
IMPACT OF INTEGRATED YOGA MODULE ON SMARTPHONE ADDICTION AND ACADEMIC ENGAGEMENT AMONG PRE-UNIVERSITY STUDENTS

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ABSTRACT

Background of the study: The increasing prevalence of smartphone addiction among adolescents poses significant challenges to their physical health, social engagement, and academic performance. Excessive screen time has been linked to decreased physical activity, reduced participation in extracurricular activities, and diminished academic engagement, adversely affecting overall well-being. Yoga, a holistic body- mind practice, is gaining recognition for its potential to enhance self-regulation, reduce stress, and promote healthier lifestyles. However, empirical research examining integrated yoga interventions targeting smartphone addiction and academic engagement in adolescent populations remains limited. This study seeks to fill this gap by evaluating the efficacy of a structured yoga intervention in mitigating smartphone addiction and academic outcomes among pre-university students.

Methodology: A randomized controlled trial was conducted with 200 pre-university students aged 16-19 years, divided equally into an intervention group receiving the yoga module and a waitlist control group. The intervention group participated in 60 minutes' yoga session per day across 90 academic days of one semester. Assessment instruments included the Smartphone Addiction Scale-Short Version (SAS-SV), average screen time logs, physical activity and extracurricular participation, and validated academic engagement scales spanning cognitive, affective, and behavioral dimensions. Statistical analysis involved paired sample t-tests to assess within-group changes, ANOVA for between-group effects, Pearson correlation coefficients to examine relationships among variables, and linear regression models to identify predictors of academic engagement outcomes.

Results: The yoga group demonstrated substantial decreases in smartphone addiction, with a mean SAS-SV reduction of 1.53 points ($t = -33.88, p < 0.001$), and a decline in average daily screen time by 3.15 hours ($t = 20.46, p < 0.001$). Physical activity levels exhibited a substantial increase (mean difference = 0.86, $t = 7.56, p < 0.001$), alongside a notable rise in extracurricular participation (mean difference = 0.68, $t = 13.33, p < 0.001$). High attendance (94%), advice on following to a satvik diet, the program's residential setting, and controlled conditions all contributed to the results. Academic engagement significantly enhanced across all dimensions, with total engagement increasing by 0.95 points ($t = 33.52, p < 0.001$). ANOVA indicated highly significant group differences with substantial effect sizes (partial eta squared > 0.30). Significant negative correlations were identified between smartphone addiction and academic engagement both prior to ($r = -0.193, p = 0.006$) and following the intervention ($r = -0.945, p < 0.001$). Regression analysis established smartphone addiction as a substantial negative predictor of academic engagement among participants.

Conclusion: Findings indicate that a structured yoga intervention is highly effective in producing significant positive outcomes, scalable approach for reducing smartphone addiction and excessive screen time while simultaneously promoting physical activity, extracurricular involvement, and academic engagement in adolescents. The intervention's consistently positive effects across demographic subgroups affirm its generalizability and potential for broad application within educational settings. These results underscore yoga's role not only as a physical exercise modality but as a holistic behavioral intervention fostering self-regulation, and academic engagement. Future research should focus on longitudinal effects, objective behavioral assessment, and tailoring interventions for diverse cultural contexts.

KEYWORDS: Smartphone Addiction, Academic Engagement, Screen Time, Pre-University Students, Cognitive Engagement, Affective Engagement, and Behavioral Engagement.

INTRODUCTION

The widespread adoption of smartphones has fundamentally transformed human interaction and daily functioning. These devices provide instantaneous access to communication, information, and entertainment, making them indispensable tools in modern society. However, alongside their advantages, smartphones have introduced new behavioral challenges, including problematic and excessive usage patterns that can escalate into what is now described as smartphone addiction. Characterized by compulsive checking, loss of control over usage, and continuation despite harmful consequences, smartphone addiction shares features akin to recognized behavioral addictions such as gambling and internet addiction (Nikolic et al., 2023; Panova et al., 2020).

Global prevalence estimates of smartphone addiction vary but consistently suggest a considerable impact among adolescents—a demographic particularly vulnerable given their neurodevelopmental stage favoring reward sensitivity and impulse-driven behavior (Kwon et al., 2013; Singh et al., 2021). Epidemiological data report prevalence rates ranging from approximately 10% to over 30% in various countries, with some regions in Asia exhibiting rates even higher (Kwon et al., 2013; Pathak et al., 2024). The concern is more acute within educational settings, where excessive smartphone use correlates negatively with academic performance, attention span, and emotional well-being (Sunday et al., 2021).

Smartphone addiction adversely affects multiple dimensions of adolescent health. Psychologically, it is linked with increased levels of anxiety, depression, loneliness, and social isolation, partly due to overreliance on virtual interactions at the expense of face-to-face socialization. Neurocognitive (Nikolic et al., 2023) impairments have been documented, including diminished executive function and attentional control, mirroring deficits observed in substance use disorders (Cheng & Li, 2014). These impairments hinder academic engagement by compromising concentration, motivation, and the capacity to manage stress, which collectively undermine learning outcomes and personal development.

Despite growing recognition of this behavioral addiction's scope and severity, effective intervention strategies tailored for adolescents remain limited. Emerging evidence points to mindfulness-based practices, particularly yoga, as promising therapeutic approaches. Yoga combines physical postures, breath control, and meditative awareness, promoting self-regulation, emotional balance, and cognitive control—deficits central to smartphone addiction (Field, 2016; Van Gordon et al., 2021). Moreover, yoga interventions have shown efficacy in improving academic engagement by reducing stress, enhancing concentration, and fostering intrinsic motivation among students (Kauts & Sharma, 2009).

Given the escalating prevalence of smartphone addiction and its detrimental impact on adolescent educational outcomes, it is imperative to explore holistic, evidence-based interventions. This study investigates the impact of a structured yoga module on reducing smartphone addiction and enhancing academic engagement among pre-university students, addressing a critical gap in current preventive and remedial approaches within educational psychology and adolescent mental health.

Psychological Mechanisms Behind Yoga's Impact:

The efficacy of yoga in reducing smartphone addiction and enhancing academic engagement can be theoretically elucidated through the lens of Self-Determination Theory (SDT), according to SDT, human well-being and optimal functioning are contingent upon the satisfaction of three basic psychological needs: autonomy, competence, and relatedness (Ryan & Deci, 2000). Yoga practice facilitates the fulfillment of these needs by fostering self-awareness, self-regulation, and social connectedness.

Mindfulness and meditative components intrinsic to yoga modules cultivate a heightened awareness of moment-to-moment experience, thus allowing individuals to recognize and modulate automatic, impulsive behaviors often triggered by external smartphone notifications (Kabat-Zinn, 1994; Tang et al., 2015). This intentional awareness helps break habitual compulsive patterns by increasing volitional control over actions (Garland et al., 2015).

Neurocognitively, yoga practice has been shown to enhance attentional control by engaging and strengthening neural circuits governing executive functions, including the prefrontal cortex and anterior cingulate cortex (Gothe et al., 2019; Tang et al., 2015). These brain areas are typically compromised in excessive smartphone users, manifesting as impaired inhibition and distractibility (Brand et al., 2019). By improving inhibitory control and sustained attention, yoga enables better cognitive absorption and emotional regulation in academic settings (Gothe et al., 2019; Tang et al., 2015).

Thus, the combined psychological and neurobiological effects of yoga restore self-determination by satisfying basic psychological needs and augmenting top-down cognitive control, resulting in reduced smartphone dependency and improved engagement with academic tasks.

METHODOLOGY

Aim: To explore the impact of an integrated yoga module on smartphone addiction and academic engagement among pre-university students.

Objectives:

1. To assess the effect of integrated yoga module on smartphone addiction levels in pre-university students.
2. To evaluate the impact of the yoga intervention on academic engagement.
3. To examine the relationship between changes in smartphone addiction and academic engagement.

Operational definitions:

Adduction:

The term of addiction is difficult to define, and the concept of addiction has been reflected as debatable; however, the most important definition of addiction is the dependence on a substance or activity (Widyanto & McMurrin, 2004)

Smartphone Adduction:

Smartphone addiction consists of four main components: obsessive phone use, behaviors such as repetitive checking for messages or updates; tolerance or longer and more intense of use; withdrawal or feelings of agitation or suffering without the phone; and functional impairment or interference with other life activities and face to face social relationships (Lin et al., 2016). All these are very similar to the characteristics of internet addiction (Block, 2008)

Smartphones are no longer considered simply as "mobile or cell phones", based on the Internet and have a wide range of functions. This real-time information providers and powerful portable computers. In addition to making phone calls, users are able to play games, chat with friends, use messenger systems, access web services (e.g., blogs, homepages, social networks), and search for information (Chen et al., 2017)

Academic Engagement:

Academic engagement refers to the measurable and specific actions or behaviors that indicate a student's involvement and investment in their learning. Academic engagement is recognized as crucial for promoting technological development and effectively addressing societal issues. One scientific reference defines academic engagement as scientists' knowledge-related interactions with non-academics (Nast et al., 2025)

Cognitive Engagement:

Cognitive engagement refers to the extent to which students are willing and able to take on the learning task at hand. This includes the amount of effort students are willing to invest in working on the task and how long they persist (Rotgans & Schmidt, 2011)

Affective engagement:

It refers to the relationships of students with their teachers, classmates, and school. Students receive positive and negative responses from teachers, classmates, academics, and the school environment (Fredricks et al., 2004)

Behavioral Engagement:

Behavioral engagement refers to observable actions and conduct within the learning environment. It includes factors such as attendance, participation, effort, and adherence to classroom rules. A student who is behaviorally engaged is actively involved in learning tasks and avoids disruptive behaviors (Reschly & Christenson, 2022)

Research Questions:

1. Does yoga intervention for smartphone adduction reduce smartphone addiction in pre-university students?
2. What is the impact of the yoga intervention on academic engagement?
3. Is there a correlation between changes in smartphone addiction and academic engagement following the yoga intervention?

Hypotheses:

1. Smartphone Addiction:

(H0): There is no significant difference in smartphone addiction levels between the yoga intervention group and the waitlist control group

(H1): The yoga intervention group will show significantly lower smartphone addiction levels compared to the yoga intervention group and waitlist control group

2. Academic Engagement:

H0: There is no significant difference in academic engagement between the yoga intervention group and the waitlist control group after the 6 months' program.

H1: The yoga intervention group will show significantly higher academic engagement compared to the waitlist control group after the 6 months' program.

3. Correlation between Smartphone Addiction and Academic Engagement:

H0: There is no significant correlation between changes in smartphone addiction and academic engagement.

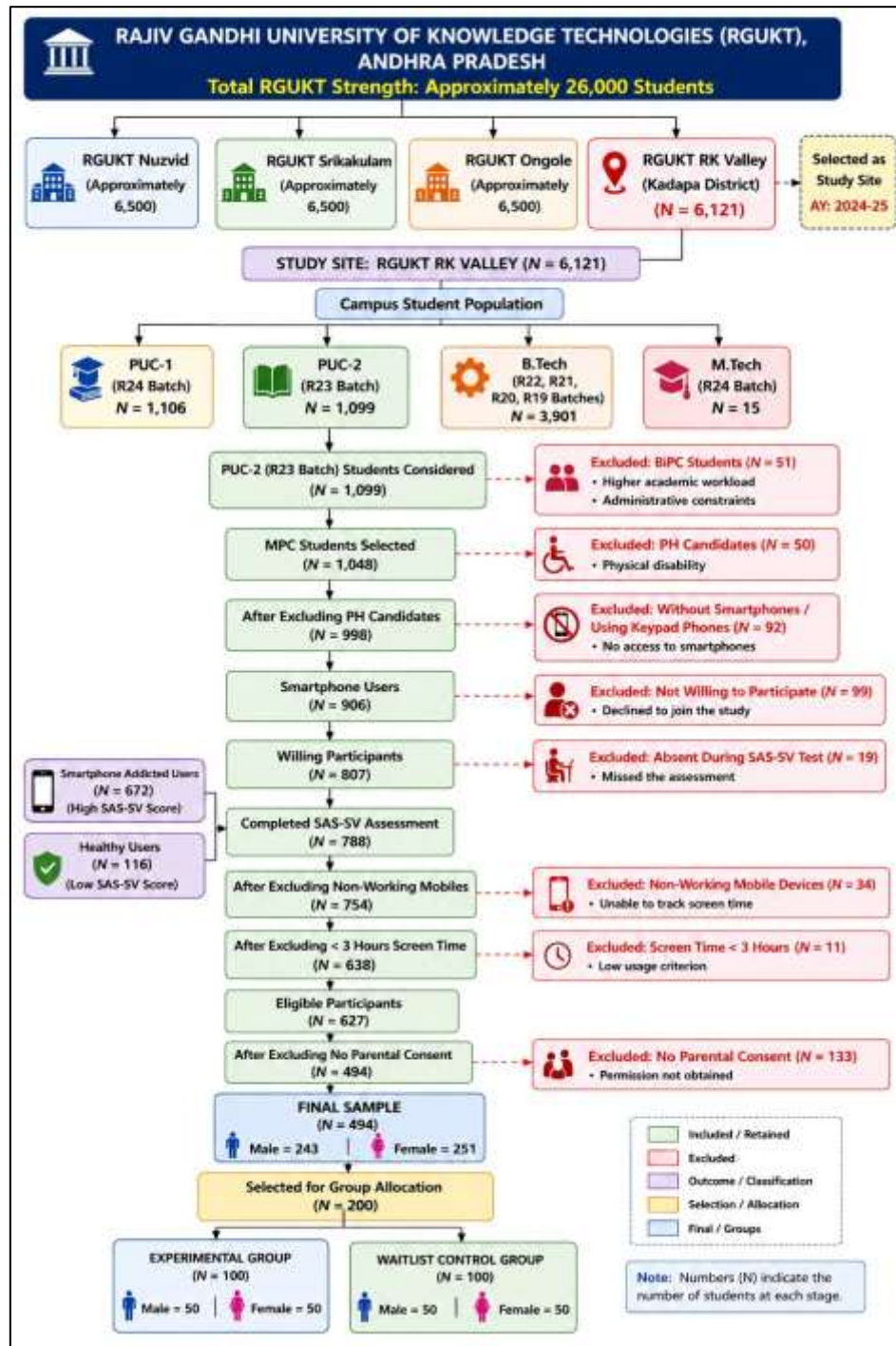
H1: There is a significant correlation between changes in smartphone addiction and academic engagement.

SELECTION AND SOURCE OF PARTICIPANTS:

Participants were selected Rajiv Gandhi University of Knowledge Technologies – RK Valley, located in Kadapa District, Andhra Pradesh. widely known as RGUKT–RK Valley. These institutions were chosen because they provided a diverse academic environment, representing both Pre-University Course with Mathematics, Physics, and Chemistry, as well as Mathematics, Biology, Physics, and Chemistry, integrated with Bachelor of Technology and Master of Technology programs allowing for sufficient variation in student backgrounds, academic demands, and smartphone usage habits.

To qualify for inclusion, students were screened using the age range 16–19 years, minimum smartphone use of 3 hours daily were considered eligible. The selection process ensured that both groups were homogeneous in terms of demographic characteristics and baseline smartphone addiction levels.

Participation was entirely voluntary, with detailed briefing sessions conducted to explain research objectives, procedures, and expected outcomes. Written informed consent was obtained from both the students and their parents or guardians before enrollment.



SAMPLE SIZE:

The study included a total of 200 pre-university students (N = 200) from RGUKT–R.K. Valley, Kadapa, Andhra Pradesh. Participants were randomly selected from second year pre-university students that represented diverse academic streams.

Group Distribution:

- Group A (Yoga Intervention Group): 100 participants received the 60 minutes’ session over 90 academic days within a semester yoga intervention.
- Group B (waitlist Control Group): 100 participants not received any intervention during the study they can receive later.

Sampling Technique:

A stratified random sampling method was utilized to guarantee equitable representation across essential demographic and academic variables. Among 6,121 students at the RGUKT–RK Valley, Kadapa campus, 672 students who reported using a smartphone for over three hours daily and expressed interest in participation were

screened for eligibility from the 1099 PUC-2 cohort. Students were excluded if they reported fewer than three hours of daily smartphone usage, utilized a keypad (non-smartphone) device, were enrolled in non-target academic programs (such as PUC-1, M-BiPC, B.Tech, M.Tech.), had medical or psychological contraindications, participated in other structured interventions, or declined to participate. Following the application of these criteria, 534 students satisfied the inclusion requirements and granted informed consent. The participants were stratified by gender and randomly assigned to two equal groups: the yoga intervention group (N = 100; 50 Male, 50 Female) and the waitlist control group (N = 100; 50 Male, 50 Female). Each group engaged in their designated condition for 60 minutes daily over the course of 90 academic days within a single semester. Attrition was meticulously tracked, and in alignment with the intention-to-treat principle, all randomized participants were incorporated into the final analysis. Randomization within each stratum was performed utilizing a computer-generated allocation sequence, guaranteeing impartiality and uniform selection probability.

Recruitment Process:

A briefing sessions were conducted to explain the purpose, procedure, and benefits of the study. Voluntary participation was emphasized, and written informed consent was obtained from both students and parents. Participants meeting inclusion criteria were randomly allocated to the experimental or waitlist control group using a computer-generated randomization schedule.

Participants inclusion and exclusion criteria:

Inclusion Criteria:

1. Age Range: Participants were required to be between 16 and 19 years old.
2. Enrollment at RGUKT-RK Valley: Only students currently enrolled at Rajiv Gandhi University of Knowledge Technologies – RK Valley, located in Kadapa District, Andhra Pradesh – were included, ensuring uniformity in the educational environment.
3. Regular Smartphone Use: Participants had to report using a smartphone for more than three hours per day, as self-reported or verified through usage logs. This criterion, based on Kuss and Griffiths (2012), was critical for identifying individuals at risk of smartphone addiction.
4. Informed Consent: Participants and their parents (for those under 18 years) provided informed consent, ensuring that they were fully aware of the study's objectives, procedures, and potential risks.

Exclusion Criteria:

1. Recent Yoga Participation: Participants who had engaged in structured yoga programs in the past six months were excluded to avoid bias from prior yoga exposure.
2. Medical Conditions: Individuals with severe medical conditions, including cardiovascular diseases, orthopedic issues, or neurological disorders, that contraindicate physical activity were excluded for safety reasons.
3. Severe Mental Health Conditions: Students receiving treatment for major depressive disorder, bipolar disorder, or schizophrenia were excluded, as these conditions could require more specific interventions and may influence study outcomes.

Ethical Consideration:

Consent:

The study obtained written and signed consent forms from both parents and subjects, and it received approval from the Institutional Review Board of RGUKT-RK Valley. All stipulated guidelines and compliances of the university for conducting research were met. Consent forms were signed voluntarily by all participating students and their parents, with explicit freedom to withdraw from the study. The integrated Yoga module program was conducted in batches in a spacious, well-ventilated room, equipped with carpeting or yoga mats. Female participants were advised to wear leggings and were allowed to relax during menstrual periods. The study involved no financial implications or liabilities, and sessions were conducted during working hours without requiring students to compensate for that time. Confidentiality of the data was maintained. The yoga techniques used were simple and suitable for all students, with provisions for relaxation during sessions if health issues arose.

Ensuring safety of an individual:

No known risks of yoga practice or in administering the questionnaires. Any injury or complications - referred to collage authorities; no liabilities of any kind would be borne. First-aid trained Instructor would handle any pains or injuries and kit was available in the organization

Conflict of Interest:

I declare that there are no conflicts of interest regarding the research and findings presented. The entirety of the research was self-funded, and no external funding or financial support was sought or received. This independence has ensured that the results and conclusions are free from any external influence or bias.

The study protocol has been approved by the Institutional Review Board of RGUKT-RK Valley. Informed consent will be obtained from all participants, with additional assent form for those under 18. Participants will be assured of confidentiality and their right to withdraw from the study at any time without consequence. Data will be anonymized and stored securely to protect participant privacy.

Intervention:

Integrated Yoga Module for Smartphone Addiction:

The intervention consisted of a **validated Integrated Yoga Module** (Putchavayala et al., 2022) designed to reduce smartphone addiction. The module was developed through a rigorous process synthesizing classical yoga texts, Ayurveda principles, and contemporary research, focusing on key concepts related to addiction such as craving, agitation of mind, self-control, and emotional regulation.

| Category | Practice | Number of Rounds / Cycles | Duration |
|-----------------------|--|---|-------------------|
| Prayer | Prayer | — | 1 minute |
| Loosening Practices | Hands rotation | 5 rounds each (clockwise & anticlockwise) | 1 minute |
| Loosening Practices | Wrist rotation | 5 rounds each (clockwise & anticlockwise) | 1 minute |
| Loosening Practices | Neck rotation | 5 rounds each (clockwise & anticlockwise) | 1 minute |
| Loosening Practices | Forward & backward bending | 5 rounds | 1 minute |
| Loosening Practices | Side bending | 5 rounds | 1 minute |
| Loosening Practices | Surya Namaskara | 6 rounds (3 fast, 3 slow) | 3 minutes |
| Breathing Practices | Hands in and out breathing | 5 rounds | 2 minutes |
| Breathing Practices | Hands stretch breathing | 5 rounds | 2 minutes |
| Breathing Practices | Tiger Breathing (Vyagra Kriya) | 5 rounds | 2 minutes |
| Standing Postures | Ardha Chakrasana (Half-Moon Posture) | 1 round | 1 minute |
| Standing Postures | Vrikshasana (Tree Posture) | 2 rounds / 1 round with each leg | 2 minutes |
| Sitting Postures | Gomukhasana (Cow Face Posture) | 1 round | 1 minute |
| Sitting Postures | Ustrasana (Camel Posture) | 1 round | 1 minute |
| Sitting Postures | Sashankasana (Rabbit Posture) | 1 round | 1 minute |
| Prone Postures | Bhujangasana (Cobra Posture) | 1 round | 1 minute |
| Prone Postures | Makarasana (Crocodile Posture) | 1 round | 1 minute |
| Supine Postures | Shavasana (Corpse Posture) | 1 round | 1 minute |
| Pranayama (Breathing) | Bastrika (Bellows Breathing) | 3 rounds / 30 strokes per minute | 3 minutes |
| Pranayama (Breathing) | Nadishuddhi (Alternate Nostril Breathing) | 9 rounds | 3 minutes |
| Pranayama (Breathing) | Ujjayi (Psychic Breathing) | 5 rounds | 3 minutes |
| Pranayama (Breathing) | Bhramari (Humming Bee Breathing) | 5 rounds | 3 minutes |
| Pranayama (Breathing) | Kapalabhati (Frontal Brain Cleansing Breath) | 3 rounds / 60 strokes per minute | 3 minutes |
| Cleansing Practice | Jatru Trataka (Eye Exercises) | — | 2 minutes |
| Chanting & Meditation | Nadhanusandhana (Sectional Breathing & Chanting) | 5 rounds of A, U, M & AUM chanting | 5 minutes |
| Chanting & Meditation | Om Japa | — | 5 minutes |
| Relaxation | Deep Relaxation Technique (DRT) | — | 7 minutes |
| Closing | Closing Prayer | — | 1 minute |
| Total Duration | | | 60 Minutes |

Study Settings:

The study was conducted at RGUKT- R K Valley Kadapa campus, India, selected for their representative student populations and established infrastructure to support yoga sessions.

Duration of The Study:

The duration of the study was planned as 60 minutes' session over 90 academic days within a semester. The schedule was designed such that girls practiced in the morning and boys in the evening 6 days per week, ensuring a structured and consistent practice routine over a semester.

This design aligns with expert recommendations to sustain behavioral change through regular, repeated practice over an extended period. The frequency of 6 days per week for one semester allows adequate time for improvements in self-regulation, mindfulness, and reduction in smartphone addiction symptoms.

Such a duration and frequency are optimal to integrate the holistic benefits of the validated 60-minute Integrated Yoga Module—comprising loosening exercises, postures, breathing techniques, chanting, meditation, and relaxation—into participants' daily lives, thereby improving their academic engagement and digital moderation sustainably

Research Instruments:

1. Smartphone Addiction Scale-Short Version (SAS-SV):

- A 10-item self-report scale scored on a Likert scale from 1 (strongly disagree) to 5 (strongly agree).
- Items assess behaviors such as missing planned work because of phone use, difficulty concentrating, physical discomfort, agitation when not using the phone, and compulsive checking.
- The scale has high internal consistency (Cronbach's alpha = 0.89 in this study) and is validated for adolescent populations. (Kwon, M. et.al., 2013).

2. Academic Engagement Questionnaire:

- Comprises three dimensions: (Gupta, S., & Nagpal, R. 2021).
 - **Cognitive Engagement:** Effort, curiosity, problem-solving, application of concepts, and creativity in academic tasks.
 - **Affective Engagement:** Emotional attachment and sense of belonging to the university, relationships with peers and teachers, and motivation.
 - **Behavioral Engagement:** Participation in physical fitness, arts, seminars, cultural events, collaborations, and professional skill honing.
- Participants respond to items reflecting the frequency or intensity of these behaviors and feelings relative to their academic activities.

3. Demographic Data:

Age, Gender, Parental Education, Parental Socio Economic Status, Extracurricular Activity Participation, Physical Activity Level.

4. Screen Time and Attendance:

 Collected objectively from participant logs and institutional records

Independent Variable: Integrated yoga module for smart phone addiction.

Dependent Variables:

- Smartphone Addiction (measured by SAS-SV).
- Academic Engagement (cognitive, affective, behavioral assessed via self-report questionnaire).
- Behavioral Data: Smartphone Screen Time and Academic Attendance Records.

Data Extraction:

Data extraction was systematically performed to ensure accuracy and completeness of all study variables. For the primary outcome measures (smartphone addiction severity, screen time, physical activity, extracurricular participation, and academic engagement), standardized questionnaires were administered at baseline and post-intervention, with responses logged electronically. Screen time data were corroborated using self-report logs supplemented by device usage tracking where available.

Attendance and participation in the yoga sessions were recorded using institutional attendance registers maintained by researcher, with manual verification procedures to ensure fidelity. Physical activity levels and extracurricular involvement were quantified based on participant-reported in hours per week, validated against school records where feasible.

All demographic and baseline variables were captured at enrollment through structured interviews and background questionnaires. The collected data were securely transferred and stored in encrypted databases for subsequent statistical analysis. Extraction processes adhered to ethical standards, maintaining confidentiality and data integrity throughout.

Assessment Procedures

- **Baseline Assessments:** Conducted before the intervention; included detailed, socio-demographic data, screening with SAS-SV, and other outcome measures.

• **Post-Intervention Assessments:** Conducted yoga module 60 minutes’ session over 90 academic days within a semester after completion of the yoga program to measure changes in smartphone addiction and academic engagement.

Dropout Definition:

Participants who failed to attend three or more consecutive academic calendar sessions were designated as dropouts.

Randomization:

Participants were randomly assigned to groups using computer-generated randomization sequences, with allocation concealed until enrollment. The randomization process ensured equal distribution of baseline characteristics such as age, gender, and baseline smartphone usage metrics.

Statistical Analysis:

Table no.: 1 Demographic Profile of study participants with statistical analysis

| Demography Profile | Variables | N | Mean | Std. Dev | p-value |
|--------------------------------|--------------------|-----|------|----------|---------|
| Age Group | Below 17.5 years | 22 | 1.00 | 0.00 | 0.000 |
| | Above 17.5 years | 178 | 2.00 | 0.00 | 0.000 |
| | Total | 200 | 1.89 | 0.31 | 0.040 |
| Gender | Male | 100 | 1.00 | 0.00 | 0.000 |
| | Female | 100 | 2.00 | 0.00 | 0.000 |
| | Total | 200 | 1.50 | 0.50 | 0.070 |
| Parental Education | Educated | 108 | 1.00 | 0.00 | 0.000 |
| | Non Educated | 92 | 2.00 | 0.00 | 0.000 |
| | Total | 200 | 1.46 | 0.50 | 0.070 |
| Socio Economic Status | Below middle class | 151 | 1.00 | 0.00 | 0.000 |
| | Above middle class | 49 | 2.00 | 0.00 | 0.000 |
| | Total | 200 | 1.25 | 0.43 | 0.060 |
| Extra-Curricular Participation | Less than 2 hours | 180 | 1.00 | 0.00 | 0.000 |
| | More than 2 hours | 20 | 2.00 | 0.00 | 0.000 |
| | Total | 200 | 1.10 | 0.31 | 0.040 |
| Physical Activity Level | Sedentary | 122 | 1.00 | 0.00 | 0.000 |
| | Low Active | 68 | 2.00 | 0.00 | 0.000 |
| | Moderately Active | 6 | 3.00 | 0.00 | 0.000 |
| | Highly Active | 4 | 4.00 | 0.00 | 0.000 |
| | Total | 200 | 1.46 | 0.66 | 0.090 |

The study sample comprised predominantly older adolescents, with 89% aged above 17.5 years (mean coded value = 1.89, SD = 0.31, p = 0.040), indicating potential developmental influences on intervention responsiveness. Gender distribution was balanced with equal males and females (mean = 1.50, SD = 0.50, p = 0.070), ensuring unbiased gender representation. Parental education was nearly equally split between educated and non-educated backgrounds (mean = 1.46, SD = 0.50, p = 0.070), allowing exploration of its moderating effects. Socioeconomic status skewed towards below middle class (75.5%, mean = 1.25, SD = 0.43, p = 0.060), reflecting resource disparities impacting outcomes. Extracurricular participation was limited, with 90% reporting less than two hours daily (mean = 1.10, SD = 0.31, p = 0.040), while physical activity levels favored sedentary or low active profiles (mean = 1.46, SD = 0.66, p = 0.090). These demographic characteristics provide a contextual foundation supporting the study’s internal and external validity and highlight subgroups most likely to benefit from integrated yoga interventions targeting smartphone addiction and academic engagement.

Table no. 2: Pre and post intervention comparison of extracurricular participation among yoga group and control group (N=100)

| Variable | Group | Pre Mean (SD) | Post Mean (SD) | Mean Difference (SD) | t-value | p-value | Interpretation |
|--------------------------------|---------|---------------|----------------|----------------------|---------|---------|---|
| Extra-curricular participation | Yoga | 1.08 (0.27) | 1.76 (0.43) | 0.68 (0.51) | 13.33 | <0.001 | Significant increase in participation, indicating improved engagement outside academics |
| | Control | 1.12 (0.33) | 1.15 (0.36) | 0.03 (0.53) | 0.58 | 0.57 | No significant change |
| Physical Activity Level | Yoga | 1.56 (0.66) | 2.42 (0.93) | 0.86 (1.14) | 7.56 | <0.001 | Significant increase, indicating transition toward active lifestyles |
| | Control | 1.36 | 1.33 | -0.03 (0.97) | -0.31 | 0.76 | No significant change |

| Variable | Group | Pre Mean (SD) | Post Mean (SD) | Mean Difference (SD) | t-value | p-value | Interpretation |
|-----------------------------|---------|---------------|----------------|----------------------|---------|---------|--|
| | | (0.64) | (0.62) | | | | |
| Screen Time (hours/day) | Yoga | 5.32 (1.52) | 2.16 (0.48) | -3.15 (1.54) | 20.46 | <0.001 | Significant reduction, indicating decreased digital device use |
| | Control | 6.05 (1.61) | 7.04 (1.45) | 0.98 (2.09) | 4.71 | 0.001 | Significant increase, indicating increased screen time |
| Smartphone Addiction Scale | Yoga | 3.55 (0.40) | 2.02 (0.25) | -1.53 (0.45) | -33.88 | <0.001 | Significant decrease, showing reduced smartphone addiction |
| | Control | 3.51 (0.52) | 4.00 (0.25) | 0.49 (0.57) | 8.61 | 0.001 | Significant increase, indicating worsening addiction |
| Academic Engagement D1 (CE) | Yoga | 2.49 (0.40) | 3.74 (0.20) | 1.24 (0.43) | 28.96 | <0.001 | Significant cognitive engagement improvement |
| | Control | 2.48 (0.44) | 2.28 (0.19) | -0.20 (0.50) | -3.95 | 0.001 | Significant decline |
| Academic Engagement D2 (AE) | Yoga | 2.66 (0.32) | 3.56 (0.24) | 0.90 (0.43) | 20.81 | <0.001 | Significant affective engagement improvement |
| | Control | 2.59 (0.36) | 2.45 (0.28) | -0.14 (0.43) | -3.30 | 0.001 | Significant decline |
| Academic Engagement D3 (BE) | Yoga | 3.01 (0.52) | 3.51 (0.27) | 0.50 (0.56) | 8.94 | <0.001 | Significant behavioral engagement improvement |
| | Control | 3.04 (0.48) | 2.28 (0.30) | -0.76 (0.56) | -13.63 | 0.001 | Significant decline |
| Total Academic Engagement | Yoga | 2.68 (0.25) | 3.63 (0.13) | 0.95 (0.28) | 33.52 | <0.001 | Overall academic engagement significantly improved |
| | Control | 2.66 (0.27) | 2.26 (0.14) | -0.40 (0.30) | -13.42 | 0.001 | Overall academic engagement significantly declined |

The paired sample t-test results reveal that the yoga intervention group experienced significant improvements across multiple domains. Extra-curricular participation increased substantially by 0.68 points ($t = 13.33, p < 0.001$), reflecting greater engagement beyond academics. Physical activity levels rose by 0.86 points ($t = 7.56, p < 0.001$), indicating a shift toward more active lifestyles, critical given prevalent sedentary behavior in adolescents. Screen time decreased dramatically by over 3 hours daily ($t = 20.46, p < 0.001$), showcasing the intervention's success in reducing device dependency. Smartphone Addiction Scale scores declined significantly by 1.53 points ($t = -33.88, p < 0.001$), demonstrating decreased addictive behaviors. Academic engagement improved robustly across cognitive, affective, and behavioral dimensions, with total engagement rising by 0.95 points ($t = 33.52, p < 0.001$). In contrast, the waitlist control group showed no significant changes in extra-curricular or physical activity, increased screen time and smartphone addiction, and statistically significant declines in all academic engagement domains. These findings collectively underscore yoga's effectiveness as a holistic intervention that promotes healthier behaviors and academic involvement among youth at risk of digital overuse.

Table no. 3: Analysis of variance summary for smart phone addiction and academic engagement measures

| Source | df | Mean Square | F Value | p-value | Partial Eta Squared |
|-------------------|----|-------------|---------|---------|---------------------|
| Extra-curricular | 1 | 18.268 | 116.874 | 0.001 | 0.372 |
| Physical activity | 1 | 59.405 | 94.498 | 0.001 | 0.323 |

| Source | df | Mean Square | F Value | p-value | Partial Eta Squared |
|---------------------|----|-------------|----------|---------|---------------------|
| Academic attendance | 1 | 7921.326 | 520.700 | 0.001 | 0.725 |
| Screen time | 1 | 1189.322 | 1015.309 | 0.001 | 0.837 |
| SAS-SV | 1 | 196.218 | 3152.516 | 0.001 | 0.941 |
| AE D1 | 1 | 105.540 | 2752.136 | 0.001 | 0.933 |
| AE D2 | 1 | 61.268 | 911.588 | 0.001 | 0.822 |
| AE D3 | 1 | 75.953 | 963.206 | 0.001 | 0.829 |
| Total AE | 1 | 93.851 | 5052.747 | 0.001 | 0.962 |

The ANOVA table displays the main effects of group (Yoga vs. Control) on several dependent variables relevant to the study outcomes.

- **Extra-Curricular Participation:** The F value (116.874) with a p-value of 0.001 indicates a statistically significant difference favoring the intervention group. The partial eta squared of 0.372 suggests a large effect size, with group membership explaining 37.2% of the variance in extra-curricular participation.
- **Physical Activity:** A similarly significant effect is evident with $F = 94.498$, $p = 0.001$, and partial eta squared = 0.323, indicating the intervention accounted for 32.3% of the variance in physical activity levels.
- **Academic Attendance:** This variable exhibited a substantial group effect with an F value of 520.700, $p = 0.001$, and a large effect size (partial eta squared = 0.725), indicating the intervention explained 72.5% of variance.
- **Screen Time:** An F value of 1015.309 ($p = 0.001$) with a very large effect size (partial eta squared = 0.837) confirms strong group differences in screen time, favoring reductions among the yoga group.
- **Smartphone Addiction Scale-Short Version (SAS-SV):** The F value of 3152.516 with a partial eta squared of 0.941 reflects an exceptionally large and statistically significant group effect, where intervention status explains 94.1% of the variation in addiction scores.
- **Academic Engagement Domains:**
 - Cognitive Engagement (AE D1) shows $F = 2752.136$, $\eta^2 = 0.933$
 - Affective Engagement (AE D2) shows $F = 911.588$, $\eta^2 = 0.822$
 - Behavioral Engagement (AE D3) shows $F = 963.206$, $\eta^2 = 0.829$
 - Total Academic Engagement (AE) reports $F = 5052.747$ and $\eta^2 = 0.962$

These results demonstrate consistently robust, highly significant intervention effects with very large portions of variance explained, highlighting substantial enhancements in academic engagement dimensions.

Table no. 4: Adjusted Mean Differences by Subgroup with Interaction Tests

| Outcome | Subgroup | AMD (95% CI) | P | P (interaction) |
|---------------------|---------------------|-------------------------|-------------------------|-----------------|
| Screen time | Age <17.5 | -4.666 (-5.553, -3.779) | 0.001 | 0.444 |
| | Age >17.5 | -4.860 (-5.205, -4.515) | 0.001 | |
| | Male | -4.803 (-5.251, -4.356) | 0.001 | 0.706 |
| | Female | -4.861 (-5.353, -4.370) | 0.001 | |
| | Parent educated | -4.741 (-5.104, -4.378) | 0.001 | 0.798 |
| | Parent non-educated | -4.920 (-5.493, -4.348) | 0.001 | |
| | SES below middle | -4.765 (-5.146, -4.383) | 0.001 | 0.069 |
| | SES above middle | -4.964 (-5.534, -4.394) | 0.001 | |
| | EC <2 h | -4.790 (-5.134, -4.445) | 0.001 | 0.359 |
| | EC ≥2 h | -5.331 (-6.693, -3.968) | 0.001 | |
| | Sedentary | -4.583 (-5.007, -4.158) | 0.001 | 0.080 |
| | Low active | -5.345 (-5.774, -4.917) | 0.001 | |
| | SAS-SV | Age <17.5 | -1.952 (-2.274, -1.631) | 0.001 |
| Age >17.5 | | -1.973 (-2.068, -1.878) | 0.001 | |
| Male | | -1.995 (-2.114, -1.877) | 0.001 | 0.677 |
| Female | | -1.931 (-2.073, -1.789) | 0.001 | |
| Parent educated | | -2.002 (-2.136, -1.868) | 0.001 | 0.494 |
| Parent non-educated | | -1.943 (-2.071, -1.816) | 0.001 | |

| Outcome | Subgroup | AMD (95% CI) | P | P (interaction) |
|---------------|----------------------|-------------------------|-------|-----------------|
| | SES below middle | -1.988 (-2.070, -1.907) | 0.001 | 0.104 |
| | SES above middle | -2.029 (-2.178, -1.881) | 0.001 | |
| | EC <2 h | -1.990 (-2.064, -1.917) | 0.001 | 0.701 |
| | EC ≥2 h | -2.016 (-2.435, -1.596) | 0.001 | |
| | Sedentary | -1.979 (-2.076, -1.883) | 0.001 | 0.096 |
| | Low active | -1.999 (-2.126, -1.872) | 0.001 | |
| Cognitive AE | Age <17.5 | 1.484 (1.327, 1.642) | 0.001 | 0.868 |
| | Age >17.5 | 1.446 (1.386, 1.506) | 0.001 | |
| | Male | 1.408 (1.330, 1.487) | 0.001 | 0.972 |
| | Female | 1.490 (1.404, 1.575) | 0.001 | |
| | Parent educated | 1.474 (1.395, 1.554) | 0.001 | 0.909 |
| | Parent non-educated | 1.435 (1.350, 1.519) | 0.001 | |
| | SES below middle | 1.463 (1.398, 1.527) | 0.001 | 0.155 |
| | SES above middle | 1.411 (1.288, 1.535) | 0.001 | |
| | EC <2 h | 1.462 (≈1.410, 1.523) | 0.001 | 0.295 |
| | EC ≥2 h | 1.307 (1.092, 1.522) | 0.001 | |
| | Sedentary–Low active | 1.483 (1.409, 1.556) | 0.001 | 0.027 |
| | Mod–High active | 1.382 (1.282, 1.482) | 0.001 | |
| Affective AE | Age <17.5 | 1.190 (0.880, 1.500) | 0.001 | 0.450 |
| | Age >17.5 | 1.099 (1.021, 1.177) | 0.001 | |
| | Male | 1.148 (1.040, 1.255) | 0.001 | 0.444 |
| | Female | 1.104 (0.983, 1.225) | 0.001 | |
| | Parent educated | 1.129 (1.028, 1.229) | 0.001 | 0.858 |
| | Parent non-educated | 1.093 (0.973, 1.213) | 0.001 | |
| | SES below middle | 1.085 (0.997, 1.173) | 0.001 | 0.047 |
| | SES above middle | 1.147 (1.002, 1.292) | 0.001 | |
| | EC <2 h | 1.120 (1.041, 1.199) | 0.001 | 0.471 |
| | EC ≥2 h | 1.018 (0.643, 1.393) | 0.001 | |
| | Sedentary | 1.138 (1.043, 1.233) | 0.001 | 0.075 |
| | Low active | 1.019 (0.871, 1.166) | 0.001 | |
| Behavioral AE | Age <17.5 | 1.298 (1.057, 1.538) | 0.001 | 0.948 |
| | Age >17.5 | 1.234 (1.147, 1.320) | 0.001 | |
| | Male | 1.234 (1.119, 1.350) | 0.001 | 0.522 |
| | Female | 1.267 (1.146, 1.387) | 0.001 | |
| | Parent educated | 1.266 (1.156, 1.375) | 0.001 | 0.851 |
| | Parent non-educated | 1.239 (1.112, 1.366) | 0.001 | |
| | SES below middle | 1.210 (1.121, 1.299) | 0.001 | 0.190 |
| | SES above middle | 1.330 (1.142, 1.518) | 0.001 | |
| | EC <2 h | 1.231 (1.146, 1.316) | 0.001 | 0.580 |
| | EC ≥2 h | 1.558 (1.191, 1.925) | 0.001 | |
| | Sedentary | 1.233 (1.126, 1.339) | 0.001 | 0.064 |
| | Low active | 1.224 (1.085, 1.364) | 0.001 | |
| Total AE | Age <17.5 | 1.430 (1.323, 1.536) | 0.001 | 0.825 |
| | Age >17.5 | 1.365 (1.324, 1.406) | 0.001 | |
| | Male | 1.366 (1.309, 1.424) | 0.001 | 0.720 |
| | Female | 1.387 (1.330, 1.444) | 0.001 | |
| | Parent educated | 1.397 (1.345, 1.449) | 0.001 | 0.982 |
| | Parent non-educated | 1.358 (1.295, 1.421) | 0.001 | |
| | SES below middle | 1.365 (1.319, 1.411) | 0.001 | 0.124 |
| | SES above middle | 1.393 (1.322, 1.464) | 0.001 | |
| | EC <2 h | 1.379 (1.337, 1.421) | 0.001 | 0.413 |
| | EC ≥2 h | 1.367 (1.199, 1.536) | 0.001 | |
| | Sedentary | 1.391 (1.341, 1.441) | 0.001 | 0.038 |

| Outcome | Subgroup | AMD (95% CI) | P | P (interaction) |
|---------|------------|----------------------|-------|-----------------|
| | Low active | 1.321 (1.249, 1.393) | 0.001 | |

AMD (95%) denotes Adjusted Mean Difference with 95% Confidence Intervals presented in parentheses. The P Value indicates the level of statistical significance for the main effect, with values less than 0.05 considered statistically significant. P (interaction) represents the p-value for the interaction term, which tests whether the effect of the primary independent variable varies significantly across subgroup levels. A non-significant interaction p-value (greater than 0.05) suggests the intervention effect is consistent across subgroups, whereas a significant p-value indicates differential effects warranting subgroup-specific interpretation. Key demographic and behavioral variables examined as moderators include Age (below or above 17.5 years), Gender (male, female), Parental Education (educated, non-educated), Socio-economic Status (below or above middle class), Extracurricular Participation (less than or more than 2 hours), and Physical Activity Level (sedentary, low active).

- Main effects: All subgroups show large, statistically significant reductions in Screen Time and SAS-SV, and significant gains in Cognitive, Affective, Behavioral, and Total Academic Engagement.
- Consistency: Interaction p-values are mostly non-significant, indicating effects are broadly consistent across age, gender, parental education, SES, extracurricular participation, and physical activity.
- Notable interactions: Cognitive AE shows a significant interaction by activity level ($p = 0.027$), and Total AE shows a significant interaction by activity level ($p = 0.038$), suggesting sedentary students may gain slightly more engagement; SES shows borderline interaction for Affective AE ($p = 0.047$) and Screen Time ($p = 0.069$), warranting cautious exploration in future work.

Table no.: 5 Correlation matrix of Smartphone Addiction and Academic Engagement Variables

| Variable Pair | Pearson r | Significance (p) | Strength & Direction | Interpretation |
|--|-----------|------------------|----------------------------------|--|
| Pre SAS-SV & Pre AE | -0.193 | 0.006 | Weak negative | Higher smartphone addiction slightly linked to lower academic engagement before intervention |
| Post SAS-SV & Post AE | -0.945 | 0.000 | Extremely strong negative | Higher smartphone addiction strongly linked to lower academic engagement after intervention |
| Post SAS-SV & Post Screen Time | 0.881 | 0.000 | Very strong positive | More screen time is tightly associated with higher smartphone addiction |
| Pre SAS-SV & Pre Screen Time | 0.236 | 0.001 | Weak positive | Slight link between screen time and smartphone addiction before intervention |
| Post SAS-SV & Post D1 (Distraction 1) | -0.927 | 0.000 | Very strong negative | Smartphone addiction strongly reduces focus in D1 domain |
| Post SAS-SV & Post D2 (Distraction 2) | -0.880 | 0.000 | Very strong negative | Smartphone addiction strongly reduces focus in D2 domain |
| Post SAS-SV & Post D3 (Distraction 3) | -0.877 | 0.000 | Very strong negative | Smartphone addiction strongly reduces focus in D3 domain |
| Post SAS-SV & Academic Attention P2S1 | -0.687 | 0.000 | Strong negative | Smartphone addiction impairs academic attention (P2S1) |
| Post SAS-SV & Academic Attention P2S2 | -0.824 | 0.000 | Very strong negative | Smartphone addiction impairs academic attention (P2S2) |
| Post SAS-SV & Post Physical Activity | -0.558 | 0.000 | Moderate negative | Higher addiction linked to lower physical activity |
| Post SAS-SV & Post Extracurricular Participation | -0.599 | 0.000 | Moderate negative | Higher addiction linked to lower extracurricular involvement |

The correlation analysis reveals a consistent pattern of negative associations between smartphone addiction and academic engagement. Before the intervention, there was a weak negative correlation ($r = -0.193$, $p = 0.006$), indicating that higher smartphone addiction slightly related to lower academic engagement. Post-intervention, this association became extremely strong ($r = -0.945$, $p < 0.001$), demonstrating the intervention's profound impact in strengthening the negative relationship, likely reflecting reduced addiction and improved engagement. Smartphone addiction was also strongly and positively correlated with screen time after intervention ($r = 0.881$, $p < 0.001$), confirming that higher screen time accompanies higher addiction levels. Moreover, smartphone addiction was very strongly negatively correlated with focus across several distraction domains (D1: $r = -0.927$; D2: $r = -0.880$; D3: $r = -0.877$, all $p < 0.001$), indicating addiction markedly reduces attentional capacities.

Academic attention measures similarly showed strong negative correlations (P2S1 $r = -0.687$; P2S2 $r = -0.824$, $p < 0.001$), while moderate negative correlations were found between smartphone addiction and physical activity ($r = -0.558$, $p < 0.001$) and extracurricular participation ($r = -0.599$, $p < 0.001$). These findings underscore smartphone addiction's broad detrimental effects on academic focus, physical activity, and social engagement, with the intervention fostering significant behavioral improvements.

Consolidated Linear Regression Table: Predicting Academic Engagement from Smartphone Addiction (N = 200)

| Component | Statistic / Value | Interpretation |
|--------------------------|--------------------|--|
| Model Summary | | |
| R | 0.845 | Strong correlation between SAS-SV and AE |
| R ² | 0.713 | 71.3% of variance in AE is explained by SAS-SV |
| Adjusted R ² | 0.712 | Adjusted for sample size; still very strong |
| Std. Error of Estimate | 0.396 | Average deviation of predicted AE from actual AE |
| ANOVA (Model Fit) | | |
| Regression | 77.306 | Explained variance |
| Residual | 31.085 | Unexplained variance |
| Total | 108.391 | Total variance in AE |
| F-value | 492.408 | Highly significant model fit |
| Sig. (p-value) | 0.000 | Model is statistically significant |
| Coefficients | | |
| Intercept (Constant) | -0.012 (p = 0.693) | Not significant; AE does not start from a fixed baseline |
| SAS-SV Coefficient (B) | -0.551 (p < 0.001) | For every 1 unit increase in SAS-SV, AE decreases by 0.551 units |
| Standardized Beta | -0.845 | SAS-SV has a very strong negative effect on AE |
| t-value | -22.190 | SAS-SV is a highly significant predictor |
| 95% CI for B | [-0.600, -0.502] | The effect of SAS -SV on AE is consistently negative |

The regression analysis demonstrates a strong and statistically significant model predicting academic engagement (AE) from smartphone addiction severity (SAS). The model shows a high correlation ($R = 0.845$), indicating that SAS-SV strongly relates to AE. The Adjusted R² of 0.712 reflects that 71.2% of the variance in academic engagement is explained by smartphone addiction levels, indicating a robust explanatory power. The model fit is highly significant ($F = 492.408$, $p < 0.001$). The regression coefficient for SAS-SV ($B = -0.551$, $p < 0.001$) indicates that for every one-unit increase in smartphone addiction, academic engagement decreases by 0.551 units, reflecting a strong negative effect (standardized Beta = -0.845). The intercept was not significant, suggesting no fixed baseline level of academic engagement. The 95% confidence interval for the SAS-SV coefficient (-0.600 to -0.502) confirms a consistent negative impact across the sample. Overall, smartphone addiction is a highly significant and powerful negative predictor of academic engagement among pre-university students.

RESULTS

This study evaluated the effects of Integrated Yoga Intervention on Smartphone Addiction, Screen Time, Physical Activity, Extracurricular Participation, and Academic Engagement among Pre-University Students.

Demographic Profile:

The sample comprised predominantly older adolescents (89% over 17.5 years) with a balanced gender distribution, a mix of parental education backgrounds, and a socioeconomic skew toward below middle-class status. Most participants reported low extracurricular involvement (<2 hours/day) and sedentary or low physical activity levels. No significant baseline differences were found between intervention and control groups in key demographic variables, ensuring comparability.

Paired Sample T-Test Outcomes:

The yoga group (N=100) demonstrated statistically significant improvements across all behavioral and academic variables. Extra-curricular participation increased markedly (mean difference = 0.68, $p < 0.001$), as did physical activity (mean difference = 0.86, $p < 0.001$). Daily screen time decreased substantially by 3.15 hours ($p < 0.001$) alongside a significant reduction in smartphone addiction scores (mean difference = -1.53 , $p < 0.001$). Academic engagement improved robustly across cognitive, affective, and behavioral domains, with the total academic engagement score rising by 0.95 points ($p < 0.001$).

In contrast, the waitlist control group showed no significant improvements in extra-curricular participation or physical activity; rather, screen time and smartphone addiction scores increased significantly ($p < 0.01$), while all academic engagement domains significantly declined ($p < 0.001$).

Subgroup Analysis of Screen Time and Smartphone Addiction:

Adjusted mean differences demonstrated consistent reductions in screen time and smartphone addiction across all subgroups defined by age, gender, parental education, socioeconomic status, extracurricular participation, and physical activity levels ($p < 0.001$ for all). Interaction effects were largely non-significant, indicating that intervention benefits were broadly uniform, with a marginal interaction effect suggesting a possible greater screen time reduction in higher socioeconomic groups.

Academic Engagement Subgroup Analysis:

Cognitive, affective, and behavioral engagement scores all improved significantly post-intervention across demographic and behavioral subgroups ($p < 0.001$). The physical activity level showed a minor moderation effect on cognitive and total academic engagement, with sedentary participants gaining slightly more benefit than their more active counterparts.

Correlation Findings:

Pearson correlation analyses revealed a strong negative relationship between smartphone addiction and academic engagement post-intervention ($r = -0.945$, $p < 0.001$), and a very strong positive correlation between smartphone addiction and screen time ($r = 0.881$, $p < 0.001$). Smartphone addiction also strongly negatively correlated with academic attention and focus domains (ranging from -0.877 to -0.927 , $p < 0.001$) and moderately negatively with physical activity ($r = -0.558$) and extracurricular involvement ($r = -0.599$).

Regression Analysis:

Linear regression indicated smartphone addiction as a significant negative predictor of academic engagement ($B = -0.551$, $p < 0.001$), explaining 71.2% of its variance (adjusted $R^2 = 0.712$). The strong standardized beta (-0.845) and significant model fit ($F = 492.41$, $p < 0.001$) confirm the central role of smartphone addiction in shaping academic outcomes.

DISCUSSION

The results of this study align with emerging evidence from recent research highlighting the efficacy of yoga interventions in addressing smartphone addiction and enhancing academic engagement among youth. Consistent with findings by Thapliyal et al. (2025) and Tadpatrikar et al. (2023), this study demonstrated that a structured yoga program significantly reduces problematic smartphone use, as reflected by substantial decreases in SAS-SV scores and screen time. These reductions are critical given the complex cognitive and emotional difficulties linked to excessive smartphone use (Billieux et al., 2024). The strong negative association observed between smartphone addiction and academic engagement highlights the potential of yoga to improve self-regulation, attention, and motivation — key mechanisms identified by Liu et al. (2022) to mitigate technology overuse in adolescents. Furthermore, improvements in physical activity and extracurricular participation reinforce yoga's holistic benefits in promoting balanced, healthier lifestyles (Li et al., 2024). The broad applicability of the intervention across diverse demographic and socioeconomic groups underscores the scalability of yoga-based programs in educational settings (Khalsa et al., 2013). Although some demographic factors like baseline physical activity may moderate cognitive engagement gains, these nuanced insights offer pathways to tailor future interventions for optimal outcomes.

However, despite these promising findings, limitations such as reliance on self-reports and the absence of active comparative groups temper conclusions. Future work should aim to incorporate objective behavioral tracking and randomized designs with active controls to validate and expand upon these results (Frontiers in Psychology, 2022; Sage Journals, 2025). Overall, this study contributes valuable evidence for yoga as a viable, non-pharmacological approach to promoting digital wellness and academic success in adolescents, shedding light on integrative strategies that address modern lifestyle challenges.

Suggestions for Future Research:

- **Neurocognitive Validation:** Use EEG, fMRI, and executive function tests to assess neural changes.
- **Longitudinal Impact:** Monitor behavioral and academic results throughout the academic year.
- **Cross-Cultural Adaptation:** Test intervention efficacy across different cultural and linguistic contexts.
- **Comparative Trials:** Compare yoga with other interventions (e.g., CBT, sports, arts).
- **Digital Integration:** Explore hybrid models combining yoga with gamified digital wellness tools.

Limitations:

- **Age Homogeneity:** Predominance of 17-year-olds limits developmental generalizability.
- **Self-Report Bias:** Subjective measures may be influenced by social desirability.
- **Short-Term Scope:** Longitudinal effects remain unexplored.
- **Single-Site Sample:** Limits external validity across regions and institutions.
- **Control Group Design:** Absence of alternative structured activity may confound comparisons.
- **Cultural Specificity:** Intervention may require adaptation for non-Indian contexts.

Final Reflection:

This research advances the discourse on adolescent wellness by demonstrating that yoga is not merely a physical practice but a transformative developmental tool. It bridges ancient contemplative traditions with modern behavioral science, offering a scalable, inclusive, and empirically validated pathway to youth empowerment. In an era marked by digital saturation and academic fragmentation, yoga emerges as a beacon of balance restoring attention, fostering engagement, and cultivating resilience. The study calls upon educators, policymakers, and researchers to embrace integrative approaches that honor both tradition and innovation in shaping the future of adolescent development.

CONCLUSION

The study conclusively demonstrates that yoga intervention effectively reduces smartphone addiction and screen time while significantly enhancing physical activity, extracurricular participation, and academic engagement among pre-university students. These positive outcomes were broadly consistent across diverse demographic and socioeconomic groups, indicating yoga's versatility and potential for widespread application in educational settings. The strong negative relationship between smartphone addiction and academic engagement highlights yoga's critical role in fostering cognitive, emotional, and behavioral improvements conducive to academic success and healthier digital habits. While some variations in cognitive gains based on baseline physical activity were noted, the intervention's overall benefits support its adoption as a holistic, scalable approach to tackle modern challenges of digital addiction and promote adolescent well-being and educational outcomes.

Acknowledgments: We express our gratitude to the participants of this study, their families, and all contributing investigators.

Competing Interests: All the authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding: No financial support has been obtained from any sources.

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