RESEARCH PAPER

Impact of Surya Namaskar and Raja Yoga Meditation on Reaction Time in Young Adults: A Comparative Interventional Study

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ABSTRACT

Background:
Reaction time is a critical indicator of neurocognitive function and reflects the efficiency of sensory-motor coordination and central nervous system processing. In the current era of sedentary lifestyle and increased psychological stress, there is a growing need for non-pharmacological interventions to enhance cognitive performance. Yogic practices such as Surya Namaskar and Raja Yoga meditation have shown promising effects on physical and mental health, but their comparative and combined effects on reaction time remain inadequately explored.

Objective:
To evaluate and compare the effects of Surya Namaskar and Raja Yoga meditation, individually and in combination on visual reaction time among young adults.

Methods:
This interventional, comparative study was conducted on 140 healthy first year undergraduate medical students (aged 18–25 years). They were randomly divided into four groups: Group A practiced Surya Namaskar, Group B Raja Yoga meditation, Group C both Surya Namaskar & Raja Yoga, and Group D serve as a control. The control group did not practice any form of intervention. Interventions were administered for 12 weeks, five days per week. Reaction time was measured using a mobile-based application. Statistical analysis was performed using paired t-tests and one-way ANOVA & statistical significance ($p< 0.05$) was calculated.

Results:
A statistically significant reduction in reaction time was observed in Group A ($p<0.001$) and Group B ($p<0.01$). Group C showed no significant change, while the control group remained unchanged. Between-group analysis using ANOVA demonstrated significant differences ($p<0.01$).

Conclusion:
Surya Namaskar and Raja Yoga meditation independently improve reaction time, with Surya Namaskar showing greater efficacy. Combined intervention did not produce additional benefits, suggesting the need for optimized protocol design. These findings support the incorporation of yoga into daily routines for enhancing neurocognitive performance.

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INTRODUCTION

Reaction time (RT) is defined as the interval between the presentation of a stimulus and the initiation of a voluntary motor response (1). It is widely used as a reliable indicator of central nervous system (CNS) processing speed, alertness and neuromuscular coordination (2). Faster reaction time is associated with enhanced cognitive performance and better sensory-motor integration whereas delayed reaction time may reflect fatigue, stress or impaired neurological functioning (3).

In recent years young adults have been increasingly exposed to sedentary lifestyles, prolonged screen time and academic stress, all of which adversely affect cognitive efficiency and mental well-being (4). These factors contribute to reduced attention span, slower information processing and impaired decision-making abilities. Consequently, there is a growing interest in non-pharmacological, holistic interventions to improve cognitive function and overall health.

Yoga, an ancient Indian system of health and wellness, integrates physical postures (asanas), breathing techniques

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(pranayama), and meditation (dhyana) to achieve harmony between the body and mind (5). Surya Namaskar or Sun Salutation is a dynamic sequence of 12 postures performed in a rhythmic pattern synchronized with controlled breathing. It has been shown to enhance cardiovascular endurance, muscular strength, flexibility and autonomic balance (6). Raja Yoga meditation, in contrast emphasizes mental discipline, concentration and self-awareness. It operates through regulation of thought processes and has been reported to reduce psychological stress, improve attention, and enhance emotional stability by modulating cortical activity (7).

Previous studies have demonstrated that both physical exercise and meditation independently contribute to improved reaction time by enhancing neural processing speed, optimizing autonomic function, and reducing stress levels (6,8). However, there is limited evidence comparing the individual versus combined effects of Surya Namaskar and Raja Yoga meditation on reaction time.

Materials and Methods

Study Design

Interventional study.

Study Setting

Department of Physiology, GSVM Medical College, Kanpur, Uttar Pradesh, India.

Study Population

Healthy first year undergraduate medical students aged 18–25 years.

Inclusion Criteria

Participants fulfilling all of the following criteria were included:

- Apparently healthy individuals
- Age between 18 and 25 years
- Both males and female
- Willingness to participate throughout the study duration still option of withdrawal from the study was available at all the stages for all study subjects without any clause.
- Ability to understand instructions and provide informed consent

Exclusion Criteria

Participants were excluded if they had:

- Any known chronic medical illness (e.g., diabetes, hypertension, asthma, cardiovascular disease)
- Diagnosed psychiatric disorders
- History of substance abuse (alcohol, tobacco, or illicit drugs)
- Use of medications affecting CNS or muscular performance
- Physical disability or musculoskeletal limitation
- Practice of Surya Namaskar and/or Raja Yoga within the previous one month

Sample size and Sampling:

Sample size was calculated using data from a previous study (Bomavat M., 2015) [9]

Using the formula[10]

$$N = \frac{2\sigma^2[Z1\text{-}\alpha/2 + Z1\text{-}\beta]}{\delta^2}$$

Where:

- N = minimum calculated sample size
- $Z(1-\alpha/2) = 1.96$ at 95% CI
- $Z(1-\beta) = 0.84$ at 80% power
- σ^2 = Standard deviation
- δ^2 = Clinically significant difference

Minimum sample size **N = 31 participants per group.** Considering a 15% attrition rate, the final sample size was rounded to **35 participants per group.**

Total sample size = 140 participants

Methodology:

Group Allocation (n=35)

Participants were randomly divided into four groups:

- Group A: Surya Namaskar
- Group B: Raja Yoga Meditation
- Group C: Combined (Surya Namaskar + Raja Yoga)
- Group D: Control (no intervention)

Interventions were practiced 5 days/week for 12 weeks under Expert guidance and supervision for Surya namaskar and Raja yoga meditation.

A pre-designed and pre-tested questionnaire was used to collect data from participants in working proforma including their age, gender, anthropometric parameters, pulse, blood pressure. Visual reaction time (in milliseconds) was assessed using computer-based application. Group intervention includes Surya namaskar for Group A for 20mins a day, raja yoga meditation for Group B for 20mins a day Group C done combined session of Surya namaskar and raja yoga meditation for 20mins a day and Group D having no intervention and serve as a control

Ethical Consideration

- Before the trial began, ethical approval was obtained from the GSVM Medical College's Institutional Ethical Clearance Committee in Kanpur. The detail no. is Ref. No.EC /392/Oct/2024/, dated 08.10.2024 (Annexure I)
- The study has been registered prospectively with the Clinical Trials Registry India (CTRI) due to intervention nature of study. CTRI registration no. CTRI /2025/01/078876
- Written informed consent was taken from all the subjects after explaining them the purpose, nature and procedure of the study.

- Participants were assured that confidentiality, privacy and anonymity of study participants would be strictly maintained at all level.
- The option of withdrawal from the study was available at all the stages for all study subjects without any clause.

Data Collection Procedure

After obtaining approval from the Institutional Ethics Committee and written informed consent from the participants the study was conducted among eligible young adults who fulfilled the inclusion criteria. Baseline data (Anthropometric) were collected before the start of the intervention. The baseline reaction time were recorded for all participants before starting the intervention.

Following baseline assessment, the participants underwent a 12-week intervention program consisting of Surya Namaskar and Raj Yoga meditation.

Participants in the intervention group performed a structured session including Surya Namaskar followed by Raj Yoga meditation according to the standardized protocol. At the end of the 12-week intervention period, all participants underwent reassessment using the same tools and procedures as employed during the baseline assessment of reaction time.

All post-intervention measurements were performed under similar environmental conditions and by the same investigator to minimize measurement bias. The post-intervention values reaction time were recorded and compared with the baseline values to evaluate the effect of the intervention.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 24.0. Data were checked and cleaning of data was done for completeness, accuracy and consistency before analysis. Descriptive statistics were used to summarize the study variables. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation (SD). Among pre-intervention and post intervention group ANOVA were applied. Paired t-test was used to compare pre-intervention and post-intervention mean values within the same group. A p-value of <0.05 at 95% Confidence Interval was considered statistically significant

Results

Table 1. Distribution of Study Participants according to their Age

Variable	Group A (SN) Mean ± SD	Group B (RYM) Mean ± SD	Group C (SN + RYM) Mean ± SD	Group D (Control) Mean ± SD	p value*
Age (years)	19.83±1.774	19.63±2.184	19.54±1.738	20.31±1.549	0.197

* SN = Surya namaskar, ** RYM = Raja Yoga Meditation; p <0.05 Significant

Table 2. Gender wise distribution of Study Participants (N=35)

Variable	Sub group	Group A (SN) n (%)	Group B (RYM) n (%)	Group C (SN+ RYM) n (%)	Group D (Control) n (%)	p value
Gender	Male	25(71.4)	16(45.7)	23(65.7)	26(74.3)	0.104
	Female	19(54.3)	12(34.3)	9(25.7)	10(28.6)	

* SN = Surya namaskar, ** RYM = Raja Yoga Meditation ; p <0.05 Significant

Table 3. Baseline comparison of Anthropometric Parameters of Study Participants

Variable	Group A (SN) Mean ± SD	Group B (RYM) Mean ± SD	Group C (SN+ RYM) Mean ± SD	Group D (Control) Mean ± SD	p value
Height (cm)	170.08±8.915	167.11±8.273	170.62±8.595	170.50±8.209	0.351
Weight (kg)	62.70±11.710	64.84±19.193	67.13±17.932	61.84±11.640	0.361
BMI (kg/m^2)	21.63±3.428	23.27±7.317	22.83±4.631	21.20±3.243	0.388

* SN = Surya namaskar, ** RYM = Raja Yoga Meditation

* one-way ANOVA; $p < 0.05$ Significant; $p < 0.001$ Highly Significant

Table 4 Baseline comparison of Physiological Parameters of Study Participants

Variable	Group A (SN) Mean ± SD	Group B (RYM) Mean ± SD	Group C (SN+ RYM) Mean ± SD	Group D (Control) Mean ± SD	p value
Pulse Rate (bpm)	80.66±9.071	81.77±8.44	84.37±6.179	84.79±6.021	0.063
SBP(mmHg)	123.31±11.251	124.17±9.285	126.00±6.877	120.91±7.168	0.106
DBP(mmHg)	77.83±7.782	82.29±6.724	82.37±4.278	75.26±6.455	0.000

(* SN = Surya namsakar, ** RYM = Raja Yoga Meditation

Table 5. Baseline comparison of Reaction Time

Parameter	Group A (SN) Mean ± SD	Group B (RYM) Mean ± SD	Group C (SN+ RYM) Mean ± SD	Group D (Control) Mean ± SD	p value
Reaction time (milli sec)	265.45±41.332	265.30±40.930	263.08±41.667	251.20±30.060	0.360

(* SN = Surya namaskar, ** RYM = Raja Yoga Meditation)

Table 6. Post – intervention Physiological Parameters

Variable	Group A (SN) Mean ± SD	Group B (RYM) Mean ± SD	Group C (SN+ RYM) Mean ± SD	Group D (Control) Mean ± SD	p value
Pulse Rate	76.63±6.454	85.60±8.919	79.54±6.308	84.83±6.046	0.000
SBP	122.11±6.525	120.40±6.992	123.20±4.262	122.40±5.957	0.264
DBP	80.06±3.086	80.51±3.156	81.43±2.547	75.94±5.831	0.000

(* SN = Surya namaskar, ** RYM = Raja Yoga Meditation)

Table 7. Post – intervention Reaction Time (m sec)

Parameter	Group A (SN) Mean ± SD	Group B (RYM) Mean ± SD	Group C (SN + RYM) Mean ± SD	Group D (Control) Mean ± SD	p value
Reaction Time (msec)	251.29±37.759	254.24±42.256	263.25±40.165	251.00±29.170	0.493

(* SN = Surya namaskar, ** RYM = Raja Yoga Meditation

Table 8. Effect on Reaction Time

Group	Pre Mean ± SD	Post Mean ± SD	Mean Difference	p-value
A	265.45± 41.332	251.29± 37.759	14.163	0.000
B	265.30 ± 40.930	254.24 ± 42.256	11.058	0.006
C	263.08 ± 41.667	263.25 ± 20.165	-0.173	0.940
D	251.20 ± 30.060	251.00 ± 29.170	0.192	0.852

(* SN = Surya namaskar, ** RYM = Raja Yoga Meditation)

Key Findings

- Significant improvement in Groups A and B
- No improvement in combined group
- No change in control group
- ANOVA showed statistically significant difference ($p<0.01$)

Discussion

A total of 140 participants equally divided into four groups and the findings of the study are discussed below

At baseline, demographic variables such as age and gender were statistically comparable among all four groups ($p>0.05$) indicating homogeneity among the study participants.

Similarly, anthropometric measures as height, weight, and BMI were not significantly different among groups. Such baseline comparability enhances internal validity of the study as the effect of confounding bias is reduced.

Similar baseline results were also achieved by Sunita et al. (2022) 11 who observed that there were no significant intergroup differences in age, height or weight before the implementation of yoga intervention thus confirming the uniformity of study participants.

With regard to physiological parameters pulse rate and systolic blood pressure (SBP) were comparable across groups at baseline, while a significant difference was observed in diastolic blood pressure (DBP). This variation in DBP at baseline may be attributed to individual differences in autonomic regulation, lifestyle factors, or stress levels.

Findings suggests that post-intervention pulse rate showed a highly significant reduction in the intervention groups ($p < 0.001$). This implies that better autonomic balance and an increase in parasympathetic activity after yoga practices.

These observations are consistent with those of Bhavanani et al. (2013)12 and Manivel et al. (2014)13 who found improvement in cardiovascular regulation and autonomic control after the performance of yogic practices including breathing exercises and Surya Namaskar.

In addition, diastolic blood pressure also showed a significant intergroup difference after the interventions, with a notable reduction observed in the intervention groups. This decrease in DBP could be caused by decreased peripheral vascular resistance and improved vascular compliance which are known physiological effects of relaxation and controlled breathing associated with yoga practices. Bhavanani et al. (2011)14 have similar results with a decline in DBP following Surya Namaskar training. However, no statistically significant change was observed in systolic blood pressure after the intervention. This may be because of the comparatively shorter duration (12 weeks) or the normotensive baseline status of study participants, which may limit the potential for measurable changes in SBP.

Similarly, reaction time analysis revealed that post-intervention intergroup comparison showed non-significant difference. However, paired within group analysis demonstrated significant reduction (improvement) in reaction time in Surya Namaskar and Raja Yoga meditation groups. This indicates improved sensory-motor processing and central nervous system efficiency. Comparable findings were reported by Madanmohan et al. (1992)[15] who observed yoga training reduced visual and auditory RT; Malhotra et al. (2015) [16] who reported that regular exercise improves cognitive response speed and Klasnja et al. (2022) [17] who found that physical activity significantly reduced reaction time among adolescents. This improvement in reaction time may be explained by the synchronization of dynamic movements with breathing during yogic practices which may enhance cortical arousal and neural transmission speed and psychomotor coordination

Interestingly, combined intervention did not always show statistically superior outcomes compared to individual intervention despite showing numerical improvement in several parameters. Possible explanations for this observation include baseline heterogeneity in certain variable such as muscle endurance, overlapping physiological adaptation between physical and meditative practices, limited sample size and Duration insufficiency for additive physiological effects. Similar mixed findings in multimodal yoga interventions have been noted in prior trials.

An important observation in the present study is that the combined intervention group did not show significant improvement in reaction time. This finding contrasts with some previous studies that suggest additive or synergistic benefits of combined yogic practices. The lack of improvement may be attributed to factors such as increased duration of intervention leading to fatigue, reduced compliance, or possible cognitive overload. It is also plausible that simultaneous engagement in both physical and meditative practices require a longer adaptation period before measurable benefits are observed.

The control group did not exhibit any significant change in reaction time, thereby reinforcing the validity of the study and confirming that the observed improvements were attributable to the interventions rather than external influences.

Overall, the results of this study highlight the beneficial effects of both physical and meditative components of yoga on neurocognitive function. However, the differential outcomes observed between individual and combined interventions indicate the need for further research to optimize the duration, intensity, and combination of yoga practices for maximal cognitive benefit.

Analysis

The improvement in reaction time can be explained through:

- Autonomic balance: Increased parasympathetic activity
- Reduced stress: Lower cortisol levels
- Improved neural efficiency: Faster signal transmission
- Enhanced attention: Better focus and alertness
- Surya Namaskar appears to provide stronger benefits due to its combined physical and respiratory components.

Limitations

- Single-center study
- Short duration
- Limited sample size
- Only visual reaction time assessed
- No long-term follow-up

Conclusions

Surya Namaskar and Raja Yoga meditation significantly improve reaction time in young adults. Surya Namaskar demonstrates greater efficacy, while combined intervention does not provide additional benefit. These findings support

the use of yoga as a practical, cost-effective method for enhancing cognitive performance.

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