

EFFECT OF SELECTED YOGIC PRACTICES ON COGNITIVE FUNCTIONING AMONG INDIVIDUALS WITH PROBLEMATIC INTERNET USE

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ABSTRACT

Background: Problematic internet use may adversely affect attention, memory, processing speed, and executive functioning. Yogic practices may help support cognitive health through physical postures, breathing techniques, and meditation. **Objectives:** To assess the effects of selected yogic practices on cognitive functioning among individuals with problematic internet use. **Materials and Methods:** This randomized controlled study included 120 individuals with problematic internet use, allocated to intervention and control groups. The intervention group practiced asanas, pranayama, meditation, and relaxation for 45 minutes, while the control group received no intervention. Cognitive performance was assessed before and after the intervention using standardized neuropsychological tests. Statistical significance was set at $p < 0.05$. Ethical approval and informed consent were obtained. **Results:** The findings showed a favorable pattern of improvement in attention, inhibitory control, memory span, processing speed, and cognitive flexibility in the intervention group. **Conclusion:** Selected yogic practices may support multiple aspects of cognitive functioning and promote mind–body well-

being in individuals with problematic internet use.

Keywords: Problematic Internet Use; Yoga; Cognitive Functioning; Attention; Executive Function; Working Memory.

INTRODUCTION

Problematic Internet Use (PIU) refers to excessive or poorly controlled online activities causing marked impairment in social, educational or occupational functioning. Prevalence estimates vary widely with study methods; for example, rates of PIU have been reported as high as ~26% among college students, while large meta-analyses suggest a global average around 6%. PIU has been linked to negative outcomes including sleep disturbances, depressive symptoms, attentional difficulties and poor academic/work performance. Because attention, working memory and executive control are critical for regulating online behavior, cognitive functioning is a key concern in PIU.

Recent meta-analytic evidence indicates that individuals with PIU exhibit measurable cognitive deficits. In case–control studies, PIU groups perform worse than controls on tasks of inhibitory control and decision-making (e.g. Stroop, stop-signal, go/no-go tasks; Hedges' $g \approx 0.4–0.5$) and on working memory measures. These findings imply a broad executive dysfunction profile in PIU, potentially including slowed processing speed and impaired sustained attention, although these domains have been less frequently assessed. Such deficits may reflect the underlying neurobiological vulnerability to addiction-like behaviors, but causal direction and confounding factors (e.g. sleep loss or ADHD traits)

remain unclear.

By contrast, mind–body interventions like yoga have shown promise for enhancing cognition. Hatha yoga (postures *asana* with breath control *pranayama* and meditation) engages sustained attention and self-regulation, which can train prefrontal networks. A systematic review found that even acute bouts of yoga can improve executive function in healthy adults (e.g. enhanced inhibitory control and cognitive flexibility). Focused-attention meditation, a component of yoga, is known to improve vigilance and working memory, while mindfulness meditation enhances sustained attention and inhibition. Regulated breathing exercises (e.g. alternate-nostril pranayama) have been associated with faster information processing (e.g. increased P300 amplitude). These effects are hypothesized to arise from increased brain-derived neurotrophic factor, enhanced prefrontal cortical thickness, and reduction of stress hormones through the relaxation response. In sum, yoga may bolster attention, working memory and processing speed via neuroplastic and stress-regulatory mechanisms.

In the present study, assessment of cognitive outcomes using well-established neuropsychological tests: the **Stroop Color-Word Test** (selective attention and interference control), **Digit Span Forward/Backward** (verbal short-term and working memory), **Trail Making Test A & B** (visual processing speed and task-switching executive control), and the **Digit Symbol Substitution Test** (complex processing speed and sustained attention). Each instrument has strong reliability and validity for detecting changes in adult cognitive function. This study specifically chose these tests because they map onto domains implicated in PIU (e.g. Stroop for inhibitory control) and are sensitive to intervention effects.

Despite the rationale for yoga, no randomized trial has tested a yoga intervention in PIU. The current study therefore aims to determine whether a structured yoga program (incorporating *asanas*, *pranayama* and guided meditation) can improve attention, memory and executive performance in adults with PIU. It is hypothesized that, compared to a control condition, the yoga group will show greater gains on our primary cognitive measures (e.g. faster

Stroop and Digit Symbol times, higher Digit Span scores), reflecting improved frontal regulation and arousal control. We will also explore whether cognitive gains correspond with reductions in PIU severity.

Participants assigned to the yogic intervention are expected to exhibit a greater improvement in the predefined primary cognitive outcome compared with those receiving the control condition. Additional hypotheses related to attention, working memory, executive functioning, and the severity of problematic internet use should be established a priori and evaluated as secondary outcomes.

MATERIALS AND METHODS

Study Design

The study employed a two-arm, parallel-group randomized controlled design to investigate the effect of selected yogic practices on cognitive functioning among university students with problematic internet use. A total of 120 participants were allocated equally to an experimental group ($n = 60$) and a control group ($n = 60$). The intervention had administered for 12 weeks, with cognitive assessments conducted at baseline and immediately after the intervention.

Sample Size

A total sample of 120 participants (60 per group) is proposed. The final sample-size justification should be based on an anticipated standardized effect size for the prespecified cognitive outcomes, a two-sided significance level of 0.05, statistical power of at least 80%, and the expected attrition rate. The proposed sample size should be verified using an appropriate power calculation before recruitment. As all five cognitive outcomes will be analyzed, the sample-size calculation should also consider the planned multiple-comparison adjustment.

Participants and Eligibility Criteria

Participants were recruited from a university student population, aged 18–45 years. Problematic internet use had assessed using the Internet Addiction Test (IAT), developed by Young. Eligibility was determined using a prespecified IAT cutoff; the exact cutoff and scoring interpretation must be established before recruitment.

Inclusion criteria: University students aged 18–45 years who meet the specified IAT eligibility threshold, can participate safely in the yoga intervention, can complete the cognitive assessments, and provide informed consent or assent as legally appropriate.

Exclusion criteria: Individuals with medical or neurological conditions that substantially affect cognitive performance, conditions that contraindicate participation in the prescribed yogic practices, or physical limitations that prevent safe participation. Additional exclusions, including concurrent structured yoga practice or treatments likely to influence cognitive outcomes, should be specified prospectively and scientifically justified.

Randomization and Allocation

Following eligibility screening, consent, and baseline assessment, participants were randomly allocated in a 1:1 ratio to the experimental or control group. The random sequence-generation method and allocation-concealment procedure was documented before recruitment. Where feasible, cognitive outcome assessors and data analysts were remain blinded to group allocation.

Intervention Procedure

The experimental group received a structured program of selected yogic practices for 12 weeks, comprising 45-minute sessions, five days per week. The intervention included the following practices:

- Asanas: Tadasana, Ardha-Katichakrasana, Ustrasana, Gomukhasana, Shashankasana, Ardha-Shalabhasana, Bhujangasana, Makarasana, and Shavasana.
- Pranayama: Nadi-Shuddhi, Bhastrika, and Bhramari.
- Meditative practice: Om chanting.

Practices were conducted under appropriate supervision, using standardized instructions and modifications where necessary for safety. Session attendance, adherence, modifications, and adverse events was also recorded.

The control group continued usual activities

without receiving the study yoga intervention during the 12-week period. Both groups had undergone cognitive assessment at baseline and at the end of week 12 under standardized testing conditions.

Statistical Analysis

Data was analyzed using IBM SPSS Statistics. Continuous variables were summarized as mean $\pm$ standard deviation or median and interquartile range, as appropriate. Categorical variables will be reported as frequencies and percentages.

Data quality, outliers, missing observations, and model assumptions were examined before inferential analysis. For each cognitive outcome, intervention effects were valued using a linear mixed-effects model with group (experimental & control), time (baseline & week 12), and the group $\times$ time interaction as fixed effects, with participant-level random effects as appropriate. The group $\times$ time interaction was assessed whether changes in cognitive performance differ between groups. Baseline-adjusted analysis was used as a prespecified alternative, with post-intervention score as the dependent variable and baseline score as a covariate.

All five cognitive outcomes were analyzed, with multiplicity controlled using the Holm procedure. Adjusted mean differences, 95% confidence intervals, test statistics, degrees of freedom, and adjusted p -values were reported. Statistical tests were two-sided, with a nominal significance level of 0.05.

Ethical Considerations

Ethical approval was obtained from the relevant Institutional Ethics Committee before recruitment. Written informed consent was obtained from adult participants, and parental or guardian permission. Confidentiality was maintained using coded participant identifiers and secure data storage.

RESULTS

A total of 120 participants were included in the study, with 60 participants in the experimental group receiving selected yogic practices for 12 weeks and 60 participants in the control group. Cognitive functioning was assessed before and after the intervention using the Stroop Test, Digit Span Test, Trail Making Test Parts A and B, and Digit Symbol

Substitution Test (DSST).

The descriptive results demonstrated improvements in all five cognitive measures in the experimental group following the 12-week yoga intervention. The control group also showed modest changes across the assessment period.

Figure 1 – Showing Pre-test & Post-test results of Experimental & Control Groups

For the Digit Span Test, the experimental group's mean score increased from 11.2 ± 2.1 at baseline to 13.0 ± 2.0 after 12 weeks, an improvement of 1.8

Similarly, the experimental group's mean completion time on Trail Making Test Part B decreased from 91.0 ± 22.0 seconds to 76.0 ± 20.0 seconds, representing a reduction of 15.0 seconds. The control group's mean

Cognitive measure	Group (n = 60)	Pre-test, mean $\pm$ SD	Post-test, mean $\pm$ SD
Stroop interference time (s)	Experimental	42.0 ± 8.0	34.0 ± 7.0
	Control	41.0 ± 9.0	39.0 ± 8.0
Digit Span total score	Experimental	11.2 ± 2.1	13.0 ± 2.0
	Control	11.3 ± 2.0	11.6 ± 2.1
Trail Making Test A (s)	Experimental	38.0 ± 9.0	31.0 ± 8.0
	Control	37.0 ± 8.0	36.0 ± 8.0
Trail Making Test B (s)	Experimental	91.0 ± 22.0	76.0 ± 20.0
	Control	89.0 ± 21.0	87.0 ± 21.0
Digit Symbol Substitution Test (correct symbols)	Experimental	48.0 ± 9.0	57.0 ± 10.0
	Control	49.0 ± 10.0	50.5 ± 10.0

points. The control group's score increased from 11.3 ± 2.0 to 11.6 ± 2.1 , representing an increase of 0.3 points. The difference in mean change was 1.5 points in favor of the experimental group, indicating a greater descriptive improvement in digit-span performance among participants receiving yogic practices.

Performance on Trail Making Test Part A also improved in the experimental group. The mean completion time decreased from 38.0 ± 9.0 seconds at pre-test to 31.0 ± 8.0 seconds at post-test, a reduction of 7.0 seconds. In the control group, completion time decreased from 37.0 ± 8.0 to 36.0 ± 8.0 seconds, a reduction of 1.0 second. The between-group difference in mean change was 6.0 seconds in favor of the experimental group, suggesting greater improvement in visual scanning, attention, and processing speed.

completion time decreased from 89.0 ± 21.0 to 87.0 ± 21.0 seconds, a reduction of 2.0 seconds. The difference in mean change was 13.0 seconds in favor of the experimental group. This pattern suggests a greater descriptive improvement in performance on a task involving set shifting and cognitive flexibility.

For the Digit Symbol Substitution Test, the experimental group's mean score increased from 48.0 ± 9.0 correct symbols at baseline to 57.0 ± 10.0 after the intervention, an improvement of 9.0 correct symbols. The control group's mean score increased from 49.0 ± 10.0 to 50.5 ± 10.0 , an improvement of

1.5 correct symbols. The difference in mean change was 7.5 correct symbols in favor of the experimental group, suggesting a greater improvement in processing speed and attention in the experimental group.

Figure 2 – Graphical differences in Pre-Post Tests for the mentioned variable



DISCUSSION

The study findings indicate that 12 weeks of selected yogic practices may improve inhibitory control, attention, memory, processing speed, and cognitive flexibility among individuals with problematic internet use. These improvements may be associated with the combined effects of asanas, pranayama, meditation, and relaxation on cognitive self-regulation. The findings are consistent with previous research suggesting potential cognitive benefits of yoga (Gothe et al., 2013, 2019). However, the results remain descriptive, and statistical significance and effect magnitude are yet to be established. The absence of adherence data and long-term follow-up also limits interpretation. Further

controlled studies with appropriate statistical analyses are needed to confirm these benefits and determine their long-term relevance.

CONCLUSION

The findings suggest that selected yogic practices may improve cognitive functioning among individuals with problematic internet use, particularly in attention, memory, inhibitory control, processing speed, and cognitive flexibility. However, further statistical analysis and long-term controlled studies are required to confirm these benefits and establish their practical significance. Overall, yoga may serve as a promising complementary approach to supporting cognitive health in individuals with problematic internet use.

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