

**Wang, Y. et al.: Impact of Daily Activity Allocation on Problematic Internet Use
among University Students: A Compositional Perspective**

<https://doi.org/10.1556/2006.2025.00039>

Supplementary materials

Section S1 Log-ratio variance of the sample

Table S1. The log-ratio variance matrix of 8 activities.

Variable	Sleep	MVPA	LPA	Game	Video	Class	Learn	Other
Sleep	0	0.52	0.49	1.02	0.52	0.80	0.76	0.49
MVPA	0.52	0	0.75	1.40	1.09	1.28	1.25	1.18
LPA	0.49	0.75	0	1.48	0.90	1.24	1.18	1.17
Game	1.02	1.40	1.48	0	1.42	1.83	2.10	1.90
Video	0.52	1.09	0.97	1.42	0	1.36	1.44	1.26
Class	0.80	1.28	1.24	1.83	1.36	0	1.20	1.67
Learn	0.76	1.25	1.12	2.10	1.44	1.20	0	1.49
Other	0.49	1.18	1.12	1.90	1.26	1.67	1.49	0

The variation matrix records the log-ratio variances between each pair of components. The closer the value is to zero, the more consistent the components are in proportion.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities.

Note. The log-ratio variance is a statistical method used to measure the variability in the proportional relationships between variables in compositional data. In compositional data, the values of each variable typically represent a part of a whole, and they are interdependent, meaning that they cannot be analyzed independently via conventional methods. To eliminate this dependency, researchers calculate log-ratios, which are the logarithms of the ratios between variables, for analysis.

The log-ratio variance describes the variation in the proportions of two components (e.g., two activities) across different samples. If the log-ratio variance is close to 0, the proportions of the two components are relatively consistent and show little variation.

A larger variance indicates greater differences in the proportions of the two components.

In the context of this table, the log-ratio variance reflects the fluctuation in time allocation between different activities. For example, the log-ratio variance between sleep and light physical activity (LPA) is 0.49, indicating that the time allocation between these two activities shows the least difference across samples, whereas the log-ratio variance between gaming and learning is 2.10, indicating that the time allocation between these two activities shows the greatest difference.

Section S2 Comparison of R-squared values between CoDA models and linear models

Table S2. Comparison of R-squared values between different models.

Activity	CoDA Models		Linear Models	
	Multiple R ²	Adjusted R ²	Multiple R ²	Adjusted R ²
Sleep	0.123	0.12	0.011	0.01
MVPA	0.123	0.12	0.015	0.014
LPA	0.123	0.12	0.01	0.009
Game	0.123	0.12	0.044	0.043
Video	0.123	0.12	0.062	0.062
Class	0.123	0.12	0.017	0.016
Learn	0.123	0.12	0.021	0.021

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities.

Note. The CoDA model calculates the seven log-ratios from eight time-use variables and integrates them uniformly into the regression model. Therefore, the results of the regression inherently account for (1) the compositional nature of time-use data, (2) the limited nature of time-use data, and (3) the joint effects (covariates) of time-use data on problematic internet use (PIU). As a result, the explanatory power of CoDA regression is consistently greater than that of traditional regression; moreover, its R-squared value is constant (because all the models uniformly control for all the time-use variables).

Notably, this method of controlling covariates by integrating all time-use variables uniformly is not feasible in traditional regression. Time-use data are compositional, which means that the independence of the variables can never be satisfied (without any processing). Considering that CoDA regression provides substantial explanatory power, it is essential to emphasize its importance in future research involving time-use variables, especially when aiming for results with practical insights and significance.

Section S3. Instrumental Variable Test

Table S3. Instrumental variable test results.

Variable	PIU		PIUR		RKF
	B	<i>p</i>	B	<i>p</i>	
Sleep	165.4	.291	3.65	.302	1.19
MVPA	-29.8**	.003	-0.69*	.011	10.88***
LPA	-289.8	.726	-6.76	.726	0.12
Game	22.9**	.005	0.53*	.015	8.89**
Video	36.9*	.011	0.86*	.022	6.50*
Learn	-163.7	.628	-3.82	.628	0.23
Class	-29.4**	.007	-0.69*	.019	8.87**
Other	128.2	0.09	2.99	.119	3.12

Adjusted for sex, age, parents' educational attainment, and annual household income.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities. PIU: Problematic Internet Use; PIUR: Problematic Internet Use Risk.

RKF: Robust Kleibergen–Paap Wald F-statistic.

*: $p < .05$; **: $p < .01$; ***: $p < .001$.

Section S4. Isotemporal Substitution Model for Absolute PIU Risk

Table S4. Isotemporal substitution model results: absolute PIU risk (30 minutes).

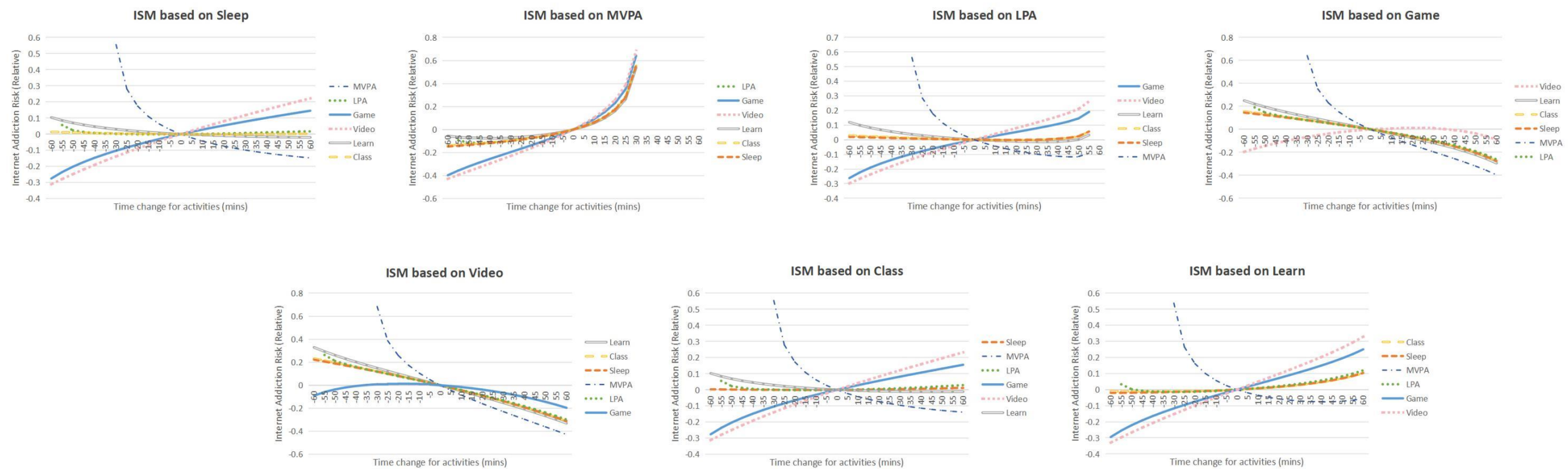
	Sleep↓	MVPA↓	LPA↓	Game↓	Video↓	Learn↓	Class↓	Other↓
Sleep↑	0	0.182 [0.077, 0.287]	0 [-0.039, 0.043]	-0.034 [-0.068, 0.003]	-0.045 [-0.078, -0.011]	0.01 [-0.026, 0.048]	0.001 [-0.033, 0.038]	-0.009 [-0.043, 0.027]
MVPA↑	-0.032 [-0.068, 0.005]	0	-0.032 [-0.073, 0.012]	-0.064 [-0.098, -0.028]	-0.075 [-0.107, -0.041]	-0.023 [-0.059, 0.015]	-0.031 [-0.066, 0.005]	-0.041 [-0.075, -0.006]
LPA↑	0.002 [-0.034, 0.041]	0.185 [0.076, 0.292]	0	-0.032 [-0.067, 0.007]	-0.043 [-0.077, -0.007]	0.012 [-0.026, 0.052]	0.004 [-0.033, 0.042]	-0.007 [-0.042, 0.031]
Game↑	0.026 [-0.01, 0.064]	0.211 [0.105, 0.313]	0.026 [-0.015, 0.069]	0	-0.022 [-0.055, 0.014]	0.036 [-0.001, 0.074]	0.027 [-0.008, 0.064]	0.016 [-0.019, 0.052]
Video↑	0.039 [0.001, 0.078]	0.225 [0.119, 0.326]	0.039 [-0.004, 0.084]	0.003 [-0.035, 0.042]	0	0.049 [0.01, 0.089]	0.04 [0.003, 0.078]	0.029 [-0.008, 0.067]
Learn↑	-0.005 [-0.04, 0.033]	0.177 [0.072, 0.281]	-0.005 [-0.045, 0.038]	-0.038 [-0.073, -0.002]	-0.05 [-0.082, -0.015]	0	-0.004 [-0.039, 0.033]	-0.014 [-0.048, 0.022]
Class↑	0 [-0.035, 0.037]	0.182 [0.077, 0.286]	0 [-0.04, 0.043]	-0.034 [-0.069, 0.003]	-0.046 [-0.078, -0.011]	0.01 [-0.027, 0.048]	0	-0.01 [-0.044, 0.027]
Other↑	0.009 [-0.026, 0.047]	0.193 [0.088, 0.296]	0.009 [-0.031, 0.052]	-0.025 [-0.06, 0.012]	-0.037 [-0.07, -0.002]	0.019 [-0.017, 0.057]	0.01 [-0.024, 0.047]	0

The x-axis represents an increase of 30 minutes in specific activity time, while the y-axis represents a decrease of 30 minutes in specific activity time.

The figure illustrates the absolute risk effects of substituting specific activity times on internet addiction. It indicates the change in the objective probability of developing internet addiction compared to baseline levels.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities. PIUR: Problematic Internet Use Risk.

Figure S1. ISM analysis of PIU risk based on different daily activities.



Note. This figure illustrates the predicted changes in PIU risk when various daily activities are reallocated for university students. Each graph represents the substitution effect of one primary activity (sleep, MVPA, LPA, gaming, videos, class, or learning) with other activities held constant.

X-axis: The base time allocated to the selected activity in minutes. A positive value indicates a decrease in base activity time and an increase in allocated activity time, whereas a negative value indicates an increase in base activity time and a decrease in allocated activity time.

Y-axis: Changes in PIU risk relative to the baseline (predicted level based on the geometric mean) after allocating time.

ISM: Isotemporal Substitution Model; MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Videos: Short Videos; Class: Classroom Learning; Learn: Autonomous Study. PIU: Problematic Internet Use.

Section S5. Holidays in China 2024 (Feb-Mar)

Table S5. Holidays and observances in China in 2024.

Date	Day	Name	Type
1-Jan	Monday	New Year's Day	National holiday
4-Feb	Sunday	Special Working Day	Working day on weekend
9-Feb	Friday	Spring Festival Eve	Observance
10-Feb	Saturday	Chinese New Year	National holiday
11-Feb	Sunday	Spring Festival Golden Week Holiday	National holiday
12-Feb	Monday	Spring Festival Golden Week Holiday	National holiday
13-Feb	Tuesday	Spring Festival Golden Week Holiday	National holiday
14-Feb	Wednesday	Spring Festival Golden Week Holiday	National holiday
15-Feb	Thursday	Spring Festival Golden Week Holiday	National holiday
16-Feb	Friday	Spring Festival Golden Week Holiday	National holiday
17-Feb	Saturday	Special Working Day	Working day on weekend
18-Feb	Sunday	Spring Festival Golden Week Holiday	National holiday
24-Feb	Saturday	Lantern Festival	Observance
8-Mar	Friday	International Women's Day	Half day holiday
11-Mar	Monday	Zhonghe Festival	Observance
12-Mar	Tuesday	Arbor Day	Observance
20-Mar	Wednesday	March Equinox	Season

Section S6. Sex Differences in the Association Between Compositional Activity

Time and PIU/PIUR

First, we examined the relationship between activity time and PIU/PIUR after adjusting for time codependence in both the male and female groups (Tables R1–R2). Given that the isotemporal substitution model enables precise numerical comparisons, this step aimed primarily to confirm the relationships between time variables and PIU rather than to compare effect sizes. For PIU, no significant differences were observed in the effects of activity time between male and female participants. Specifically, in both groups, sleep, moderate-to-vigorous physical activity (MVPA), classroom learning (Class), and autonomous learning (Learn) were significantly negatively associated with PIU, whereas time spent on gaming (Game) and short videos (Video) were positively correlated. In contrast, light physical activity (LPA) and unobserved time (Other) were not significantly related to PIU. For PIUR, the results were largely consistent with those for PIU, except that unobserved time was positively associated with PIUR. Overall, no significant sex differences were observed.

Table S6. Compositional regression model estimates for PIU and PIUR in male participants.

Variable	PIU			PIUR		
	B_1	p	95% CI	B_2	p	95% CI
Sleep	-1.92*	.035	[-3.772, -0.063]	-0.93*	.039	[-1.831, -0.049]
MVPA	-2.08**	.006	[-3.804, -0.584]	-0.35*	.024	[-0.421, -0.150]
LPA	-0.63	.439	[-2.315, 1.036]	-0.2	.130	[-0.663, -0.061]
Game	4.72***	<.001	[2.514, 5.302]	0.51***	<.001	[0.281, 0.739]
Video	4.12***	<.001	[2.371, 5.861]	0.40**	.005	[0.125, 0.688]
Class	-2.29**	.002	[-3.778, -0.801]	-0.26*	.029	[-0.492, -0.027]
Learn	-0.87*	.034	[-1.682, -0.067]	-0.26*	.027	[-0.499, -0.031]
Other	1.28	.143	[-0.592, 3.159]	0.34*	.022	[0.051, 0.643]

Adjusted for age.

Ordinary least squares with robust standard errors and cluster options for provinces were used to obtain more rigorous results.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities. CI:

Confidence Interval. PIU: Problematic Internet Use; PIUR: Problematic Internet Use Risk.

*: $p < .05$; **: $p < .01$; ***: $p < .001$.

Table S7. Compositional regression model estimates for PIU and PIUR in female participants.

Variable	PIU			PIUR		
	B_1	p	95% CI	B_2	p	95% CI
Sleep	-2.58*	.036	[-5.007, -0.161]	-0.63**	.006	[-1.074, -0.185]
MVPA	-2.03**	<.001	[-2.941, -1.116]	-0.32***	<.001	[-0.498, -0.153]
LPA	-0.69	0.128	[-1.571, 0.197]	0.01	0.883	[-0.148, 0.173]
Game	1.93***	<.001	[1.344, 2.525]	0.26***	<.001	[0.157, 0.372]
Video	4.71***	<.001	[3.833, 5.579]	0.78***	<.001	[0.609, 0.964]
Class	-1.12**	.008	[-1.946, -0.290]	-0.15***	<.001	[-0.216, -0.078]
Learn	-0.99*	.007	[-1.718, -0.260]	-0.18**	.007	[-0.314, -0.050]
Other	0.54	0.323	[-0.531, 1.607]	0.22*	.028	[0.023, 0.415]

Adjusted for age.

Ordinary least squares with robust standard errors and cluster options for provinces were used to obtain more rigorous results.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities. CI: Confidence Interval. PIU: Problematic Internet Use; PIUR: Problematic Internet Use Risk.

*: $p < .05$; **: $p < .01$; ***: $p < .001$.

Sex Differences in the Relative Causal Relationships

Next, we employed instrumental variables (IVs) to examine whether the causal relationships underlying the observed associations differed by sex (Tables R3–R4).

For PIU, no significant sex differences were observed in the causal estimates. MVPA and classroom learning had a negative causal effect on PIU, whereas gaming and short videos had a positive causal effect. In contrast, sleep, LPA, autonomous learning, and unobserved time did not have a causal relationship with PIU.

For PIUR, a sex difference was observed only in the effect of short videos. Among the female participants, the ilr of short videos significantly influenced PIUR ($B = 0.65$, $p = .039$, RKF = 5.69). However, among male participants, this causal effect was not significant ($B = 0.98$, $p = .156$, RKF = 5.79). Since holidays were used as the instrumental variable and the number of male participants during holidays was relatively small ($n = 180$), this may have affected the precision and validity of the IV estimation. Therefore, the current findings are insufficient to determine whether the lack of significance reflects a true sex difference or is merely due to measurement error.

Table S8. Instrumental variable test results in male participants.

Variable	PIU		PIUR		RKF
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	
Sleep	136.7	0.214	2.29	0.292	1.91
MVPA	-31.5**	0.005	-0.74*	0.037	9.89***
LPA	-218.3	0.762	-3.66	0.751	0.1
Game	35.88**	0.008	0.51*	0.032	5.28*
Video	58.62*	0.024	0.98	0.156	5.79*
Learn	-45.82	0.261	-0.77	0.319	1.38
Class	-42.47**	0.015	-0.69*	0.038	7.52**
Other	106.6	0.622	1.78	0.636	0.25

Adjusted for age.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities. RKF: Robust Kleibergen–Paap Wald F-statistic. PIU: Problematic Internet Use; PIUR: Problematic Internet Use Risk.

*: $p < .05$; **: $p < .01$; ***: $p < .001$.

Table S9. Instrumental variable test results in female participants.

Variable	PIU		PIUR		RKF
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	
Sleep	94.51	0.189	2.6	0.216	2.12
MVPA	-17.58**	<.001	-0.48*	0.029	13.49***
LPA	-163.6	0.702	-4.5	0.704	0.15
Game	16.12**	0.031	0.44*	0.029	5.73*
Video	23.62*	0.024	0.65*	0.039	5.69*
Learn	-1100.7	0.965	-30.29	0.965	1.93
Class	-21.23**	0.026	-0.58*	0.026	6.43**
Other	253.6	0.848	6.98	0.857	0.03

Adjusted for age.

MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities. RKF: Robust Kleibergen–Paap Wald F-statistic. PIU: Problematic Internet Use; PIUR: Problematic Internet Use Risk.

*: $p < .05$; **: $p < .01$; ***: $p < .001$.

Sex Differences in the Isotemporal Substitution Model

Finally, we used the isotemporal substitution model (ISM) to evaluate whether the effect sizes of activity time substitutions exhibited sex differences. Consistent with the analyses in the main text, we calculated the effect sizes by substituting activity time in increments of ± 30 minutes. Sex differences were assessed based on whether the 95% confidence intervals (CIs) for the same activity substitution overlapped between the two groups.

Tables S10–R13 present the full ISM results for both the male and female groups. In summary, across all comparisons, no instances where the 95% CIs of activity substitution effects did not overlap were found. Overall, the analysis did not reveal any significant sex differences in the relationships among variables, causal directions, or effect sizes discussed in the main text. This finding is promising, as it suggests that adjusting lifestyle strategies can effectively prevent PIU regardless of sex; this aligns with previous research (Coyne et al., 2020; Zeng et al., 2022; Ross et al., 2020), which has highlighted the broad benefits of activities such as exercise, sleep, and learning.

Table S10. Isotemporal substitution model results: problematic internet use (30 minutes) - male.

Variable	Sleep↓	MVPA↓	LPA↓	Game↓	Video↓	Class↓	Learn↓	Other↓
Sleep↑	0	2.71 [0.224, 5.195]	0.228 [-1.415, 1.871]	-1.678 [-2.93, -0.425]	-1.597 [-2.882, -0.313]	0.169 [-0.949, 1.286]	-0.288 [-1.618, 1.041]	-0.326 [-1.449, 0.798]
MVPA↑	-0.932 [-2.382, 0.517]	0	-0.716 [-2.633, 1.201]	-2.622 [-4.075, -1.169]	-2.542 [-3.999, -1.084]	-0.776 [-2.143, 0.592]	-1.233 [-2.73, 0.265]	-1.27 [-2.618, 0.078]
LPA↑	-0.025 [-1.347, 1.298]	2.673 [0.056, 5.290]	0	-1.714 [-3.061, -0.367]	-1.634 [-3.014, -0.254]	0.132 [-1.128, 1.392]	-0.325 [-1.738, 1.089]	-0.362 [-1.617, 0.892]
Game↑	1.269 [0.068, 2.47]	3.967 [1.547, 6.386]	1.485 [-0.127, 3.097]	0	-0.341 [-1.636, 0.954]	1.426 [0.296, 2.555]	0.969 [-0.304, 2.241]	0.931 [-0.186, 2.049]
Video↑	1.242 [0.013, 2.472]	3.94 [1.529, 6.351]	1.458 [-0.179, 3.096]	-0.447 [-1.739, 0.844]	0	1.399 [0.25, 2.548]	0.942 [-0.372, 2.256]	0.905 [-0.241, 2.05]
Class↑	-0.098 [-1.261, 1.065]	2.599 [0.184, 5.015]	0.118 [-1.49, 1.725]	-1.788 [-3.005, -0.571]	-1.708 [-2.946, -0.469]	0	-0.398 [-1.699, 0.903]	-0.436 [-1.539, 0.667]
Learn↑	0.276 [-0.937, 1.489]	2.974 [0.565, 5.382]	0.492 [-1.128, 2.112]	-1.414 [-2.625, -0.203]	-1.333 [-2.592, -0.075]	0.433 [-0.717, 1.582]	0	-0.062 [-1.192, 1.068]
Other↑	0.328 [-0.815, 1.472]	3.026 [0.649, 5.403]	0.544 [-1.037, 2.126]	-1.361 [-2.537, -0.185]	-1.281 [-2.49, -0.072]	0.485 [-0.589, 1.559]	0.028 [-1.225, 1.282]	0
The x-axis represents an increase of 30 minutes in specific activity time, while the y-axis represents a decrease of 30 minutes in specific activity time. MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities.								

Table S11. Isotemporal substitution model results: problematic internet use (30 minutes) - female.

Variable	Sleep↓	MVPA↓	LPA↓	Game↓	Video↓	Class↓	Learn↓	Other↓
Sleep↑	0	3.28 [1.770, 4.789]	0.371 [-0.528, 1.271]	-1.135 [-1.805, -0.464]	-1.428 [-2.077, -0.778]	-0.017 [-0.617, 0.582]	0.279 [-0.404, 0.962]	-0.166 [-0.759, 0.427]
MVPA↑	-1.237 [-2.172, -0.301]	0	-0.873 [-2.059, 0.313]	-2.38 [-3.306, -1.453]	-2.672 [-3.563, -1.782]	-1.262 [-2.14, -0.384]	-0.966 [-1.896, -0.035]	-1.411 [-2.272, -0.549]
LPA↑	-0.138 [-0.909, 0.634]	2.528 [0.986, 4.070]	0	-1.28 [-2.039, -0.522]	-1.573 [-2.329, -0.817]	-0.163 [-0.877, 0.551]	0.134 [-0.653, 0.92]	-0.311 [-1.011, 0.388]
Game↑	0.782 [0.057, 1.508]	3.193 [1.604, 4.783]	1.146 [0.217, 2.075]	0	-0.653 [-1.346, 0.04]	0.757 [0.097, 1.417]	1.054 [0.343, 1.764]	0.609 [-0.03, 1.248]
Video↑	1.14 [0.416, 1.865]	3.586 [1.999, 5.173]	1.504 [0.561, 2.447]	-0.002 [-0.711, 0.706]	0	1.115 [0.462, 1.769]	1.412 [0.7, 2.123]	0.966 [0.331, 1.602]
Class↑	0.042 [-0.658, 0.742]	3.270 [1.708, 4.831]	0.406 [-0.514, 1.326]	-1.101 [-1.794, -0.407]	-1.393 [-2.065, -0.722]	0	0.313 [-0.403, 1.03]	-0.132 [-0.756, 0.492]
Learn↑	-0.145 [-0.862, 0.572]	3.499 [1.916, 5.082]	0.219 [-0.719, 1.156]	-1.288 [-1.973, -0.602]	-1.581 [-2.254, -0.907]	-0.17 [-0.828, 0.488]	0	-0.319 [-0.952, 0.315]
Other↑	0.171 [-0.535, 0.878]	3.122 [1.558, 4.686]	0.535 [-0.38, 1.45]	-0.971 [-1.653, -0.29]	-1.264 [-1.929, -0.599]	0.146 [-0.491, 0.783]	0.443 [-0.26, 1.145]	0
The x-axis represents an increase of 30 minutes in specific activity time, while the y-axis represents a decrease of 30 minutes in specific activity time.								
MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities.								

Table S12. Isotemporal substitution model results: relative problematic internet use risk (30 minutes) - male.

	Sleep↓	MVPA↓	LPA↓	Game↓	Video↓	Learn↓	Class↓	Other↓
Sleep↑	0	0.569 [-0.389, 1.554]	0.118 [-0.111, 0.373]	-0.21 [-0.344, -0.059]	-0.156 [-0.298, 0.004]	-0.021 [-0.177, 0.151]	0.001 [-0.122, 0.132]	-0.057 [-0.178, 0.074]
MVPA↑	-0.029 [-0.19, 0.148]	0	0.085 [-0.172, 0.376]	-0.237 [-0.384, -0.067]	-0.184 [-0.338, -0.009]	-0.052 [-0.222, 0.139]	-0.03 [-0.182, 0.135]	-0.087 [-0.232, 0.073]
LPA↑	-0.032 [-0.176, 0.125]	0.529 [-0.42, 1.535]	0	-0.239 [-0.376, -0.083]	-0.187 [-0.333, -0.021]	-0.054 [-0.215, 0.124]	-0.033 [-0.171, 0.116]	-0.09 [-0.223, 0.056]
Game↑	0.162 [0.026, 0.306]	0.748 [-0.259, 1.654]	0.286 [0.049, 0.539]	0	-0.01 [-0.161, 0.155]	0.138 [-0.016, 0.301]	0.161 [0.035, 0.293]	0.099 [-0.023, 0.227]
Video↑	0.125 [-0.016, 0.274]	0.708 [-0.286, 1.629]	0.247 [0.009, 0.503]	-0.102 [-0.247, 0.058]	0	0.101 [-0.058, 0.272]	0.124 [-0.005, 0.26]	0.062 [-0.064, 0.196]
Learn↑	0.028 [-0.106, 0.172]	0.599 [-0.36, 1.562]	0.145 [-0.082, 0.395]	-0.188 [-0.317, -0.044]	-0.133 [-0.272, 0.022]	0	0.026 [-0.1, 0.162]	-0.032 [-0.153, 0.099]
Class↑	0.008 [-0.117, 0.141]	0.575 [-0.376, 1.549]	0.124 [-0.1, 0.371]	-0.205 [-0.333, -0.062]	-0.151 [-0.286, -0.001]	-0.015 [-0.166, 0.149]	0	-0.051 [-0.167, 0.073]
Other↑	0.058 [-0.066, 0.19]	0.633 [-0.336, 1.583]	0.177 [-0.048, 0.422]	-0.162 [-0.287, -0.022]	-0.106 [-0.24, 0.042]	0.034 [-0.112, 0.193]	0.056 [-0.058, 0.178]	0
The x-axis represents an increase of 30 minutes in specific activity time, while the y-axis represents a decrease of 30 minutes in specific activity time. The figure illustrates the relative risk effects of substituting specific activity times on internet addiction. It shows the percentage increase in the risk of developing internet addiction compared to baseline levels. MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities.								

Table S13. Isotemporal substitution model results: relative problematic internet use risk (30 minutes) - female.

	Sleep↓	MVPA↓	LPA↓	Game↓	Video↓	Learn↓	Class↓	Other↓
Sleep↑	0	0.518 [0.181, 0.855]	-0.006 [-0.11, 0.105]	-0.118 [-0.204, -0.026]	-0.148 [-0.231, -0.058]	0.009 [-0.078, 0.101]	-0.013 [-0.092, 0.07]	-0.031 [-0.11, 0.053]
MVPA↑	-0.111 [-0.219, 0.006]	0	-0.117 [-0.246, 0.023]	-0.221 [-0.325, -0.108]	-0.249 [-0.348, -0.14]	-0.103 [-0.212, 0.014]	-0.124 [-0.228, -0.012]	-0.14 [-0.243, -0.03]
LPA↑	0.013 [-0.077, 0.107]	0.531 [0.186, 0.875]	0	-0.107 [-0.197, -0.011]	-0.137 [-0.226, -0.042]	0.021 [-0.073, 0.12]	-0.001 [-0.088, 0.09]	-0.019 [-0.105, 0.072]
Game↑	0.091 [0.004, 0.181]	0.617 [0.281, 0.945]	0.084 [-0.024, 0.196]	0	-0.065 [-0.151, 0.025]	0.099 [0.012, 0.19]	0.077 [-0.006, 0.162]	0.058 [-0.024, 0.143]
Video↑	0.132 [0.046, 0.221]	0.662 [0.328, 0.983]	0.125 [0.016, 0.239]	0.005 [-0.082, 0.097]	0	0.141 [0.054, 0.231]	0.118 [0.037, 0.201]	0.099 [0.018, 0.182]
Learn↑	0 [-0.084, 0.087]	0.517 [0.184, 0.849]	-0.007 [-0.112, 0.104]	-0.119 [-0.202, -0.031]	-0.149 [-0.23, -0.062]	0	-0.014 [-0.094, 0.07]	-0.032 [-0.111, 0.051]
Class↑	0.015 [-0.067, 0.1]	0.534 [0.2, 0.866]	0.008 [-0.096, 0.118]	-0.105 [-0.19, -0.015]	-0.135 [-0.217, -0.047]	0.023 [-0.064, 0.114]	0	-0.017 [-0.096, 0.066]
Other↑	0.031 [-0.05, 0.116]	0.552 [0.22, 0.882]	0.025 [-0.079, 0.134]	-0.089 [-0.173, -0.001]	-0.12 [-0.201, -0.034]	0.04 [-0.045, 0.128]	0.018 [-0.061, 0.099]	0
The x-axis represents an increase of 30 minutes in specific activity time, while the y-axis represents a decrease of 30 minutes in specific activity time. The figure illustrates the relative risk effects of substituting specific activity times on internet addiction. It shows the percentage increase in the risk of developing internet addiction compared to baseline levels. MVPA: Moderate-to-Vigorous Physical Activity; LPA: Light Physical Activity; Video: Short Video; Class: Classroom Learning; Learn: Autonomous Study; Other: Unobserved Activities.								

Section S7. Measurement Tools

Informed Consent

The purpose of this study is to examine the link between time spent on daily activities and attitudes toward internet use. If you decide to participate, the study will take approximately **3–7 minutes** to complete.

In this study, you will be asked to:

- Provide information about how you have allocated your time recently;
- Answer questions regarding your attitudes toward internet use;
- Fill out some basic personal information (no private information will be involved).

We estimate that approximately 2,500 student participants from across China will take part in this study.

Your participation in this study is completely voluntary. You are free not to participate or to withdraw at any time. All of your responses will be kept confidential. If you have any questions about this study, you may contact **Frank.Wang@outlook.com**.

☐ I understand the purpose and nature of this study, and I agree to participate voluntarily.

Sleep

In the past month, what time did you usually go to bed at night?

- Before 8:00 PM
- 8:00 PM–8:29 PM
- 8:30 PM–8:59 PM
- 9:00 PM–9:29 PM
- 9:30 PM–9:59 PM
- 10:00 PM–10:29 PM
- 10:30 PM–10:59 PM
- 11:00 PM–11:29 PM
- 11:30 PM–11:59 PM
- 12:00 AM–12:29 AM
- 12:30 AM–12:59 AM

- 1:00 AM–1:29 AM
- 1:30 AM–1:59 AM
- 2:00 AM–2:29 AM
- 2:30 AM–2:59 AM
- 3:00 AM–3:29 AM
- 3:30 AM–3:59 AM
- After 4:00 AM

In the past month, how many minutes did it usually take you to fall asleep each night?

- 0–5 minutes
- 5–10 minutes
- 10–15 minutes
- 15–20 minutes
- 20–25 minutes
- 25–30 minutes
- 30–35 minutes
- 35–40 minutes
- 40–45 minutes
- 45–50 minutes
- 50–55 minutes
- 55 minutes–1 hour
- More than 1 hour

In the past month, what time did you usually wake up each morning?

- Before 4:00 AM
- 4:00 AM–4:29 AM
- 4:30 AM–4:59 AM
- 5:00 AM–5:29 AM
- 5:30 AM–5:59 AM
- 6:00 AM–6:29 AM
- 6:30 AM–6:59 AM
- 7:00 AM–7:29 AM
- 7:30 AM–7:59 AM
- 8:00 AM–8:29 AM
- 8:30 AM–8:59 AM
- 9:00 AM–9:29 AM
- 9:30 AM–9:59 AM
- 10:00 AM–10:29 AM
- 10:30 AM–10:59 AM
- 11:00 AM–11:29 AM
- 11:30 AM–11:59 AM

- After 12:00 PM

Physical Activities

In the past 7 days, on how many days did you engage in vigorous physical activities? (e.g., lifting heavy objects, aerobic exercises, or fast cycling)

- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
- 7 days

On those days, how much time did you usually spend on vigorous physical activities?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on how many days did you engage in moderate-intensity physical activities? (e.g., lifting light objects, cycling at a regular pace, or playing doubles tennis, excluding walking!)

- 0 days

- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
- 7 days

On those days, how much time did you usually spend on moderate-intensity physical activities?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on how many days did you walk for at least 10 minutes at a time?

- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
- 7 days

On those days, how much time did you usually spend walking?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on how many days did you spend more than 10 minutes doing low-intensity activities other than walking? (Physical activities with an intensity of 2–4 on a perceived exertion scale of 0–10, usually without noticeable changes in heart rate or breathing, such as household chores, stretching, etc.)

- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
- 7 days

On those days, how much time did you usually spend on low-intensity activities other than walking?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours

- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

Sedentary behavior

In the past 7 days, on average, how much time per day did you spend playing video games (including mobile games and computer games)?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on average, how much time per day did you spend watching short videos (e.g., TikTok, Kuaishou, Xiaohongshu, WeChat Channels, etc.)?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours

- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on average, how much time per day did you spend in front of a screen? (e.g., watching TV, using a computer, playing on a phone, etc.)

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on average, how much time per day did you spend on classroom learning (referring to mandatory class time)?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours

- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on average, how much time per day did you spend on self-directed learning (referring to learning activities outside of classroom learning, such as completing assignments, extra studies, etc.)?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

In the past 7 days, on average, how much time per day did you spend in front of a screen for classroom learning and study purposes?

- I do not engage in this activity
- 0–0.5 hours
- 0.5–1 hour

- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

Overall, in the past 7 days, how much time did you spend sitting or lying down while awake? This can include any form of activity (excluding sleep and exercise), such as watching TV, reading, sitting in a car, eating, etc.

- I do not engage in these activities
- 0–0.5 hours
- 0.5–1 hour
- 1–1.5 hours
- 1.5–2 hours
- 2–2.5 hours
- 2.5–3 hours
- 3–3.5 hours
- 3.5–4 hours
- 4–4.5 hours
- 4.5–5 hours
- 5–5.5 hours
- 5.5–6 hours
- 6–6.5 hours
- 6.5–7 hours
- 7–7.5 hours
- 7.5–8 hours
- More than 8 hours

Attention Check

What is the normal color of mineral water?

- White
- Yellow
- Colorless

Problematic Internet Use

(1 = Strongly Disagree, 4 = Strongly Agree)

- People have told me more than once that I spend too much time online.
- I feel uncomfortable if I do not go online for a period of time.
- I find myself spending more and more time online.
- When the internet disconnects or I cannot get online, I feel restless.
- No matter how tired I am, I always feel energized when I am online.
- I always intend to spend just a little time online, but I often end up staying much longer than expected.
- Even though being online negatively affects my daily relationships, I still have not reduced my internet usage.
- More than once, I have slept less than four hours because of being online.
- Since last semester, on average, I have spent significantly more time online each week compared to before.
- If I do not go online for a while, I feel depressed.
- I cannot control my urge to go online.
- I find myself engaging less with my friends and more with the internet.
- I have experienced back pain or other physical discomfort because of being online.
- The first thing I think of when I wake up in the morning is going online.
- Being online has already negatively impacted my academic or work performance.
- If I do not go online for a while, I feel like I am missing out on something.
- Because of being online, my interactions with my family have decreased.
- Because of being online, my time for regular leisure activities has decreased.
- Each time I get offline intending to do something else, I cannot resist going back online just to check again.
- Without the internet, my life would be joyless.
- Being online has negatively impacted my physical health.
- I have tried to spend less time online, but I have not been able to do it.
- I have developed a habit of reducing my sleep time to have more time online.
- Compared with before, I now need to spend more time online to feel satisfied.
- I have skipped meals because of being online.
- Staying up late online has made me feel tired during the day.

Demographic variables

What is your sex?

- Male
- Female

What is your age? (Please fill in your age in full years)

What is the highest level of education your parents have completed?

- Primary school or below
- Middle school
- High school/vocational school/technical school
- Associate degree
- Bachelor's degree
- Master's degree
- Doctorate
- Prefer not to answer

What is your approximate annual household income?

- Below 20,000 RMB
- 20,000–60,000 RMB
- 60,000–150,000 RMB
- 150,000–300,000 RMB
- 300,000–500,000 RMB
- 500,000–1,000,000 RMB
- Above 1,000,000 RMB
- Prefer not to answer

References:

- Coyne, S. M., Rogers, A. A., Zurcher, J. D., Stockdale, L., & Booth, M. (2020). Does time spent using social media impact mental health?: An eight year longitudinal study. *Computers in Human Behavior*, 104, 106160. <http://doi.org/https://doi.org/10.1016/j.chb.2019.106160>
- Ross, R., Chaput, J.-P., Giangregorio, L. M., Janssen, I., Saunders, T. J., Kho, M. E., Poitras, V. J., Tomasone, J. R., El-Kotob, R., McLaughlin, E. C., Duggan, M., Carrier, J., Carson, V., Chastin, S. F., Latimer-Cheung, A. E., Chulak-Bozzer, T., Faulkner, G., Flood, S. M., Gazendam, M. K., ... Tremblay, M. S. (2020). Canadian 24-Hour Movement Guidelines for Adults aged 18-64 years and Adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. *Applied Physiology, Nutrition, and Metabolism*, 45(10 (Suppl. 2)), S57–S102. <https://doi.org/10.1139/apnm-2020-0467>
- Zeng, M., Chen, S., Zhou, X., Zhang, J., Chen, X., & Sun, J. (2022). The relationship between physical exercise and mobile phone addiction among Chinese college students: Testing mediation and moderation effects. *Frontiers in Psychology*, 13, 1000109. <https://doi.org/10.3389/fpsyg.2022.1000109>