awareness: No significant differences were found between any of the groups.
Memory: The Hatha Yoga group scored significantly higher than the Control group ($p < 0.01$).
Understanding: No significant differences were found between any of the groups.
Reasoning Ability: The Hatha Yoga group scored significantly higher than the Control group ($p < 0.05$).
Problem-Solving Ability: No significant differences were found between any of the groups.
Total Overall Score: The Hatha Yoga group scored significantly higher than both the Walking and Control groups ($p < 0.01$).

Table-8: Tests of Between-Subjects Effects (Effect size)

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	Awareness	0.01	2.00	0.00	1.27	0.29	0.03
	Memory	0.07	2.00	0.03	10.10	0.00	0.18
	Understanding	0.00	2.00	0.00	0.11	0.90	0.00
	Reasoning_ability	0.03	2.00	0.02	4.61	0.01	0.09
	Problem_solving_ability	0.01	2.00	0.00	1.48	0.23	0.03
	Total_overall_score	0.38	2.00	0.19	11.44	0.00	0.20

Table-8 can be interpreted as follows:

- **Awareness:** $\eta^2 = 0.027$, a small effect size.
- **Memory:** $\eta^2 = 0.182$, a medium effect size.
- **Understanding:** $\eta^2 = 0.002$, a negligible effect size.
- **Reasoning Ability:** $\eta^2 = 0.092$, a medium effect size.
- **Problem-Solving Ability:** $\eta^2 = 0.031$, a small effect size.
- **Total Overall Score:** $\eta^2 = 0.201$, a medium effect size.

In summary, the Hatha Yoga group demonstrated significantly higher scores on memory and total overall score compared to the Control group. However, there were no significant differences between the groups for awareness, understanding, or problem-solving ability.
A one-way ANOVA was conducted to examine differences in cognitive factors across the three groups. The results indicated a significant main effect of group on memory, $F(2, 91) = 10.10$, $p < 0.001$, and total overall score, $F(2, 91) = 11.44$, $p < 0.001$. Post hoc comparisons using Tukey's HSD revealed that the Hatha Yoga group scored significantly higher on both memory and total overall score compared to the Control group ($p < 0.01$ for both comparisons). However, there were no significant differences between the groups for awareness, understanding, or problem-solving ability. To assess the magnitude of the group differences on the cognitive factors, partial eta-squared (η^2) was calculated. Partial eta-squared represents the proportion of variance in the dependent variable that is explained by the independent variable (group).

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While the ANOVA results indicated significant differences for memory and total overall score, the effect sizes (table-8) were moderate, suggesting that the group differences were not particularly large. Awareness, understanding, and problem-solving ability showed negligible or small effect sizes, indicating that the groups did not differ substantially on these factors.

The outcomes discussed above are in line with the study by Verma et al. (2015), focused on the effect of yoga practices on cognitive development in rural residential school children in Maharashtra, India. The study concluded that yoga practices significantly improved selected cognitive development variables (awareness and attention, memory and understanding and reasoning) among adolescent rural residential school children.
Jois et al. (2017), investigated the effects of Superbrain Yoga on short-term memory and selective attention among students in Mysore district. The study highlighted the effectiveness of Superbrain Yoga in improving cognitive functions such as memory and attention among students.
A systematic review of yoga for mental and physical health in college students (Kanojia, 2022)
which also included secondary and senior secondary school students, emphasized the holistic benefits of yoga in enhancing both cognitive and mental health among students.
These studies collectively demonstrate that yoga can significantly enhance various cognitive abilities, including awareness, memory, understanding, reasoning, and problem-solving. Integrating yoga into school curricula could be a strategic approach to fostering cognitive development and emotional resilience among students.

IV. Conclusion:
The findings provide evidence to support the alternative hypothesis. The results suggest that participation in Hatha Yoga has a positive impact on memory and overall cognitive performance compared to a Control group. While Walking did not show significant differences, further research is needed to explore the potential benefits of this intervention on cognitive factors.

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