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Original Article

Associations between Smartphone Usage with Upper-Body Abnormalities, Obesity, Mental Wellbeing and Physical Fitness of High-School Male Students

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Abstract

Background: The growing prevalence of smartphone usage among adolescents has not been adequately addressed in terms of its impact on their physical and mental health in prior research. Therefore, the objective of this study was to explore the relationships between smartphone usage and upper body abnormalities, obesity, mental well-being, and physical fitness among male high school students.

Methods: This was a descriptive correlational study. The statistical sample comprised 384 male students, with a mean age of 17.04 years (±0.83), from high schools situated in the 5th district of Tehran, Iran in 2023. Smartphone usage was measured by asking "How much (in hours) do you use smartphones on average during day". Upper-body-abnormalities was measured using plastic goniometer and flexible ruler. DASS-21 was used for measuring mental wellbeing. Push-up test was used for assessing physical fitness. The data were analyzed using the independent t-test and the Pearson correlation test.

Results: Smartphone usage demonstrated a significant correlation with body mass index (BMI) ($r=0.527$, $P<0.001$), forward head posture ($r=0.396$, $P<0.001$), and thoracic kyphosis ($r=0.442$, $P<0.001$). In contrast, no significant relationships were found between smartphone usage and lumbar lordosis ($r=0.050$, $P=0.452$), depression ($r=-0.029$, $P=0.680$), anxiety ($r=0.058$, $P=0.481$), or stress ($r=-0.084$, $P=0.268$). Additionally, a significant association was observed between smartphone usage and push-up performance ($r=-0.352$, $P<0.001$).

Conclusions: Smartphone addiction has harmful effects on head and neck abnormalities, obesity and physical fitness, but it could not negatively affect a person's mental wellbeing. These findings can be used as a warning signal to limit the excessive usage of and dependency on smartphones in male adolescents.

Keywords: Smartphone, Musculoskeletal diseases, Adiposity, Physical fitness, Mental health

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1. Introduction

The swift evolution of communication technologies in contemporary society has profoundly transformed our psychological and social environments (1). Among these innovations, smartphones emerge as particularly prominent devices. A smartphone is a mobile electronic device that provides connectivity to a cellular network (2). Initially created for the purpose of facilitating phone calls and emails, smartphones have since expanded their functionality to include internet browsing, gaming, and text messaging (3). Due to the advancement of features and functionality of smartphones, the numbers of users have significantly increased over the last five years (4). Between 2019 and 2024, the number of individuals using smartphones has risen by 114.97%, reaching a total of 4.88 billion users in the current year. The ownership of mobile phones is expanding at a remarkably fast pace, with approximately 60% of the world's population now owning a smartphone, compared with 34% in 2019 (5). Based on the global statistics released in 2021, Iran is estimated to have 58.2 million smartphone users, ranking 15th in the world (5). With a population of 84 million people reported by the National Statistics Center in 2019, the smartphone penetration rate in Iran is projected to be approximately 69% in 2021 (6). This represents a 28% increase from the previous year. Despite the convenience offered by smartphones, its excessive usage significantly impacts an individual's efficiency and is commonly linked to a dependency on social media platforms. This

addiction poses risks to physical health, leading some individuals to become socially isolated as they are isolated from society (7, 8). Prolonged use of a mobile phone while frequently looking downward may lead to the development of wrinkles in the neck region over time (9). Excessive smartphone usage can delay the development of the right hemisphere of the brain while accelerating the growth of the left hemisphere (10). With the widespread use of smartphones, there has been a rise in neck injuries among users due to poor posture and prolonged bending that can cause disc injuries in the neck. Moreover, negative psychological effects like depression and anxiety may also are associated with excessive smartphone usage (11, 12).

It is important to recognize that not every user experiences the health-related consequences associated with smartphone use; in fact, it is probable that only a subset of users encounters these problems. A significant aspect to examine in this context is the excessive and compulsive engagement with smartphones, which has led to the emergence of a condition referred to as 'smartphone addiction' (13, 14). Smartphone addiction, frequently referred to as 'nomophobia' - the anxiety associated with being without a mobile device - typically arises from the excessive engagement with the Internet and mobile phones. In essence, smartphone addiction can be characterized through multiple definitions (13, 15, 16). Nevertheless, behaviors such as constantly checking or using the phone, experiencing distress when not with it, and using the phone in a manner that disrupts social interactions and daily activities accurately characterize addiction to this device (17). The increasing dependence of adolescents on smartphones has become a notable societal issue. The availability of internet applications and online gaming, combined with insufficient oversight, frequently results in evident indicators of addiction. The swift rise in mobile phone use, especially among adolescents, has prompted concerns among specialists about the negative consequences associated with excessive use of these devices. Smartphone addiction is characterized by hazardous behaviors, including compulsive habits, diminished functionality, and symptoms of withdrawal. These behaviors negatively impact academic performance (18), leading to decreased motivation (19) and disrupted sleep patterns (20). Additionally, individuals may experience heightened restlessness and discomfort when separated from their smartphones (14, 15). Teenagers with extroverted personalities, impulsivity, and feelings of insecurity are particularly vulnerable to low self-esteem, with increased phone dependency resulting in prolonged usage (21).

The growing prevalence of smartphones among adolescents has not been adequately addressed in terms of their impact on both physical and mental health in prior research. Therefore, this study aimed to explore the correlation between smartphone usage and various physical and mental health factors in teenagers. Specifically, the study examined upper body abnormalities, obesity, mental wellbeing, and physical fitness as potential outcomes influenced by excessive smartphone use. Overall, the objective of this study was to analyze the relationships between smartphone usage and upper body abnormalities, obesity, mental wellbeing, and physical fitness among male high school students.

2. Methods

2.1. Design and Participants

The study employed a descriptive correlational design. The sample comprised 384 male students, with a mean age of 17.04 years, who were actively enrolled in high schools within the 5th district of Tehran, Iran in 2023. Participants were selected using a convenience sampling method. The inclusion criteria were: 1) being a male high school student, 2) absence of any physical or mental disabilities, and 3) obtaining written consent from both the student and their parents for participation. The exclusion criteria were: 1) the presence of any musculoskeletal pain, 2) any neurological conditions, congenital or acquired spinal deformities, or neck and trunk hypotonia, 3) cognitive impairments, 4) visual impairments, and 5) failure to complete the questionnaires.

2.2. Measures

2.2.1. Smartphone usage: To assess smartphone usage, participants were asked: "On average, how many hours do you spend using smartphones daily for various activities, including social networking and gaming?" In accordance with international guidelines, children between the ages of 5 and 17 are recommended to limit their smartphone usage

to no more than two hours per day. Consequently, we categorized the participants into two groups: low usage (≤2 hours per day) and high usage (≥2 hours per day).

2.2.2. Upper-body abnormalities: The forward head position of the participants was assessed using a plastic goniometer. They were instructed to stand in a relaxed manner and to perform neck flexion and extension three times. Subsequently, they were directed to maintain their head in a comfortable position. The examiner, situated on the left side of the participant, then calibrated the fixed arm of the goniometer to be perpendicular to the ground, aligned the goniometer's axis parallel to the spinous process of the seventh cervical vertebra in the lateral view, and positioned the movable arm at the cartilage of the anterior aspect of the ear. The angle formed between the movable arm and the horizontal line extending through the seventh cervical vertebra was documented as the craniovertebral angle. This procedure was repeated three times, with a two-minute interval between each trial. An angle of 21 degrees or greater was classified as a complication.

A flexible ruler was used to evaluate the degree of thoracic kyphosis and lumbar lordosis. The participants were positioned in an upright stance, ensuring that their upper bodies were free from obstruction and their feet were aligned at shoulder width. The examiner identified and marked the locations of the spinous processes of the second thoracic vertebra, the twelfth thoracic vertebra, the second lumbar vertebra, and the second sacral vertebra. The flexible ruler was then positioned along these spinous processes to measure the curvature associated with kyphosis and lordosis. Maintaining the ruler's position, it was subsequently transferred onto a sheet of white paper, where the curvature outlines were traced. The marked locations of the second thoracic, twelfth thoracic, second lumbar, and second sacral vertebrae were also noted on the paper. From the resulting illustration, straight lines were drawn to connect the points of the second thoracic and twelfth thoracic vertebrae, as well as the second lumbar and second sacral vertebrae, referred to as line (L). An additional line, designated as line (H), was drawn perpendicular to the arc. Finally, the angles of kyphosis and lordosis were computed using the formula Θ=4 Arc tang (2h/l).

2.2.3. Obesity: Body mass index (BMI) serves as a key indicator of obesity. It is among the most recognized anthropometric measures employed to assess overweight and obesity. The assessment of BMI begins with the measurement of weight in kilograms, which is obtained using a digital scale. Subsequently, height is measured in meters with a standard measuring device. The final calculation of BMI is performed using the formula kg/m^2.

2.2.4. Depression, Anxiety, Stress Questionnaire (DASS-21): DASS-21 was created as a condensed version of the Depression, Anxiety, Stress Questionnaire (DASS) to assess various psychological constructs (22). This instrument evaluates three dimensions of mental well-being: depression, comprising eight items; anxiety, consisting of seven items; and stress, which includes six items. Responses are recorded on a 4-point Likert scale, ranging from zero (not applicable to me at all) to three (entirely applicable to me). In the present study, the Cronbach's alpha for DASS-21 was found to be 0.92, and its validity was corroborated by nine experts, yielding a CVI of 0.88 and a CVR of 0.90.

2.2.5. Physical fitness: Physical fitness was assessed through the push-up fitness test, which evaluates upper body strength and endurance. In this assessment, the participant begins by positioning themselves on a mat with their hands placed shoulder-width apart and their elbows fully extended. The individual then lowers their body until their elbows form an approximate 90-degree angle before returning to the starting position with extended elbows. The legs remain unanchored, allowing for continuous movement within the specified range without any pauses or breaks. The participant's body moves in a vertical direction, and the total count of correctly executed push-ups within a 60-second timeframe was recorded as the participant's score.

2.3. Statistical Analysis

The data analysis was performed using SPSS version 27. Descriptive statistics, such as mean and standard deviation, were applied to summarize the data. The Kolmogorov-Smirnov test was conducted to evaluate the normality of the data distribution, which confirmed that the data followed a normal distribution ($P>0.05$). An independent t-test

was executed to compare the study variables between students classified as having low and high smartphone usage. Furthermore, the Pearson correlation test was employed to investigate the relationships among the variables, with a significance threshold set at P<0.05.

3. Results

3.1. Demographic and Descriptive Data

Table 1 presents the demographic and descriptive data obtained from the study. A total of 384 participants, aged between 16 and 18 years, were included, with a mean age of 17.04±0.83 years. Among these individuals, 372 (96.9%) reported using smartphones, while 12 (3.1%) did not. The participants had an average height of 1.72±0.51 meters and an average weight of 65.9±3.74 kg, resulting in a mean Body Mass Index (BMI) of 21.8±1.22, which is classified as normal. The analysis indicated that the average daily smartphone usage was 3.84±0.57 hours, surpassing the recommended maximum of 2 hours. Regarding upper-body postural abnormalities, the average forward head posture was measured at 25.78±2.28 degrees, thoracic kyphosis at 24.29±2.76 degrees, and lumbar lordosis at 22.47±2.55 degrees. Furthermore, the average scores for depression, anxiety, and stress were recorded as 10.87±1.03, 7.67±0.68, and 5.92±0.49, respectively; this suggests a normal range of mental health. Finally, the average number of push-ups performed was 6.84±0.71.

Table 1: Demographic and descriptive data

Variable	Mean±SD
Age (years)	17.04±0.83
Height (m)	1.72±0.51
Weight (kg)	65.9±3.74
BMI	21.8±1.22
Smartphone usage (hour)	3.84±0.57
Forward head	25.78±2.28
Thoracic kyphosis	24.29±2.76
Lumbar lordosis	22.47±2.25
Depression	10.87±1.03
Anxiety	7.67±0.68
Stress	5.92±0.49
Push-up	6.84±0.71

BMI: Body Mass Index; SD: Standard Deviation

3.2. Comparison of Research Variables between High and Low Smartphone Usage

Table 2 illustrates the average and standard deviation of various health metrics, including BMI, forward head posture, thoracic kyphosis, lumbar lordosis, as well as measures of mental health such as depression, anxiety, and stress, alongside push-up performance among participants categorized by their smartphone usage. Specifically, 286 participants (74.4%) reported using smartphones for more than 2 hours per day, while 98 participants (25.6%) used them for 2 hours or less. The findings indicate that individuals with high smartphone usage exhibited significantly elevated levels of BMI, forward head posture, and thoracic kyphosis compared with their low usage counterparts (P<0.001). In contrast, no significant difference in lumbar lordosis was observed between the two groups (P=0.694).

Table 2: Mean and SD of studied variables across high and low smartphone usage

Variables	High(n=286)		Low(n=98)		Comparison
	Mean	SD	Mean	SD	
BMI	23.5	1.24	20.1	0.86	t=5.684 P<0.001
Forward head	27.49	2.64	22.96	2.44	t=-5.639 P<0.001
Thoracic kyphosis	25.69	2.36	23.47	1.85	t=6.661 P<0.001
Lumbar lordosis	22.53	2.25	22.38	2.14	t=0.586 P=0.694
Depression	10.90	1.11	10.78	0.98	t=-1.053 P=0.263
Anxiety	7.59	0.58	7.71	0.63	t=0.985 P=0.198
Stress	5.96	0.43	5.88	0.28	t=-1.210 P=0.259
Push-up	5.82	0.59	7.58	1.03	t=4.285 P<0.001

BMI: Body Mass Index; SD: Standard Deviation

Table 3: Correlation matrix of studied variables with smartphone usage

	BMI	Forward head	Thoracic kyphosis	Lumbar lordosis	Depression	Anxiety	Stress	Push-up
Smartphone usage	r=0.527 P<0.001	r=0.396 P<0.001	r=0.442 P<0.001	r=0.050 P=0.452	r=-0.029 P=0.680	r=0.058 P=0.481	r=-0.084 P=0.268	r=-0.352 P<0.001

BMI: Body Mass Index

Furthermore, mental health assessments revealed no significant disparities in depression, anxiety, and stress levels between participants with high and low smartphone usage (P=0.263, P=0.198, and P=0.259, respectively). Notably, participants with high smartphone usage demonstrated a significantly greater number of push-ups compared to those with lower usage (P<0.001).

3.3. Associations between Study Variables

Table 3 presents the findings from the correlation matrix concerning the variables under investigation, which include BMI, forward head posture, thoracic kyphosis, lumbar lordosis, depression, anxiety, stress, and push-up performance in relation to smartphone usage. The analysis revealed a direct and significant correlation between smartphone usage and BMI (P<0.001), forward head posture (P<0.001), and thoracic kyphosis (P<0.001). In contrast, no significant correlations were found between smartphone usage and lumbar lordosis (P=0.452), depression (P=0.680), anxiety (P=0.481), or stress (P=0.268). Additionally, an indirect and significant relationship was identified between smartphone usage and push-up performance (P<0.001).

4. Discussion

The purpose of this study was to investigate the associations between smartphone usage with upper body abnormalities, obesity, mental wellbeing and physical fitness in high-school male students. The study showed that higher using smartphones was associated with higher risk of obesity in adolescents. This result was also further supported by the finding that the participants with high smartphone usage had significantly higher BMI than those with low smartphone usage. This is a very important finding in this study and also confirm the results of previous studies (23-28), showing that using smartphones, tablets and computers result in increased weight gain and consequently higher risk of obesity in children and adolescents. To interpret this finding, research indicated that children who engage in a sedentary lifestyle, particularly those who devote their leisure time to media consumption such as smartphones, are at a higher risk of becoming obese (23, 24). In fact, time spent on energy-intensive activities is supplanted by sedentary lifestyle like smartphone usage. Consequently, while using a smartphone, bodily movement is limited primarily to the fingers, leaving other parts of the body inactive (25, 27). This lack of physical activity leads to fat accumulation and, ultimately, obesity. Additionally, the tendency for individuals to consume high-calorie foods while engaged in smartphone activities, often without conscious awareness, along with the tendency to skip meals, further contributes to the obesity linked to smartphone use (25, 26). Additionally, while using smartphones, basic metabolic rates may decline. Conversely, increased smartphones consumption may be associated with higher intake of energy-dense foods, fats, sugary and salty snacks, and soft drinks, while simultaneously leading to a lower consumption of fruits and vegetables (27). Health-related behaviors established during childhood and adolescence often carry over into adulthood. Consequently, the repercussions of unhealthy practices, such as excessive smartphone usage, are likely to endure into later life. Therefore, it is advisable for parents and educators to explore psychological interventions and strategies aimed at mitigating and managing screen time for children.

A notable discovery from this study was the direct and significant correlation between smartphone usage and the presence of forward head posture and thoracic kyphosis. This was also further supported by the finding that the participants with high smartphone usage had significantly higher forward head and thoracic kyphosis than those with low smartphone usage. This is also a very important finding in this study and confirm the results of previous studies (29-34), showing that using smartphones, tablets and computers result in increased weight gain and consequently higher risk of obesity in children and adolescents. Forward head and thoracic kyphosis disorders are physical problems in which the head bends forward

abnormally and deviates from the normal axis of the spine. These complications are usually caused by pressure on the neck and surrounding muscles (30, 31). To interpret these findings, it can be sated that prolonged use of smartphones by children, particularly when seated in improper positions and neglecting ergonomic principles, can result in joint disorders affecting the spine, hands, and arms (29). Common medical issues associated with excessive computer use include shoulder drooping, arthritis, and the development of muscle cysts in the hands. Research indicated that individuals who frequently use smartphones may experience muscle and joint pain (30, 31), as well as movement disorders (32), cyst formation (33), or joint disabilities (34) due to overuse. Additionally, teenagers may be at risk of developing hand and arm vibration syndrome after extended periods of smartphone engagement. Experts attribute these disorders primarily to excessive smartphone usage, a sedentary lifestyle, and improper ergonomic practices during prolonged use. Long-term immobility, particularly during childhood and adolescence, combined with genetic predispositions and other unidentified factors, can lead to significant structural changes and severe spinal deformities, such as forward head and kyphosis, which may persist into adulthood (30-32). Excessive smartphone usage among children has led to a decrease in physical activity, resulting in a sedentary lifestyle. This sedentary behavior can negatively impact the spine due to lack of attention, eventually leading the brain to perceive poor posture as normal. Additionally, prolonged smartphone use can cause neck pain as the forward bending position places strain on the neck muscles, potentially leading to chronic pain. Studies indicated that abnormal head positioning and reduced neck curvature can result in spinal cord tension and various neurological issues (29, 30). Excessive use of smartphones is associated with the development of forward head posture and thoracic kyphosis, primarily due to sedentary behaviors, reduced levels of physical activity, and heightened stress on the muscles in the neck and upper back.

Other study findings revealed no significant correlation between smartphone usage and various components of mental well-being, such as depression, anxiety, and stress. This conclusion was further corroborated by the observation that participants categorized into high and low smartphone usage groups exhibited no notable differences in their mental well-being metrics, including depression, anxiety, and stress. These results imply that smartphone use does not adversely affect mental well-being. Furthermore, these findings were consistent with other studies suggesting that smartphone usage does not contribute to psychological problems (35, 36). Nevertheless, other research has demonstrated that smartphone usage can result in psychological issues like sleep disturbances, anxiety, and stress (14, 17). Consequently, additional research is necessary to arrive at a conclusive understanding of the impact of excessive smartphone use on the mental well-being of adolescents. It is essential to recognize that smartphones provide a multitude of functionalities, including communication, gaming, and entertainment, among others. Since each of these activities can exert different influences on individuals, it is imperative to conduct a comprehensive analysis of smartphone usage patterns among teenagers and their potential effects on mental health.

Ultimately, our analysis revealed that smartphone usage had an indirect yet significant correlation with physical fitness, specifically measured by push-up performance. Furthermore, this conclusion was bolstered by the observation of notable differences in push-up scores between participants categorized into high and low smartphone usage groups. This finding is particularly significant within the context of this study and corroborates the outcomes of earlier research (37-39), showing that using smartphones, tablets and computers result in a decreasing in physical fitness in youth. To interpret this finding, it can be stated that individuals who are addicted to smartphones demonstrated a decreased tendency to engage in daily walking. This addiction can have a detrimental impact on physical health as it leads to a reduction in physical activity, specifically walking, which can contribute to an increase in fat mass and a decrease in muscle mass, ultimately leading to negative health outcomes.

4.1. Limitations

One limitation of this study was the absence of an analysis regarding the specific types of smartphone usage. Future investigations should aim to explore the diverse forms of smartphone engagement and their potential effects on various physical and psychological dimensions. Furthermore, this

study employed only a single measure of physical fitness (i.e., push-ups), which primarily assessed upper body muscular endurance and strength. Considering that physical fitness comprises multiple elements, including strength, endurance, flexibility, speed, and agility, further studies are warranted to evaluate a broader range of fitness components. Finally, this study did not quantify physical activity levels. Investigating physical activity as a mediating variable in the relationship between smartphone usage and both physical and psychological outcomes could provide a more nuanced understanding of its implications.

5. Conclusions

The present study revealed that male students exhibit a usage of smartphones that exceeds the average, highlighting the need for enhanced oversight from both parents and educators. Additionally, the adverse consequences of prolonged smartphone usage on the musculoskeletal health and physical fitness of male adolescents underscore the necessity for the implementation of corrective exercises and appropriate ergonomic training to alleviate abnormalities and potential discomfort. Future investigations should prioritize the creation of customized corrective exercise programs and ergonomic interventions aimed at addressing musculoskeletal concerns. Ultimately, the role of physical education teachers is considered crucial, as their insights regarding student engagement in physical activities can significantly influence the overall physical health of high school male students.

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Authors' Contribution

Sara Bagheri: Substantial contributions to the conception and design of the work, acquisition, analysis, and interpretation of data for the work, reviewing the work critically for important intellectual content. Sheyda Ranjbari: Contribution to the design of the work, drafting the work and reviewing it critically for important intellectual content. Hassan Shafaei: Contribution to the design of the work, drafting the work and reviewing it critically for important intellectual content. Saeed Ghorbani: Acquisition, analysis, and interpretation of data for the work, reviewing the work critically for important intellectual content. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such as the questions related to the accuracy or integrity of any part of the work.

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Ethical Approval:

The current study was approved by the Institute Ethics Review Board with the code of IR.IAU.AK.REC.1398.003. Additionally, written informed consent was obtained from the parents of the children.

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