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Narrative Review of the Morphofunctional Underpinnings and Comprehensive Rehabilitation Strategies for Smartphone-addicted University Students

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Abstract: The widespread availability of mobile phones has contributed to a high prevalence of digital addiction worldwide. Smartphone addiction or problematic smartphone use (SA/PSU) has become a widespread issue, especially among university students. Due to concerns about SA/PSU and cyber addiction in young people, research has focused on the structural and functional effects on the brain and the behavioral consequences of spending too much time on mobile phones. This review investigates the impact of excessive smartphone use on this demographic group's physical and mental health. An advanced search on PubMed based on primary keywords, clustered in syntactic associations looked for academic work focusing on: ((((smartphone addiction) and (problematic smartphone use)) and (students) and (Physical exercises)) and (Physical Activity). The relationship (((smartphone addiction) and (problematic smartphone use) and (systematic review) identified 22 papers, published between 2016 and 2024, 16 of which were during the Covid era and post-pandemic periods (2020-2024). Smartphone overuse-induced alterations in cerebral gray matter were observed in four trials. The beneficial influence of physical activity on smartphone addiction was emphasized in 11 publications (selected 9) identified by the advanced search with the syntactic relationship. The narrative review offers a comprehensive overview of effective strategies for addressing SA/PSU. This includes utilizing exercise and psychological interventions to combat digital addiction. Furthermore, studies have looked into the potential benefits of physical exercise and specific strategies addressing these issues. Engaging in physical activity may help offset the negative effects of SA/PSU, and targeted strategies are necessary for preventing and treating these problems in young people. Political and educational decision factors must implement targeted strategies and integrated social education policies to prevent smartphone overuse and pejorative consequences in adolescents and young people.

Keywords: smartphone addiction, problematic smartphone use, university students, brain networks, physical exercise, psychological strategies

1. Introduction

The biggest change in addiction today is the role of technology. Cyber addiction or "cyberism" refers to an over-reliance on technology and the internet. Digital addiction is a broad term that encompasses addiction to any form of digital media, including the Internet, digital gaming, and social media. The global usage of the Internet has increased significantly in recent years, with smartphones becoming the primary means of access. Smartphones have become an essential part of daily life due to the advancement of mobile technology and digitization. The widespread use of smartphones has led to behavioral dependence, and compulsive internet use, resulting in significant impairment of physical, psychological, and social functioning. Smartphone addiction or problematic smartphone use (SA/PSU) has become a pervasive issue, particularly among university students.

In 2023, approximately 6.718 billion people worldwide owned at least one smartphone (1). In Romania, 64% of urban residents use the Internet, 88% own a cell phone, and 59% have a subscription (2).

Cyber addiction including smartphone addiction (SA), refers to an over-reliance on digital media. It encompasses internet addiction, online gaming addiction, and social media addiction, all of which can lead to severe consequences in academic performance, mental health, sleep patterns, and the social and professional life of the students.(3–5)

Social media companies use particular strategies to engage us, offering habit-forming products: Snapchat and Snapstreaks, YouTube and Netflix video auto-play, constant scrolling on Twitter and Facebook, requests for connections on LinkedIn, Instagram, and Facebook notifications, Tinder, swipe left or right, Instagram, Snapchat, and Facebook photo tagging.

Smartphones, because of their portability and easy access to the internet, have the potential to create high dependency and are a significant risk factor for problematic and addictive behaviors. Smartphone addiction, especially social media addiction, has important repercussions on adolescents and students, affecting various aspects of cognitive function, emotional regulation, and mental well-being.

In nursing or kinesiotherapy education curricula and clinical healthcare settings, the integration of Internet services has shown the potential to enhance student's learning activity and improve the quality of the teaching-learning process (6).

Medical nursing students have reported experiencing significant educational benefits from using digital devices, benefits that go beyond traditional learning (7) These advantages include improved communication in clinical decision-making and evidence-based practice.

Panova and Carbonell (2018) suggest the term "problematic smartphone use" (PSU) and question whether mobile phone overuse is a real addiction. Phone addicts are not yet officially recognized as an addiction in the DSM-V (as gaming addiction) (8). Consequently, smartphone overuse (PSU) is being increasingly discussed, referring to excessive use that interferes with various areas of a person's life.

Other studies have recognized smartphone addiction/ problematic smartphone use (SA/PSU) as a behavioral addiction, characterized by excessive use that disrupts daily life and causes harmful effects.

This addiction has parallels with substance-related and behavioral addictive disorders, showing prevalent addictive behaviors. (9,10).

Phone addicts become conditioned to compulsively seek and crave euphoria when offline or "offline/ “off-drug”, and recreate the sense of excitement. They report feeling a pleasurable mood burst, delight, or “rush” from simply checking their phone and favorite apps.

Brain imaging studies have shown that excessive use of smartphones and social media shares similarities with other forms of addiction.

Since both terms are used in the specialized literature, we decided that the abbreviation in this paper should bring together both names **SA/PSU**.

Prevalence of Internet and SA/PSU and their consequences on physical, psychological, academic performance, and social functioning

Smartphone addiction (**SA/PSU**) defined as the excessive use of smartphones leading to negative impacts on daily life, has become a significant issue, especially among university students.

The transition to university life often comes with increased autonomy and stress, making students more susceptible to developing unhealthy coping mechanisms, such as smartphone overuse.

Users often underestimate the time they spend on their smartphones or fail to regulate their usage, leading to significant physical health problems, psychological harm, and social impairments.

University students are at high risk for problematic online behaviors, including excessive phone use and specific internet addictions like social media, gaming, and pornography. These behaviors have been studied extensively, revealing significant impacts on physical and mental health, academic performance, and social interactions. The specific internet addictions in students are:

1. **Problematic Smartphone Use (SA/PSU)**
2. **Problematic Social Media Use (PSMU)**
3. **Internet Gaming Disorder (IGD)**
4. **Problematic Internet Pornographic Use (PIPU)**

These domains of problematic behavior are linked to negative health impacts: sedentary lifestyles, sleep disruptions, eye strain, and poor posture (11–13) and can lead to decreased physical fitness and increased risk of chronic diseases (14).

Medical students are predisposed to overuse of digital devices and cyber addiction**. About** 19.5% are considered addicted to smartphones often leading to disrupted daily routines and negative impacts on mental health and behavior (11). Almost half (46%) report neck disorders related to excessive use (15).

Rates of phone addiction among nursing students in 15 countries ranged from 19% to 72%, with an average of 40-50%. This addiction has been linked to a decline in career development. (16)

Paradoxically 42% of 300 healthy students (half males half females) in Physical Education Universities and the Faculty of Sport Sciences and Sports Teaching and Management were addicted to mobile phone overuse. Their physical activity levels were: adequate (65.3% of subjects), low (32.7%), and 2% were inactive (17).

SA/PSU correlates significantly with poor sleep quality, depression, anxiety, and stress (12,18,19).

A variety of factors across personal, emotional, cognitive, and executive domains influence risk factors for **SA/PSU**:

- The personal factors relate to interpersonal relationships, anxiety, and perceived academic pressure.
- **The affective ones** involve a strong need for online social interaction and a low perception of social support. The cognitive ones include high levels of stress and learning burnout.
- The executive issues encompass prolonged usage duration, poor self-control, and usage before sleep (16).

Lin et al. (2016) proposed specific diagnostic criteria for **SA/PSU**, including (10):

1. Symptom criteria: Lack of self-control, withdrawal symptoms, extended usage beyond intended periods, and continued use despite negative consequences.
2. Functional impairment criteria: Various functional impairments due to smartphone overuse.
3. Exclusion criteria

Excessive mobile phone use in adolescents and young adults is linked to fatigue, headaches, sleep disorders, memory loss, hallucinations, negative emotions like anxiety and depression, **lower perceived social support, and lower communication skills.(7,13)**

SA/PSU is strongly associated with mental health problems, including anxiety, social isolation, interpersonal relationship issues, musculoskeletal pain, neurological problems, emotional dysregulation, and impulsivity. (20)
Addiction to mobile phones and the internet in young people is strongly linked to eating disorders, unhealthy eating patterns (such as consuming large amounts of soda and junk food or fast food regularly), and obesity. Additionally, they are negatively linked to healthy behaviors such as skipping breakfast and physical activity.
(21,22).

Teasing about being overweight and weight stigma are associated with a decrease in health-promoting behaviors, internalizing this stigma is linked to lower levels of physical activity.

Also, everyday weight discrimination and smartphone overuse jointly affect physical activity levels, especially among female college students. (23–25)
Depression and internet addiction (**IA**) are widespread and burdensome problems among adolescents. A meta-analysis of 42 studies involving 102,769 participants confirmed a positive correlation between depressive disorders and **IA** in adolescents. The findings indicated that depressive adolescents were at a higher risk of developing IA, and adolescents with IA were at a higher risk of developing depressive disorders (26,27). Depression in **SA/PSU** can lead to social isolation and issues in maintaining healthy relationships. (9,28,29)

SA/PSU in students is associated with poorer self-control, higher perceived stress, and lower academic performance, often leading to learning burnout (27). These issues can lead to more severe consequences, emotional imbalance, and even suicide due to cyberbullying and internet fraud (30,31)

Adolescents are especially susceptible to excessive smartphone use due to their ongoing brain development and their tendency to be influenced by their peers. During adolescence, the brain undergoes significant changes, affecting impulse control, emotional regulation, and the maturation of the prefrontal cortex, which is responsible for higher cognitive abilities. Because this region is not fully developed, adolescents may struggle with impulsivity, decision-making, planning and organizing issues, and emotional control. They are more sensitive to rewards and tend to avoid risks. Additionally, they experience intense mood swings and are strongly influenced by social and external pressures when it comes to modeling behaviors.
In the era of cyber addiction, specific terms emerged that are linked to **SA/PSU**:
Phubbing, FoMO, and NoMO.

Phubbing represents the act of ignoring someone in favor of a smartphone (the phone addicted starts messaging or scrolling on his/her phone when you're talking to them face-to-face).
Phubbing is linked to loneliness, reduced life satisfaction, and psychological distress. It is predicted by factors such as phone use duration, anxiety, negative self-perception, and hostility (29).

FoMO (Fear of Missing Out), induced by excessive social media use, is a distressing psychological state experienced by some adolescents and adults who feel anxious or uncomfortable about missing enjoyable or interesting experiences they are not part of. Higher levels of FoMO are linked to reduced cortical cerebral gray matter thickness in the right precuneus, which has a strong functional interaction with the default mode network (**DMN**) involved in social cognitive and self-referential domains. (28,32).

Nomophobia (No-Mobilephone-Phobia) refers to the fear or anxiety of being without a cell phone or in situations where a cell phone cannot be used. This condition is commonly observed among young people and can lead to significant psychological, emotional, social, and physical side effects due to excessive smartphone use. NoMO is an informal way of referring to nomophobia (33,34).

Nomophobia, the fear of being without a mobile phone, is common among nursing students. This disorder is closely linked to procrastination and social anxiety, and it has a detrimental impact on social interactions and academic performance (33)
A systematic review of 370 articles found that nomophobia prevalence ranged from 15.2% to 99.7% among the young participants. Excessive smartphone use exacerbates psychological and emotional distress, social problems, and physical health issues.(34)
Over 19.5% of the medical assistance students had a high risk for nomofobic behavior, characterized by:

- high levels of social anxiety
- daily phone usage, exceeding one hour
- frequent (more than eight times) checking the phone during the class
- age: 21 or 22 years old
- early onset of smartphone use (between 11 and 13 years old)

SA/PSU was associated with **physical and mental health issues.**

- Musculoskeletal pathologies like chronic back and neck pain due to poor posture from excessive smartphone overuse (15) were correlated with low physical activity during the pandemic (35)
- cognitive inflexibility, impulsivity, shyness, and low self-esteem are prevalent among mobile phone addicted (36).
- sleep disturbances and poor sleep quality are common, exacerbating symptoms of depression and anxiety. (18, 35–37)
- reduced academic performance, procrastination, impulsivity, low self-esteem, dysfunctional social interaction, solitude, and suicide all were associated with excessive mobile phone use (38).

Excessive mobile phone use can negatively affect the spine due to the neck flexion that puts pressure on it. Studies have shown that most people spend an average of two hours a day using mobile phones or tablets, and the inappropriate head position affects the curvature of the spine, leading to imbalances. Smartphone overuse is associated with neck disorders among university students, with the prevalence of neck and back pain in 46% of students (15).

Chronic back conditions were associated with low levels of physical activity. In a study group comprising physiotherapy students only every fifth person reported high physical activity during the COVID-19 pandemic (35).

The muscles and ligaments in the spine can be impacted when tilting the head to look at a phone, resulting in discomfort. An adult's head typically weighs between 4 and 5 kg and is supported by the spine when sitting upright. The "text neck posture" and head tilt add weight to the spine, with the pressure increasing based on the inclination. At a 15-degree angle, the pressure is equivalent to approximately 12 kg, at 30 degrees is 18 kg, at 45 degrees is 22 kg, and at 60 degrees is 27 kg. Pain can occur at any level and may be mechanical or inflammatory, accompanied by hand numbness and dizziness.

Excessive use of social media and smartphones is linked to emotional and cognitive issues: depression, anxiety, poor cognition, social isolation, cognitive-emotional dysregulation, and lower self-esteem, with important social impact (31,39)

Poor sleep quality due to SA/PSU affects academic performance, particularly in demanding fields like medicine (9,37)

Smartphone overuse negatively impacts social interactions, interpersonal communications, and social life, reducing learning efficacy and social abilities (40)
Studies showed females are more likely to exhibit **SA/PSU**, with higher addiction scores compared to males (11,17)

A recent study has revealed gender differences in the molecular pathways that drive reward-related behaviors. There are differences and similarities between the molecular mechanisms that reinforce functional connections in two brain regions — hippocampus (Hipp) and the nucleus accumbens (NAc) —involved in reward signaling. Males use exclusively NMDA receptor-dependent mechanisms, while females use non-canonical pathways (the alternative calcium channels and estrogen receptors) to generate postsynaptic Long-term Potentiation (**LTP**).

LTP is considered a key mechanism by which memories are stored, by strengthening synaptic connections in response to activity patterns.

LTP involves biochemical and structural changes in the neurons, crucial for the brain's adaptability, neuroplasticity, memory, and cognitive functions.

Both sexes display similar magnitudes of Hipp-NAc postsynaptically LTP. However, males rely on NMDA receptors (NMDAR) to strengthen connections between Hipp and NAc. Females require non-canonical pathways: L-type voltage-gated Ca2+ channels (VGCC) for postsynaptic Ca2+ influx, and estrogen receptor α (ERα) activity, for LTP (while males do not). The findings highlight the need for more gender-specific research to develop effective therapies in disorders involving these biochemical pathways (like depression and substance abuse), to improve patient outcomes (41).

Brain connectomics, cerebral structural and functional changes in the brain, effects of SA/PSU

To understand the neurobiological issues behind excessive mobile phone use, social media addiction, and internet dependence, and their negative effects on the brains and mental well-being of teenagers and young adults, it is important to review the brain anatomy and functions involved. "**Connectomics**" is a new field in neuroscience that focuses on mapping and studying neural connections throughout the brain. The "framework of connectomics" refers to an integrative conceptual and methodological approach used in studies exploring the complex architecture of neural networks, explaining the brain's overall functioning, including cognitive, behavioral, and emotional processes.

Resting-state functional connectivity (**rsFC**) of the triple-network model refers to how different neural networks in the brain interact during brain rest (without a specific processing or attention task). These studies use functional magnetic resonance imaging (**fMRI**) to measure the synchronization of neural activity between these networks while subjects rest in the scanner (42).

In this context, the triple-network model refers to three large and interconnected brain networks, which are distinct neural circuits, with tightly collaborative roles:

(i) **Central Executive Network (CEN) (43-45))**
(ii) **Default Mode Network (DMN) (46–49)**
(iii) **Salience Network (SN) (50–52)**

Each of these networks plays a distinct yet interconnected role in various cognitive and emotional processes, contributing to the complexity of human thought, behavior, and social interaction.

(i) The **Central Executive Network** (CEN) is a critical neural network for the higher executive functions of the brain. This includes cognitive processes such as attentional control, planning, decision-making, monitoring, and behavioral control. The CEN is crucial for focus, problem-solving, and multitasking activities. The structures that make up the CEN are:

1. Dorsolateral prefrontal cortex (dlPFC):

o Is involved in complex cognitive processes such as planning, organizing, and regulating rule-based behavior.

- It plays a significant role in maintaining and manipulating information in working memory.

2. Posterior parietal cortex:
- Contributes to spatial attention and sensory information integration.
- Involved in orienting attention and coordinating activities between different brain areas.

3. Anterior cingulate cortex (ACC):
- Participates in error monitoring and cognitive control.
- Is essential for detecting conflicts and managing behavioral responses

(ii) **Default Mode Network** (DMN) is active when the brain is at rest and not focused on the external environment. It is associated with daydreaming, mind-wandering, self-referential thought, and autobiographical memory. Its **key structures consist of:**

1. **Medial prefrontal cortex (mPFC)**: Engages in self-referential processing and reflective thought.
2. **Posterior cingulate cortex (PCC) / precuneus**: Involved in self-reflection and the integration of information about the self.
3. **Angular gyrus**: Plays a role in the retrieval of autobiographical memories.
4. **Hippocampus**: Critical for memory formation and retrieval, often active in recollecting past experiences.

(iii) The **Salience Network** (SN) detects and filters relevant stimuli from the environment, coordinating cognitive and behavioral responses, and integrating interoceptive and emotional information. It focuses on what is most relevant for survival and immediate needs. Anatomically, it is known as the mid-cingular-insular network, with key structures:

1. **Anterior insula (AI):** Involved in emotional and interoceptive processing. Detects and integrates sensory and emotional information.
2. **Anterior cingulate cortex (ACC)**: Involved in emotion regulation, conflict monitoring, decision-making, reward processing, and error detection.
3. **Subcortical structures**: Including the amygdala and thalamus, which are involved in emotional processing and sensory relay.

Other important functional neuronal hubs are:

- Ventral Attention Network (VAN) (53-55)
- Dorsal Attention Network (DAN) (57–59)
- Reward Network (60–62)

Ventral Attention Network (VAN) is involved in detecting unexpected, novel, or salient stimuli that demand attention and reorienting attention towards these stimuli. The main anatomical structures that comprise the VAN are:

- Temporoparietal junction (TPJ): This region is located at the intersection of the temporal and parietal lobes and is crucial for shifting attention to novel or unexpected stimuli/ changes in the environment.
- Ventral frontal cortex: Involved in the control and reorientation of attention.
- **Inferior frontal cortex (iFC)**
- **Anterior insula (AI)**

Both networks (**SN** and **VAN**) are involved in the detection of salient stimuli and the reorientation of attention. There is some overlap in their functions, especially in how they contribute to the attention and processing of important stimuli.

Dorsal Attention Network (DAN) is a brain network involved in spatial attention orientation and the voluntary control of eye movements. DAN is known as the dorsal frontoparietal network (D-FPN), which is made up of these structures:

1. **Posterior parietal cortex (PPC):**
- **Superior parietal lobule (SPL)**
- **Intraparietal sulcus (IPS)**

2. **Frontal cortex**:
   - **Frontal eye fields (FEF)**
   - **Dorsal premotor cortex (dPMC)**

These structures cooperate to control the direction and focus of visual attention and guide eye and hand movements toward desired objectives in the visual space.

The VAN is primarily lateralized on the right side of the brain and functions complementarily to the dorsal attention network. While the dorsal network is involved in voluntary and goal-directed attention control, the ventral network is responsible for detecting unexpected events or stimuli and redirecting attention to them.

The **Reward Network** is involved in processing reward-related stimuli, motivation, and reinforcement learning. This network underlies the experiences of pleasure and drives goal-directed behavior. The k**ey structures are:**

1. **Ventral tegmental area (VTA):** Produces dopamine, a key neurotransmitter in reward signaling.
2. **Nucleus accumbens (NAc)**: Central to the reward circuit, involved in the processing of pleasure and reinforcement.
3. **Prefrontal cortex (PFC):** Involved in decision-making, planning, and moderating social behavior in response to reward.
4. **Amygdala**: Processes emotions and reward-related cues.

The anterior cingulate cortex (**ACC**) is part of the mesocorticolimbic system. It is associated primarily with the salience network activated by reward-related stimuli, playing a critical role in substance addiction. (63)

The **ACC** has been one of the most frequently implicated regions in Internet addiction. (64)

The elevated levels of γ-aminobutyric acid and the imbalanced ratio of γ-aminobutyric acid to glutamate in the **ACC** elucidate the neurophysiological basis of neurotransmission in adolescents addicted to the Internet and smartphones. (65)

Brain imaging studies have revealed similarities between problematic phone and social media overuse and other forms of addiction, indicating rewarding effects on the brain but negatively impacting inhibitory control mechanisms and reducing gray matter volumes in areas such as the nucleus accumbens, amygdala, and insula. These findings suggest that dependence on social media (addiction) may have detrimental effects. (42,66,67)

A systematic review analyzed 28 relevant articles focusing on structural MRI, resting-state fMRI, and task-based fMRI studies related to social networking site use. Excessive and regular addictive behaviors on social media recruit specific regions in the DMN, mentalizing and self-referential cognition network, salience, and reward networks. This excessive bioelectrical recruitment leads to obsessive, and compulsive checking of the phone and pleasurable mood bursts and euphoria by using favorite online social networking platforms or apps. (42)

Problematic and addictive use of social networking sites results in:

(1) reduced volume (gray matter) of the amygdala, ventral striatum, orbitofrontal cortex, subgenual anterior cingulate cortex and the posterior insula

(2) increased activity of the ventral striatum and precuneus (in response to social media incentive cues)

(3) abnormal functional connectivity of the DAN

(4) inter-hemispheric communication issues. (42)

Decreased cortical thickness in posterior regions of DMN is associated with FOMO, experienced by smartphone and social media addicts. The precuneus shows a significant functional connection with the DMN, which is involved in social cognitive and self-referential domains. (32)

A systematic review and meta-analysis of structural and functional issues in individuals with **SA/PSU** analyzed imagery studies from 421 participants (165 excessive users vs. controls) and 276 subjects. Smartphone-addicted users vs. controls). Excessive use was associated with reduced brain volume compared to non-excessive users, especially in the subcortical regions (p <0.001), and this effect was more pronounced in teenagers than in adults (p <0.001). Functional magnetic resonance imaging (fMRI) studies revealed enhanced brain activity in smartphone-addicted individuals compared to those with regular use.

Regarding altered brain activity, there were converging foci in the middle frontal gyrus, lingual gyrus, and posterior lobe of the cerebellum. (67)

Kwon (2022) found great dysfunctional connectivity between the DMN and attentional networks in 30 male problematic smartphone users compared to 35 non-problematic users. The study identified an altered resting-state functional connectivity of the dorsal anterior cingulate cortex (dACC) within the intrinsic brain networks, specifically the VAN and DMN, in phone-addicted males. (68)

The orbitofrontal cortex (OFC) is part of varying brain networks, modulating and regulating social, emotional, and motivational behavior. OFC has direct reciprocal connections to regions of the temporal lobe (such as the amygdala, entorhinal cortex, and hippocampus), and other cortical regions including the cingulate cortex, caudate nucleus, hypothalamus, and ventral tegmental area. Lee (2019) investigated structural gray matter abnormalities in smartphone addicts, particularly those who spend time excessive time on social networking platforms. Reduced gray matter volume (GMV) in the lateral OFC was correlated with an increased tendency to be absorbed by smartphone overuse. Results suggested that gray matter abnormalities in the lateral OFC affect regulatory control over previously reinforced behaviors and could contribute to SA/PSU. (69)

The lack of objective longitudinal imagery records to investigate the neuroplastic neuroadaptations secondary to cyber-addiction currently prevents recognition of phone addiction. The Diagnostic and Statistical Manual of Mental Disorders (fifth edition) reports only substance-related addictive disorders (alcohol, tobacco, stimulants, marijuana, and opioids) or gambling disorders. (8, 70,71)

The human brain undergoes neuroplastic modifications during an individual's lifetime, and both the structural and functional neuroplastic changes are modulated by experience.

fMRI studies suggest a positive relationship between regular physical exercise/activity (PE/A) performed at any age) and cognitive performance. **PE/A** is thought to increase the expression of neurotrophic factors and can stimulate neuronal growth and neurogenesis in specific brain areas. (72)

Brain imaging and electrophysiology studies suggest that PE/A promotes lasting brain plasticity, particularly in regions like the hippocampus.

To eliminate genetically influential error factors Tarkka et al (2019) studied 46 healthy male monozygotic twins (average age 34.5 years), examining the impact of differing PE/A levels on brain plasticity. The more physically active monozygotic twins exhibited greater gray matter volumes in key brain areas related to motor control and memory, like the striatum, prefrontal cortex, and hippocampus, with smaller volumes in the anterior cingulate area. Functional differences were also observed in somatosensory processing and EEG. Their findings indicated regular exercise promotes brain plasticity, enhancing motor control and memory functions. (73)

Zou et al. (2021) highlighted the significant impact of PE/A on the brain. Using the voxel-based morphometry (VBM) method in 251 college students, they demonstrated correlations between the levels of **PE/A** and gray matter volume (**GMV**) in the right fusiform gyrus, left precuneus, left insula, and the left triangular part of the inferior frontal gyrus. Higher levels of PE/A were associated with increased GMV in those brain regions. Moreover, the study revealed that the GMV of the left insula moderates the relationship between SA/PSU and depression, underscoring the importance of PE/A for mental well-being. These findings suggest that engaging in regular PE/A can help mitigate some of the negative effects of addiction on psychological symptoms.(74,75)

Targeted strategies to combat digital addiction: physical activity/ exercise and psychological interventions

Insufficient **PE/A** and SA/PSU are unhealthy coexisting behaviors among university students. (76,77). Increased and regular physical activity, associated with modifications of phone usage patterns, are effective and economical (or even free) measures for preventing addictive behaviors and promoting mental well-being. In a German study with 503 participants (average age 29.19), three experimental groups were tasked with reducing daily smartphone use by 60 minutes, increasing PA/E by 30 minutes, or associating both interventions, over 14 days. A control group maintained their usual behavior. Assessments showed that all interventions led to increased PA/E and reduced symptoms of SA/PSU, depression, and anxiety. The groups reducing smartphone use, alone or combined with increased activity, also reported higher positive mental health levels. These effects, especially those related to smartphone reduction, were more stable over time than increased physical activity alone. (78)

Regular exercise and kinesiotherapy can play a crucial role in helping adolescents reduce excessive mobile phone use and lead healthier, more balanced lives. **PE/A** must be integrated into comprehensive intervention strategies to develop personalized rehabilitation programs with positive effects on phone-addicted students. (79,80)

Exercise could serve as an effective strategy for preventing or reducing mobile phone addiction in adolescents. A systematic review and meta-analysis of 12 randomized controlled trials, including 861 subjects, found that exercise intervention significantly reduced SA/PSU in adolescents. The intervention involved a single exercise session incorporating different skills, lasting 30-60 minutes, three or more times per week for over eight consecutive weeks. (81)

The encouraging preventive measure of **PA/E** and the direct inverse relationship between physical effort and SA/PSU was confirmed by a recent systematic literature review of 31 studies from 12 countries (more than 45% from China), despite methodological issues and the unevenness of intervention research.(82)

Multiple meta-analyses show that a promising strategy to improve PE/A and achieve behavioral detox rehabilitation programs paradoxically involves smartphone-based intervention. The effectiveness of Internet mHealth in promoting **PE/A** indicates promising results for behavior change but requires a more systematic approach to developing these technological interventions. (83, 84)

Physical exercises are considered an effective strategy for preventing or reducing mobile phone addiction in adolescents. Structured PE/A programs have decreased screen time and improved students' overall well-being. The following types of exercises are particularly beneficial. (85):

1. Aerobic exercises

Aerobic exercises are excellent for improving cardiovascular health, boosting energy levels, and enhancing mood. They also provide a healthy distraction from PSU. Examples include:

- Running and jogging: These activities can be done individually or in groups, providing flexibility and the opportunity for social interaction.
- Cycling: Whether on stationary bikes or outdoors, cycling is an excellent way to boost cardiovascular fitness.
- Swimming: A low-impact exercise that works the entire body and is suitable for students of all fitness levels.
- Dance Classes: Activities like Zumba or hip-hop dance classes combine fitness with fun, making them appealing to students promote subjective well-being. Better-designed and conducted studies are needed in the future. (86)

2. Strength training

Strength training helps build muscle, improve posture (which can be negatively affected by prolonged Smartphone use), and enhance overall physical health. Suitable exercises include:

- Weightlifting: Using free weights or weight machines to build strength.
- Bodyweight exercises: Push-ups, pull-ups, squats, and lunges can be done with minimal equipment.
- Resistance bands: These are portable and versatile, allowing for a variety of strength-training exercises. Resistance training and exercises induced functional and structural brain changes, especially in the frontal lobe, and were accompanied by improvements in executive functions, and socio-emotional levels, even in old persons. (87)

3. Flexibility and balance exercises

These exercises improve flexibility, reduce the risk of injury, and enhance mental relaxation, counteracting the physical strain from smartphone use. Examples include:

- Yoga: Combines physical postures, breathing exercises, and meditation to improve flexibility and reduce stress.
- Pilates: Focuses on core strength, flexibility, and mindful movement.
- Chinese traditional exercises Tai Chi, Baduanjin, Qigong: A low-impact exercise that involves slow, deliberate movements and deep breathing, are beneficial for improving sleep quality, mental health, body flexibility, and students' physical fitness. (88)

4. Team sports

Team sports promote physical activity, enhance social interaction, and provide a sense of community, reducing reliance on smartphones for social connectivity. Popular options include:

- Basketball: Encourages teamwork and cardiovascular fitness.
- Soccer: A dynamic sport that improves endurance and coordination.
- Volleyball: Enhances reflexes, strength, and teamwork.

5. Outdoor activities offer the additional benefit of exposure to nature, which can further reduce stress and improve mental health. These activities include:

- Hiking: Provides cardiovascular exercise and a connection with nature.
- Rock climbing: Combines physical strength, endurance, and problem-solving skills.
- Kayaking or canoeing: Offers a full-body workout and a calming natural environment.

6. Mind-body exercises

Mind-body exercises focus on the connection between mental and physical health, promoting mindfulness and reducing stress:

- Tai Chi and Qigong: Both practices involve slow, controlled movements and focus on breathing, enhancing mental clarity and physical balance.

- Mindful Walking: Incorporating mindfulness techniques into walking can help reduce stress and increase awareness of physical sensations.

7. Fitness classes

Group fitness classes can be highly motivating and provide a structured environment for exercise. Examples include:

- Spin classes: High-energy cycling classes, are great for cardiovascular fitness.
- High-intensity interval training combines short bursts of intense activity with rest, effective for improving fitness in a short amount of time.
- Aerobics classes: Combine cardiovascular exercise with music, making workouts enjoyable and engaging.

Physical exercise is not just an alternative approach, but a necessary method in combating PSU/SA/PSU. The important milestones for a long-term goal include the frequency of training (3–4 times a week), the duration of each session (40–90 to 120 minutes), and the appropriate training period (between 8–10 and 12 weeks) (75)

Regular exercise enhances physical health, reducing the risk of chronic diseases in adulthood and improving overall fitness. It also helps mitigate some physical consequences of excessive mobile phone use, such as poor posture and repetitive strain injuries.

Exercise has well-documented psychological benefits, including reducing symptoms of anxiety and depression, improving mood, and enhancing cognitive function. In a sample of 4624 university students (55.5% females and 44.5% males, aged 17-25 years), the prevalence of SA/PSU and depression were 27.5% and respectively 25.1%. Moderate or high-intensity **PE/A** can modulate the relationship between SA/PSU and depression. (76)

In a Chinese study on college students, the prevalence of suicide attempts was found to be 3.5%, while 7.2% of subjects reported suicidal ideation. Both were positively linked to SA/PSU and negatively correlated with physical activity.(89)

Evening moderate to intense workouts, lasting longer than 90 minutes can impair sleep quality.(90)

Current interventions for SA/PSU include digital detoxes, app usage tracking, and behavioral strategies to reduce screen time. However, these methods often have limited long-term success.

When developing a smartphone detoxification intervention for university students, it's crucial to include a variety of physical exercises that are engaging, accessible, and effective in promoting overall well-being.

To successfully integrate these exercises into a detoxification program, universities decision factors must take some mandatory steps:

- Provide a range of fitness classes at different times to accommodate various schedules and interests.
- Promote outdoor activities: organize hiking trips, yoga sessions, or team sports events.
- Provide resources to ensure students have access to gym facilities, equipment, and trained instructors.
- Encourage participation: Use campus-wide campaigns, social media, and incentives (such as free memberships or rewards) to encourage students to participate.
- Coaching, mentoring, and monitoring progress: Keep track of student participation and collect feedback to enhance the program.

Universities should implement policies and educational programs**, and d**evelop multidisciplinary strategies to address the negative impacts of internet and mobile phone addiction on students' health and academic performance (11,31).

Psychological and **educational interventions** for reducing mobile phone addiction include:

1) **Cognitive behavioral therapy** (CBT) is a widely used psychological intervention that helps individuals change negative thought patterns and behaviors. For SA/PSU, a 75-minute weekly CBT program for 9 weeks can help students develop healthier habits and reduce reliance on their devices. (65 91)
2) **Mindfulness-based interventions**, such as meditation and mindful breathing, encourage present-moment awareness and can reduce compulsive smartphone use. These interventions help individuals develop greater self-control and awareness of phone usage patterns. (92-95)
3) Other psychological approaches include **group therapy**, where students can share experiences and support each other, and individual counseling, which can address underlying issues, manage emotions, reduce FoMO, and improve sleep quality to alleviate symptoms of depression and anxiety.(18,28)

Combining physical exercise with psychological interventions may offer synergistic benefits (*„Mens sana in corpore sano"*). The holistic approach, which addressed both physical health and mental well-being, was appreciated by the students. For example, exercise can improve mood and cognitive function, making individuals more receptive to psychological interventions. Conversely, psychological strategies can enhance motivation and adherence to exercise programs.

Identification of various risk factors for SA/PSU among nursing and medicine students is important. These include personal factors such as anxiety in interpersonal relationships and perceived academic pressure, affective factors like high stress and learning burnout, cognitive factors such as the need for online social interaction and low perception of social support, as well as executive factors like extended usage duration, poor self-control, and usage before sleep.(16)

There is an increasing demand for interventions that address both the physical and psychological aspects of addiction. These interventions are fundamental to behavioral strategies and techniques, such as setting specific times for mobile phone use and creating phone-free zones. Additionally, current interventions for social media addiction and SA/PSU may include short-term Digital Detox Programs aimed at reducing screen time.

Ironically, there are 6 Apps to stop smartphone addiction, reminding you to put down your phone: these ***apps'*** usage tracking tools monitor and limit overuse: *Offtime* (iOS, Android), *Moment* (iOS), *BreakFree* (iOS, Android), *Flipd* (iOS, Android), *AppDetox* (Android) and *Stay on Task* (Android).(96)

Discussion

Digital addiction is a multifaceted issue with extensive personal, social, and psychological ramifications. It demands attention due to its high prevalence and the significant negative effects on individuals' mental health, relationships, and on their daily functioning.

Structural and functional neural abnormalities, particularly in brain regions involved in executive functions and emotional processing, underscore the need for interventions to mitigate the psychosomatic negative repercussions of smartphone overuse in adolescents and students,

Addressing this addiction involves understanding its risk factors, diagnostic criteria, and the broader impact of digital addiction.

This narrative review explores the impact of problematic smartphone overuse on the somato-psychic well-being in the University demographic segment. Concerns about SA/PSU and cyber-addiction among young populations led to research on structural and functional neural repercussions and the behavioral consequences of excessive mobile phone use.

Physical activity emerges as a potential moderating factor, offering a pathway to counteract some of the detrimental impacts of cyber addiction.

The article collates management recommendations and multidisciplinary behavioral intervention strategies in educational institutions to address the harmful effects of internet and smartphone addiction on students' health and academic performance (11,31).

Universities should establish policies that promote balanced and ecological digital usage to support students in managing internet addiction and encourage active outdoor lifestyles and sportive activity to mitigate physical and mental health issues associated with digital addiction. (24, 82, 92)

Education institutions should promote ergonomic solutions and adjustments to prevent musculoskeletal problems related to prolonged smartphone use (97,98) and educational programs to manage emotions, reduce FoMO, and NoMO, and improve sleep quality, to alleviate symptoms of depression and anxiety. (18,28).

Designing tailored interventions to address weight stigma and mobile phone overuse may help improve physical activity among female students. 23, 24)

Conclusions

The review provides comprehensive insights into effective strategies for mitigating SA/PSU, exploiting the beneficial effects of exercise and psychological interventions in this behavioral addictive pattern. The paper emphasizes the urgent need for specific educational interventions and policy adjustments in universities to address the widespread problem of cyber addiction among students.

Together with promoting cooperation between various university departments to develop a cohesive approach to student wellness, political and educational decision factors should provide training programs for faculty, staff, and students on the advantages of physical activity and psychological well-being. Implementing these comprehensive approaches can bring about significant advantages, addressing both the physical and psychological aspects of Internet addiction.

Continuous research is essential to evaluate the effectiveness of interventions and develop targeted strategies for preventing and treating SA/PSU in university students

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