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Smartphone Addiction and Cardiovascular Reactivity to Acute Mental Stress among Young Adults

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ABSTRACT

Background: Excessive smartphone use has become common among young adults and may influence stress levels, sleep patterns and autonomic regulation. Acute mental stress produces measurable cardiovascular changes, mainly through sympathetic activation. Assessment of heart rate and blood pressure response during mental stress can help in understanding cardiovascular reactivity in relation to smartphone addiction.

Aim: The study was conducted to assess the association between smartphone addiction and cardiovascular response to acute mental stress in young adults.

Methods: Smartphone addiction was assessed using the Smartphone Addiction Scale-Short Version. Participants were categorized into lower and higher smartphone addiction groups using the median SAS-SV score as the cut-off. Baseline heart rate and blood pressure were recorded after rest, followed by acute mental stress induced using a mental arithmetic task. Post-stress cardiovascular parameters were recorded, and cardiovascular reactivity was calculated as the difference between post-stress and baseline values.

Results: Acute mental stress significantly increased heart rate, blood pressure, mean arterial pressure and rate pressure product from baseline values ($p < 0.001$). Participants with higher smartphone addiction had significantly greater cardiovascular reactivity, including higher ΔRPP, than those with lower smartphone addiction (2328.73 ± 451.95 vs 1535.98 ± 412.16; $p < 0.001$). SAS-SV score showed a significant positive correlation with ΔRPP ($r = 0.685$, $p < 0.001$).

Conclusions: Higher smartphone addiction was associated with greater cardiovascular reactivity to acute mental stress in young adults. These findings suggest that excessive smartphone use may be associated with altered autonomic stress response and increased cardiac workload even in apparently healthy individuals.

Keywords*: Smartphone addiction, acute mental stress, cardiovascular reactivity, heart rate, blood pressure, young adults.*

INTRODUCTION

Smartphone use has become a routine part of daily life, especially among young adults and medical students. It is used for communication, study, entertainment, social networking and online academic work. Although smartphones have many benefits, excessive and uncontrolled use may gradually become problematic. In many students, frequent checking of notifications, prolonged screen exposure, late-night use and fear of missing out can interfere with sleep, attention, emotional balance and day-to-day functioning. This pattern is often described as problematic smartphone use or smartphone addiction, although the term "addiction" is still discussed with caution in behavioural research (Panova & Carbonell, 2018).

Smartphone addiction is not only a behavioural issue; it may also have physiological relevance. Previous studies have reported its association with stress, anxiety, depressive symptoms, poor sleep and reduced life satisfaction among young individuals (Elhai et al., 2016; Elhai et al., 2017; Samaha & Hawi, 2016; Thomée et al., 2011). In students, this becomes more important because academic pressure, irregular sleep, long sitting hours and continuous digital exposure may act together. The Smartphone Addiction Scale and its short version have been widely used to quantify this pattern of excessive smartphone use in research settings (Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013).

From a physiology point of view, the autonomic nervous system plays an important role in maintaining cardiovascular stability during rest and stress. Heart rate and blood pressure are continuously regulated by sympathetic and parasympathetic activity. When a person is exposed to mental stress, there is usually sympathetic activation, resulting in an increase in heart rate, systolic blood pressure, diastolic blood pressure and myocardial workload. Such changes are part of normal cardiovascular reactivity, but exaggerated or repeated responses may indicate altered autonomic regulation (Carter & Goldstein, 2015; Carter & Ray, 2009).

Acute mental stress can be assessed in the laboratory using simple tasks such as mental arithmetic, Stroop test or other cognitive challenges. These tasks produce measurable cardiovascular responses and are commonly used to study autonomic reactivity. Mental stress has been shown to increase blood pressure and alter heart rate variability during controlled experimental conditions (Hjortskov et al., 2004; Kirschbaum et al., 1993; Mestanik et al., 2015). Cardiovascular response to laboratory mental stress is also considered important because higher stress reactivity has been associated with future cardiovascular risk status (Chida & Steptoe, 2010).

Heart rate variability is an important non-invasive marker of autonomic function, but even simple cardiovascular parameters such as heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure and rate pressure product can provide useful information regarding autonomic response to stress. Stress-related reduction in heart rate variability and increased sympathetic arousal have been described in earlier literature (Kim et al., 2018; Shaffer & Ginsberg, 2017). Similarly, psychological stress has long been recognised as one of the factors influencing cardiovascular health through neuroendocrine and autonomic mechanisms (McEwen, 1998; Rozanski et al., 1999).

Excessive smartphone use may influence autonomic activity through several possible pathways. These include mental over-engagement, sleep disturbance, emotional arousal, reduced physical activity, musculoskeletal discomfort and persistent exposure to digital notifications. Alassiri et al. (2020) reported that exposure to cell phones was associated with reduction in heart rate variability among medical students. Katiyar et al. (2024) also studied the effect of smartphone usage on neck muscle and hand grip strength, suggesting that smartphone use may have measurable effects beyond behaviour alone. These findings support the need to examine smartphone use from a broader physiological perspective.

Although several studies have examined smartphone addiction in relation to stress, sleep and mental health, relatively fewer studies have focused on its association with cardiovascular response to acute mental stress in young adults. This aspect is relevant because students with higher smartphone addiction may show altered autonomic response when exposed to acute cognitive stress. Early identification of such changes may help in understanding the physiological impact of excessive smartphone use before clinically apparent cardiovascular problems develop.

Therefore, the present study was conducted to assess smartphone addiction and cardiovascular reactivity to acute mental stress in young adults. The study aimed to evaluate changes in heart rate and blood pressure following acute mental stress and to determine whether smartphone addiction score was associated with the magnitude of cardiovascular response.

METHODS:

This cross-sectional analytical study with an acute experimental component was conducted in the Department of Physiology, Autonomous State Medical College, Sultanpur, Uttar Pradesh, India, among apparently healthy young adults. The study was carried out after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment. The study was conducted over a period of one year.

The sample size was calculated for assessing the correlation between smartphone addiction score and cardiovascular reactivity to acute mental stress. Considering an expected correlation coefficient of 0.30, 95% confidence level, 80% power and 5% level of significance, the minimum required sample size was calculated to be 85 participants. Therefore, a total of 85 participants aged 18–25 years were included in the study.

Apparently healthy young adults who were willing to participate were enrolled. Participants with known cardiovascular disease, hypertension, diabetes mellitus, respiratory illness, psychiatric illness, acute illness, history of smoking or alcohol intake, or current use of drugs affecting autonomic or cardiovascular function were excluded. Participants who had consumed caffeine or had performed heavy exercise within two hours before testing were also excluded.

Basic demographic details including age, gender, height and weight were recorded using a structured proforma. Body mass index was calculated as weight in kilograms divided by height in metres squared. Smartphone addiction was assessed using the Smartphone Addiction Scale–Short Version. The SAS-SV consists of 10 items scored on a six-point Likert scale, with higher scores indicating greater smartphone addiction tendency.

All recordings were performed in a quiet room under comfortable environmental conditions. Participants were asked to sit comfortably and rest for 10 minutes before recording baseline parameters. Baseline heart rate, systolic blood pressure and diastolic blood pressure were recorded in the sitting position. Pulse pressure was calculated as systolic blood pressure minus diastolic blood pressure. Mean arterial pressure was calculated as diastolic blood pressure plus one-third of pulse pressure. Rate pressure product was calculated as heart rate multiplied by systolic blood pressure.

Acute mental stress was induced using a mental arithmetic task. Participants were asked to perform serial subtraction continuously for 5 minutes under time pressure. Immediately after completion of the task, heart rate and blood pressure were recorded again. Post-stress recordings were taken in the same sitting position using the same procedure as baseline recordings. The difference between post-stress and baseline values was considered as cardiovascular reactivity to acute mental stress.

Participants were classified into lower and higher smartphone addiction groups using the median SAS-SV score as the cut-off. Cardiovascular reactivity parameters were compared between lower and higher smartphone addiction groups. Correlation between smartphone addiction score and cardiovascular reactivity was also assessed.

Data were entered in Microsoft Excel and analysed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. Normality of continuous variables was assessed before applying parametric tests. Paired t-test was used to compare baseline and post-stress cardiovascular parameters. Independent t-test was used to compare cardiovascular reactivity between lower and higher smartphone addiction groups. Pearson correlation test was used to assess the association between SAS-SV score and cardiovascular reactivity parameters. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 85 participants were included in the study. The mean age of the participants was 21.40 ± 2.40 years. The mean BMI was 22.60 ± 2.39 kg/m². The mean daily smartphone use was 6.56 ± 1.58 hours, and the mean SAS-SV score was 33.67 ± 8.29. Among the participants, 47 (55.3%) were females and 38 (44.7%) were males. Night-time smartphone use was reported by 46 (54.1%) participants, while smartphone use before sleep was reported by 58 (68.2%) participants. Based on the median SAS-SV cut-off, 41 (48.2%) participants were included in the lower smartphone addiction group and 44 (51.8%) in the higher smartphone addiction group (Table 1).

Table 1. Baseline demographic and smartphone-use characteristics of participants (N=85)

Characteristic	Total participants (N=85)
Age (years), mean ± SD	21.40 ± 2.40
Height (cm), mean ± SD	164.41 ± 7.21
Weight (kg), mean ± SD	61.20 ± 8.35
BMI (kg/m²), mean ± SD	22.60 ± 2.39
Daily smartphone use (hours), mean ± SD	6.56 ± 1.58
SAS-SV score, mean ± SD	33.67 ± 8.29
Gender	
Female	47 (55.3%)
Male	38 (44.7%)
MBBS Year	
1st year	18 (21.2%)
2nd year	18 (21.2%)
3rd year	17 (20.0%)
Final year	17 (20.0%)
Intern	15 (17.6%)
Night-time smartphone use	
Yes	46 (54.1%)
No	39 (45.9%)
Smartphone use before sleep	
Yes	58 (68.2%)
No	27 (31.8%)
Smartphone addiction group	
Lower smartphone addiction	41 (48.2%)

Higher smartphone addiction	44 (51.8%)

Following acute mental stress, all cardiovascular parameters showed a statistically significant increase from baseline values. Heart rate increased from 71.35 ± 5.00 to 80.99 ± 6.25 beats/min, while systolic blood pressure increased from 113.62 ± 6.14 to 124.08 ± 7.18 mmHg. Similar significant increases were observed in diastolic blood pressure, pulse pressure, mean arterial pressure and rate pressure product. The increase in all parameters was statistically significant with $p < 0.001$ (Table 2, Figure 1 and Figure 2).

Table 2. Comparison of cardiovascular parameters before and after acute mental stress

Parameter	Baseline	Post-stress	Mean change	t	p
HR	71.35 ± 5.00	80.99 ± 6.25	9.64	28.23	<0.001
SBP	113.62 ± 6.14	124.08 ± 7.18	10.46	25.59	<0.001
DBP	72.98 ± 4.03	78.94 ± 4.97	5.96	24.92	<0.001
PP	40.65 ± 5.96	45.14 ± 6.94	4.49	11.34	<0.001
MAP	86.53 ± 3.94	93.99 ± 4.79	7.46	30.73	<0.001
RPP	8109.69 ± 749.47	10056.04 ± 1036.03	1946.34	30.58	<0.001

Figure 1. Comparison of baseline and post-stress heart rate, systolic blood pressure, diastolic blood pressure, pulse pressure and mean arterial pressure among study participants

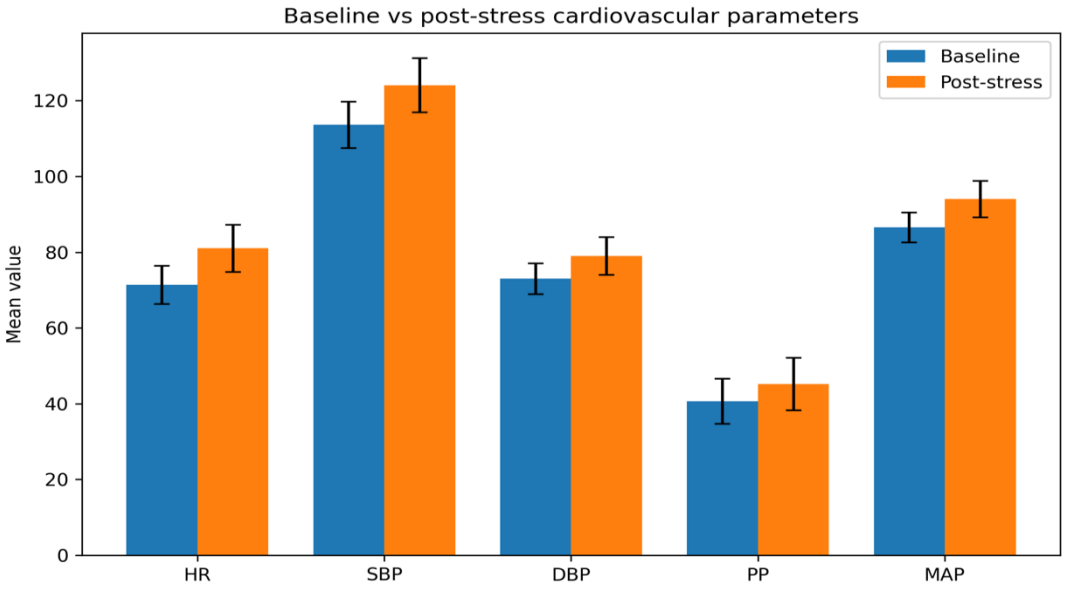
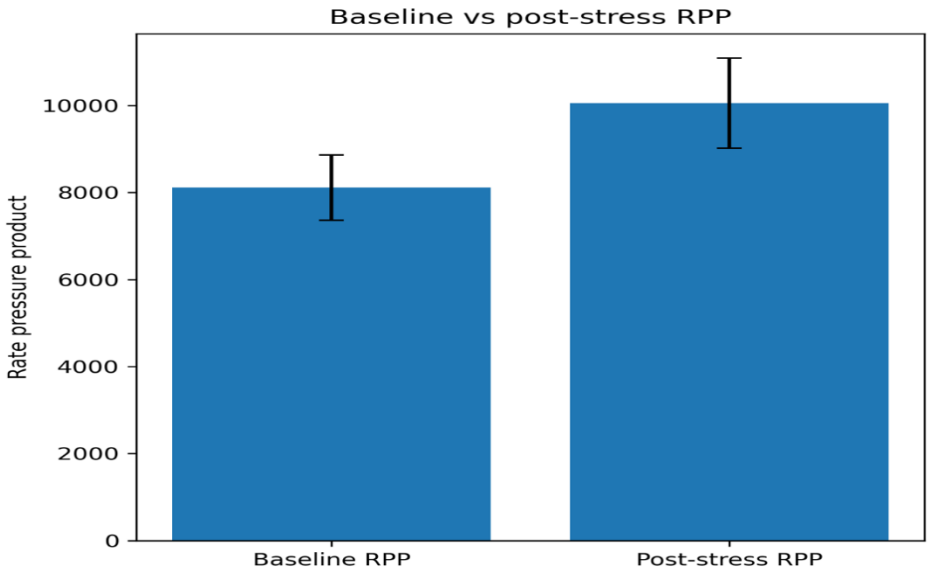


Figure 2. Comparison of baseline and post-stress rate pressure product among study participants.

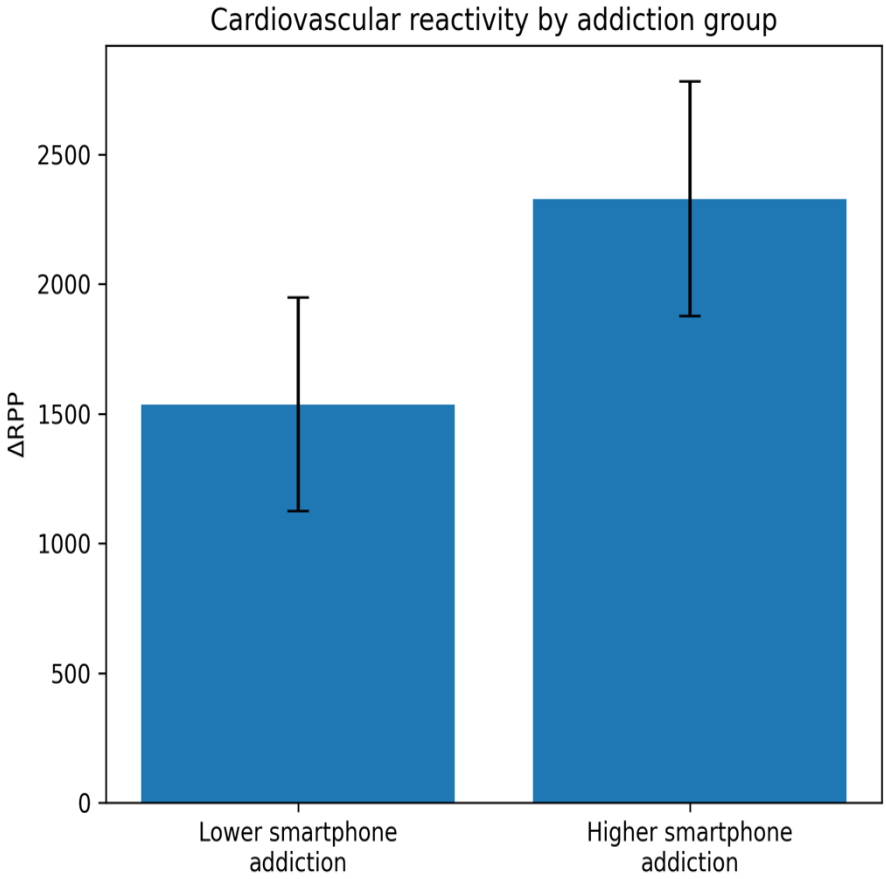


Cardiovascular reactivity was compared between lower and higher smartphone addiction groups. Participants in the higher smartphone addiction group showed significantly greater reactivity for heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure and rate pressure product compared with the lower smartphone addiction group. The mean ΔRPP was 1535.98 ± 412.16 in the lower smartphone addiction group and 2328.73 ± 451.95 in the higher smartphone addiction group. All between-group differences were statistically significant with $p < 0.001$ (Table 3 and Figure 3).

Table 3. Comparison of cardiovascular reactivity between lower and higher smartphone addiction groups

Parameter	Lower addiction	Higher addiction	t	p
ΔHR	7.76 ± 2.61	11.39 ± 2.55	6.48	<0.001
ΔSBP	8.44 ± 3.21	12.34 ± 3.26	5.56	<0.001
ΔDBP	5.05 ± 1.76	6.82 ± 2.25	4.05	<0.001
ΔMAP	6.18 ± 1.79	8.66 ± 1.94	6.12	<0.001
ΔRPP	1535.98 ± 412.16	2328.73 ± 451.95	8.46	<0.001

Figure 3. Comparison of change in rate pressure product between lower and higher smartphone addiction groups

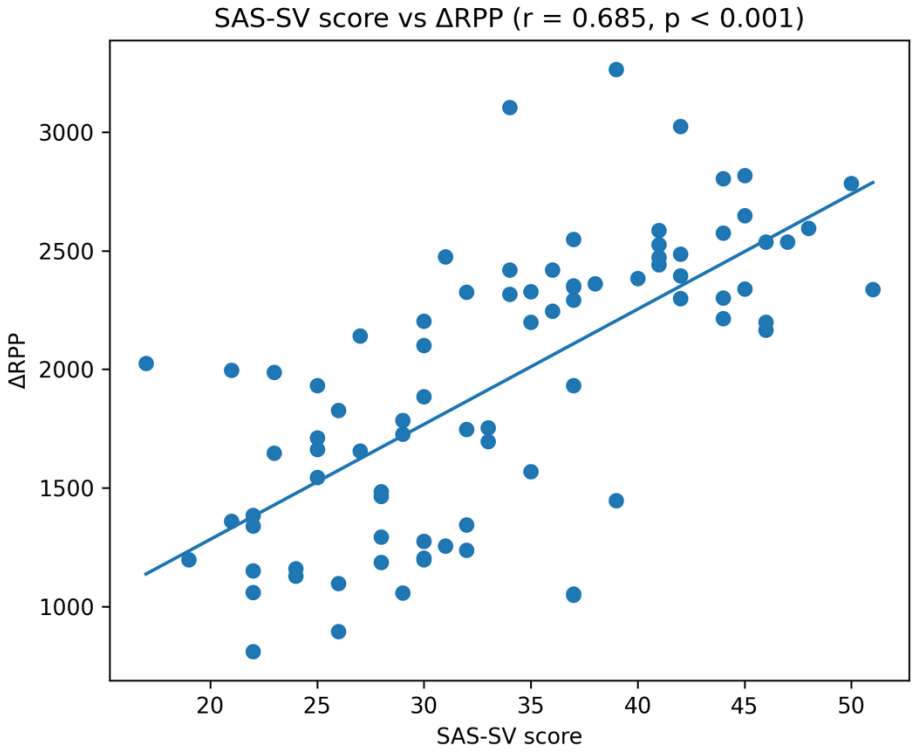


Correlation analysis showed a significant positive correlation between SAS-SV score and cardiovascular reactivity parameters. SAS-SV score showed positive correlation with ΔHR ($r = 0.583$), ΔSBP ($r = 0.514$), ΔDBP ($r = 0.521$), ΔMAP ($r = 0.631$) and ΔRPP ($r = 0.685$). All correlations were statistically significant with $p < 0.001$. The strongest correlation was observed between SAS-SV score and ΔRPP (Table 4 and Figure 4).

Table 4. Correlation of SAS-SV score with cardiovascular reactivity parameters

Parameter	Pearson r	p
ΔHR	0.583	<0.001
ΔSBP	0.514	<0.001
ΔDBP	0.521	<0.001
ΔMAP	0.631	<0.001
ΔRPP	0.685	<0.001

Figure 4. Correlation between SAS-SV score and change in rate pressure product after acute mental stress.



DISCUSSION

The present study assessed the association between smartphone addiction and cardiovascular reactivity to acute mental stress in young adults. The main finding was that acute mental stress produced a significant rise in heart rate, blood pressure, mean arterial pressure and rate pressure product. Another important finding was that participants with higher smartphone addiction showed greater cardiovascular reactivity than those with lower smartphone addiction. Smartphone addiction score also showed a significant positive correlation with all measured reactivity parameters, with the strongest correlation observed for ΔRPP.

The rise in cardiovascular parameters after acute mental stress reflects normal activation of the sympathetic nervous system. During mental arithmetic or similar cognitive stress tasks, the body responds with increased sympathetic outflow and reduced parasympathetic influence, leading to elevation in heart rate, blood pressure and myocardial workload. Similar cardiovascular responses to laboratory mental stress have been reported in earlier studies (Carter & Goldstein, 2015; Hjortskov et al., 2004; Mestanik et al., 2015). Yuenyongchaiwat (2017) also reported that mental stress testing produced cardiovascular responses and may be useful in understanding blood pressure regulation.

In the present study, rate pressure product increased markedly after stress. RPP is a useful indirect indicator of myocardial oxygen demand because it combines heart rate and systolic blood pressure. Therefore, the observed increase in RPP suggests that acute mental stress increased cardiac workload in the participants. This is physiologically relevant because repeated exaggerated cardiovascular responses to stress may contribute to adverse cardiovascular risk over time. Chida and Steptoe (2010) reported that greater cardiovascular reactivity to laboratory mental stress was associated with poorer future cardiovascular risk status, supporting the importance of studying stress reactivity even in apparently healthy young adults. Participants with higher smartphone addiction had greater changes in heart rate, blood pressure, MAP and RPP compared with the lower addiction group. This suggests that excessive smartphone use may be associated with altered autonomic responsiveness during acute stress. Previous studies have shown that problematic smartphone use is related to perceived stress, anxiety, depressive symptoms, poor sleep and reduced well-being (Elhai et al., 2016; Elhai et al., 2017; Samaha & Hawi, 2016; Thomée et al., 2011). These factors can increase physiological arousal and may partly explain the higher cardiovascular response seen in participants with higher smartphone addiction.

The positive correlation between SAS-SV score and cardiovascular reactivity further supports this association. Among all parameters, ΔRPP showed the strongest correlation with smartphone addiction score. This finding indicates that higher smartphone addiction was linked not only with isolated heart rate or blood pressure changes, but also with greater combined cardiac workload during stress. Alassiri et al. (2020) reported that cell phone exposure was associated with reduced heart rate variability among medical students, suggesting possible autonomic involvement. Similarly, Kim et al. (2018) described

the relationship between stress and heart rate variability, showing that stress-related autonomic changes can be detected through non-invasive cardiovascular measures.

Smartphone addiction may affect cardiovascular response through multiple pathways. Late-night use and pre-sleep smartphone exposure may disturb sleep, while constant notifications, social media engagement and fear of missing out may maintain a state of psychological alertness. Reduced physical activity and prolonged sitting may also contribute to poor autonomic balance. In addition to these effects, smartphone use has been associated with physical outcomes such as neck muscle and hand grip changes, showing that excessive use can have measurable physiological effects beyond behaviour alone (Katiyar et al., 2024). Thus, smartphone addiction should not be viewed only as a lifestyle habit but also as a possible contributor to altered physiological regulation in young adults.

The findings of this study have practical implications. Young adults, especially medical students, are commonly exposed to academic stress as well as prolonged smartphone use. Simple parameters like heart rate, blood pressure, MAP and RPP can be used as low-cost indicators to assess cardiovascular response to stress. Early recognition of excessive smartphone use and its physiological associations may help in promoting healthier digital habits, sleep hygiene and stress management practices.

This study had some limitations. It was conducted in a single centre among young adults, so the findings may not be generalised to all age groups. Smartphone addiction and daily smartphone use were assessed using self-reported information, which may have recall bias. Grouping of participants into lower and higher smartphone addiction categories was based on study-specific SAS-SV scores, which may limit comparison with studies using fixed diagnostic cut-off values. Heart rate variability and biochemical stress markers such as cortisol were not assessed, so detailed autonomic and hormonal responses could not be evaluated. The study measured acute cardiovascular reactivity only, and long-term cardiovascular outcomes were not studied. Also, because of the cross-sectional nature of the study, causality cannot be established.

Despite these limitations, the study provides useful evidence that higher smartphone addiction is associated with greater cardiovascular reactivity to acute mental stress in young adults. The findings support the need for further studies with larger samples, longitudinal design and detailed autonomic assessment to understand the long-term physiological impact of excessive smartphone use.

CONCLUSIONS

The present study showed that acute mental stress produced a significant increase in heart rate, blood pressure, mean arterial pressure and rate pressure product among young adults. Participants with higher smartphone addiction demonstrated greater cardiovascular reactivity than those with lower smartphone addiction, and SAS-SV score showed a significant positive correlation with stress-induced cardiovascular changes.

The novelty of this study lies in assessing the association of smartphone addiction tendency with immediate cardiovascular response to acute mental stress using simple physiological parameters. These findings suggest that excessive smartphone use may be associated with altered autonomic responsiveness even in apparently healthy young adults. The study adds to current scientific knowledge by highlighting smartphone addiction tendency as a possible behavioural factor associated with cardiovascular stress reactivity, supporting the need for early awareness, healthy digital habits and stress-control measures in young populations.

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