

Association of Exercise Frequency with Smartphone Addiction and Psychosocial Well-being among Undergraduate Medical Students: An Analytical Cross-sectional Study

Running title: Exercise, Smartphone Addiction and psychosocial well-being

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ABSTRACT

Background: Medical students experience psychological distress and smart phone addiction along with prolonged study hours. Exercise behaviour is a modifiable but complex factor related to smartphone addiction, sleep and psychosocial well-being. **Objective:** To evaluate the association of exercise frequency with smartphone addiction, sleep and psychosocial parameters among undergraduate medical students. **Methods:** A descriptive, observational, analytical cross-sectional study was conducted among 380 undergraduate medical students, selected by simple random sampling. Data were collected using a pretested structured questionnaire, which had sections on sleep, self-esteem, hopelessness, self-belief, emotional disturbance, depression, anxiety, stress, social behaviour and smartphone addiction. Exercise frequency was categorised as daily, four to six days/week, two to three days/week, and one day/week or rarely. Welch's analysis of variance with Games–Howell post-hoc testing was used. Spearman correlation was used to assess monotonic associations. A secondary binary comparison used Welch's two-sample t-test. **Results:** Exercise frequency differed significantly across groups for self-esteem, emotional disturbance, depression, stress, smartphone addiction and sleep disturbance. Stress showed a weak inverse correlation ($p=-0.129$, $P=0.012$), whereas sleep disturbance showed a weak positive correlation ($p=0.104$, $P=0.042$) with exercise frequency. No significant monotonic correlation was observed between exercise frequency and smartphone addiction. **Conclusion:** Exercise behaviour was associated with multiple psychosocial and behavioural outcomes, but the direction and magnitude of associations varied according to the frequency and type of exercise.

Keywords: Exercise; Smartphone addiction; Medical students; Depression; Psychosocial well-being

INTRODUCTION

Physical activity is an integral part of healthy living and contributes to both physical and psychological well-being. The World Health Organization recommends regular physical activity for adults, reflecting the significant role of physical activity in prevention of non-communicable disease and promotion of health.¹ Huge academic curriculum, prolonged hours of studying, examinations, irregular sleep schedules and high psychological stress can restrict opportunities for regular exercise and hence,

encouraging sedentary behaviour among medical students. A systematic review involving medical students has found a significant association between physical activity and lower burnout and better quality of life, suggesting that physical activity may have effect over psychosocial well-being as well.²

In a randomised control trial, exercise interventions reduce depression scores and improve the quality of life among depressed individuals.^{3, 4} Furthermore, meta-analytic evidence suggests that physical activity interventions may improve self-esteem and self-

concept, indicating that an active lifestyle may reduce of psychopathological symptoms.⁵ These findings provide a biological and behavioural rationale for examining exercise in relation to multiple aspects of psychosocial well-being among youth.

At present, smartphone use has become deeply integrated into every student's life. Although smart phones provide substantial academic, social, recreational and communication services, uncontrolled usage can result in addiction- which has been reported frequently among Asian medical students(41.93%).⁶ Systematic reviews have linked smartphone addiction with anxiety, depression and other psychological outcomes, though the direction and causality of the associations remain uncertain.⁷ Physical activity may affect smartphone use through behavioural change, time displacement, self-regulation and sleep. Studies among university students have reported inverse relationship between smartphone addiction and physical activity.⁸ while a study among U.S. college students demonstrated relationships between mobile-phone use, physical activity and sedentary behaviour.⁹ Recent systematic reviews have suggested that greater physical activity may be associated with lower smartphone addiction among university students, although cross-sectional nature of the studies limits causal inferences.^{10, 11} Differences in definitions of physical activity, exercise frequency, exercise duration, exercise intensity may contribute to inconsistent findings, as two students exercising on the same number of days may differ substantially in duration, intensity and energy expenditure.

Smartphone addiction has been associated with poor sleep quality among medical students.^{12, 13} Recent evidence among college students suggests that physical exercise may modify the relationship between smartphone addiction and sleep quality, while another study demonstrated a relationship between physical activity, sleep quality, self-control and mobile-phone addiction.^{14, 15} These observations suggest that physical activity, smartphone addiction and psychological well-being constitute interconnected behavioural nature and personality of an individual.

A systematic review and meta-analysis of randomised controlled trials among university students reported outcome-specific differences between different exercise modalities for depression, anxiety and stress.¹⁶ A recent meta-analysis examining physical activity and mobile-phone addiction among college students reported an overall inverse relationship.¹⁷

Despite these findings, relatively few studies have simultaneously examined exercise frequency, exercise type, smartphone addiction, sleep and multiple dimensions of psychosocial well-being in undergraduate medical students. The present study therefore assessed the association of self-reported exercise frequency with smartphone addiction, sleep disturbance and psychosocial parameters, including self-belief, self-esteem, hopelessness, emotional

functioning, depression, anxiety, stress and social behaviour. Exercise type was additionally examined as a separate categorical exposure. Given the cross-sectional design, the study was intended to identify associations rather than establish causal effects. By examining these domains concurrently, the study aims to provide a more integrated understanding of the behavioural and psychological factors associated with the well-being of undergraduate medical students and to generate evidence that may inform future student-wellness and lifestyle interventions.

MATERIALS AND METHODS

Study Design and Setting

A descriptive, observational, analytical cross-sectional study was conducted among undergraduate Bachelor of Medicine and Bachelor of Surgery (MBBS) students at a tertiary medical teaching institution in eastern India between September and December 2024.

Study Population and Sampling

Undergraduate students from all the four professional phases were eligible for inclusion. A total of 380 students constituted the analytical sample. The sample size of the parent study was calculated using Cochran's formula, assuming a 52% prevalence of smartphone addiction and a 5% absolute allowable error.¹³ Students who were present on the day of data collection and provided written informed consent were selected by consecutive sampling. Students with a previously diagnosed psychological disorder predating entry into the medical course were excluded.

Data Collection and Study Instruments

Data were collected using a predesigned, pretested and structured questionnaire. The questionnaire included sociodemographic characteristics, exercise behaviour, smartphone use, sleep disturbance and psychosocial parameters.

Depression, anxiety and stress were assessed using the Depression, Anxiety and Stress Scale-21. Smartphone addiction was assessed using the Smartphone Addiction Scale-Short Version. Additional domains included self-belief, self-esteem, hopelessness, emotional functioning, social behaviour, overeating, allergy symptoms and gastrointestinal symptoms.

The questionnaire underwent face and content validation by experts in community medicine and psychiatry. Its internal consistency was good, with a Cronbach's alpha of 0.93.

Assessment of Exercise

Exercise frequency was the principal exposure variable which was categorised into four groups: daily, four to six days/week, two to three days/week, and one day/week or rarely. Exercise was self-reported. No validated quantitative physical-activity questionnaire or objective activity-monitoring device was used.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 23. Continuous variables were expressed as mean $\pm$ standard deviation whereas categorical variables were expressed in terms of frequencies and percentages. The four exercise-frequency groups were compared for psychosocial, behavioural, smartphone-related and sleep outcomes. Because several variables showed unequal variances, Welch's analysis of variance was used as the omnibus test where appropriate. Games–Howell post-hoc analysis was used to identify specific pairwise differences following significant omnibus results. Spearman rank correlation was used to assess monotonic relationships between exercise frequency and continuous study parameters. A secondary binary comparison was performed by combining participants

into no/rare exercise and exercising groups by Welch's two-sample t-test. Exercise type was analysed separately using Welch's analysis of variance because of heterogeneity of variance across groups, followed by Games–Howell post-hoc comparisons. All statistical tests were two-tailed and $P < 0.05$ was considered statistically significant.

Ethical Considerations

The study received approval from the responsible institutional ethics committee on July 20, 2024. (Ref. No. MC/KOL/ECNON-SPON/2527/06/2024). Written informed consent was obtained from all participants. Anonymity and confidentiality were maintained throughout the study.

RESULTS

The study comprised of 380 undergraduate medical students. Exercise frequency was reported as daily by 64 (16.8%) participants, four to six days/week by 72 (18.9%), two to three days/week by 114 (30.0%), and one day/week or rarely by 130 (34.2%) participants (Table 1).

Table 1. Distribution of participants according to exercise frequency

Exercise frequency	n	%
Daily	64	16.8
Four to six days/week	72	18.9
Two to three days/week	114	30.0
One day/week or rarely	130	34.2
Total	380	100

Significant differences across exercise-frequency categories were observed for self-esteem, emotional score, depression, stress, smartphone addiction and sleep disturbance (Table 2). The highest mean SAS-SV score was observed in the four-to-six-days/week group (36.07 ± 9.37), followed by the two-to-three-days/week group (30.21 ± 10.90), one-day/week-or-rarely group (29.23 ± 13.11) and daily group (26.52 ± 11.03).

Table 2. Comparison of psychosocial and behavioural parameters according to exercise frequency

Parameter	Daily	Four to six days/week	Two to three days/week	One day/week or rarely	Welch's ANOVA P
Self-belief	24.20 $\pm$ 5.65	25.49 $\pm$ 4.58	23.74 $\pm$ 5.33	24.06 $\pm$ 5.03	0.100
Self-esteem	20.53 $\pm$ 5.93	21.42 $\pm$ 5.40	19.19 $\pm$ 5.79	19.68 $\pm$ 5.04	0.046
Hopelessness	19.20 $\pm$ 4.07	20.40 $\pm$ 6.10	19.23 $\pm$ 5.64	18.49 $\pm$ 5.62	0.190
Emotional score	17.64 $\pm$ 3.85	19.65 $\pm$ 6.22	16.67 $\pm$ 4.36	18.28 $\pm$ 4.45	0.002
Depression	13.16 $\pm$ 9.48	16.36 $\pm$ 13.81	16.53 $\pm$ 11.50	12.59 $\pm$ 8.87	0.012
Anxiety	11.81 $\pm$ 9.50	13.11 $\pm$ 12.11	12.49 $\pm$ 9.60	12.80 $\pm$ 8.62	0.886
Stress	17.34 $\pm$ 8.30	16.36 $\pm$ 12.46	18.07 $\pm$ 10.61	14.22 $\pm$ 8.71	0.011
Social behaviour	15.64 $\pm$ 3.29	15.65 $\pm$ 2.13	15.75 $\pm$ 3.63	16.69 $\pm$ 3.89	0.078
SAS-SV score	26.52 $\pm$ 11.03	36.07 $\pm$ 9.37	30.21 $\pm$ 10.90	29.23 $\pm$ 13.11	<0.001
Sleep disturbance	15.13 $\pm$ 3.35	14.63 $\pm$ 2.53	15.26 $\pm$ 2.97	15.89 $\pm$ 3.43	0.034

Values are mean $\pm$ standard deviation. SAS-SV: Smartphone Addiction Scale–Short Version.

Spearman correlation showed a weak inverse association between exercise frequency and stress ($\rho = -0.129$, $P = 0.012$) and a weak positive association between exercise frequency and sleep disturbance ($\rho = 0.104$, $P = 0.042$). No significant associations were observed for self-belief, self-esteem, hopelessness, emotional score, depression, anxiety, social behaviour or smartphone addiction (Table 3).

Table 3. Spearman rank correlation between exercise frequency and study parameters

Variable	Spearman ρ	P
Self-belief	-0.071	0.169
Self-esteem	-0.071	0.168
Hopelessness	-0.079	0.123
Emotional score	0.007	0.886
Depression	-0.043	0.399
Anxiety	0.068	0.187
Stress	-0.129	0.012
Social behaviour	0.086	0.096
SMA	-0.040	0.439
Sleep disturbance	0.104	0.042

SMA: smartphone addiction.

In the secondary binary comparison, exercising students had lower sleep disturbance scores but higher depression and stress than students reporting no or rare exercise. Social behaviour scores were lower among exercising students, while SAS-SV scores did not differ significantly between the two groups (Table 4).

Table 4. Comparison of parameters between no/rare exercise and exercising students using Welch's two-sample t-test

Parameter	No/rare exercise Mean	Exercise Mean	t value	P
Sleep disturbance score	15.885	15.044	2.3723	0.0185
Self-belief score	24.062	24.360	-0.5405	0.5893
Self-esteem score	19.677	20.176	-0.8702	0.3849
Hopelessness score	18.492	19.560	-1.7767	0.0768
Emotional score	18.277	17.776	0.9975	0.3194
Depression score	12.585	15.616	-2.8113	0.0052
Anxiety score	12.800	12.496	0.3043	0.7611
Stress score	14.215	17.392	-3.1191	0.0020
DASS total score	39.600	45.504	-2.0950	0.0369
Social behaviour score	16.692	15.696	2.5215	0.0124
SAS-SV score	29.231	30.952	-1.279	0.2024
Overeating	1.708	1.784	-1.5968	0.1116
Allergy	1.492	1.600	-1.9993	0.0466
GI tract score	1.108	1.160	-1.4594	0.1455

Values are mean scores. DASS: Depression, Anxiety and Stress Scale; SAS-SV: Smartphone Addiction Scale–Short Version; GI: gastrointestinal.

Sleep disturbance 1.471 0.226 None

Social behaviour 2.049 0.110 None

GI tract score 2.443 0.067 None

Exercise type: 0=no exercise; 1=free-hand movement; 2=cycling/jogging; 3=gym workout. P values for pairwise comparisons are adjusted. Welch F: Welch's analysis of variance statistic. DASS: Depression, Anxiety and Stress Scale; SAS-SV: Smartphone Addiction Scale–Short Version; GI: gastrointestinal.

DISCUSSION

The present study found that exercise behaviour is associated with multiple aspects of mental well-being, smartphone addiction and sleep among undergraduate medical students. However, the results also

demonstrate that these relationships are non-linear and cannot be adequately described by assuming that increasing exercise frequency produces progressively better psychological outcomes because of the cross-sectional nature of the study.

The significant association between exercise frequency and self-esteem is consistent with previous evidence showing improvements in self-esteem and self-concept following physical-activity interventions.⁵ Exercise has also been linked with reduced depressive symptoms in meta-analyses,^{3, 4} while physical activity among medical students has been linked with lower burnout and better quality of life.² In the present study, however, the relationship was not uniform. Although the comparison demonstrated differences in self-esteem and depression across exercise-frequency groups, the corresponding Spearman correlations were not significant for either self-esteem or depression. This suggests that differences between individual exercise frequency categories cannot be interpreted as a linear dose-response relationship.

Stress showed a weak but statistically significant inverse correlation with exercise frequency. This finding is compatible with the broader literature supporting psychological benefits of physical activity.²⁻⁴ Nevertheless, the secondary binary analysis showed higher stress among students reporting exercise than among those reporting no or rare exercise. These apparently contrasting findings illustrate the importance of how exercise is quantified. Categorising students into only two groups may conceal non-linear patterns across more detailed frequency categories. A better alternative explanation is reverse causation. Students experiencing greater psychological stress may deliberately undertake exercise as a coping mechanism. Similarly, students with greater academic workload may differ simultaneously in both exercise behaviour and stress levels. Owing to the cross-sectional design of the study, the temporal relationship between exercise and psychological outcomes cannot be determined.

Exercise frequency was significantly associated with smart phone addiction. However, the highest SAS-SV score occurred in the four-to-six-days/week group rather than among students reporting little or no exercise. Moreover, Spearman correlation between exercise frequency and SAS-SV score was not statistically significant, and the secondary binary comparison also showed no significant difference. Previous studies have identified significant association between smartphone addiction and physical activity,^{8, 9} while systematic reviews have suggested that greater physical activity is linked with lower smartphone addiction among university students.^{10, 11} The most recent meta-analytic evidence also supports an overall inverse relationship between physical activity and mobile-phone addiction.¹⁷ The discrepancy reflect differences in study populations, definitions of exercise and physical activity, smartphone-use patterns and study design. One important explanation is that the present study assessed exercise frequency rather than total physical activity. Frequency does not incorporate duration or intensity of exercise. Consequently, frequency-based categorisation may not adequately

capture the physiological exposure relevant to smartphone addiction.

Sleep provides another important dimension of the study. Exercise frequency showed a weak positive Spearman correlation with sleep disturbance, while the binary comparison showed lower sleep disturbance among exercising students. This inconsistency suggests that the relationship may be sensitive to categorisation and is not necessarily monotonic. Previous systematic reviews have found significant association between smartphone addiction and poor sleep among medical students.^{12, 13}

Physical activity may alter this relationship through directing the leisure time into exercise, encouraging social interactions and reduction of stress, anxiety and depression. Exercise may provide structured non-screen time, whereas excessive smartphone use may displace sleep and physical activity. Evidence has suggested that physical exercise may modify the association between smartphone addiction and sleep quality,¹⁴ while self-control over smart phone usage may form a chain linking physical activity and sleep.¹⁵ The relationship between physical activity and smartphone addiction involves multiple interlinked pathways. Excessive smartphone use may displace the time available for physical activity and sleep, while psychological distress may influence both smartphone use and exercise behaviour.^{14, 15} Thus, the apparently inconsistent associations observed in the present study may reflect the complexity of these interconnected behaviours.

Overall, the findings are broadly consistent with the existing literature,²⁻⁵ while also highlighting differences from studies reporting a predominantly inverse relationship between physical activity and smartphone addiction.^{10, 11, 17} The discrepancies may be attributable to differences in data quantification and population characteristics. Rather than restricting the analysis to depression or anxiety, the study considered multidimensional psychosocial assessment incorporating self-belief, self-esteem, hopelessness, emotional functioning, depression, anxiety, stress, social behaviour, smartphone addiction and sleep disturbance. Hence, such a wide spectrum assessment suggests that exercise behaviour may be related to different aspects of student well-being in various ways. The findings of our study support physical activity as part of a healthy lifestyle and suggest potential psychosocial benefits, like the existing literature.¹⁻⁵ Hence, the curriculum must include significant time allotment for encouraging physical activity while simultaneously addressing mental health, sleep hygiene, academic stress and problematic smartphone use. Future research should therefore use validated quantitative physical-activity measures, objective smartphone-use data and validated sleep assessments, together with longitudinal designs capable of establishing temporal relationships.

Strengths and Limitations

The study's principal strength was its multidimensional assessment of psychosocial well-being alongside exercise, smartphone addiction and sleep. However, the cross-sectional design prevents causal inference. Exercise was self-reported and did not quantify intensity, duration or total activity volume. Residual confounding by academic workload, baseline psychological status, sleep schedule, social support and smartphone-use patterns cannot be excluded. The single-institution setting also limits generalisability.

CONCLUSION

Exercise behaviour was associated with several psychosocial, smartphone-related and sleep outcomes among undergraduate medical students. However, the associations were not consistently linear or directionally uniform. The findings therefore support an association between exercise behaviour and student well-being rather than a causal protective effect. Future longitudinal studies using objective and validated measures of physical activity, smartphone use and sleep are needed to clarify these relationships.

Data Availability Statement

Data availability upon reasonable request subject to institutional/ethical restrictions.

Conflicts of Interest

The authors declare that they have no conflicts of interest

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