Original Article

The Effects of Internet Gaming and Social Media Use On Physical Activity, Sleep, Quality of Life, and Academic Performance among University Students in Hong Kong: A Preliminary Study

Abstract:

Introduction: With the rapid increase in the prevalence of the Internet and/or smartphone usage worldwide in the last decade, engagement in internet gaming and social media may be problematic and may lead to negative consequences on mental and physical health among young adults. The main objectives of the present study are (1) to investigate how internet gaming and social media impact on physical activity, sleep quality, quality of life (QoL), and academic performance of university students in Hong Kong and (2) to investigate how physical activity and sleep associate with QoL and academic performance of university students in Hong Kong. **Methods:** This study employed a longitudinal design with 3-month duration. Hong Kong university students (n = 15; 4 males; mean age = 26.87 years) completed the questionnaires, wore a device to measure their physical activity and sleep, provided screen time data showing the time usage of applications on gaming and social media categories, and academic transcript for the study. **Results:** Internet gaming was negatively correlated with physical activity and psychological QoL (r_s = −0.49 to −0.62); social media use was negatively correlated with physical activity and sleep quality (r_s = −0.48 to −0.63); internet gaming and smartphone addiction were negatively correlated with academic performance (r_s = −0.51 to −0.53); physical activity was positively correlated with psychological QoL (r_s = 0.49). **Conclusion:** The results emphasized that internet gaming and smartphone addiction tend to have negative impact on physical activity, psychological QoL, sleep, and academic performance. The findings may be regarded as a direction for health-care providers to develop and evaluate the intervention to treat the specific type of internet/smartphone overuse.

Keywords: *Internet gaming, physical activity, quality of life, sleep, social media*

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Introduction

With the rapid increase in the prevalence of the Internet and/or smartphone usage worldwide in the last decade, studies on internet addiction and the associated health implications have greatly increased.[1] Among different behaviors on the internet, engagement in internet gaming and social media are more problematic, as they may lead to symptoms associated with addiction.[2,3] Numbers of negative consequences on mental and physical health, such as anxiety disorder, depression, suicidal ideation, more frequent headaches, and musculoskeletal pain, were found to be associated with heavy internet use or internet addiction among adolescents.[4-6]

Internet gaming and social media overuse are also suggested to be the significant factors of reduced physical activity.[7-9] Some studies reported a negative correlation between online game usage and physical activity among emerging adults.[7,8] Specifically, length and frequency of online game play were found to be negatively correlated with length and frequency of exercise among American male undergraduates.[7] Another research showed that emerging Swiss male adults with a lower level of sport and exercise had more symptoms of gaming disorder, compared with those with a higher level of sport and exercise.[8] Moreover, a longitudinal study on German university students indicated that Facebook addictive behavior is negatively correlated to physical activity.[9] That is, with higher addiction to Facebook, the less frequent they engaged in physical exercise.

Apart from physical activity, previous studies show that excessive use of internet

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gaming and social media lead to negative influences on sleep.[10-12] Problematic or addictive gaming was found to be highly associated with sleep problems including insomnia, shorter sleep duration, and poorer sleep quality.[10] In addition, there was a strong association between social media usage and sleep disturbance in university students.[11] In a cross-sectional study conducted in Chongqing, China, more than half of undergraduate students who were social media users reported poor sleep quality.[12] Thus, with greater and more frequent internet gaming or social media use, the risks of experiencing sleep disturbance are higher.

Internet gaming and social media do not only affect physical activity and sleep but are further associated with quality of life (QoL) and academic performance. Physical activity can provide positive influence on health, which contribute to QoL.[13] Students with higher GPA are found to be more engaged in physical activities than those with lower GPA.[14] Moreover, poor sleep quality was found to be associated with poor QoL,[15] while sleep debt was associated with poor academic performance in Hong Kong adolescents.[16]

To summarize, internet gaming and social media can lead to further consequences on QoL and academic performance in Hong Kong students. Therefore, investigating the impacts of internet gaming and social media on physical activity, sleep, QoL, and academic performance is very important for the well-being of the students in Hong Kong.

Prior studies have documented the negative impacts of internet gaming and social media overuse including reduced physical activity, poor sleep quality, reduced QoL, and reduced academic performance.[7-16] However, hardly, any study has been conducted to examine both smartphone activities simultaneously among any population such as university students in Hong Kong. Hence, little is known about the comparison of their impacts as well as the combined effects on concerned health behaviors and functional outcomes. Moreover, previous studies have rarely used objective measurement on the smartphone usage, physical activity, and sleep, which could provide more accurate and reliable data than subjective measurement since there may be biases or difficulties in recalling and computing the actual usage on gaming and social media as well as physical activity level and sleep quality. In addition, studies in this area conducted in East Asia are limited. Majority of them are from Western countries which may involve cultural differences such as lifestyles, academic demands, living, and school environment of university students, affecting the engagement in physical activity, internet gaming, and social media.

To address all of these gaps and provide useful information for health-care professionals to prioritize and design interventions, the present study has three main objectives: (1) to investigate how internet gaming and social media impact on physical activity and sleep quality

of university students in Hong Kong; (2) to investigate how internet gaming and social media impact on QoL and academic performance of university students in Hong Kong; (3) to investigate how physical activity and sleep associate with QoL and academic performance of university students in Hong Kong. According to the objectives, this study has three hypotheses:

- Hypothesis 1: More internet gaming and social media precede decrease in physical activity and sleep quality, respectively
- Hypothesis 2: More internet gaming and social media precede lower academic performance and decrease in psychological QoL, respectively
- Hypothesis 3: More physical activity engagement and better sleeping quality precede increase in psychological QoL and higher academic performance, respectively.

Methods

Study design and procedure

This study employed a longitudinal design with 3-month duration. There were 15 participants participated in the study. Each participant was requested and agreed to: (1) fill in a background information sheet; (2) wear ActiGraph GT9X (a device to measure their physical activity and sleep) on the wrist of their nondominant hand during the 1st week of each month; (3) provide the screen time data showing the time usage of applications on gaming and social media categories every weekend across these 3 months; (4) complete six questionnaires (see *Instrument* section below for details) and self-report the time use on smartphone, social media, and gaming at the end of every month; (5) provide their academic transcript at the end of the semester.

Participants

Eligible participants fulfilled the criteria below: (1) aged between 18 and 35; (2) current university students in Hong Kong; (3) able to read traditional Chinese characters and speak Cantonese; (4) have smartphone with iOS or Android operating system; (5) with internet access; (6) were living in Hong Kong; and (7) able to complete all the online questionnaires. Meanwhile, participants who met the following criteria were excluded: (A) self-reported diagnosis of psychiatric problems such as depression or anxiety disorder; (B) self-reported diagnosis of neurological disease such as stroke or narcolepsy; (C) self-reported upper limb disability that affecting smartphone or Internet use.

Measures

Background information sheet

It included items on gender, age, study major in the university, current occupation other than a student, and monthly salary.

Smartphone screen time

iPhone users are able to assess the recorded actual time use on different applications through "Screen Time" under the existing system, while Android users needed to download an application with the same function. At the end of every week, participants needed to capture the time use of two categories: social media and gaming. Common social media applications include Facebook, Instagram, and WhatsApp. Any games under the gaming category in App Store or Google Play were considered as gaming applications. The data of total time use in social media and gaming categories were collected.

Actigraph GT9X

Actigraph GT9X (ActiGraph Corporation, Pensacola, FL) is a device widely used to assess physical activity and sleep in daily living objectively.[17] GT9X is the latest model, after the previous model GT3X. As compared with gold standard measure by doubly labeled water technique, GT3X was reported to have a strong correlation with Pearson's $r = 0.41–0.69$.[18] In this study, Actigraph GT9X was adopted to collect the corresponding data. Each participant needed to wear the assigned device on their nondominant wrist, as suggested by ActiGraph Corporation to ensure accuracy, during the 1st week of each month. 24-h activities data in those 3 weeks were recorded.

Internet Gaming Disorder Scale-Short Form 9

The Internet Gaming Disorder Scale-Short Form (IGDS-SF9) was developed based on Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition criteria and includes nine self-reported items with 5-point Likert scale to assess addictive gaming. One of the items as a sample is: "Do you systematically fail when trying to control or cease your gaming activity?" With higher score, the level of gaming problematic use is higher. Previous study reported the scale has excellent level of internal consistency ($\alpha = 0.93$) for students in Hong Kong.[19]

Bergen Social Media Addiction Scale

The Bergen Social Media Addiction Scale (BSMAS) consists of six self-reported items with 5-point Likert scale to assess the risk of social media problematic use. One of the sample questions is: "How often during the last year have you felt an urge to use social media more and more?" Higher score implies higher level of social media problematic use. With earlier study supported, this scale has good level of internal consistency ($\alpha = 0.85$) with Hong Kong students.[19]

Smartphone Application-Based Addiction Scale

The Smartphone Application Based Addiction Scale (SABAS) consists of six self-reported items with 6-point Likert scale to assess the risk of problematic use of smartphone applications. One of the sample questions is: "My smartphone is the most important thing in my life." Higher levels of problematic use on smartphone applications indicated by higher score obtained. Previously, a study pointed out that SABAS had an adequate level of internal consistency ($\alpha = 0.78$) for students in Hong Kong.[19]

International Physical Activity Questionnaire

The International Physical Activity Questionnaire (IPAQ) comprises seven self-reported items about the time spent on different physical activities within the past week. One of the sample questions is: "During the last 7 days, on how many days did you do vigorous physical activities?" With different levels of activities, the time spent will be converted to corresponding metabolic equivalent of task (MET). The satisfactory test–retest reliability of IPAQ was reported as intraclass correlation coefficient $=0.79$.[20]

Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) consists of 24 items with 4-point Likert scale (0–3) to assess the sleep quality. For this study, only 19 items were adopted since five items involve rating by the roommate or bed partner. One of the sample questions is, "During the past month, how often have you had trouble sleeping because you had bad dreams?" Higher score means poorer level of sleep quality. The Chinese version of PSQI had good internal consistency ($\alpha = 0.82$-0.83) and test–retest reliability ($r = 0.77–0.85$) at 2–3-week interval.[21]

World Health Organization Quality of Life Questionnaire-Brief version

It includes 28 items with 5-point Likert scale (1–5) to assess the QoL in four domains: physical, psychological, social, and environment. A sample item is "Do you have enough energy for everyday life?" With higher scores, it represents a better QoL (except 3 items with reversed code). The Chinese version of World Health Organization Quality of Life Questionnaire-Brief version reached good internal consistency with $\alpha = 0.76–0.87$.[22]

Academic transcript

Each participant was requested to provide a transcript copy at the end of that experimental semester. The academic results were collected for exploring any potential association with internet/smartphone overuse.

Ethical consideration

This study has been approved by the Human Subjects Ethics Sub-committee (HSESC) of The Hong Kong Polytechnic University (HSESC Reference Number: HSEARS20190829001). Meanwhile, informed consent in written form was obtained from each participant before the study started.

Statistical analysis

All data analyses were conducted using SPSS 25.0 (SPSS Inc., Chicago, IL, USA). Shapiro–Wilk test was used to check the normality of the data. Based on hypotheses of this study, correlations of the changes between following variables with subjective and objective data were examined, respectively: (A) internet gaming and social media with physical activity and sleep quality; (B) internet gaming and social media with QoL and academic performance; and (C) physical activity and sleep quality with QoL and academic performance. Spearman's correlation analysis was used to analyze each association above. Both the subjective and objective data of each variable were examined. For example, objective data of social media (time use recorded by screen time) were correlated with both objective data of physical activity (MET measured by Actigraph) and subjective data of physical activity (IPAQ) respectively. The changes of each variable between every two time points were calculated including changes between Time 2 (end of 2nd month) and Time 1 (end of 1st month) and between Time 3 (end of 3rd month) and Time 1. The changes of the variables were correlated using Spearman's correlation. For example, the change of internet gaming between Time 2 and Time 1 was correlated with the change of sleep quality between Time 2 and Time 1. The significance level for all analyses was set as $P \leq 0.05$. Using one-tail test, type I error at 0.05; power at 0.8, supposed the effect size of rho at 0.6, the required sample size is 13. Therefore, our sample size 15 is sufficient for the analysis, especially for the nature of preliminary study.

Results

Table 1 presents the participants' characteristics ($n = 15$; 26.7% males). The participants aged between 21 and 33 years with a mean of 26.87 ± 3.11. All participants were current university students in Hong Kong (93.3% full time; 6.7% part time), and 86.7% of them were studying in health-related program. The mean of their GPA was 3.50 ± 0.27. Two-fifths of the participants were under employed and most of them had monthly income <10,000 HKD.

Table 1: Participant's characteristics (*N*=15)

	n (%)
Age (years), mean±SD	26.87±3.11
Gender (male)	4 (26.7)
Major (health-related)	13 (86.7)
Having a job (yes)	6 (40.0)
Monthly salary/allowance (10,000 HKD and below)	14 (93.3)
Full-time student (yes)	14 (93.3)
Academic performance (GPA), mean±SD	3.50±0.27

1 USD≈7.8 HKD. HKD: Hong Kong Dollar, SD: Standard deviation, GPA: Grade point average

Table 2 presents the performance of gaming, social media use, physical activity, sleep, and QoL of the participants across 3 months. In brief, objective gaming time at 2 months after baseline was higher than the other two time points. Both self-reported and objective social media time and self-reported physical activity reached the peak at 3 months after baseline. Self-reported gaming time, objective physical activity, all sleep-related items, and the four domains of QoL showed little fluctuation across three time points. Table 3 presents the normality of these variables. Both the self-reported and objective game time were significantly deviated from normal distributions. Similarly, self-reported social media time, self-reported physical activity, and objective total sleep time were significantly deviated from the normal.

Tables 4 and 5 present the correlations of changes in gaming, social media, physical activity, sleep, QoL, and academic performance between 1 month and 2 months after baseline [Table 4] and those between 1 month and 3 months after baseline [Table 5]. Specifically, in Table 4, objective measured time for gaming was significantly correlated with objective sleep latency ($r_s = -0.52$; $P = 0.02$), self-reported physical QoL ($r_s = -0.46$; $P = 0.04$), self-reported psychological QoL ($r_s = -0.49$; $P = 0.03$), and self-reported environment QoL ($r_s = -0.50$; $P = 0.03$). The score of BSMAS was significantly correlated with self-reported physical activity ($r_s = -0.63$; $P = 0.006$), objective total sleep time ($r_s = -0.48$; $P = 0.04$), and the score of PSQI ($r_s = -0.51$; $P = 0.03$). The objective measured time for social media was significantly correlated with objective physical activity ($r_s = 0.51$; $P = 0.03$), objective sleep latency ($r_s = 0.51$; $P = 0.03$), self-reported psychological QoL ($r_s = 0.46$; $P = 0.04$), and self-reported social QoL ($r_s = 0.65$; $P = 0.004$). The score of SABAS was significantly correlated with objective total sleep time ($r_s = -0.45$; $P = 0.048$) and self-reported social QoL ($r_s = -0.46$; $P = 0.04$). In Table 5, the score of IGDS-SF9 was significantly correlated with self-reported physical activity ($r_s = -0.45$; $P = 0.047$). Self-reported gaming time was significantly correlated with objective physical activity ($r_s = -0.62$; $P = 0.007$) and academic performance ($r_s = -0.51$; $P = 0.03$). Self-reported social media time was significantly correlated with self-reported physical QoL ($r_s = 0.47$; $P = 0.04$). The score of SABAS was significantly correlated with academic performance ($r_s = -0.53$; $P = 0.02$).

Tables 6 and 7 present the correlations of changes in physical activity, sleep, QoL, and academic performance between 1 month and 2 months after baseline [Table 6] and those between 1 month and 3 months after baseline [Table 7]. In Table 6, self-reported PSQI sleep quality was significantly correlated with self-reported social QoL ($r_s = -0.45$; $P = 0.047$). In Table 7, self-reported physical activity was significantly correlated

Table 2: Internet gaming, social media use, physical activity, sleep, and quality of life across three time points

	Mean±SD		
	1 month	2 months	3 months
Self-reported gaming time (min/day)	41.54±63.34	38.00±48.43	39.33±76.69
Objective gaming time (min/month)	810.07±1306.03	1161.00±1867.27	800.00±1894.26
Self-reported social media time (min/day)	188.73±99.79	180.54±104.85	217±120.12
Objective social media time (min/month)	3364.87±1871.87	3401.27±2228.89	3755.20±2176.83
Self-reported physical activity (MET/week)	2330.8±1785.64	2175.77±1604.78	2807.2±1965.10
Objective physical activity (MET/min)	2.12±0.25	2.13±0.24	2.13±0.20
Self-reported sleep quality using PSQI	5.8±2.68	5.87±2.33	4.67±1.99
Objective average sleep latency (min)	1.63±0.69	1.38±0.82	1.69±0.69
Objective average sleep efficiency (%)	81.76±3.86	82.40±4.02	80.99±3.79
Objective total sleep time	383.21±75.71	387.93±68.40	368.28±66.01
Self-reported physical QoL	15.09±2.00	14.86±1.88	14.86±2.25
Self-reported psychological QoL	12.58±2.15	12.36±2.27	12.80±2.43
Self-reported social QoL	14.05±1.58	13.42±1.85	14.31±1.98
Self-reported environment QoL	12.17±2.04	11.60±1.87	11.73±1.78

Objective gaming and social media time are assessed using smartphone; objective sleep and physical activity is assessed using Actigraph GT9X. PSQI: Pittsburgh sleep quality index, QoL: Quality of life, SD: Standard deviation, MET: Metabolic equivalent of task

Table 3: Normality of internet gaming, social media use, physical activity, sleep, and quality of life across three time points

	W (P)		
	1 month	2 months	3 months
Self-reported gaming time (min/day)	0.68 (<0.001)***	0.80 (0.004)**	0.55 (<0.001)***
Self-reported gaming time using IGDS-SF9	0.89 (0.07)	0.90 (0.10)	0.82 (0.008)**
Objective gaming time (min/month)	0.68 (<0.001)***	0.68 (<0.001)***	0.49 (<0.001)***
Self-reported social media time (min/day)	0.96 (0.61)	0.88 (0.04)*	0.90 (0.09)
Self-reported social media time using BSMAS	0.94 (0.36)	0.89 (0.07)	0.92 (0.17)
Objective social media time (min/month)	0.94 (0.36)	0.93 (0.26)	0.92 (0.20)
Self-reported smartphone time using SABAS	0.94 (0.43)	0.98 (0.98)	0.93 (0.26)
Self-reported physical activity (MET/weeks)	0.90 (0.09)	0.88 (0.049)*	0.91 (0.12)
Objective physical activity (MET/min)	0.97 (0.87)	0.94 (0.41)	0.893 (0.07)
Self-reported sleep quality using PSQI	0.94 (0.43)	0.92 (0.19)	0.94 (0.43)
Objective average sleep latency (min)	0.95 (48)	0.89 (0.06)	0.96 (0.72)
Objective average sleep efficiency (%)	0.95 (0.48)	0.93 (0.29)	0.94 (0.42)
Objective total sleep time	0.97 (0.78)	0.73 (0.001)**	0.92 (0.21)
Self-reported physical QoL	0.90 (0.09)	0.95 (0.51)	0.92 (0.20)
Self-reported psychological QoL	0.95 (0.50)	0.94 (0.42)	0.93 (0.30)
Self-reported social QoL	0.90 (0.09)	0.91 (0.16)	0.91 (0.11)
Self-reported environment QoL	0.91 (0.12)	0.90 (0.11)	0.97 (0.80)

*$P<0.05$, **$P<0.01$, ***$P<0.001$. Objective gaming and social media time are assessed using smartphone; objective sleep and physical activity is assessed using Actigraph GT9X. IGDS-SF9: Internet gaming disorder scale-short form, BSMAS: Bergen social media addiction scale, SABAS: Smartphone application-based addiction scale, PSQI: Pittsburgh sleep quality index, QoL: Quality of life, MET: Metabolic equivalent of task

with self-reported physical QoL ($r_s = -0.51$; $P = 0.03$), self-reported psychological QoL ($r_s = -0.52$; $P = 0.02$), and self-reported environment QoL ($r_s = -0.54$; $P = 0.02$). Objective physical activity was significantly correlated with self-reported psychological QoL ($r_s = 0.49$; $P = 0.03$) and academic performance ($r_s = 0.48$; $P = 0.03$). Self-reported PSQI sleep quality was significantly correlated with self-reported social QoL ($r_s = -0.47$; $P = 0.04$). Objective sleep latency was significantly correlated with self-reported environment QoL ($r_s = -0.48$; $P = 0.04$).

Discussion

The main objectives of the present study are to investigate how internet gaming and social media impact on physical activity, sleep quality, QoL, and academic performance of university students in Hong Kong and to investigate how physical activity and sleep associate with QoL and academic performance of university students in Hong Kong. All three hypotheses are partially supported by our findings. Corresponding to hypothesis 1, internet gaming and social media use were found to be negatively

Table 4: Correlations of changes in gaming, social media, physical activity, sleep, and quality of life between 1 month and 2 months after baseline

	r_s (P)						SABAS
	Gaming			Social media			
	IGDS-SF9	Self-report time	Objective time	BSMAS	Self-report time	Objective time	
Self-reported physical activity	−0.13 (0.32)	−0.13 (0.33)	−0.41 (0.07)	−0.63 (0.006)**	0.55 (0.02)*	−0.29 (0.15)	0.43 (0.053)
Objective physical activity	−0.41 (0.07)	−0.14 (0.32)	−0.15 (0.30)	−0.04 (0.44)	−0.05 (0.43)	0.51 (0.03)*	−0.13 (0.32)
Self-reported PSQI sleep quality	−0.35 (0.10)	−0.22 (0.21)	−0.15 (0.29)	−0.51 (0.03)*	−0.15 (0.30)	−0.33 (0.11)	−0.03 (0.46)
Objective average sleep latency	−0.38 (0.08)	0.02 (0.48)	−0.52 (0.02)*	−0.25 (0.19)	0.22 (0.21)	0.51 (0.03)*	−0.23 (0.20)
Objective average sleep efficiency	−0.25 (0.19)	−0.27 (0.16)	0.07 (0.41)	0.03 (0.46)	0.38 (0.08)	−0.04 (0.45)	−0.41 (0.07)
Objective total sleep time	−0.30 (0.14)	−0.32 (0.12)	−0.25 (0.19)	−0.48 (0.04)*	0.09 (0.37)	−0.12 (0.33)	−0.45 (0.048)*
Self-reported physical QoL	0.04 (0.45)	−0.31 (0.13)	−0.46 (0.04)*	−0.39 (0.08)	0.16 (0.29)	0.37 (0.09)	−0.21 (0.22)
Self-reported psychological QoL	0.01 (0.50)	−0.31 (0.13)	−0.49 (0.03)*	−0.32 (0.12)	0.49 (0.03)*	0.46 (0.04)*	−0.22 (0.21)
Self-reported social QoL	0.29 (0.15)	−0.06 (0.42)	−0.25 (0.19)	0.02 (0.48)	0.22 (0.22)	0.65 (0.004)**	−0.46 (0.04)*
Self-reported environment QoL	0.08 (0.39)	−0.09 (0.37)	−0.50 (0.03)*	−0.15 (0.29)	0.32 (0.13)	0.42 (0.06)	−0.03 (0.46)

*P<0.05, **P<0.01. IGDS-SF9: Internet gaming disorder scale-short form, BSMAS: Bergen social media addiction scale, SABAS: Smartphone application based addiction scale, PSQI: Pittsburgh sleep quality index, QoL: Quality of life

Table 5: Correlations of changes in gaming, social media, physical activity, sleep, and quality of life between 1 month and 3 months after baseline

	r_s (P)						SABAS
	Gaming			Social media			
	IGDS-SF9	Self-report time	Objective time	BSMAS	Self-report time	Objective time	
Self-reported physical activity	−0.45 (0.047)*	−0.23 (0.21)	−0.01 (0.48)	−0.13 (0.32)	0.15 (0.30)	−0.23 (0.21)	−0.06 (0.42)
Objective physical activity	−0.12 (0.34)	−0.62 (0.007)**	0.10 (0.37)	0.38 (0.08)	0.12 (.33)	−0.21 (0.23)	−0.26 (0.18)
Self-reported PSQI sleep quality	0.04 (0.45)	−0.04 (0.45)	−0.23 (0.21)	0.05 (0.43)	0.26 (0.18)	−0.09 (0.38)	0.19 (0.25)
Objective average sleep latency	0.10 (0.37)	−0.15 (0.30)	−0.38 (0.08)	0.14 (0.30)	0.33 (0.12)	0.06 (0.41)	0.04 (0.45)
Objective average sleep efficiency	−0.18 (0.26)	0.08 (0.40)	−0.03 (0.45)	−0.18 (0.26)	0.30 (0.14)	0.41 (0.06)	−0.26 (0.17)
Objective total sleep time	−0.09 (0.38)	0.11 (.35)	−0.34 (0.11)	−0.28 (0.16)	0.27 (0.16)	0.41 (.07)	−0.34 (0.11)
Self-reported physical QoL	−0.03 (0.46)	−0.14 (.31)	−0.01 (0.49)	0.06 (0.41)	0.47 (0.04)*	0.18 (0.27)	0.21 (0.23)
Self-reported psychological QoL	0.03 (0.46)	−0.38 (.08)	−0.01 (0.48)	−0.07 (0.40)	0.29 (0.15)	−0.38 (0.08)	0.10 (0.36)
Self-reported social QoL	−0.08 (0.38)	0.12 (0.34)	−0.03 (.46)	−0.21 (0.23)	0.20 (0.24)	0.31 (0.13)	−0.12 (0.33)
Self-reported environment QoL	0.03 (0.46)	−0.08 (0.39)	−0.10 (.36)	0.03 (0.46)	0.18 (0.26)	−0.32 (0.12)	0.37 (0.09)
Academic performance[a]	−0.28 (0.16)	−0.51 (0.03)*	0.02 (0.47)	−0.07 (0.41)	0.35 (0.10)	−0.17 (0.27)	−0.53 (0.02)*

*P<0.05, **P<0.01, [a]Academic performance was only assessed at 3 months after baseline and was not a change. IGDS-SF9: Internet gaming disorder scale-short form, BSMAS: Bergen social media addiction scale, SABAS: Smartphone application-based addiction scale, PSQI: Pittsburgh sleep quality index, QoL: Quality of life

Table 6: Correlations of changes in physical activity, sleep, and quality of life between 1 month and 2 months after baseline

	r_s (P)					
	Physical activity		Sleep			
	Self-report	Objective	Self-report PSQI sleep quality	Objective average sleep latency	Objective average sleep efficiency	Objective total sleep time
Self-reported physical QoL	0.06 (0.41)	0.42 (0.06)	0.09 (0.38)	0.22 (0.21)	−0.28 (0.16)	−0.07 (0.41)
Self-reported psychological QoL	0.21 (0.23)	0.24 (0.19)	−0.13 (0.33)	0.29 (0.15)	0.09 (0.38)	0.14 (0.31)
Self-reported social QoL	−0.36 (0.10)	0.31 (0.13)	−0.45 (0.047)*	0.36 (0.10)	−0.19 (0.25)	−0.16 (0.28)
Self-reported environment QoL	0.07 (0.40)	0.24 (0.20)	−0.20 (0.24)	0.27 (0.17)	−0.28 (0.16)	−0.18 (0.26)

*P<0.05. PSQI: Pittsburgh sleep quality index, QOL: Quality of life

correlated with physical activity significantly, and social media use and smartphone addiction were found to be negatively correlated with sleep. Corresponding to hypothesis 2, internet gaming was found to be negatively correlated with psychological QoL significantly, and internet gaming and smartphone addiction were negatively correlated with academic performance significantly. However, there was no significantly negative

Table 7: Correlations of changes in physical activity, sleep, and quality of life between 1 month and 3 months after baseline

	r_s (P)					
	Physical activity		Sleep			
	Self-report	Objective	Self-report PSQI sleep quality	Objective average sleep latency	Objective average sleep efficiency	Objective total sleep time
Self-reported physical QoL	−0.51 (0.03)*	0.20 (0.24)	−0.21 (0.23)	0.44 (0.051)	−0.12 (0.34)	−0.07 (0.41)
Self-reported psychological QoL	−0.52 (0.02)*	0.49 (0.03)*	−0.26 (0.18)	0.42 (0.06)	−0.31 (0.13)	−0.23 (0.21)
Self-reported social QoL	−0.36 (0.10)	−0.13 (0.32)	−0.47 (0.04)*	0.40 (0.07)	−0.01 (0.48)	0.23 (0.20)
Self-reported environment QoL	−0.54 (0.02)*	0.30 (0.14)	−0.24 (0.19)	0.48 (0.04)*	−0.37 (0.09)	−0.25 (0.19)
Academic performance[a]	0.22 (0.21)	0.48 (0.03)*	−0.03 (0.46)	0.10 (0.36)	−0.01 (0.49)	−0.27 (0.17)

*$P<0.05$. [a]Academic performance was only assessed at 3 months after baseline and was not a change. PSQI: Pittsburgh sleep quality index, QoL: Quality of life

correlation between social media and psychological QoL. Corresponding to hypothesis 3, physical activity was found to be positively correlated with psychological QoL and academic performance significantly. However, there was no significant correlation between sleep and psychological QoL; sleep and academic performance. The findings are explained as follows.

Negatively significant correlation between self-reported time for gaming and objective physical activity; score of IGDS-SF9 and self-reported physical activity; score of BSMAS and self-reported physical activity were found in the present study. These results are consistent with previous findings, which revealed that internet gaming and social media overuse are the significant factors of reduced physical activity.[7-9] The result can be explained by displacement hypothesis supported by previous study, which stated that spending time on one activity leaves less time for others.[23,24] Engaging in sedentary behaviors including video gaming can impede physical activity by reducing the time available for being physically active.[23] The hypothesis is further explained by the sense of flow and pleasure experienced by the video game players, causing lost track of time and less time in engaging in physical activities.[24]

The present study revealed a negatively significant relationship between smartphone addiction and with total sleep time. The results are supported by previous studies which revealed that excessive or problematic use of internet gaming and social media lead to negative influences on sleep and are highly associated with sleep problems including insomnia, shorter sleep duration, and poorer sleep quality.[10-12] Study further suggested that adolescents with a smartphone and those with a conventional mobile phone were more likely to go to bed later as the exposure to blue light from screens suppressed the production of melatonin, thereby delaying sleep onset and reducing sleep duration and quality.[25] However, contrary to our expectation, time for gaming was negatively correlated with sleep latency.

This study showed a positively significant correlation between social media usage and social QoL. Possible explanations of the result can be concluded from prior research. It was suggested the main use of social media for university students is to maintain connection with old friends, thereby enhancing their social capital.[26] Interaction and communication with others on social media can enable individuals to obtain social benefits, thus improving life satisfaction.[27] In addition, this study revealed a significant negative correlation between gaming and both psychological and environment QoL. The results can be supported by the previous study which pointed out the linkage between problematic gaming and low life satisfaction and self-esteem.[28] Life satisfaction was found to be a negative predictor of online gaming addiction.[29] People who spent more time on online gaming felt unhappy and tried to forget their daily lives.[30] Gaming was suggested to be used as a means of compensating life satisfaction, emotional coping, stress relief, and escape from reality.[31]

A negatively significant correlation between smartphone addiction and academic performance was also found in the current study. This result is consistent with those of prior research.[32] University students regarded smartphones as sources of entertainment instead of work tools.[33] Thus, a time trade-off would be made between smartphone use and learning-related activities. In other words, the more time they spend on smartphones, the less time they engage in their studies, in terms of academic assignments and reading quantities.[34] Therefore, their decisions to use smartphones may adversely affect their academic performance. Moreover, smartphone addiction may prevent students from concentrating on their studies.[35] They may be constantly interfered by various applications on their mobile phones without sufficient control, leading to frequent task switching or multitasking during their study time.[36] In addition, the desire to continuously catch up with the world and not to miss anything happening online may result in losing focus necessary for achieving satisfactory academic performance.[37]

A positively significant correction in physical activity and psychological QoL was found in the present study, which matches with our expectation based on the previous

study.[13] It provided evidence that psychological QoL is related to physical activity, which matched the conclusion in a review of mental benefits associated with physical activity.[38] Physical activity improves mood and reduces symptoms of depression and anxiety, thus improving QoL. In addition, social QoL and PSQI sleep quality had a negatively significant correlation, which implied a positively significant correlation between social QoL and sleep quality. It matches another study which pointed out that poor sleep was related to reduced social activities in daily life due to daytime fatigue, as well as impairment in social functioning such as irritability and problems with interpersonal relationships.[39] Furthermore, the significant inverse correlation between physical QoL and physical activity, as well as environment QoL and physical activity were not expected.

Limitations

This study has several limitations. First, the present study was conducted in late 2019, in which social unrest happened in Hong Kong. Due to the unstable social situation, participants spent more time on social media or smartphone use than usual for latest news, information sharing, and discussion. Meanwhile, they were confined at home due to safety issues so that time for physical activity may be deprived. Moreover, the social unrest has brought well-being problems and hindered the QoL of Hong Kong people.[40] These may affect the generalizability of the study. Second, the academic performance may not reflect the impact of social media and gaming, which had been already collected 1 month before the examination due to the delay in examination caused by the social unrest. Third, the accuracy of the data obtained depends on the participants' compliance in wearing the Actigraph throughout the designated period in the study. Due to discomfort and inconvenience, some participants were reluctant to wear the device while doing vigorous exercises, grooming, or sleeping. Nonadherence to the device was also related to forgetfulness after removal for showering. Fourth, the small sample size of 15 participants may lead to a decrease of the study power, thus making the study less likely to be generalized.

Conclusion

The present study suggested that internet gaming was negatively correlated with physical activity and psychological QoL; smartphone addiction was negatively correlated to sleep and academic performance; physical activity was positively correlated to psychological QoL.

The results may provide important information for health-care providers when they are dealing with online behaviors of young adults, who often use internet/smartphone and who are at risk of internet/smartphone overuse. More specifically, the results will help health-care providers to understand which types of overuse contribute the most to low levels of physical activity, poor sleep, and/or impaired QoL in young adults. Health-care providers will be able to use the findings to determine how to best prioritize targets for intervention when treating such overuse problems. The findings can also be used to inform policy decisions regarding the potential need to support the development and evaluation of interventions to treat one or both types of overuse.

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Conflicts of interest

There are no conflicts of interest.

References

1. Bélanger RE, Akre C, Berchtold A, Michaud PA. A U-shaped association between intensity of internet use and adolescent health. Pediatrics 2011;127:e330-5.
2. Kuss DJ, Griffiths MD. Internet gaming addiction: A systematic review of empirical research. Int J Mental Health Addict 2012;10:278-96.
3. Kuss DJ, Griffiths MD. Online social networking and addiction – A review of the psychological literature. Int J Environ Res Public Health 2011;8:3528-52.
4. Van den Bulck J. Television viewing, computer game playing, and Internet use and self-reported time to bed and time out of bed in secondary-school children. Sleep 2004;27:101-4.
5. Hakala PT, Rimpelä AH, Saarni LA, Salminen JJ. Frequent computer-related activities increase the risk of neck-shoulder and low back pain in adolescents. Eur J Public Health 2006;16:536-41.
6. Kim JH, Lau CH, Cheuk KK, Kan P, Hui HL, Griffiths SM. Brief report: Predictors of heavy internet use and associations with health-promoting and health risk behaviors among Hong Kong University students. J Adolesc 2010;33:215-20.
7. Ballard M, Gray M, Reilly J, Noggle M. Correlates of video game screen time among males: Body mass, physical activity, and other media use. Eat Behav 2009;10:161-7.
8. Henchoz Y, Studer J, Deline S, N'Goran AA, Baggio S, Gmel G. Video gaming disorder and sport and exercise in emerging adulthood: A longitudinal study. Behav Med 2016;42:105-11.
9. Brailovskaia J, Teismann T, Margraf J. Physical activity mediates the association between daily stress and Facebook Addiction Disorder (FAD) – A longitudinal approach among German students. Comput Human Behav 2018;86:199-204.
10. Achab S, Nicolier M, Mauny F, Monnin J, Trojak B, Vandel P, *et al*. Massively multiplayer online role-playing games: Comparing characteristics of addict vs non-addict online recruited gamers in a French adult population. BMC Psychiatry 2011;11:144.
11. Levenson JC, Shensa A, Sidani JE, Colditz JB, Primack BA. The association between social media use and sleep disturbance among young adults. Prev Med 2016;85:36-41.
12. Xu XL, Zhu RZ, Sharma M. The influence of social media on sleep quality: A study of undergraduate students in Chongqing, China. J Nurs Care 2015;4:253.

13. Kaleta D, Makowiec-Dabrowska T, Dziankowska-Zaborszczyk E, Jegier A. Physical activity and self-perceived health status. Int J Occup Med Environ Health 2006;19:61-9.

14. Keating XD, Castelli D, Ayers SF. Association of weekly strength exercise frequency and academic performance among students at a large university in the United States. J Strength Cond Res 2013;27:1988-93.

15. Sasai T, Inoue Y, Komada Y, Nomura T, Matsuura M, Matsushima E. Effects of insomnia and sleep medication on health-related quality of life. Sleep Med 2010;11:452-7.

16. Mak KK, Lee SL, Ho SY, Lo WS, Lam TH. Sleep and academic performance in Hong Kong adolescents. J Sch Health 2012;82:522-7.

17. Cabanas-Sánchez V, Esteban-Cornejo I, Migueles JH, Banegas JR, Graciani A, Rodríguez-Artalejo F, *et al*. Twenty four-hour activity cycle in older adults using wrist-worn accelerometers: The seniors-ENRICA-2 study. Scand J Med Sci Sports 2020;30:700-8.

18. Chomistek AK, Yuan C, Matthews CE, Troiano RP, Bowles HR, Rood J, *et al*. Physical activity assessment with the ActiGraph GT3X and doubly labeled water. Med Sci Sports Exerc 2017;49:1935-44.

19. Leung H, Pakpour AH, Strong C, Lin YC, Tsai MC, Griffiths MD, *et al*. Measurement invariance across young adults from Hong Kong and Taiwan among three internet-related addiction scales: Bergen Social Media Addiction Scale (BSMAS), Smartphone Application-Based Addiction Scale (SABAS), and Internet Gaming Disorder Scale-Short Form (IGDS-SF9) (Study Part A). Addict Behav 2020;101:105969.

20. Macfarlane DJ, Lee CC, Ho EY, Chan KL, Chan DT. Reliability and validity of the Chinese version of IPAQ (short, last 7 days). J Sci Med Sport 2007;10:45-51.

21. Tsai PS, Wang SY, Wang MY, Su CT, Yang TT, Huang CJ, *et al*. Psychometric evaluation of the Chinese version of the Pittsburgh Sleep Quality Index (CPSQI) in primary insomnia and control subjects. Qual Life Res 2005;14:1943-52.

22. Fu TS, Tuan YC, Yen MY, Wu WH, Huang CW, Chen WT, *et al*. Psychometric properties of the World Health Organization Quality Of Life Assessment-Brief in methadone patients: A validation study in northern Taiwan. Harm Reduct J 2013;10:37.

23. Mutz DC, Roberts DF, van Vuuren DP. Reconsidering the displacement hypothesis: Television's influence on children's time use. Commun Res 1993;20:51-75.

24. Sherry J. Flow and media enjoyment. Commun Theory 2004;14:328-47.

25. Lemola S, Perkinson-Gloor N, Brand S, Dewald-Kaufmann JF, Grob A. Adolescents' electronic media use at night, sleep disturbance, and depressive symptoms in the smartphone age. J Youth Adolesc 2015;44:405-18.

26. Ellison NB, Steinfield C, Lampe C. The benefits of Facebook "friends:" Social capital and college students' use of online social network sites. J Comput Mediat Commun 2007;12:1143-68.

27. Zhan L, Sun Y, Wang N, Zhang X. Understanding the influence of social media on people's life satisfaction through two competing explanatory mechanisms. Aslib J Info Manag 2016;68:347-61.

28. Männikkö N, Billieux J, Kääriäinen M. Problematic digital gaming behavior and its relation to the psychological, social and physical health of Finnish adolescents and young adults. J Behav Addict 2015;4:281-8.

29. Dönmez Ş, Cömert IT. The Relationship among Online Gaming Addiction, Mindfulness, and Life Satisfaction. XVI European Congress of Psychology, Moscow, Russia; July 2-5, 2019.

30. Floros G, Siomos K. Patterns of choices on video game genres and Internet addiction. Cyberpsychol Behav Soc Netw 2012;15:417-24.

31. Li D, Liau A, Khoo A. Examining the influence of actual-ideal self-discrepancies, depression, and escapism, on pathological gaming among massively multiplayer online adolescent gamers. Cyberpsychol Behav Soc Netw 2011;14:535-9.

32. Junco R, Cotten SR. No A 4 U: The relationship between multitasking and academic performance. Comput Educ 2012;59:505-14.

33. Lepp A, Barkley JE, Sanders GJ, Rebold M, Gates P. The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. Int J Behav Nutr Phys Act 2013;10:79.

34. Hawi NS, Samaha M. To excel or not to excel: Strong evidence on the adverse effect of smartphone addiction on academic performance. Comput Educ 2016;98:81-9.

35. Selwyn N. Schooling the mobile generation: The future for schools in the mobile-networked society. Br J Sociol Educ 2003;24:131-44.

36. David D, Jung-Hyun K, Brickman JS, Ran W, Curtis CM. Mobile phone distraction while studying. New Media Soc 2015;17:1661-79.

37. Firat M. Multitasking or continuous partial attention: A critical bottleneck for digital natives. Turk Online J Distance Educ 2013;14:266-72.

38. Penedo FJ, Dahn JR. Exercise and well-being: A review of mental and physical health benefits associated with physical activity. Curr Opin Psychiatry 2005;18:189-93.

39. Kahraman M. Clinical update on epidemiology, pathogenesis and nonpharmacological treatment of insomnia. Turk J Neurol 2006;12:87-97.

40. Shek DT. Protests in Hong Kong (2019-2020): A perspective based on quality of life and well-being. Appl Res Qual Life 2020;15:619-35.