Research paper

Sex differences in association between Internet addiction and aggression among adolescents aged 12 to 18 in mainland of China

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ABSTRACT

Background: Previous studies have reported that Internet addiction (IA) is an important predictor of aggression. However, little is known whether aggression is a risk factor of IA. This study aims to explore whether IA can predict total and sub-types of aggression, whether aggression also can predict IA, and the potential sex difference.
Method: A total of 15,977 adolescents aged 12 to 18 were recruited though a stratified cluster sampling across five representative provinces in mainland of China. Young's Internet Addiction Test (IAT) and Buss and Warren's Aggression Questionnaire (BWAQ) were used to measure IA and aggression, respectively.
Results: The prevalence of IA and total aggression was 16.8 % and 25.0 %, respectively. Binary logistic regression analysis indicated that IAT score was significantly associated with total and five sub-types of aggression ($P <$ 0.001). However, scores of physical aggression, hostility, and indirect aggression were positively associated with IA ($P < 0.001$), while verbal aggression and anger were not significant ($P > 0.05$). Moreover, the interaction of sex and IA was significant for aggression. Specifically, females with IA had higher risks of anger and indirect aggression but had lower risks of physical and verbal aggression compared to males with IA.
Limitations: Cross-sectional design, self-reported information, and only Chinese rural adolescents.
Conclusions: IA is a strong risk factor of total and five sub-types of aggression, while not all sub-types of aggression are predictors of IA. Prevention programs for adolescents' IA and aggression should consider different aggression sub-types and sex.

1. Introduction

Internet accessibility has increasing rapidly in recent years, especially for developing countries (Agbaria, 2021; Hahn and Kim, 2014). Although there are various benefits of Internet, a loss of control and excessive Internet use has been proposed as a novel psycho-behavioral disorder named Internet addiction (IA) (Lee et al., 2020; Yen et al., 2011), which is first conceptualized by Young (1996). The symptoms or signs of IA include an excessive occupation with Internet, a felt need to use Internet, repeated attempts to stop Internet use, a loss of time spent away from Internet, spending more time than planned on Internet, and feeling uneasy when being off Internet (Shaw and Black, 2008; Young,

1998a, 1998b).

According to recent reviews, the prevalence of IA is higher in South-East Asia than that in other regions of the world and IA is considered as a major public health issue in China, Japan, and South Korea (Kuss et al., 2014; Kuss et al., 2021; Pan et al., 2020). In China, the prevalence of IA has an increasing trend year by year (Shao et al., 2018), and the pooled overall prevalence among college students was 11.3 % (95 % CI: 10.1 %– 12.5 %) (Li et al., 2018). However, compared to ample previous studies for Chinese college students (Chou et al., 2018; Shen et al., 2020; Shen et al., 2021; Shi and Du, 2019), the characteristics of IA among Chinese adolescents, such as junior and senior high-school students, have not been clearly delineated (Lin et al., 2018). Adolescents are the most

vulnerable group for developing IA (Arrivillaga et al., 2020), since they generally have changeability in cognitive control and boundary setting skills (Agbaria, 2021; Lee et al., 2020; Obeid et al., 2019). Therefore, it has great significance to explore the prevalence and characteristics of IA among adolescents, which is particularly important to prevent IA and its adverse outcomes.

Substantial previous studies supported that IA was related to a number of psychological impairments among adolescents (Huang et al., 2020a, 2020b; Marin et al., 2020), such as anxiety (Pan and Yeh, 2018; Shen et al., 2020), depression (Fumero et al., 2018; Seki et al., 2019), impaired cognitive ability (Jorgenson et al., 2016), sleep disorders (Guo et al., 2018; Kuss et al., 2021), and lower levels of life satisfaction (Park et al., 2017; Tang et al., 2014). Besides, more and more scholars are paying emerging attention to the relationship between IA and aggression (Agbaria, 2021; Hahn and Kim, 2014; Kim, 2013). The definition of aggression refers to any acts with the immediate intent to hurt another individual that could result in physical and psychological damage (Buss and Perry, 1992). Generally, the sub-types of aggression include physical aggression, verbal aggression, hostility, anger, and indirect aggression (Kang et al., 2021; Zhang et al., 2018). Recently, Agbaria et al. revealed that IA was positively associated with aggressive behaviors among Israeli-Palestinian students graded 9 to 12 (Agbaria, 2021). With regard to different sub-types of aggression, Kim et al. supported that the level of IA was independently associated with all aggression sub-types among Korean youths and the highest positive correlation was found between hostility score and IA test score (Kim, 2013). However, to the best of our knowledge, there is no prior work focusing on the association between IA and aggression based on adolescents in mainland of China. Thus, it is very necessary to understand whether Chinese adolescents with IA are vulnerable to develop total and different sub-types of aggression (Ko et al., 2009a; Yen et al., 2011).

Beyond the predictive effect of IA on aggression, a bi-directional relationship was detected in some existing literature. Specifically, IA could predict aggression and vice versa (Lim et al., 2015). Empirical evidence has supported that total aggression was a predictive factor for IA (Izmir et al., 2019; Lee et al., 2020; Obeid et al., 2019). Among sub-types of aggression, some previous studies found that adolescents with hostility may have the highest risk of IA (Ko et al., 2009a; Yen et al., 2011). However, a meta-analysis revealed that anger was associated with IA with the largest effect size (Koo and Kwon, 2014). Given the controversial and inconsistent findings, it is significant to explore which sub-types of aggression is the strongest predictor for IA. In addition to hostility and anger, whether other sub-types of aggression are also the risk factors of IA warrants further research.

Besides, there are conflicting findings regarding the effect of sex in the association between IA and aggression. For example, a previous study indicated that hostility was associated with IA only for male adolescents but not for female adolescents (Ko et al., 2009a). On the contrary, other studies did not find a significant sex difference in the association between IA and aggression (Izmir et al., 2019; Kim, 2013; Ko et al., 2009b). Therefore, whether there is sex difference should be addressed via more research. In addition, some psychological factors were associated with both IA and aggression, such as social support (Lin et al., 2018; Mo et al., 2018), psychological resilience (Tang et al., 2020), emotional regulation (Arrivillaga et al., 2020), and loneliness (Koo and Kwon, 2014; Ostovar et al., 2016). Thus, these factors should be controlled as confounders when examining the association between IA and aggression (Ko et al., 2009b).

The aims of the current study are following. First, we explore whether IA can predict total and five sub-types of aggression, including physical aggression, verbal aggression, hostility, anger, and indirect aggression. Second, we further assess whether total and five sub-types of aggression can predict IA, and which sub-types of aggression has strongest predictive effect on IA. Third, we examine if there is sex difference in the association between IA and aggression, and whether males and females with and without IA have different risks of aggression.

2. Methods

2.1. Procedures and participants

A multi-stage cluster sampling was adopted in this cross-sectional study from February to October 2015. In Stage 1, China was divided into five geographic locations (northern, southern, eastern, western, and central). Five representative provinces (Heilongjiang, Guangdong, Anhui, Yunnan, and Hubei) were randomly selected from each region (Tang et al., 2020). In Stage 2, three counties were chosen randomly in each province. In Stage 3, we selected two or three junior and senior high schools in each county based on enrollment size. In Stage 4, we used random digits to choose two or three classes from every grade (7th to 12th) in each selected school. Finally, we invited all students in the selected class to participate in this survey voluntarily.

The study was approved by the Medical Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology. All participants were informed that they had rights to participate in or refuse the survey without any condition. Then, they were explicitly assured that all information during the investigation would be treated confidentially and anonymously. Informed written consent was obtained from every participant and their parents (or legal guardians) before the filed investigation.

A total of 16,400 students were recruited in the survey. Then, 270 were excluded due to the missing data was >15 % of items in the whole questionnaire, and 153 were excluded since they did not provide any information regarding Internet addiction or aggression. Finally, 15,977 students' questionnaires were qualified in the final analysis, and the actual response rate was 97.42 % (15,977/16,400).

2.2. Measurements

2.2.1. Internet addiction

Internet addiction (IA) was assessed using Chinese version of the Young's Internet Addiction Test (IAT). IAT was the most common scale to screen IA worldwide and was validated in Chinese adolescents with satisfactory psychometric properties (the Cronbach's α was 0.93) (Lai et al., 2013). IAT comprises 20 items rated in a 5-point Likert scale (from 1 = "not at all" to 5 = "always"). Total score of IAT ranges from 20 to 100 and higher score suggests the greater level of problematic Internet use (Young, 1998a, 1998b). In the current study, we not only described the IAT score but also used the validated cut-off criteria, which including "average Internet user" (20–49 points), "having occasional or frequent problems" (50–79 points), and "having significant problems" (80–100 points) because of Internet use (Guo et al., 2018; Young and de Abreu, 2011). Participants were considered to have IA if they were classified as "having occasional or frequent problems" or "having significant problems" (IAT score ≥ 50) (Lu et al., 2020). The Cronbach's alpha of IAT in this study was 0.930.

2.2.2. Aggression

Chinese version of Buss and Warren's Aggression Questionnaire (BWAQ) was administered to assess total and sub-types of aggression (Maxwell, 2008). BWAQ is consists of 34 items and five dimensions, including physical aggression, verbal aggression, anger, hostility, and indirect aggression. Each item was answered on a 5-point Likert scale ranging from 1 (not at all like me) to 5 (completely like me). Raw scores for total and five subscales were first calculated, with higher scores indicating higher levels of total and subtypes of aggression. According to the interpretation of BWAQ, T-scores have a mean of 50 and a standard deviation of 10 based on raw scores. Participants were classified into seven groups according to their T-score ranges: very low (≤29T), low (30T–39T), low average (40T–44T), average (45T–55T), high average (56T–59T), high (60T–69T), and very high (≥70T) (Buss and Warren, 2000). The current study categorized "high average", "high", and "very high" groups as having aggression (≥56T), while other groups were

categorized as no aggression (Kang et al., 2021). BWAQ has good psychometric properties in previous studies (Huang et al., 2017; Tang et al., 2013). The Cronbach's α of the whole scale was 0.863. The Cronbach's α of five subscales ranged from 0.507 to 0.742.

2.2.3. Social support

Chinese version of the Adolescent Social Support Scale (ASSS) was used to measure participants' utilization of social resources (Dai, 2014). ASSS has 17 items using a 5-point Likert scale (from 1 = "totally inconsistent" to 5 = "totally consistent"). Higher score suggests more perceived social support (Zhang et al., 2018). The Cronbach's α of ASSS in this study was 0.935.

2.2.4. Psychological resilience

Psychological resilience was measured using Resilience Scale for Chinese Adolescents (RSCA). RSCA has 27 items using a 5-point Likert scale (from 1 = "totally inconsistent" to 5 = "totally consistent") (Hu, 2008). Higher total score of RSCA indicated better psychological resilience. RSCA has good reliability and validity in previous studies, and the Cronbach's α was 0.90 (Han et al., 2018). In the present study, the Cronbach's α of RSCA was 0.780.

2.2.5. Emotional regulation

Emotional regulation was measured via the 4-item subscale from Goleman's Emotional Intelligence Inventory. The subscale had 4-point responses (from 1 = "always like this" to 4 = "never like this"). Higher total scores represent greater ability of emotional regulation (Goleman, 1995). The scale had an acceptable internal consistency in a previous study (Cronbach α = 0.83) (Tang et al., 2018) and in the present study (Cronbach α = 0.762).

2.2.6. Loneliness

Loneliness was measured by University of California Los Angeles Loneliness Scale (UCLALS). UCLALS was an unidimensional and self-reported measurement of perceived isolation, which has 21 items with 5-point Likert scale responses (from 1 = "totally inconsistent" to 5 = "totally consistent") (Russell, 1996). Higher total scores indicating greater loneliness. UCLALS showed high internal consistency and good validity in previous studies (the Cronbach's α was 0.94) (Hirsch et al., 2012). The Cronbach's α of UCLALS in this study was 0.918.

2.2.7. Demographic variables

Demographic variables included sex (1 = male, 2 = female), age, grade (1 = 7th to 9th, 2 = 10th to 12th), single-child family (0 = no, 1 = yes), caregiver (1 = parents, 2 = grandparents, 3 = other), caregiver's education (1 = primary school or less, 2 = junior high school, 3 = senior high school, 4 = college or more), and family income (average family income per month in RMB: 1 = 6000~, 2 = 4000–5999, 3 = 2000–3999, 4 = 1000–1999, 5 = ~999).

2.3. Statistical analysis

First, categorical variables were summarized by prevalence or proportion [n (%)], while continuous variables were described by mean (SD). Second, the univariate analysis of IA and aggression was assessed using the chi-square test and *t*-test. Third, in order to examine independent effect of Internet addiction on total and five sub-types of aggression (0 = no, 1 = yes), a set of binary logistic regression analysis was performed due to aggression scores did not fit the normal distribution. We included IAT score as an independent variable. Fourth, to assess independent effect of aggression on IA (0 = no, 1 = yes), two models of binary logistic regression analysis were performed. In Model 1, we included total aggression score as an independent variable. In Model 2, we included five sub-types of aggression score as five independent variables. Fifth, to explore potential sex differences, the chi-square test and ANOVA were used to compare the score and

prevalence of aggression between groups of interaction for sex × IA (1 = Male without IA, 2 = Female without IA, 3 = Male with IA, 4 = Female with IA). Last, to further examine the interaction of sex and Internet addiction, three models of binary logistic regression analysis for aggression were ran separately. In Model 1, we included an interaction term of sex and IA as an independent variable. In Model 2, the categorical variable of sex × IA was included, the reference group was Male without IA. In Model 3, the categorical variable of sex × IA was included again, while the reference group was Male with IA.

In all models of binary logistic regression analysis mentioned above, we included sex, age, grade, single-child family, caregiver, caregiver's education, family income, social support, psychological resilience, emotional regulation, and loneliness as confounding variables. The results were displayed with odds ratios (ORs) and 95 % confidence intervals (95 % CIs). The threshold of significance was defined as $P < 0.05$. All statistical analyses were performed by SPSS 26.0.

3. Results

3.1. Characteristics of participants and prevalence of Internet addiction and aggression

Of 15,977 participants, the proportion of males and females was 51.8 % (8279) and 48.2 % (7718), respectively. The age ranged from 12 to 18 years and the mean (SD) age was 15.21 (1.74) years. Other demographic characteristics of participants were reported in Table 1.

The score of IAT was 35.84 (14.44). In total, the prevalence of IA was 16.8 % (2680). Specifically, 15.5 % (2478) of participants had occasional or frequent Internet use problems, 1.3 % (202) had significant Internet use problems, and 83.2 % (13317) were average Internet user. The score of BWAQ was 67.55 (15.24). The prevalence of total aggression and different sub-types of aggression was 25.0 % (total aggression), 23.9 % (physical aggression), 21.7 % (verbal aggression), 23.5 % (anger), 25.5 % (hostility), and 24.3 % (indirect aggression), respectively.

3.2. Univariate analysis of Internet addiction and aggression

All demographic and confounding variables were significantly associated with IA, except for caregiver and caregiver's education. In particular, males had significant higher prevalence of IA than females (21.1 % vs. 12.0 %, $P < 0.001$). All variables were significantly associated with total aggression. Male participants had slightly higher prevalence of total aggression than female participants (25.9 % vs. 24.0 %, $P < 0.01$) (Table 1).

3.3. Binary logistic regression analysis of aggression

After controlling for demographic characteristics and confounding factors, IAT score was associated with total aggression (OR = 1.036, 95 % CI = 1.033–1.039), physical aggression (OR = 1.029, 95 % CI = 1.026–1.032), verbal aggression (OR = 1.019, 95 % CI = 1.020–1.026), anger (OR = 1.023, 95 % CI = 1.020–1.026), hostility (OR = 1.029, 95 % CI = 1.026–1.032), and indirect aggression (OR = 1.031, 95 % CI = 1.028–1.034) (all $P < 0.001$). In addition, sex was associated with all five sub-types of aggression. Specifically, compared to the male, the female had lower risks for physical aggression (OR = 0.505, 95 % CI = 0.464–0.550) and verbal aggression (OR = 0.790, 95 % CI = 0.727–0.859) but had higher risks for anger (OR = 1.488, 95 % CI = 1.365–1.621), hostility (OR = 1.169, 95 % CI = 1.073–1.274), and indirect aggression (OR = 1.220, 95 % CI = 1.123–1.325) (all $P < 0.001$) (Table 2).

3.4. Binary logistic regression analysis of Internet addiction

In Model 1, total aggression score was significantly associated with

Table 1
General characteristics of participants and prevalence of Internet addiction and total aggression.

Variables	Total	Internet addiction			Total aggression		
		Yes	No	χ^2/t	Yes	No	χ^2/t
Sex				236.55***			7.91**
Male	8279 (51.8)	1750 (21.1)	6529 (78.9)		2145 (25.9)	6134 (74.1)	
Female	7718 (48.2)	930 (12.0)	6788 (88.0)		1851 (24.0)	5867 (76.0)	
Grade				13.39***			35.74***
7–9	8727 (54.6)	1376 (15.8)	7351 (84.2)		2017 (23.1)	6710 (76.9)	
10–12	7270 (45.4)	1304 (17.9)	5966 (82.1)		1979 (27.2)	5291 (72.8)	
Single-child family[a]				29.82***			0.52
Yes	5509 (34.7)	1045 (19.0)	4464 (81.0)		1395 (25.3)	4114 (74.7)	
No	10,379 (65.3)	1616 (15.6)	8763 (84.4)		2574 (24.8)	7805 (75.2)	
Caregiver[a]				3.91			42.57***
Parents	12,104 (77.0)	2018 (16.7)	10,086 (83.3)		2890 (23.9)	9214 (76.1)	
Grandparents	2011 (12.8)	320 (15.9)	1691 (84.1)		553 (27.5)	1458 (72.5)	
Others	1599 (10.2)	293 (18.3)	1306 (81.7)		491 (30.7)	1108 (69.3)	
Caregiver's education[a]				7.72			11.63**
Primary school or less	4300 (27.6)	702 (16.3)	3598 (83.7)		1110 (25.8)	3190 (74.2)	
Junior high school	6937 (44.5)	1145 (16.5)	5792 (83.5)		1651 (23.8)	5286 (76.2)	
Senior high school	3322 (21.3)	575 (17.3)	2747 (82.7)		882 (26.6)	2440 (73.4)	
College or more	1044 (6.7)	205 (19.6)	839 (80.4)		272 (26.1)	772 (73.9)	
Family income (RMB)[a]				41.18***			21.41***
6000~	2104 (13.9)	397 (18.9)	1707 (81.1)		614 (29.2)	1490 (70.8)	
4000–5999	2760 (18.2)	538 (19.5)	2222 (80.5)		694 (25.1)	2066 (74.9)	
2000–3999	5624 (37.2)	938 (16.7)	4686 (83.3)		1374 (24.4)	4250 (75.6)	
1000–1999	2636 (17.4)	421 (16.0)	2215 (84.0)		635 (24.1)	2001 (75.9)	
~999	2004 (13.2)	263 (13.1)	1741 (86.9)		496 (24.8)	1508 (75.2)	
Age, mean (SD)	15.21 (1.74)	15.36 (1.64)	15.18 (1.76)	24.68***	15.35 (1.70)	15.17 (1.75)	31.03***
Social support, mean (SD)	62.85 (14.33)	56.27 (14.01)	64.17 (14.02)	707.82***	58.72 (14.49)	64.22 (14.00)	454.05***
Psychological resilience, mean (SD)	91.91 (12.90)	85.97 (11.53)	93.11 (12.83)	712.45***	87.06 (11.99)	93.53 (12.79)	790.58***
Emotional regulation, mean (SD)	11.49 (2.66)	10.19 (2.72)	11.75 (2.57)	806.47***	9.96 (2.71)	12.00 (2.44)	1970.72***
Loneliness, mean (SD)	44.31 (14.04)	50.78 (15.57)	43.01 (13.34)	712.93***	50.25 (15.53)	42.33 (12.92)	1012.63***
IAT score, mean (SD)	35.84 (14.44)	61.26 (10.40)	30.72 (8.52)	26,503.644***	43.58 (16.65)	33.25 (12.61)	1700.23***
BWAQ, mean (SD)	67.55 (15.24)	77.80 (16.80)	65.49 (14.03)	1598.81***	88.16 (11.07)	60.69 (8.97)	24,856.42***
Total	15,977 (100.0)	2680 (16.8)	13,317 (83.2)		3996 (25.0)	12,001 (75.0)	

IAT: Internet Addiction Test, BWAQ: Buss Warren Aggression Questionnaire.
[a] There was missing data (single-child family = 109, caregiver = 283, caregiver's education = 394, family income = 869).
*** $P < 0.001$.
** $P < 0.01$.

IA (OR = 1.039, 95 % CI = 1.036–1.043, $P < 0.001$). In addition, social support, psychological resilience, and emotional regulation were inversely associated with IA, while loneliness was positive related to IA (all $P < 0.001$). Older participants were more likely to reported IA (OR = 1.087, 95 % CI = 1.037–1.138, $P < 0.001$). Compared to the male, the female were less likely to reported IA (OR = 0.536, 95 % CI = 0.486–0.592, $P < 0.001$). Compared to participants from multi-child family, participants from single-child family had higher risk of IA (OR = 1.161, 95 % CI = 1.050–1.284, $P < 0.01$) (Table 3).

In Model 2, Collinearity diagnosis of logistic regression analysis indicated that Tolerance ranged from 0.603 to 0.744, and Variance inflation factor (VIF) ranged from 1.345 to 1.659. These results revealed that there were no significant collinear effects among independent variables and all five subtypes of aggression were independently associated with IA. Of five sub-types of aggression, physical aggression score (OR = 1.043, 95 % CI = 1.031–1.054), hostility score (OR = 1.055, 95 % CI = 1.043–1.067), and indirect aggression score (OR = 1.079, 95 % CI = 1.063–1.095) were significantly associated with IA (all $P < 0.001$). However, verbal aggression score and anger score were not significantly associated with IA ($P > 0.05$) (Table 3).

3.5. Sex difference for the association between Internet addiction and aggression

The score of BWAQ was significantly different among four groups of sex × IA ($P < 0.001$). For example, physical aggression score from high to low was followed: Male with IA (16.13) > Female with IA (14.62) > Male without IA (13.30) > Female without IA (11.72) ($P < 0.05$). In addition, the prevalence of total and sub-types of aggression was also significantly different among four groups ($P < 0.001$). For example, the prevalence of physical aggression from high to low was followed: Male with IA (47.7 %) > Female with IA (36.3 %) > Male without IA (25.5 %) > Female without IA (14.5 %) ($P < 0.05$). The score and prevalence of other sub-types of aggression among males and females with and without Internet addiction were shown in Table 4.

In Model 1 of binary logistic regression (Table 5), the interaction of sex and IA was positively associated with total and all sub-types of aggression (all $P < 0.001$). In Model 2, compared to males without IA, males with IA (OR = 2.633, 95 % CI = 2.323–2.984, $P < 0.001$) and females with IA (OR = 2.600, 95 % CI = 2.218–3.048, $P < 0.001$) had higher risk odds of total aggression. For five sub-types of aggression, females without IA had lower risk odds of physical aggression (OR = 0.468, 95 % CI = 0.425–0.515, $P < 0.001$) and verbal aggression (OR = 0.740, 95 % CI = 0.675–0.811, $P < 0.001$) but had higher risk odds of anger (OR = 1.416, 95 % CI = 1.287–1.558, $P < 0.001$) and indirect aggression (OR = 1.109, 95 % CI = 1.012–1.215, $P < 0.05$) when compared to males without IA. Besides, males and females with IA had greater risks of total and sub-types of aggression, except for the association between females with IA and physical aggression (OR = 1.142, 95 % CI = 0.976–1.336, $P > 0.05$).

In Model 3, when compared to males with IA, females with IA had lower risks for physical aggression (OR = 0.532, 95 % CI = 0.447–0.633, $P < 0.001$) and verbal aggression (OR = 0.831, 95 % CI = 0.693–0.995, $P < 0.05$) but had higher risks for anger (OR = 1.454, 95 % CI = 1.216–1.738, $P < 0.001$) and indirect aggression (OR = 1.242, 95 % CI = 1.046–1.474, $P < 0.05$). In addition, both males and females without IA had significantly lower risks for total and five sub-types of aggression than males with IA (all $P < 0.001$) (Table 5).

Table 2
Binary logistic regression of total and five sub-types of aggression [OR (95 % CI)].

Variables	Total aggression	Physical aggression	Verbal aggression	Anger	Hostility	Indirect aggression
IAT score	1.036 (1.033, 1.039)***	1.029 (1.026, 1.032)***	1.019 (1.016, 1.022)***	1.023 (1.020, 1.026)***	1.029 (1.026, 1.032)***	1.031 (1.028, 1.034)***
Social support	1.001 (0.998, 1.005)	0.997 (0.993, 1.000)	1.002 (0.999, 1.006)	1.004 (1.001, 1.008)*	0.997 (0.994, 1.001)	0.996 (0.992, 0.999)*
Psychological resilience	0.995 (0.991, 0.999)*	0.991 (0.987, 0.995)***	1.025 (1.020, 1.029)***	0.992 (0.988, 0.996)***	0.996 (0.992, 1.001)	0.996 (0.992, 1.000)
Emotional regulation	0.804 (0.789, 0.818)***	0.883 (0.868, 0.898)***	0.880 (0.865, 0.896)***	0.785 (0.771, 0.799)***	0.827 (0.813, 0.842)***	0.888 (0.873, 0.904)***
Loneliness	1.018 (1.015, 1.022)***	0.999 (0.996, 1.003)	1.011 (1.008, 1.015)***	1.007 (1.004, 1.011)***	1.035 (1.032, 1.039)***	1.005 (1.002, 1.009)**
Age	0.995 (0.955, 1.036)	1.010 (0.971, 1.051)	0.979 (0.942, 1.018)	0.989 (0.950, 1.029)	0.966 (0.928, 1.006)	1.004 (0.965, 1.043)
Sex (ref. = male)						
Female	1.026 (0.941, 1.118)	0.505 (0.464, 0.550)***	0.790 (0.727, 0.859)***	1.488 (1.365, 1.621)***	1.169 (1.073, 1.274)***	1.220 (1.123, 1.325)***
Grade (ref. = 7–9)						
10–12	1.077 (0.936, 1.238)	0.931 (0.812, 1.067)	1.018 (0.889, 1.166)	1.043 (0.907, 1.199)	1.128 (0.981, 1.297)	1.231 (1.076, 1.409)**
Single-child family (ref. = no)						
Yes	1.014 (0.926, 1.110)	1.013 (0.928, 1.105)	0.967 (0.886, 1.056)	0.985 (0.899, 1.079)	0.902 (0.823, 0.998)*	1.091 (1.000, 1.190)
Caregiver (ref. = parents)						
Grandparents	1.165 (1.027, 1.322)*	1.129 (0.998, 1.278)	1.141 (1.010, 1.288)*	1.103 (0.972, 1.252)	1.062 (0.935, 1.206)	0.985 (0.870, 1.115)
Others	1.214 (1.055, 1.398)**	1.135 (0.988, 1.303)	1.172 (1.021, 1.345)*	1.099 (0.953, 1.267)	1.095 (0.951, 1.261)	1.093 (0.954, 1.252)
Caregiver's education (ref. = primary school or less)						
Junior high school	0.972 (0.876, 1.078)	0.982 (0.887, 1.087)	0.898 (0.813, 0.993)*	0.965 (0.870, 1.070)	1.052 (0.949, 1.167)	1.007 (0.911, 1.113)
Senior high school	1.046 (0.921, 1.187)	1.069 (0.945, 1.210)	0.900 (0.795, 1.018)	1.043 (0.919, 1.184)	1.124 (0.990, 1.276)	1.031 (0.912, 1.165)
College or more	1.076 (0.897, 1.292)	0.932 (0.778, 1.116)	0.854 (0.714, 1.021)	1.120 (0.934, 1.342)	1.121 (0.932, 1.349)	1.011 (0.848, 1.206)
Family income (RMB, ref. = 6000~)						
4000–5999	0.785 (0.681, 0.906)**	0.772 (0.673, 0.886)***	0.969 (0.844, 1.113)	0.808 (0.701, 0.931)**	0.968 (0.837, 1.120)	0.894 (0.779, 1.025)
2000–3999	0.749 (0.660, 0.850)***	0.711 (0.629, 0.803)***	0.902 (0.797, 1.022)	0.719 (0.634, 0.816)***	0.926 (0.813, 1.054)	0.820 (0.726, 0.926)**
1000–1999	0.704 (0.607, 0.816)***	0.728 (0.632, 0.840)***	0.875 (0.758, 1.011)	0.766 (0.662, 0.886)***	0.890 (0.766, 1.033)	0.744 (0.645, 0.859)***
~999	0.809 (0.691, 0.946)**	0.806 (0.692, 0.939)**	0.933 (0.799, 1.089)	0.738 (0.630, 0.864)***	0.995 (0.848, 1.166)	0.798 (0.684, 0.930)**

IAT: Internet Addiction Test.
*** $P < 0.001$.
** $P < 0.01$.
* $P < 0.05$.

Fig. 1 showed OR and 95 % CI of Model 2 and Model 3 for total and five sub-types of aggression among males and females with and without Internet addiction.

4. Discussion

This is the first study to explore the association between Internet addiction (IA) and aggression via a large sample of adolescents in mainland of China. The current work revealed several key and novel findings. First, IA was the risk factor of total and five sub-types of aggression after controlling demographic characteristics and other confounders, such as social support, psychological resilience, emotional regulation, and loneliness. Second, not all sub-types of aggression were significantly associated with IA. Specifically, physical aggression, hostility, and indirect aggression could predict IA, but verbal aggression and anger could not. Third, the interaction of sex and IA was significant for aggression. Compared to males with IA, females with IA had higher risks of anger and indirect aggression, but had lower risks of physical and verbal aggression. These findings provided more detailed information regarding the relationship between IA and aggression. Further, it could benefit for policy-makers to prevent adolescents' IA and aggressive behaviors.

In the current study, the prevalence of IA among Chinese high-school students was 16.8 %, which is slightly higher than that among Chinese university students (11.3 %, 95 % CI: 10.1 %–12.5 %) (Li et al., 2018). However, the finding is consistent with a recent review indicated that the prevalence of IA based on scoring >50 on IAT ranged from 14.7 % to 67.5 % in Asia (Kuss et al., 2021). As the measurement and cut-off value across different studies were defined diversely, it may be difficult to compare the prevalence of IA (Kuss et al., 2021; Shen et al., 2020). Besides, sampling population and year of the survey might also influence the prevalence of IA (Guo et al., 2018; Pan et al., 2020). For instance, all participants of the current study were from rural China where Internet accessibility was not as good as it in urban China. Specifically, the number of urban Internet users was near three times more than rural Internet users. Furthermore, the year when we conducted the study was in 2015 and Internet penetration was not as wide as nowadays (Peng et al., 2021). Thus, future studies should pay long-term attention to the prevalence of IA among adolescents.

Several theoretical models could explain why adolescents reported higher prevalence of IA than other populations. First, an individual may be at greater risk for IA when he/she has pre-existing psychopathology

Table 3
Binary logistic regression of Internet addiction [OR (95 % CI)].

Variables	Model 1	Model 2
Aggression		
Total aggression score	1.039 (1.036, 1.043)***	NA
Physical aggression score	NA	1.043 (1.031, 1.054)***
Verbal aggression score	NA	0.993 (0.976, 1.009)
Anger score	NA	1.007 (0.995, 1.020)
Hostility score	NA	1.055 (1.043, 1.067)***
Indirect aggression score	NA	1.079 (1.063, 1.095)***
Social support	0.983 (0.979, 0.987)***	0.984 (0.980, 0.988)***
Psychological resilience	0.984 (0.979, 0.989)***	0.986 (0.981, 0.990)***
Emotional regulation	0.922 (0.904, 0.941)***	0.918 (0.899, 0.937)***
Loneliness	1.007 (1.003, 1.011)***	1.006 (1.002, 1.010)**
Age	1.087 (1.037, 1.138)***	1.086 (1.036, 1.138)**
Sex (ref. = male)		
Female	0.536 (0.486, 0.592)***	0.540 (0.487, 0.599)***
Grade (ref. = 7–9)		
10–12	0.890 (0.759, 1.045)	0.885 (0.754, 1.040)
Single-child family (ref. = no)		
Yes	1.161 (1.050, 1.284)**	1.156 (1.045, 1.278)**
Caregiver (ref. = parents)		
Grandparents	0.879 (0.758, 1.020)	0.887 (0.764, 1.030)
Others	0.812 (0.689, 0.958)*	0.816 (0.692, 0.962)*
Caregiver's education (ref. = primary school or less)		
Junior high school	1.127 (0.999, 1.269)	1.118 (0.992, 1.260)
Senior high school	1.165 (1.006, 1.348)*	1.148 (0.992, 1.329)
College or more	1.387 (1.135, 1.696)**	1.383 (1.129, 1.692)**
Family income (RMB, ref. = 6000~)		
4000–5999	1.141 (0.973, 1.337)	1.148 (0.978, 1.347)
2000–3999	0.913 (0.790, 1.054)	0.918 (0.794, 1.061)
1000–1999	0.860 (0.727, 1.018)	0.869 (0.734, 1.029)
~999	0.707 (0.585, 0.853)***	0.717 (0.594, 0.867)**

In Model 1, total aggression was included as an independent variable.
In Model 2, five sub-types of aggression were included as five independent variables.
*** $P < 0.001$.
** $P < 0.01$.
* $P < 0.05$.

and negative cognitions of compulsive use, both of which are emerging in period of adolescence (Griffiths et al., 2016). Second, adolescents are prone to take addictive behaviors, such as IA or alcohol addiction, to cope with anxiety, frustration, and academic failure (Arrivillaga et al., 2020; Lim et al., 2015). Besides, the displacement theory posits that compulsive engagement in social network platforms via Internet. The phenomenon is especially popular among adolescents, which could prevent them from social interactions in real-life and further impact their well-being (Agbaria, 2021; Ostovar et al., 2016).

Consistent with prior research, our results support that IA is a positive predictor of total and sub-types of aggression (Kim, 2013; Lim et al.,

2015; Obeid et al., 2019). A strong association between IA and aggression might stem from that several core symptoms in IA diagnosis are strongly related to aggressive behaviors, including preoccupation, uncontrolled impulse, impairment of control, and impairment of decision-making ability (Hahn and Kim, 2014). Among them, uncontrolled impulse may be the most essential element since IA is generally to be recognized as a form of impulsive control disorder (Dell'Osso et al., 2006). Given the patients with impulsive control disorder are known to display aggressive tendencies, thus, individuals with IA may be more likely to show aggression with similar pattern (Kim, 2013).

Besides, other underlying mechanisms also could explain the association between IA and aggression. First, some Internet activities, such as video gaming, shopping online, and video viewing, would decrease the motivation to restrict violence and the guilt for violent behaviors. Second, many online behaviors are anonymous, which might decrease personal responsibility and provide higher arousal, overloading sensory, and novel stimulus. Thus, Internet overuse could further decrease self-awareness, minimize the concern for social interaction, weaken controls based on guilt, shame, and fear. Eventually, these negative effects might contribute to aggressive behaviors (Ko et al., 2009b).

Although most previous studies were tend to believed that IA was risk factor of aggression (Kim, 2013; Lim et al., 2015; Obeid et al., 2019), it seems more suitable and appropriate to screen individuals' aggression to predict IA. On the one hand, IA was considered to be included in the category of substance use and addictive disorders in the Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) (Hahn and Kim, 2014), while aggression was just defined as aggressive personality traits in some prior research (Kuang et al., 2020). On the other hand, IA is commonly a latent addictive behavior while aggression is generally overt in adolescents' daily life. Therefore, it is more reasonable to use a personality trait to predict an addictive disorder and use an overt behavior to predict a latent behavior.

Total aggression was significantly associated with IA, which is aligned with previous studies demonstrating aggression was a predictor of IA (Koo and Kwon, 2014; Lim et al., 2015). A possible explanation is that Internet can be used as an easily accessible alternative to defuse or relieve negative emotional statuses, such as aggressive personality traits. To some extent, Internet is the only way to release latent aggressive impulses, which are not acceptable in real world but can be expressed in virtual world (Koo and Kwon, 2014). Another possible explanation is that aggression and IA have common neurobiology and impairment in the neural circuitry or in the neuromodulator system (Huang et al., 2020a, 2020b; Pan and Yeh, 2018). These common impairments could lead to the simultaneous development of aggression and IA (Hahn and Kim, 2014). Specifically, the neurobiology of aggression could be explained by dysfunctions of brain circuitry, neurotransmitters, neuropeptides or genes, which might also be a neurobiological mechanism for IA (Siever, 2008).

Surprisingly, our results suggested that not all sub-types of aggression can predict IA. Meanwhile, the finding indicated that physical aggression, hostility, and indirect aggression were the more powerful predictors for IA than verbal aggression and anger. Our finding is partly consistent with prior work supported that hostility could positively predict IA with large effect size (Ko et al., 2009a). Many Internet activities, especially online violent gaming, create a world where adolescents with hostility can express their aggression unconditionally. Accordingly, more intervention of IA should be tailored for specific forms of aggression and IA prevention programs are supposed to focus on adolescents with physical aggression, hostility, and indirect aggression (Ko et al., 2009a). However, we found that verbal aggression and anger were not significantly associated with IA. This finding is inconsistent with a meta-analysis, which supported that anger was the strongest risk factor of IA (Koo and Kwon, 2014). All in all, although the five sub-types of aggression have a distinct effect on IA, this novel finding of the current study should be verified in more future research.

With regard to sex difference, our results indicated that the

Table 4

The score and prevalence of aggression among males and females with and without Internet addiction.

Variables	Total (n = 15,997)	Sex × Internet addiction					
		Male without IA (n = 6529)	Female without IA (n = 6788)	Male with IA (n = 1750)	Female with IA (n = 930)	χ^2/F	Pairwise comparison
Score of BWAQ, mean (SD)							
Total aggression score	67.55 (15.24)	65.50 (14.23)	65.48 (13.84)	77.05 (16.58)	79.20 (17.11)	537.74***	d > c > a, b
Physical aggression score	13.01 (4.71)	13.30 (4.59)	11.72 (3.85)	16.13 (5.81)	14.62 (5.43)	513.93***	c > d > a > b
Verbal aggression score	12.09 (3.25)	12.01 (3.29)	11.80 (3.09)	13.11 (3.43)	12.90 (3.24)	97.73***	a, b > c > d
Anger score	15.55 (4.58)	14.64 (4.17)	15.60 (4.51)	17.07 (4.82)	18.76 (5.11)	320.14***	d > c > b > a
Hostility score	17.29 (5.30)	16.41 (4.96)	16.88 (4.98)	20.05 (5.57)	21.31 (5.85)	443.81***	d > c > b > a
Indirect aggression score	12.09 (3.77)	11.55 (3.61)	11.78 (3.53)	13.93 (4.05)	14.71 (3.98)	373.09***	d > c > b > a
Prevalence of aggression, n (%)							
Total aggression	3996 (25.0)	1305 (20.0)	1361 (20.1)	840 (48.0)	490 (52.7)	1050.73***	d > c > a, b
Physical aggression	3824 (23.9)	1668 (25.5)	983 (14.5)	835 (47.7)	338 (36.3)	965.55***	c > d > a > b
Verbal aggression	3479 (21.7)	1397 (21.4)	1234 (18.2)	568 (32.5)	280 (30.1)	207.40***	a, b > c > d
Anger	3760 (23.5)	1092 (16.7)	1579 (23.3)	626 (35.8)	463 (49.8)	670.81***	d > c > b > a
Hostility	4085 (25.5)	1317 (20.2)	1520 (22.4)	766 (43.8)	482 (51.8)	778.21***	d > c > b > a
Indirect aggression	3889 (24.3)	1275 (19.5)	1450 (21.4)	718 (41.0)	446 (48.0)	661.66***	d > c > b > a

IA: Internet addiction, BWAQ: Buss Warren Aggression Questionnaire.

a: Male without IA, b: Female without IA, c: Male with IA, d: Female with IA in pairwise comparison.

*** $P < 0.001$.

Table 5

Binary logistic regression of aggression for interaction of sex and Internet addiction [OR (95 % CI)].

	Variables	Total aggression	Physical aggression	Verbal aggression	Anger	Hostility	Indirect aggression
Model 1	Sex × IA	2.241 (1.928, 2.605)***	1.323 (1.138, 1.157)***	1.353 (1.160, 1.580)***	2.130 (1.835, 2.472)***	1.993 (1.710, 2.323)***	2.184 (1.889, 2.525)***
Model 2	Male without IA	1.000	1.000	1.000	1.000	1.000	1.000
	Female without IA	0.952 (0.865, 1.046)	0.468 (0.425, 0.515)***	0.740 (0.675, 0.811)***	1.416 (1.287, 1.558)***	1.081 (0.983, 1.188)	1.109 (1.012, 1.215)*
	Male with IA	2.633 (2.323, 2.984)***	2.147 (1.907, 2.417)***	1.565 (1.380, 1.774)***	1.924 (1.688, 2.192)***	1.997 (1.758, 2.268)***	2.110 (1.867, 2.385)***
	Female with IA	2.600 (2.218, 3.048)***	1.142 (0.976, 1.336)	1.300 (1.105, 1.529)**	2.797 (2.384, 3.280)***	2.322 (1.976, 2.730)***	2.621 (2.247, 3.057)***
Model 3	Male with IA	1.000	1.000	1.000	1.000	1.000	1.000
	Female with IA	0.988 (0.827, 1.180)	0.532 (0.447, 0.633)***	0.831 (0.693, 0.995)*	1.454 (1.216, 1.738)***	1.163 (0.971, 1.394)	1.242 (1.046, 1.474)*
	Male without IA	0.380 (0.335, 0.430)***	0.466 (0.414, 0.524)***	0.639 (0.564, 0.725)***	0.520 (0.456, 0.592)***	0.501 (0.441, 0.569)***	0.474 (0.419, 0.536)***
	Female without IA	0.361 (0.318, 0.410)***	0.218 (0.192, 0.247)***	0.473 (0.416, 0.538)***	0.736 (0.647, 0.838)***	0.541 (0.476, 0.616)***	0.526 (0.465, 0.595)***

IA: Internet addiction.

In Model 1, the interaction term of sex × IA was included.

In Model 2, the categorical variable of sex × IA was included, the reference group was male without IA.

In Model 3, the categorical variable of sex × IA was included, the reference group was male with IA.

Confounding variables included age, grade, single-child family, caregiver, caregiver's education, family income, social support, psychological resilience, emotional regulation, and loneliness in the three models.

*** $P < 0.001$.

** $P < 0.01$.

* $P < 0.05$.

prevalence of IA and aggression among male adolescents was significantly higher than that among female adolescents, which is congruent with some prior studies (Huang et al., 2017; Wu et al., 2016; Xin et al., 2018). Besides, our finding further suggested that the interaction of sex and IA was significant and distinct for different sub-types of aggression. Particularly, when compared to males with IA, females with IA had higher risks of anger and indirect aggression but had lower risks of physical and verbal aggression. The finding is inconsistent with a previous study, which indicated that male adolescents with severe IA showed significantly higher scores in all sub-types of aggression than females with severe IA (Kim, 2013). This innovative finding of the present study may partly because of the differences in socialization and biological features between males and females (Kim, 2013; Xin et al., 2018). Indeed, female adolescents are known to use Internet mainly for online shopping, watching movies, and online chatting, while male adolescents are tend to play violent Internet games (Fumero et al., 2018; Ko et al., 2009b). In consequence, males and females with IA could show

different forms of aggressive behaviors. On the other hand, males are generally stronger than females in physical. Moreover, according to Chinese traditional values, boys should be extravert and active while girls are supposed to be introverted and passive in personality (Lansford et al., 2012). Thus, males have higher odds of direct aggression and lower odds of indirect aggression than females beyond the influence of IA in the current study.

There are several limitations should be noted. First and most important, the study design is cross-sectional. Thus, we are unable to permit any causal relationship between IA and aggression. Future research could employ a longitudinal design to follow adolescents over time to understand the temporal association between IA and aggression. Second, the self-reported questionnaire may be subjected to reporting bias. In future studies, it may be helpful to take other methods of information collection, such as peer reporting or parents reporting (Agbaria, 2021). Third, although the study recruited a large sample from five provinces across mainland of China, all participants were from rural
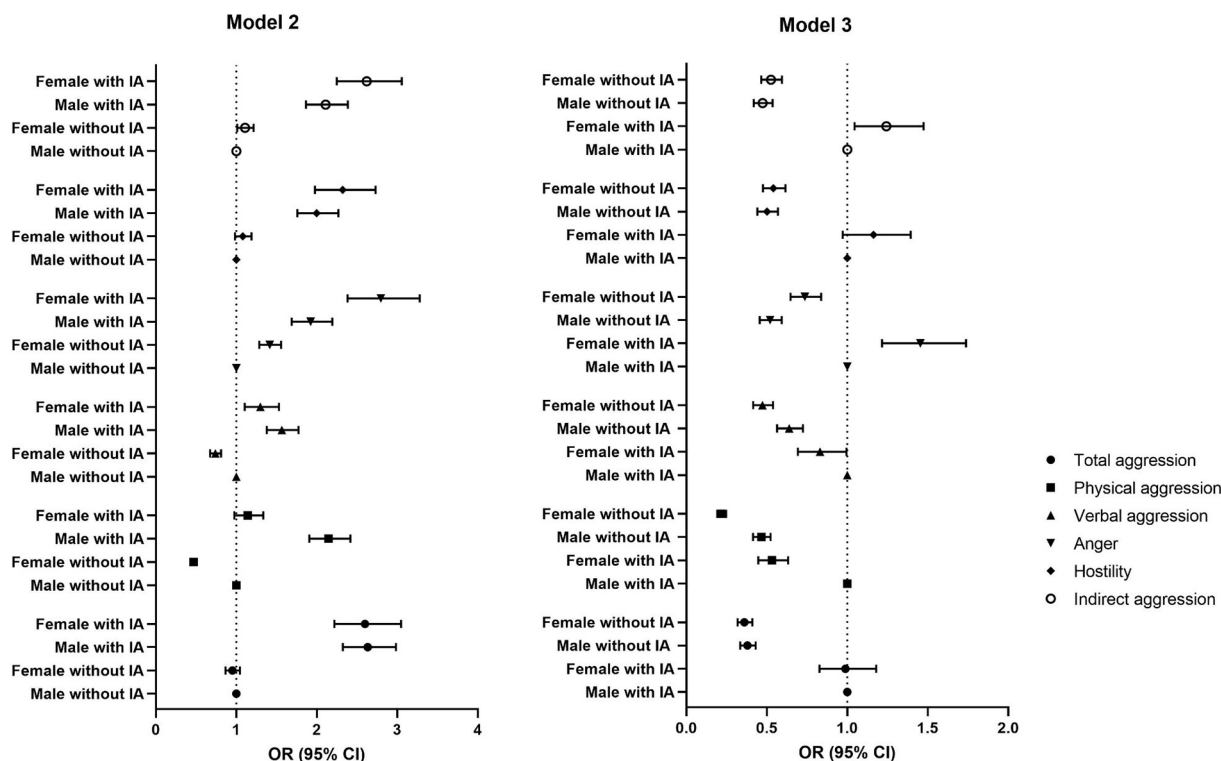
Fig. 1. Binary logistic regression of aggression among males and females with and without Internet addiction.
In Model 2, the categorical variable of sex × IA was included, the reference group was Male without IA. In Model 3, the categorical variable of sex × IA was included, the reference group was Male with IA. Confounding variables included age, grade, single-child family, caregiver, caregiver's education, family income, social support, psychological resilience, emotional regulation, and loneliness in the two models.

areas. It would limit the generalizability of our findings to Chinese urban adolescents. Therefore, in the following study, we will recruit more representative participants via a multi-center sampling method in both rural and urban China. Finally, the influence of watching violent videos, playing online games, and viewing porn webs was neglected in the research. These Internet activities might be important confounders, which should be controlled in the association between IA and aggression (Kim, 2013; Xin et al., 2018).

5. Conclusion

This study not only contributes novel theoretical understandings of the relationship between IA and aggression, but also provides several practical implications for preventing IA and aggression. The findings suggest that IA plays a prominent role in total and five sub-types of aggression among Chinese adolescents. Therefore, IA intervention seems a promising strategy for preventing adolescents' aggressive behaviors. However, not all sub-types of aggression are predictors of IA, and early intervention efforts for IA should target to those adolescents who presented hostility, physical aggression, and indirect aggression. Moreover, sex is a key influencing factor of both IA and aggression, and males and females with and without IA have different risks of aggression. Thus, different strategies based on sex could be more effective and economic than one-size-fits-all method in developing prevention programs for adolescents' addictive and aggressive behaviors.

CRediT authorship contribution statement

Chang Peng and Tengyun Guo developed the initial manuscript. Junhan Cheng, Mengni Wang, and Fajuan Rong were responsible for the data collection and the data analysis. Shiyang Zhang, Yafei Tan, Hongli Ding, and Yan Wang contributed substantially to the revision and refinement of the manuscript. Yizhen Yu guided the overall design of the study. All authors have read and approved the final manuscript.

Conflict of interest

All authors declare no conflict of interest.

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