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Relationship between smartphone addiction and physical activity in Chinese international students in Korea

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Background and Aims: Excessive usage of smartphones may induce social problems, such as depression and impairment of social and emotional functioning. Moreover, its usage can impede physical activity, but the relationship between smartphone addiction and physical activity is obscure. Therefore, we examined the relationship and the impact of excessive smartphone use on physical activity. *Methods:* This study collected data through the structured questionnaire consisting of general characteristics, the number and hours of smartphone usage, and the Smartphone Addiction Proneness Scale (SAPS) from 110 Chinese international students in Korea. The body composition and physical activity, such as the total daily number of steps and consumed calories, were measured. *Results:* In this study, high-risk smartphone users showed less physical activity, such as the total number of steps taken and the average consumed calories per day. Moreover, their body composition, such as muscle mass and fat mass, was significantly different. Among these factors, the hours of smartphone use revealed the proportional relationship with smartphone addiction ($\beta = 0.209$, $p = 0.026$), while the average number of walking steps per day showed a significant reverse proportional tendency in participants with smartphone addiction ($\beta = -0.883$, $p < 0.001$). *Conclusions:* Participants with smartphone addiction were less likely to walk for each day. Namely, smartphone addiction may negatively influence physical health by reducing the amount of physical activity, such as walking, resulting in an increase of fat mass and a decrease of muscle mass associated with adverse health consequences.

Keywords: smartphone use, mobile phone addiction, daily walking, sedentary behaviors, physical health

INTRODUCTION

Many digital devices which have evolved from personal desktops, such as notebook computers, tablets, and other mobile devices, have become ubiquitous in today's world. Smartphones, in particular, have brought many changes to our daily lives since they provide various functions including a camera, multimedia player, phone, Internet browser, navigation system, e-mail, gaming device, and social networking services (SNS) all in one portable device (Boulos, Wheeler, Tavares & Jones, 2011; Kim, Lee, Lee, Nam & Chung, 2014; Mok et al., 2014). Many smartphone users are constantly on their devices using social networking sites while on public transportation or having meals (Park & Lee, 2011). Recently, Roberts, Yaya and Manolis (2014) suggested that structural characteristics, including stylized ringtones, compelling graphics and/or certain tactile features of the phone such as buttons and wheels, may induce and/or reinforce mobile phone use, consequently provoking addiction. According to a 2013 survey on Internet addiction, 11.8% of Koreans are addicted to smartphone use with adolescents and those in their twenties showing a particularly high addiction rate (Nam, Aum & Park, 2014). Korea has one of the world's most advanced Wi-Fi mobile systems in terms of speed and accessibility, which also contributes to the Internet and smartphone addiction in Korea (Kim, 2013).

While smartphones have made life more convenient, it has also brought many side-effects (Kim et al., 2014). Kuss and Griffiths (2011) reported that excessive smartphone use can decrease real-life social interaction, lower academic performance, and negatively affect relationships. Moreover, excessive smartphone use can give rise to adverse effects similar to those caused by problematic Internet use, including comorbid psychiatric disorders and the impairment of social and emotional functioning due to the portability factor that allows for real-time and personalized Internet services anywhere (Boulos et al., 2011; Ha et al., 2006; Shapira et al., 2003). Excessive smartphone use can also disrupt physical activity (Lepp, Barkley, Sanders, Rebold & Gates, 2013). Functions such as calling, sending and receiving text messages, updating social networking sites, and browsing the Internet, have historically been defined as sedentary behaviors (Rosenberg et al., 2010). Such inactive behavior correlates with various health problems including obesity or metabolic syndrome because it results in low levels of energy expenditure (Hamilton, Hamilton & Zderic, 2007; Owen, Healy, Matthews & Dunstan, 2010). Specifically, high Internet and computer use, considered as sedentary behaviors, are associated with higher body mass index and lower physical activity levels (Kautiainen, Koivusilta, Lintonen, Virtanen & Rimpelä, 2005; Tammelin, Ekelund, Remes & Näyhä, 2007). Furthermore, Katzmarzyk, Church, Craig and Bouchard (2009) reported that there was a dose-

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response association between sitting time and mortality from all types of cardiovascular disease. Similarly, high frequency users of smartphones can impede physical activity and promote sedentary behaviors, such as watching television and using computers, resulting in the reduction of cardiorespiratory fitness. However, the relationship between smartphone use and physical activity is obscure (Lepp et al., 2013).

METHODS

Participants and procedure

One hundred and ten Chinese international students enrolled in the Department of Chinese at Hanseo University in Korea were recruited as the subjects for this study. Participants (67 males and 43 females) aged 19 to 25 (mean age 21.03 ± 1.61 years) have been studying in Korea for an average of 11 months. This study collected data through a structured questionnaire consisting of general characteristics, the number and total hours of smartphone usage, and the Smartphone Addiction Proneness Scale (SAPS). All questionnaires were in the self-report format and translated from English into Chinese by a professor in the Chinese department to ensure all participants fully understood. Lastly, body composition and physical activity were measured.

Measure of smartphone addiction

The SAPS used in this study was developed by the National Information Society Agency (Shin, Kim & Chung, 2011), which has been reported to be a reliable and valid diagnostic scale for screening adolescents who may be at risk of smartphone addiction (Cronbach's α coefficient = 0.814) (Kim et al., 2014; Shin et al., 2011). The SAPS contains 15 items consisting of four subdomains: (1) disturbance of adaptive functions, (2) virtual life orientation, (3) withdrawal, and (4) tolerance. These items are scored on a 4-point scale, ranging from 1 ('Strongly disagree') to 4 ('Strongly agree'), with higher scores reflecting a greater severity of smartphone addiction. The level of smartphone addiction was categorized as high-risk, potential-risk, or no-risk based on the total score for three components of disturbance of daily routines, withdrawal, and tolerance. Participants were classified as high-risk smartphone users if their total score was equal to or greater than 44. Participants were classified as potential-risk smartphone users if their total score had a range of 40 to 43. Participants were classified as no-risk smartphone users if their total score was equal to or less than 39. In this study, the Cronbach's α coefficient was 0.852, and Spearman's correlation coefficients between the total score of SAPS and the scores of four subdomains (disturbance of adaptive functions, virtual life orientation, withdrawal, and tolerance) were 0.849, 0.809, 0.806, and 0.810, respectively ($p < 0.001$).

Measures of physical activity and body composition

For measuring physical activity levels, a 3D-Sensor Pedometer (Polylight Design CO., Taipei, Taiwan) was carried in a subject's pocket or bag for 7 days. Before issuing the pedometer, we noted the individual's age, gender, height and weight. This pedometer measured the steps and calorie consumption for 7 days, with the exception of sleeping and taking a shower. The pedometer may be useful in assessing physical activity in a large and free-living population as its validity for physical activity measurement has been confirmed in previous studies (Sequeira, Rickenbach, Wietlisbach, Tullen & Schutz, 1995; Tudor-Locke, Williams, Reis & Pluto, 2002). Tudor-Locke et al. (2005) suggested that measurement during any 3 days can provide a sufficient estimate for physical activity. Body weight, fat mass and muscle mass of subjects were measured using the bioelectrical impedance analysis (BIA) method with the InBody 320 Body Composition Analyzer (BioSpace, Seoul, Korea), while height was measured with the BMS 330 anthropometer (BioSpace, Seoul, Korea).

Statistical analyses

Statistical analysis was conducted with the SPSS statistical software (version 21.0; SPSS Inc, Chicago, IL). Descriptive analyses were performed on all variables and the Kolmogorov–Smirnov test was used to determine the normality of distribution for the examined variables. Because the data were not normally distributed, nonparametric tests were used. The Kruskal–Wallis test was conducted to compare variables based on the levels of smartphone addiction and the Tukey ranks test was performed for the post-hoc analysis. The relationship between the level of smartphone addiction and gender was analyzed using the Chi-square test. p-value resulting from the Chi-square test was adjusted by Fisher's exact test and Bonferroni correction for multiple comparisons ($p_{Bonf} < 0.008$). Correlational analyses were used to examine the relationship between variables, especially between the level of smartphone addiction and physical activity. Cronbach's α coefficients were used to determine the reliability of the SAPS, while Spearman's correlation coefficients between the total score of SAPS and the scores of subdomains consisting of SAPS were calculated to investigate the validity of the SAPS. Finally, hierarchical regression analyses were conducted to examine the associations of the level of smartphone addiction with variables related to physical activity, and multicollinearity was examined using Variance Inflation Factor (VIF) statistics ($2.190 \leq$ VIF values ≤ 6.716). The significance level for all analyses was set a priori at $p \leq 0.05$.

Ethics

The Institutional Review Board of Hanseo University approved the study. All participants were informed of the study and provided informed consent.

RESULTS

General characteristics of participants

Based on the evaluation by the SAPS, 60.0% ($n = 66$; 34.63 ± 3.55) were no-risk smartphone users, 20.9% ($n = 23$; 41.43 ± 0.99) were potential-risk smartphone users, and 19.1% ($n = 21$; 46.24 ± 3.22) were high-risk smartphone users. The level of smartphone addiction significantly differed by gender ($\chi^2 = 9.835$, $p_{Bonf} = 0.007$). Specifically, more female students were high risk smartphone users than male students (32.6% vs. 10.4%, respectively).

Relationship between physical activity, body composition and the level of smartphone addiction

The subjects' physical activity and body composition based on the level of smartphone addiction resulting from the Kruskal–Wallis test are presented in Table 1. There were no significant differences in the height and weight after controlling the effect of gender on the level of smartphone addiction. On the other hand, there were significant differences in muscle mass, fat mass, average number of walking steps per day, and the average consumed calories per day. Moreover, these results showed significant correlations between these variables and the level of smartphone addiction. Specifically, the muscle mass of participants with high-risk smartphone addiction was significantly lower than those with no-risk and potential risk ($p = 0.001$), and muscle mass was in inverse proportion to the level of smartphone addiction ($r = -0.245$, $p = 0.010$). Contrarily, fat mass for high-risk smartphone users was significantly higher than subjects with lower risk levels ($p < 0.001$), and it was in proportion to the level of smartphone addiction ($r = 0.435$, $p < 0.001$). The average number of walking steps and average consumed calories per day in subjects with high-risk addiction were significantly lower (all *ps* < 0.001), resulting in a significant negative relationship (*rs* = –0.798 and –0.578, respectively, *ps* < 0.001).

Effects of variables on the level of smartphone addiction

Hierarchical regression analyses were conducted to verify the relative explanatory values of three sets of variables on the level of smartphone addiction: (1) gender and body composition factors, including height, weight, muscle mass and fat mass, (2) the behavioral aspects of smartphone usage (i.e., the number of hours of smartphone use per day), and (3) physical activity factors, such as the average number of walking steps and consumed calories per day. The gender and body composition were first controlled in Block 1, and the behavioral aspects of smartphone usage were entered in Block 2. Finally, the physical activity factors were controlled in Block 3.

The changes in R^2 showed that predictive power improved whenever the other variables were added to the model. Consequently, the % of variability increased from 30.3% to 72.5%. Each Block represented significant explanatory values to the level of smartphone addiction ($F(5, 104) = 8.848$, $p < 0.001$, $F(7, 102) = 19.869$, $p < 0.001$, $F(9, 100) = 28.648$, $p < 0.001$, respectively). The fat mass emerged as a significant factor in Block 1 ($\beta = 0.467$, $p = 0.001$), and the hours of use per day significantly explained the variance in the level of smartphone addiction in Model 2 ($\beta = 0.528$, $p < 0.001$). The final model of regression analysis revealed that the hours of use per day and the average number of walking steps per day significantly explained the variance in the level of smartphone addiction (βs = 0.209 and –0.838, $p = 0.026$ and $p < 0.001$, respectively) (Table 2). These results suggested that increased hours of smartphone usage and less walking steps per day constituted the potential risk factors of smartphone addiction.

Table 1. Body composition, physical activity, and usage time of smartphone based on level of smartphone addiction

Variable	No-risk ($n = 66$)	Potential-risk ($n = 23$)	High-risk ($n = 21$)	Total ($n = 110$)	*p*-value[†] (Partial correlation coefficient[‡])
Height (cm)	171.58 ± 9.01	168.57 ± 7.87	167.33 ± 7.12	170.14 ± 8.57	0.086 ($r = -0.012$)
Weight (kg)	63.73 ± 10.09	62.48 ± 10.93	60.81 ± 11.16	62.91 ± 10.44	0.402 ($r = 0.061$)
Muscle mass (kg)	27.91 ± 6.40[a]	26.09 ± 6.07[a]	21.14 ± 5.93[b]	26.24 ± 6.71	0.001 ($r = -0.245^{*}$)
Fat mass (kg)	14.20 ± 5.04[a]	17.30 ± 6.70[a]	22.10 ± 6.76[b]	16.35 ± 6.48	<0.001 ($r = 0.435^{**}$)
Average number of walking steps for a day	8,159.83 ± 1,220.34[a]	5,022.48 ± 1,560.65[b]	3,930.43 ± 543.06[c]	6,696.44 ± 2,189.93	<0.001 ($r = -0.798^{**}$)
Average consumed calories for a day	463.49 ± 119.37[a]	299.91 ± 72.02[b]	276.86 ± 35.68[b]	393.65 ± 131.20	<0.001 ($r = -0.578^{**}$)
Number of use per day	12.35 ± 12.60[a]	30.26 ± 27.67[b]	58.15 ± 34.49[c]	24.65 ± 27.79	<0.001 ($r = 0.624^{**}$)
Hours of use per day	3.73 ± 2.01[a]	8.22 ± 3.06[b]	10.86 ± 4.10[c]	6.03 ± 4.01	<0.001 ($r = 0.697^{**}$)

Only significant ($p < 0.05$) group differences are indicated, and all values are expressed as mean ± standard deviation.

[†]*p* values were resulted from the Kruskal–Wallis test followed by Tukey ranks test for the *post-hoc* analysis.

[*] represents $p < 0.05$, and [**] represents $p < 0.001$.

[a, b,] and [c] mean symbols of *post-hoc* results.

[‡]Partial correlation coefficient *(r)* was resulted from the correlation analysis after converting the gender variable to the dummy variable (male = 0, female = 1) to control the effect of the gender.

Table 2. Hierarchical regression analysis of variables related to the level of smartphone addiction (n = 110)

	Variables	Standardized coefficients (Beta)	t	R^2 change	F change
Model 1				0.303	8.848
Block 1	Gender (male = 0)	0.057	0.467		
	Height (cm)	0.101	0.742		
	Weight (kg)	–0.136	–0.650		
	Muscle mass (kg)	–0.181	–0.883		
	Fat mass (kg)	0.467	3.467*		
Model 2				0.279	33.378
Block 1	Gender (male = 0)	0.005	0.051		
	Height (cm)	0.067	0.623		
	Weight (kg)	–0.154	–0.931		
	Muscle mass (kg)	–0.015	–0.090		
	Fat mass (kg)	0.195	1.680		
Block 2	Number of use per day	0.152	1.451		
	Hours of use per day	0.528	5.393**		
Model 3				0.143	25.416
Block 1	Gender (male = 0)	–0.086	–1.036		
	Height (cm)	0.044	0.493		
	Weight (kg)	–0.015	–0.107		
	Muscle mass (kg)	–0.112	–0.842		
	Fat mass (kg)	–0.006	–0.061		
Block 2	Number of use per day	0.064	0.741		
	Hours of use per day	0.209	2.259*		
Block 3	Average number of walking steps for a day	–0.838	–6.416**		
	Average consumed calorie for a day	0.218	1.673		

* represents $p < 0.05$, and ** represents $p < 0.001$.
The overall R^2 of Models 1, 2, and 3 are 0.303, 0.582, and 0.725, respectively.

DISCUSSION

In this study, participants with high-risk smartphone addiction had a significantly lower average number of walking steps and consumed calories per day. High-risk smartphone users also had significantly more fat mass and less muscle mass than no-risk and potential-risk subjects, while their height and weight were not significantly different. In addition, they spent significantly more time using their smartphones and used them more often than no-risk and potential-risk users. These results suggest that subjects with smartphone addiction spent more time using their smartphones and were involved in less walking each day, resulting in lower energy expenditure, which may contribute to reducing muscle mass and increasing fat mass. A significant reverse proportional relationship between the level of smartphone addiction and the amount of daily walking was also verified by the hierarchical regression analysis.

Physical activity is important to health benefits and can reduce the risk of mortality. All healthy adults need moderate-intensity aerobic activity for a minimum of 30 minutes, five days a week or vigorous-intensity aerobic activity for a minimum of 20 minutes, three days a week to enhance and maintain health (Haskell et al., 2007). The recommended moderate-to-vigorous physical activity is equivalent to 7,100 to 11,000 steps per day. Roughly 7,000~8,000 steps per day is considered as the reasonable threshold of free-living physical activity in adults related to the minimal amounts of time spent in moderate-to-vigorous physical activity according to current public health guidelines (Tudor-Locke et al., 2011). On the other hand, anything less than this threshold of 7,000~8,000 steps per day is reported to be associated with adverse health outcomes. Schmidt, Cleland, Shaw, Dwyer and Venn (2009) reported that people taking less than 5,000 steps per day had a significantly higher prevalence of cardiometabolic risk than those totaling more steps per day. Women taking 5,000~7,500 steps per day had a significantly lower BMI than those taking less than 5,000 steps per day (Krumm, Dessieux, Andrews & Thompson, 2006). Our study also showed that subjects with high-risk smartphone addiction took an average of 4,000 steps per day and had higher fat mass and lower muscle mass, compared to participants taking an average of 8,000 steps per day. Lepp et al. (2013) also reported that cell phone use disrupted leisure time physical activity, promoting sedentary behaviors and reduced cardiorespiratory fitness, like peak oxygen consumption. From these studies, it can be inferred that smartphone addiction may have an adverse impact on physical health by resulting in less physical activity.

This study dealt with a novel and noteworthy phenomenon: the relationship between smartphone use and physical activity. Namely, smartphone addiction was associated with less physical activity, such as daily walking, and consequently may be harmful to physical health by resulting in higher fat mass and decreasing muscle mass induced by less physical activity. However, our study should be interpreted with several limitations. First, the generalizability of the findings may be limited because participants of this study were confined to Chinese international students and the sample size was small. Moreover, this study only focused on subjects in their early twenties. Secondly, the findings of this study may be susceptible to report bias, such as the total hours of smartphone use per day because of the self-report questionnaire. Finally, no additional information including the effect of stress, self-efficacy, and impulsivity on smartphone addiction, depression, social support, and their physical health conditions was provided. Wu, Cheung, Ku and Hung (2013) reported that low Internet self-efficacy, positive outcome expectancies, and high impulsivity were verified as potential risk factors of addictive tendencies toward social networking sites among Chinese smartphone users. Therefore, further studies should include a larger sample of subjects, include other age groups, and consist of more specific measurements in order to validate the relationship between smartphone addiction and physical activity. Further studies should also be conducted to provide the definite reason and effect of smartphone addiction on physical activity and/or physical health.

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Authors' contributions: Kim SE performed the data analysis, drafted, and wrote the manuscript. Jee YS designed the study, obtained university funding and IRB approval, and assisted with data collection and draft of the manuscript. Kim JW translated the structured questionnaire, collected data and commented on writing the manuscript. All authors read and approved this final manuscript.

Conflict of interest: The authors declare that they have no conflicts of interest.

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