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RESEARCH ARTICLE

DOES SMARTPHONE ADDICTION IMPAIR MAXIMAL EXERCISE CAPACITY IN YOUNG ADULTS?

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ABSTRACT

Purpose: Smartphone addiction may reduce the time allocated for physical activity participation. However, it is not known if there is a direct association between smartphone addiction and reduced exercise capacity. Our aim was to investigate whether smartphone addiction impairs maximal exercise capacity, as well as analyze its influence on the perceived benefits of exercise and physical activity habits in young adults.
Material and Methods: Forty-six volunteers were evaluated by a symptom-limited incremental exercise test. Smartphone addiction of volunteers was evaluated using Smartphone Addiction Scale- Short Form. Physical activity participation and perceived benefits of physical activity participation were evaluated using International Physical Activity Questionnaire- Short Form and Exercise Benefits/Barriers Scale, respectively.
Results: The prevalence of smartphone addiction was 65% in young adults. No significant association was detected between smartphone addiction and any of maximal exercise capacity metrics including test duration, maximum workload achieved in watts or maximum heart rate ($p>0.05$). Smartphone addiction did not correlate to physical activity participation either ($p>0.05$). Univariate linear regression revealed Exercise Benefits/Barriers Scale score was able to explain 41% of variance in exercise test duration and 37% of variance in maximal workload ($p<0.01$), and it was also correlated to physical activity level ($r=0.424$; $p<0.01$)
Conclusion: Smartphone addiction did not directly translate into lower physical activity participation or worse exercise capacity. However, perception of the benefits of exercise had a great influence on physical activity and exercise capacity, which highlights the importance of increasing the awareness of the benefits of physical activity among young adults for maintaining physical health.

Keywords: Addiction, exercise capacity, exercise perception, physical activity, smartphone

INTRODUCTION

The maximum exercise capacity of an individual is directly associated with overall and cardiovascular mortality, independent of age, sex, comorbidities or documented cardiovascular diseases. It is reported that every 1-MET increase in the maximum exercise capacity reduces mortality risk by 12% (1). Consequently, it is recommended that healthcare professionals should encourage both the patients and the general population to achieve and maintain high levels of exercise capacity (2). This also highlights the importance of regular monitoring of exercise capacity, especially in the risky populations. On the other hand, physical activity level is one of the major contributors to maximum exercise capacity, which makes it equally important for maintaining good health. However, physical inactivity and sedentary lifestyle are spreading worldwide, and the penetration of television, smartphones and video entertainment devices in daily life poses a major risk for such behavior (3).

Smartphones made daily life more convenient since they provide various additional functions such as cameras, navigation systems, internet access, gaming and social media services. However, excessive usage of these devices may have many side effects including a decrease in real-life social interactions, lower academic performance, anxiety problems and a decline in relationships (4, 5). In addition to psychological and social problems, excessive smartphone use may also result in physical inactivity since sending and receiving messages, watching videos and browsing the web or social networking sites are considered sedentary behaviors (6). Younger individuals are especially at risk for developing smartphone addiction. Studies show that smartphone addiction is very common among university students, and individuals tend to be less physically active in their lives as the hours of smartphone use increase (7, 8). Considering that the long-term use of smartphones reduces the time allocated for physical activity, we hypothesized that it may also impair the physical fitness and maximal exercise capacity of individuals.

Studies investigating the direct association between smartphone addiction and exercise capacity are lacking in the literature. It is not known whether smartphone addiction in young individuals translates into impairment of maximal exercise capacity. On the other hand, individuals' understanding of the benefits of exercise greatly influences their attitude toward physical activity, and it is reported that smartphone addiction may adversely affect the perceived benefits of exercise in young individuals as well (9). Accordingly, we hypothesized to detect significant associations among smartphone usage, exercise capacity, physical activity level and exercise perception. Our aim in this study was to investigate whether smartphone addiction impairs exercise capacity, as well as analyze its influence on the perceived benefits of exercise and physical activity habits in young adults.

MATERIAL AND METHODS

Study design and participants

A prospective, cross-sectional study was conducted. 46 university students aged between 18-25 years were included in the study. Brochures were posted on various noticeboards throughout the university for inviting volunteers for the current study. Among 74 volunteers who met the inclusion criteria, 46 volunteers were included in the study cohort using simple random sampling approach. Most of the volunteers were students at faculty of health sciences, however, there were volunteers from the faculties of engineering and social sciences as well. Inclusion criterion was having a smartphone with continuous internet access. Exclusion criteria was having any diagnosed chronic disease that may impede exercise capacity, such as cardiac, pulmonary or neurological diseases, and history of any recent orthopedic injury such as sprains or fractures. The study was approved by the ethics committee of Izmir Bakircay University (Study No: 566, Approval Number: 586) and performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before being included in the study.

Outcome measures

Smartphone addiction was evaluated using Smartphone Addiction Scale- Short Form (SAS-SF). SAS-SF consists of 10 items, each scored on a six-point likert scale. Total score ranges from 10 to 60, and higher scores indicate a greater risk for smartphone addiction. Cut-off score of 31 for males, and 33 for females is indicative of smartphone addiction (10). Turkish version of the scale was used in the study, which was adapted by Noyan et al. Turkish version of SAS-SF has Cronbach's alpha coefficient of 0.867 and test/retest reliability coefficient of 0.926, both indicating high reliability. Concurrent validity is confirmed by its significant correlations with Internet Addiction Scale (0.320-0.555) (11).

Maximal exercise capacity was measured using a symptom-limited incremental exercise test on a clinical cycle ergometer (E100 bike, COSMED, Italy). World Health Organization (WHO) stress test protocol was used for the testing (12, 13). The initial load was set at 25 watts and increased by 25 watts every 2 minutes until volitional exertion or age-predicted maximal heart rate is reached. Participants were instructed to maintain a cadence of 65-70 rpm during

Table 1. Demographical features and the results of smartphone addiction, maximal exercise capacity, physical activity level and perceived exercise benefits assessments (n=46)

Demographics	
Age (years)	21.02±1.47
Gender, female (n)	29 (63%)
Body mass index (kg/m^2)	21.53±2.76
Smartphone addiction	
SAS-SF total score	34.02±8.81
Smartphone addicts (n)	29 (63%)
Maximal exercise capacity	
Test duration (sec)	494±148
W_{max} (watt)	120±33
HR_{max} (bpm)	166±12
HR_{max} (pred%)	83.30±5.94
IPAQ-SF (MET.min/wk)	3295±3134
EBBS total score	131±13

EBBS= Exercise Benefits/Barriers Scale; HR_{max}=maximum heart rate; IPAQ-SF= International Physical Activity Questionnaire- Short Form; SAS-SF= Smartphone Addiction Scale- Short Form; W_{max}=Maximal workload

testing. Heart rate and blood pressure were measured and recorded at rest and at the end of the testing, as well as every 3 minutes during testing. Rating of the perceived exertion was also monitored during testing using the Borg RPE scale (6-20) for ensuring maximal effort is put forth by the participant. Test duration, maximum workload achieved in watts (Wmax) and maximum heart rate achieved (HRmax) were recorded as indicators for maximal exercise capacity.

Physical activity participation was evaluated using The International Physical Activity Questionnaire-Short Form (IPAQ-SF). IPAQ-SF consists of 7 items questioning the frequency and duration of the participation in physical activities at low, moderate and vigorous intensities during the past week. It yields a numeric score for total activity participation as MET-min/week and a categorical score for the level of physical activity as low, moderate or high activity level (14). Turkish version of the questionnaire was used in the study, which was adapted by Saglam et al. It is a valid and reliable questionnaire according to its good agreement with objective accelerometer data and acceptable test-retest reliability (0.7) (15).

Perceived benefits of physical activity participation and exercise were evaluated using Exercise Benefits/Barriers Scale (EBBS). The exercise benefits component of the questionnaire includes 29 items and the exercise barriers component includes 14 items; all are scored based on a 4-point likert scale. The instrument may be scored and used in its entirety or as two separate scales. Scores on the total instrument can range from 43 to 172. The higher the score, the more positively the individual perceives exercise (16). Turkish version of the scale was used in the study, which was adapted by Ortabag et al. Turkish version of EBBS is valid and reliable scale as indicated by its validity coefficient of 0.87 and test-retest coefficient of 0.85 (17).

Statistical analysis and sample size

SPSS v.21 software program (IBM Corp., USA) was used for the analysis. The normality of the data was explored using Kolmogorov-Smirnov test. Relationships among smartphone addiction, maximum exercise capacity, physical activity level and perceived benefits of exercise were evaluated with Pearson or Spearman correlation analysis depending on the distribution properties of the data. Regression models were created to explore independent predictors of maximum exercise capacity. In addition, the participants were classified as those with and without phone addiction according to the cut-off values of SAS-SF, then maximal

Table 2. Relationship of smartphone addiction and perceived benefits of exercise with indicators of maximal exercise capacity and physical activity level (n=46)

	EBBS	Exercise test duration	W_{max}	IPAQ-SF
SAS-SF	0.058	-0.066	-0.086	0.017
EBBS		0.651*	0.607*	0.424*

Correlation coefficients (r values) are shown

* p<0.01

EBBS= Exercise Benefits/Barriers Scale; IPAQ-SF= International Physical Activity Questionnaire- Short Form; SAS-SF= Smartphone Addiction Scale- Short Form; W_{max}*=Maximal workload*

Table 3. Univariate linear regression for the prediction of maximal exercise test duration and W_{max}

Independent variable	Dependent variable	R	R^2	B	SE	p
EBBS total score	Test duration	0.651	0.423	7.146	1.257	<0.001
	W_{max}	0.607	0.369	1.480	0.290	<0.001

EBBS= Exercise Benefits/Barriers Scale; W_{max}=Maximal workload

exercise capacity, physical activity level and perceived benefits of exercise were compared between the groups using the Independent-samples T-test or Mann−Whitney U test depending on the distribution properties of the data.

G-power 3.1 software (Universitat Dusseldorf, Germany) was used for determining the sample size (18). In the literature, we were unable to find a study that investigates the association between smartphone addiction and maximal exercise capacity. However, a study reports that a regression model including "total cell phone use" was able to predict maximal exercise capacity measured by VO2max, having an effect size (f2) of 0.30 (19). Accordingly, we hypothesized the detect a similar association between smartphone addiction and Wmax with a similar effect size (f2=0.30). Then, it was calculated that minimum of 40 participants are needed for the study to detect such significant association with 90% of power at 95% confidence level.

Ethical statement

The study was approved by the Ethics Committee of Izmir Bakircay University (Date: 29.04.2022, Decision Number: 586) and conducted in accordance with Helsinki Declaration.

RESULTS

Demographical features and the assessment results of the participants are shown in Table 1. The sample consisted of mostly females. According to SAS-SF, 67% of the participants were "smartphone addicts". In the maximal exercise test, participants exercised for 494±148 seconds and reached %83±6 of their predicted HRmax. 39% of participants were classified as having a "high" physical activity level, while 44% as "moderate" and 17% as "low" physical activity level.

Correlation analysis revealed that smartphone addiction indicated by SAS-SF total score was not associated with maximal exercise capacity or physical activity level. However, perceived benefits of exercise indicated by EBBS total score significantly correlated to maximal exercise capacity metrics and physical activity level. There was no significant association between SAS-SF and EBBS total scores (Table 2). A univariate linear regression model including EBBS total score as independent variable was able to explain 41% of variance in exercise test duration and 37% of variance in Wmax (p<0.001). EBBS total score was found to be an independent predictor for both exercise test duration and Wmax. It was found that every 1 unit increase in EBBS total score results in an increase of 7.2 seconds in exercise test duration and an increase of 1.5 W in Wmax during maximal exercise testing (Table 3).

Table 4. Comparison of demographics and the results of maximal exercise capacity physical activity level and perceived exercise benefits assessments between the individuals with and without smartphone addiction

	Smartphone addicts (n=29)	Not smartphone addicts (n=17)	p value
Age (years)	21.31±1.37	20.53±1.55	0.081
Gender, female (n)	18 (62%)	11 (65%)	0.858
Body mass index (kg/m^2)	21.49±2.35	21.60±3.43	0.905
Exercise testing duration (sec)	497±140	481±161	0.421
W_{max} (watt)	122±31	114±35	0.449
HR_{max} (pred%)	83.55±6.40	82.88±5.21	0.669
IPAQ-SF (MET.min/wk)	3570±3426	2826±2590	0.443
EBBS total score	132±14	130±14	0.464

EBBS= Exercise Benefits/Barriers Scale; HRmax=maximum heart rate; IPAQ-SF= International Physical Activity Questionnaire- Short Form; SAS-SF= Smartphone Addiction Scale- Short Form; Wmax=Maximal workload

A subgroup analysis revealed that age, body mass index, exercise capacity metrics, physical activity level and the perceived benefits of exercise did not differ between the participants classified as "smartphone addicts" and "not smartphone addicts" according to SAS-SF (p>0.05) (Table 4).

Since gender may greatly influence smartphone usage habits, physical activity level and exercise perception, another subgroup analysis was conducted by comparing SAS-SF total score, IPAQ-SF (MET.min/wk) and EBBS total score between females and males. SAS-SF total score was similar in females and males (35.55±33.12 vs 33.12±8.98; p=0.602); however, females had worse physical activity participation (2704±2952 vs 4304±3264 MET.min/wk; p=0.032) and worse EBSS score (126±11 vs 140±13; p<0.001).

DISCUSSION

In this study, we demonstrated that more than half of the young adults are classified as smartphone addicts; however, smartphone addiction was not related to either maximal exercise capacity or physical activity participation. Our main hypothesis was that the smartphone addiction may impair individual's maximal exercise capacity by reducing the physical activity participation in daily life. However, this hypothesis was refuted according to our findings. On the other hand, an individual's perception of the benefits of exercise was a major predictor for physical activity participation and maximal exercise capacity, which was another hypothesis of the study. Individuals with a better perception of exercise benefits were more likely to participate in physical activity and had higher maximal exercise capacity, which confirmed our secondary hypotheses. On the other hand, we also found that prevalence of smartphone addiction is similar in genders, whereas females have worse physical activity participation and worse perception of exercise benefits compared to men.

Digital addiction, which incorporates internet, gaming, social media and digital device addictions has spread around the world in the past decade because of the rapid penetration of internet and digital technologies in our lives. COVID-19 has also exacerbated the increasing trend of digital addiction worldwide. Smartphone addiction is the most common type of digital addiction and is reported to have prevalence of 27% worldwide and 20% in Europe (20). Smartphone addiction is more common in young adults. A recent study reports a prevalence of 39% for smartphone addiction in United Kingdom in young population (21). For young Turkish population, Buke et al. (8) report the prevalence of smartphone addiction as 42% and Erdoğanoğlu et al. (22) as 53%. In our study, we found that 67% of the participants were smartphone addicts. The prevalence of smartphone addiction seems to be higher in the Turkish population compared to other regions, which is a concerning finding. Smartphone addiction is more common in developing countries, with a prevalence ranging from 30% to 60%. It is reported that individuals with economic or social disadvantages are more likely to use social media and digital devices to self-medicate, reduce stress, and alleviate mood as an escape from the unsatisfied outer environment (20). Similarly, the fact that Turkey is among the developing countries may explain our current findings on smartphone addiction. Gender may also have an influence on smartphone addiction. A recent study conducted in young Turkish population reports that females have worse smartphone addiction score compared to men and emphasizes the need for awareness training in female students (23). Smartphone addiction level was similar in genders in our study. However, we found that physical activity participation and perception of the benefits of exercise were significantly worse in females, which is a worrying finding from another perspective considering their direct influence on the maximal exercise capacity of an individual. Association of perception of the benefits of exercise with physical activity participation and exercise capacity will be discussed further in the text.

It may be assumed that smartphone addiction may result in lower physical activity participation, since it will reduce the time to be used to perform physical activities. However, the literature has conflicting findings regarding this topic, and it may not be appropriate to generalize this assumption to the whole young population. In a young Turkish sample, Buke et al. (8) report that degree of smartphone addiction is inversely related to physical activity level. Another recent study including over 50.000 youngsters reports smartphone addiction is associated with a lower participation ratio in regular physical activity (24). On the other hand, in another Turkish sample, physical activity level was not found to be related to smartphone addiction (22). Similarly, a study from Europe did not report a direct association between physical activity and smartphone addiction (25). In our study, we did not detect a significant relationship between smartphone addiction and physical activity level as well. A recent review reports that the most common problems associated with smartphone addiction include musculoskeletal pain and sleep problems; however, mental health is particularly affected due to smartphone addiction (26). It is undeniable that smartphone addiction poses great risks to physical and mental health. However, concerning physical activity, it may not be always accurate to directly associate smartphone addiction with lower physical activity participation. Physical activity participation has several major determinants including individual factors, social environment and physical environment. Individual factors include perceived enjoyment, perceived benefits of exercise, beliefs, self-discipline and time management (27). Smartphone or digital addictions may also be considered individual factors since behavioral features are part of the individual theme as well (28). Considering social and physical environments are the major determinants of physical activity participation as well, smartphone addiction may not necessarily translate into sedentary behavior or physical inactivity. This may explain why we did not detect a significant association between smartphone addiction and physical activity level in our study.

We hypothesized that smartphone addiction may impair an individual's maximal exercise capacity, because the smartphone addicts may tend to be less active during daily life. However, we did not detect an association between smartphone addiction and physical activity level in young adults. This may also explain the lack of a relationship between maximal exercise capacity metrics and smartphone addiction in our study. Literature is extremely limited regarding whether smartphone addiction results in impaired exercise capacity. We were able to find only 2 studies that investigate the association between smartphone use and exercise capacity. Lepp et al. (19) report that the total amount of smartphone use is inversely related to VO2max in college students. Authors state that high frequency smartphone users are more likely to forgo opportunities for physical activity participation. In addition, high-frequency smartphone users were found to be exhibiting more sedentary leisure time behaviors as well such as watching television, playing video games and using the computer compared to low-frequency users. Our results seem to be contradicting the results of Lepp et al. However, it should be noted that a relatively weak correlation is present between smartphone use and VO2max ($\beta = -0.25$; $p = 0.047$) in their study, which may decrease the generalizability of their results. In addition, they measured the duration of smartphone use in their study, not smartphone "addiction" as in our study. Duration of smartphone usage may not exactly reflect the smartphone addiction of an individual, which may be one of the explanations for differences between their results and ours. The results of the study of Erdoğanoğlu et al. (22) support our assumptions. In their study, no significant association was detected between smartphone addiction measured by SAS-SF as in our study and six-minute walk test. They did not find a significant relationship between smartphone addiction and physical activity level as well. We believe smartphone usage habits of young adults do not directly translate into physical inactivity or lower exercise capacity. However, cardiorespiratory fitness is one of the major determinants of cardiovascular and general health even from a young age (29). Thus, it is important to promote physical activity for maintaining cardiorespiratory endurance in young populations, independent from whether it is associated with smartphone addiction.

In our study, we found that perception of the benefits of exercise was a significant predictor for both physical activity level and maximal exercise capacity. In other words, individuals with a better perception of the benefits of exercise were more likely to participate in physical activity, and consequently had better exercise capacity. It is not surprising to detect a strong association between the perceived benefits of exercise and physical activity participation. As we discussed above, individual factors including perception and beliefs towards the benefits of exercise play a major role in physical activity participation. Being aware of the benefits of exercise on physical performance, body image and general health is a very important motivational factor for exercising (30, 31). A study from our country reports similar findings as ours. It was found that individuals with more physical activity participation had a better perception of the benefits of exercise (32). However, the benefits of physical activity are poorly understood in general population. It's reported that only 35% of Americans were aware of the physical activity guidelines and understands the benefits of exercise (33). Similarly, %15 of population was able to answer questions related to physical activity and its benefits in United Kingdom (34). These results suggest that the individuals' motivation to exercise may be increased by improving their understanding of the benefits of physical activity. Schools and universities are especially important places to develop such understanding. Young individuals should be educated on the benefits of physical activity and exercise during these eras. This may not only improve physical activity participation but may also improve maximal exercise capacity of young individuals according to our results. Our study also suggests that even a modest amount of increase in the perceived benefits of exercise translates into significant improvements in maximal exercise capacity, which emphasizes the importance of providing such awareness on the exercise benefits. It is also important to note that females had worse perception of the benefits of exercise in our study, which may explain their lower participation in physical activity as well. This emphasizes the fact that females may especially benefit from the awareness programs on the benefits of exercise.

The main limitation of our study was that we were unable to objectively measure and record the duration of smartphone use. Participants were using smartphones from a wide variety of brands and some brands were not recording the duration of use by default. Measuring the duration of smartphone use or recording the time spent in specific applications could help better examine the influence of smartphone usage habits on physical activity and exercise capacity. In addition, considering our study population consists of young and healthy individuals, metabolic rate measurements including maximum oxygen consumption (VO2max) would have provided more precise evaluation of maximal exercise capacity for this population. Unfortunately, we did not have the means to measure it in our laboratory. Addictions and habits vary considerably according to the cultural features of populations. Although we included the minimum number of participants in the study as calculated by a priori power analysis, this type of studies examining cultural phenomena greatly benefit from larger sample sizes. Our relatively small sample size may be considered as another limitation for the present study.

CONCLUSION

Smartphone addiction is common in the young adult population. However, it does not directly translate into lower physical activity participation or worse maximal exercise capacity. On the other hand, an individual's perception of the benefits of exercise has a great influence on physical activity level and exercise capacity. These results suggest the importance of increasing the awareness of the benefits of physical activity among young adults for maintaining and improving exercise capacity and consequently, general physical health.

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