Excessive and pathological Internet use – Risk-behavior or psychopathology?

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ABSTRACT

Pathological Internet use (but only with respect to gaming) is classified as mental disorder in the ICD-11. However, there is a large group of adolescents showing excessive Internet use, which may rather be considered adolescent risk-behavior. The aim was to test whether pathological and excessive Internet use should be considered as "psychopathology" or "risk-behavior".

A representative, cross-sectional sample of 11.110 students from 10 European Union countries was analyzed. Structural equation models, including the factors "risk-behavior" and "psychopathology" and the variables excessive and pathological Internet use, were tested against each other.

"Risk-behavior" was operationalized by several risk-behaviors (e.g. drug abuse, truancy, etc). "Psychopathology" included measures of several mental disorders (e.g. depression, hyperactivity, etc). Excessive Internet use was assessed as the duration and frequency of Internet use. Pathological Internet use was assessed with the Young Diagnostic Questionnaire (i.e., presence of addiction criteria).

Excessive Internet use loaded on "risk-behavior" ($\lambda = 0.484$, p < .001) and on "psychopathology" ($\lambda = 0.071$, p < .007). Pathological Internet use loaded on "risk-behavior" ($\lambda = 0.333$, p < .001) and on "psychopathology"

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($\lambda = 0.852$, p < .001). Chi-square tests determined that the loadings of excessive Internet use (χ^2 (1) = 81.98, p < .001) were significantly stronger on "risk-behavior" than "psychopathology". Vice versa, pathological Internet use loaded significantly stronger on "psychopathology" (χ^2 (1) = 107.10, p < .001).

The results indicate that pathological Internet use should rather be considered as psychopathology. Excessive Internet use on the other hand, should be classified as adolescent risk-behavior.

1. Introduction

The accessibility of the Internet in European Union countries has expanded enormously during the last decade (according to the Eurostat – the households' level of Internet access from 68% in 2010 to 90% in 2019). Growing up in our digital world bears risks, especially for the youngest members of our society (Gentile et al., 2017). Besides cyber-bullying and cyber-criminality, the addictive potential of specific Internet-applications has received increasing attention, and will need to be further addressed in the future. The World Health Organization (WHO) recently confirmed the inclusion of *Gaming Disorder* in the International Classification of Diseases 11th Revision (ICD-11; WHO, 2018); thus, set a milestone in the discourse on Internet addiction.

Pathological Internet use is an umbrella term for several different online behaviors leading to addictive symptoms (Young et al., 1999). A representative study has shown, that a pathological Internet use can affect the quality of life in many aspects (Machimbarrena et al., 2019). Not only psychological and emotional, but also the social and physical quality of life can be negatively influenced by pathological Internet use (Machimbarrena et al., 2019). So far, five online behaviors have been labelled as potentially addictive: Online games, social media, Internet pornography, gambling and online search. The inclusion of the diagnosis *Internet Gaming Disorder* in the research appendix of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), and *Gaming Disorder* in the ICD-11 confirmed the concept that Internet use – if fulfilling addiction criteria – should be treated as a mental disorder. For the diagnosis of *Internet Gaming Disorder*, nine criteria based on those for substance-use disorder and gambling disorder were developed: preoccupation, withdrawal, tolerance, unsuccessful control, loss of interest, continuation despite problems, deception, escape negative mood and risk opportunities. For the diagnosis, 5 of 9 criteria must be fulfilled within the past 12 months. Those criteria have been applied for other Internet-specific addictions, such as social media addiction, as well. In the ICD-11, *Gaming Disorder* (6C51) is included in the section of behavioral addictions (WHO, 2018).

Excessive (i.e. very frequent or enduring) use of Internet applications is common among adolescents and known to be correlated with pathological Internet use (i.e. individuals with Internet addiction use the Internet excessively; Durkee et al., 2012) as well as Internet Gaming Disorder (i.e. IGD criteria significantly predicted gaming engagement; Przybylski et al., 2017). As neither duration nor frequency of Internet use are diagnostic criteria in both DSM-5 or ICD-11, excessive use does not necessarily meet criteria for pathological internet use (addiction criteria). Thus, in addition to excessive use, it appears that other factors are required for Internet use to become pathological. Caplan and High showed in a study that in addition to excessive use, cognitive preoccupation strongly influenced the extent of the negative outcome of Internet use (Caplan and High, 2006). Another theory states, that deficient self-regulation decisively influences whether excessive Internet use becomes pathological or not (Tokunaga and Rains, 2010). Nonetheless, an excessive amount spent online bears potential risks: Other activities, such as physical fitness, sleeping pattern or real social interaction, are prone to get neglected potentially leading to a negative spiral where, in the end, the life is fully oriented towards the Internet use. The phenomena of pathological versus excessive Internet use would be comparable to excessive alcohol use (i.e., binge drinking) versus alcohol addiction. Binge drinking is defined as heavy alcohol intake without fulfilling addiction criteria (Kuntsche et al., 2017), and could serve as a

basis for defining excessive Internet use as adolescent risk-behavior. Excessive and pathological Internet use might be described as a milder version of binge-drinking and alcohol abuse, as the physical consequences are less severe. Nonetheless, a study showed, that just one day of excessive gaming shortened the deep sleep phase in adolescents, so there is a measureable immediate health impact of excessive Internet use (Dworak et al., 2007).

Adolescence is known as a phase of transition and vulnerability. In this phase, critical developmental steps (Remschmidt, 2013; Jackson & Goossens, 2020) go alongside with an essential reorganization of the brain (Giedd et al., 1999; Konrad et al., 2013). This fundamental reorganization in different areas seems to set the ground for an increased vulnerability for the incidence of mental illness (Kessler et al., 2007, Costello et al., 2003). Another frequent phenomenon that seems to be related to the specific phase of adolescence is risk-behavior (Jessor, 1991). Although the occurrence of risk-behaviors in adolescents can be regarded as normative, those behaviors can potentially endanger the physical and psychosocial development in a critical developmental age (Hurrelmann, 1990; Jessor, 1991). Risk-behaviors have been postulated to cause higher morbidity in adolescents and are often seen as promoting factor for psychiatric disorders (Jessor, 2014). The social norms determine to a large extent which behavior is categorized as healthy, which as risk-behavior, or even pathological behavior. This can lead to either an underestimation of problematic developments or prejudices against unproblematic behaviors. It has been shown previously, that risk-behaviors tend to decrease with emerging adulthood (Gardner & Steinberg, 2005).

Previous research has shown both correlations between pathological Internet use and excessive Internet use as well as associations of pathological Internet use with both several types of risk-behavior and diverse forms of psychopathology (Carli et al., 2013; Durkee et al., 2012; Durkee et al., 2016; González-Bueso et al., 2018, Kaess et al., 2014), but none of those compared excessive versus pathological Internet use regarding their classification to either psychopathology or risk-behavior. The strength and novelty of this study is to show the empirical distinction between excessive and pathological Internet use as risk-behavior or psychopathology in a large and representative European sample, using structural equitation modeling (SEM; Wasserman et al., 2015). It aims to empirically address the research question whether pathological Internet use can be classified as one form of psychopathology, while excessive Internet use can be classified as one type of risk-behavior.

2. Research methods

2.1. Subjects and procedure

Data were drawn from the baseline assessment of the multi-center study "Saving and Empowering Young Lives in Europe" (SEYLE) study. The aim of SEYLE was to develop and implement prevention programs concerning adolescent risk- and self-destructive behaviors in a randomized controlled intervention study. The representative sample of 11.110 students (participation rate of 89.6%) was recruited from 179 randomly selected schools in 10 European Countries (Austria, Estonia, France, Germany, Hungary, Ireland, Italy, Romania, Slovenia and Spain) in 2010. The sample included 4.502 males (40.7%) and 6.562 females (59.3%) with a mean age of 14.80 years (SD ± 0.839). Approval from local ethical committees was granted in each participating center. All pupils of the 8th and 9th grades in participating schools were invited to
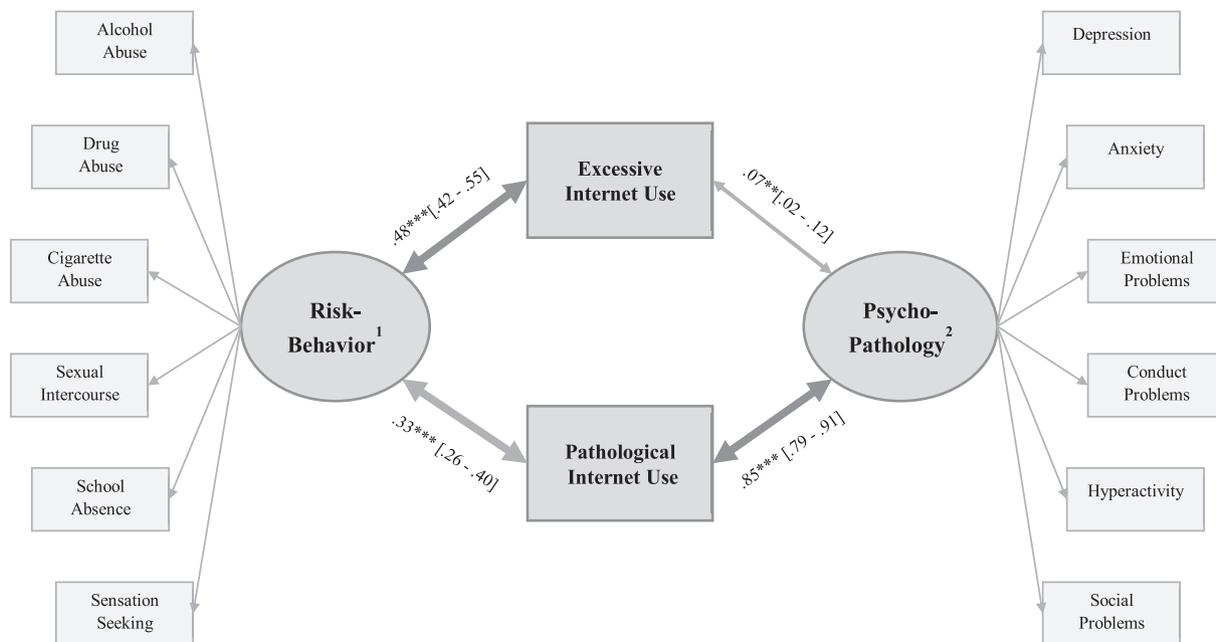
Fig. 1. Structural equation model (SEM) of risk-behavior and psychopathology and the variables excessive Internet use and pathological Internet use (*** p < .001, ** p < 0.05, 1 see coefficients in Table 1, 2 see coefficients in Table 2). Excessive Internet use shows a stronger loading on risk-behavior, and pathological Internet use shows a stronger loading on psychopathology.

Table 1A
Structural equation model (SEM) on the variables of risk-behavior.

Variable (Prevalence)	Risk-Behavior			
	Coefficient	SE	p	95%CI
Alcohol abuse				
Frequency (8.0%)	3.23	0.119	< 0.001	3.00–3.46
Quantity (9.4%)	3.60	0.122	< 0.001	3.36–3.84
Being drunk (13.8%)	4.30	0.183	< 0.001	3.94–4.66
Hangover (7.5%)	3.69	0.119	< 0.001	3.45–3.92
Illicit drug abuse				
Frequency (4.7%)	2.77	0.104	< 0.001	2.57 – 2.98
Cigarette abuse				
Number of cigarettes (20.4%)	2.15	0.076	< 0.001	2.00–2.30
First time of smoking (25.9%)	1.40	0.051	< 0.001	1.30–1.50
Precocious sexual intercourse				
Number (2.8%)	2.15	0.122	< 0.001	1.91–2.39
No use of condom (2.8%)	1.56	0.072	< 0.001	1.42 – 1.70
School absence				
Truancy (2.6%)	1.05	0.102	< 0.001	0.853–1.25
Sensation seeking				
Ride with drunken driver (16.9%)	1.05	0.046	< 0.001	0.962–1.14
Ride a bike without helmet (29.2%)	0.618	0.359	< 0.001	0.547 - 0.688
Urban railway surfing (5.2%)	0.907	0.090	< 0.001	0.731–1.08
Seek out dangerous places (31.7%)	1.07	0.042	< 0.001	0.988–1.15

Table 2A
Structural equation model (SEM) on variables of psychopathology.

Variable	Psychopathology			
	Coefficient	SE	p	95% CI
Depression	0.851	0.016	< 0.001	0.820 − 0.882
Anxiety	0.837	0.017	< 0.001	0.805 − 0.870
Emotional problems	0.734	0.013	< 0.001	0.708 − 0.760
Conduct problems	0.407	0.014	< 0.001	0.379 − 0.435
Hyperactivity	0.458	0.012	< 0.001	0.435 − 0.482
Social problems	0.358	0.015	< 0.001	0.328 − 0.387

participate in the study. Informed written consent was obtained from all participating pupils and at least one caregiver. The SEYLE study was registered in the US National Institute of Health (NIH) clinical trial registry (NCT00906620) and German Clinical Trials Register (DRKS00000214). The detailed protocol and methodological approach of the SEYLE study can be found elsewhere (Wasserman et al., 2010; Carli et al., 2013a; Carli et al., 2013b). For further verification of the representativeness of the sample, key parameters of the SEYLE sample (average age, number of immigrants, population density, net income, gender ratio) were compared with the corresponding available national data (Eurostat, 2010), which confirmed the high representativity (Durkee et al., 2012; Carli et al., 2013a; Carli et al., 2013b).

2.2. Measures

Excessive Internet use was measured as a latent variable, combined from the variables Internet use duration and frequency. First by asking for the typical time spent watching TV, playing on the computer or surfing the Internet (duration). Secondly, Internet use was assessed by asking for the frequency of use (daily, weekly, monthly, never; frequency). **Pathological Internet use** was assessed using the well-established Young Diagnostic Questionnaire (YDQ; Young, 1998).

The focus of the YDQ lies on criteria measuring symptoms of addiction, including items for tolerance (item 2), loss of control (item 3 and 5), withdrawal symptoms (item 4), jeopardizing or loosing opportunities and relationships (item 6), deception of others (item 7), and

negative mood regulation (item 8). The YDQ includes furthermore items asking indirectly about excessive Internet use (e.g. item 1, preoccupation with the Internet). The psychometric properties of the German version of the YDQ was examined within two independent samples in a study of Wartberg and colleagues, they found a satisfactory construct validity and a sufficient reliability (Wartberg et al., 2017). The YDQ score from 0 to 8 reflects symptoms of clinical impairment or distress. Three categories were defined for the YDQ: (scoring 0–2) adaptive Internet use, (scoring 3–4) maladaptive Internet use and (scoring ≥ 5) pathological Internet use.

Risk-behavior was assessed as latent variable (substance abuse, sensation seeking and delinquent behaviors), using the well-established Global School-Based Student Health Survey (GSHS; WHO, 2013). The assessed risk-behaviors were: alcohol abuse (frequency; quantity of alcohol drinking; times of being drunk and times of hangover); illicit drug abuse (frequency); cigarette abuse (number of cigarettes; first time of smoking); precocious sexual intercourse (number, no use of condom); truancy; sensation seeking and delinquent behaviors (ride with a drunken driver; ride a bike/ scooter without helmet; urban railway surfing; seek out dangerous places).

The latent variable psychopathology, composed of depression, anxiety, emotional problems, conduct problems, hyperactivity and social problems, was assessed with the Beck Depression Inventory (BDI-II; Beck et al., 1996), the Zung Self-Rating Anxiety Scale (Z-SAS; Zung 1971) and the Strengths and Difficulties Questionnaire (SDQ; Goodman et al., 1998). The BDI-II is a 21-item questionnaire which measures depressive symptoms within the last two weeks (item scores 0–3). The item "loss of libido" was replaced by the mean of the other 20 items. The scores of depressive symptoms were classified into four categories: (scoring 0–13) no depression, (scoring 14–19) mild depression, (scoring 20–28) moderate depression and (scoring 29–63) severe depression. Anxiety levels were measured using the Z-SAS, a 20-item questionnaire with scores from 20 to 80. Four categories for the total score were defined: (scoring 20–44) normal anxiety, (scoring 45–59) moderate anxiety, (scoring 60–74) severe anxiety and (scoring 75–80) extreme anxiety. With the 25-item SDQ, emotional and conduct problems, hyperactivity, peer relationship and pro-social behavior were measured. Based on the total score, the categorization in (scoring 0–15) "normal", (scoring 16–19) "borderline" and (scoring 20–40) "severe" was defined.

2.3. Statistical analysis

All analyses were calculated using Stata 16 (StataCorp, 2015). The demographics of the sample have been calculated with descriptive statistics. Further, generalized structural equation models (GSEM) were calculated (Rabe-Hesketh at al., 2004). The generalized GSEM, developed by Rabe-Hesketh et al. (2004), does not make the assumption of a normal distribution and allows a large class of probability distributions of the variables. The models included linear and logistic regression. The SEM included the variables excessive Internet use (duration and frequency), pathological Internet use, risk-behavior, and psychopathology. The loading on risk-behavior and psychopathology was calculated for excessive and pathological Internet use. In the SEM excessive Internet use was operationalized as duration of Internet use and frequency of Internet. Pathological Internet use was operationalized as the categories of the YDQ, as the sum score was very skewed with the highest frequency at 0. Finally, the loadings of the independent variables on the dependent variables were compared with a chi-square test. For all calculations, a significance level of 0.05 was predetermined.

3. Results

The final sample included 11.110 students: 4.502 males (40.7%) and 6.562 females (59.3%) with a mean age of 14.80 years (SD ± 0.839). Altogether, 42.6% of the adolescents reported a typical time of media consumption of 1–2 h per day. Less than an hour use per day was

reported by 15.7%, 3–4 h by 32.3%, 5–6 h by 7.2% and 7–8 h by 1.3%. A minority of 0.8% reported a use of media for more than eight hours per day. Furthermore, 61.2% of the adolescents reported using the Internet every day, followed by 26.5% who use the Internet several times a week. Only 7.6% reported using the Internet once a week, 3.0% once a month or less and 1.8% reported never to use the Internet. Adaptive Internet use was reported by 83.2%, maladaptive Internet use by 13.1% and pathological Internet use was reported by 3.8%.

Tables 1 and 2 in the appendix include all types of risk-behavior and forms of psychopathology contributing to the "risk-behavior factor" or "psychopathology factor" respectively. All risk-behaviors showed a strong loading on the risk-behavior factor with a significance of p < .001, detailed coefficients are listed in table 1. All measures of psychopathology showed strong loadings on the psychopathology factor with a significance of p < .001, detailed coefficients are listed in table 2. The correlation between the latent variables risk behavior and psychopathology was r = 0.26.

Excessive Internet use ($\lambda = 0.484$, p < .001, SE = 0.033, 95%-CI = $0.419 - 0.549$) and pathological Internet use ($\lambda = 0.333$, p < .001, SE = 0.035, 95%-CI = $0.264 - 0.401$) both showed significant loadings on the risk-behavior factor. Excessive Internet use ($\lambda = 0.071$, p = .007, SE = 0.026, 95%-CI = 0.019 - 0.122) and pathological Internet use ($\lambda = 0.852$, p < .001, SE = 0.032, 95%-CI = $0.790 - 0.914$) also showed significant loadings on the psychopathology factor. The general structural equation model is plotted in Fig. 1.

A chi-square test was performed to examine differences in loadings of the independent variables on risk-behavior and psychopathology. The loading of excessive Internet use ($\chi^2 (1) = 81.98$, p < .001) was significantly stronger on the risk-behavior factor. The loading of pathological Internet use was significantly stronger on the psychopathology factor than the risk-behavior factor ($\chi^2 (1) = 107.10$, p < .001).

Fig. 1

4. Discussion and conclusion

The current study aimed to empirically test the classification of pathological and excessive Internet use as either risk-behavior or psychopathology. For this purpose, a representative sample of 11.110 students from ten different European countries answered questions about their Internet use, risk-behaviors and mental health. Analysis included structural equation models with the latent factors risk-behavior and psychopathology as dependent variables and excessive Internet use (duration, frequency) as well as pathological Internet use (YDQ) as independent variables. Pathological Internet use was primarily associated with psychopathology; however, it also showed significant but smaller associations with risk-behavior. Excessive Internet use, was rather associated with the factor risk-behavior, albeit a very small but still significant association was found with psychopathology.

The results support the categorization of pathological Internet use as a form of psychopathology and therefore, it should be treated like a mental disorder. The findings also support the inclusion of *Gaming Disorder* in the diagnostic classifications and encourages the inclusion of further addictive online behavior in the diagnostic category of addictions. For excessive Internet use the results support a categorization as risk-behavior. Hence, the comparison to binge drinking as one important form of alcohol misuse seems appropriate. Furthermore, those results support, that duration and frequency of Internet use are not diagnostic criteria for pathological Internet use, but might be used for assessment of adolescents at-risk.

The results indicate that Internet use seems to range on a continuum from healthy via excessive to pathological. This was indicated by the lack of a clear separation line between risk-behavior and psychopathology since both pathological as well as excessive Internet use were related to both constructs but with different strengths. Thus, our data is in line with the ongoing and appropriate discussion about categorical versus dimensional diagnostic approaches for mental disorders in

general and addictions specifically. A dimensional model from risk-behavior to psychopathology might describe the spectrum of Internet use the best. At one end, there is the unproblematic Internet use, at the other end a pathological uncontrollable Internet use that is associated with substantial burden of disease. In between, there is an excessive or risky Internet use, that – similar to binge drinking – might cause some problems but is still controllable and not or not yet pathological. Similar patterns have been described also for depression and anxiety not only the conditions meeting the full criteria need attention, but also sub-threshold conditions as early warning signs of mental health problems and behaviors (Balázs et al., 2013). A dimensional model of Internet use can address the critical comments, that within the official diagnostic criteria for Internet Gaming Disorder, users that are in a middle or mixed group are not yet adequately classified (Colder Carras and Kardefelt-Winther, 2018). Those could be identified as engaged or at-risk users without putting a pathology label on them. Alongside with diagnostic classification, a dimensional approach could be developed to guide prevention and interventions. In healthy users and especially adolescents, the universal prevention measures like raising awareness about the risks of the Internet should be applied. The training for responsible Internet use should be part of their basic education. Selective and indicated preventive measures can be implemented to identify and provide early interventions to at-risk users. The goal is to prevent or stop the transition from excessive to pathological Internet use. Preventive measures that have been implemented on a large scale in schools have shown first successes (Szász-Janocha et al., 2019). If full criteria of pathological Internet use are met, an early onset of therapy is of high importance (Zajac et al., 2017). To this aim, suitable and effective treatments have to be established. Especially with regard to the long-term effectiveness of therapies, there is still a lack of research (Zajac et al., 2017). If a pathological Internet use remains undetected or un-treated, it might become chronic and comorbidities arises (Carli et al., 2013a; Carli et al., 2013b). The clinical manifestation of pathological Internet us can show in many and complex facets. The symptoms of addiction (e.g. urge to use the Internet, not being able of control the use) are often concomitant with symptoms of depression, anxiety and sleep disorders (Gentile et al., 2017; Lam, 2014). The association with comorbidities can in turn influence Internet behavior: A *meta*-analysis showed that loneliness and depression can lead to increased Internet use (Tokunaga, 2017).

Although the current article clearly indicates the possible threats of excessive and pathological Internet use, it has to be kept in mind that in the contemporary world the digital devices and applications are natural part of peoples' lives, especially of young people's lives. Some authors claim that the negative impact of the time spent in the Internet can be overestimated, if the content of internet behaviors and meaning-making is not taken into account (Orben & Przybylski, 2019; Orben & Przybylski, 2020). While in some cases an excessive use constitutes a risk-behavior, there are many passionate users with a high amount of time spent online without a risk or behavioral problems. Billieux and colleagues showed the importance of this distinction in Internet Gaming Disorder, pointing at the criterion of functional impairment caused by problematic gaming included in the ICD-11 (Billieux et al., 2019). The distinction between pathological and passionate users might be caused primarily by a deficient ability to control and monitor the own Internet use in pathological users (Tokunaga, 2016). A recent review article emphasizes that many studies on associations between digital technology and social media use and adolescents' well-being do not consider necessary nuances and therefore the knowledge about effects is inconclusive (Orben, 2020). Also, different cohorts within the digital generation can have slight changes digital use and its impact on socioemotional wellbeing (Bohnert & Gracia, 2020). In addition, it is important to remember that it is not the Internet itself that is addictive, but it is always about the specific applications that might be addictive (Ryding and Kaye, 2018).

The strength of this study is the large, representative sample which allowed a valid estimation of the classification of pathological and excessive Internet use. Furthermore, the homogenous methodology and standardized procedures applied in all countries increase the validity, reliability and comparability of the data. The data for the study was collected already approximately ten years ago and with the change of the digital habits the data on both frequency of Internet use and prevalence of pathological Internet use are likely outdated. Still it can be expected to find similar results nowadays (i.e. associations between Internet use, risk-behavior and psychopathology), as the analysis was focused on the associations between variables and not on the absolute numbers of frequency or prevalence. A potential limitation is the application of self-report methods which are prone to recall and social desirability biases (Fisher and Katz, 2000). In addition, the item assessing the duration of Internet use, included watching television as well, which could have confounded the results. However, the results were even stronger when only the frequency of Internet use was included in the model, showing a significant loading on risk-behavior ($\lambda = 0.60$) but no significant loading on psychopathology ($\lambda = -0.04$). This indicates that the results in the model with the latent variable excessive Internet use were not confounded by the item assessing the duration of Internet use including watching television. The YDQ was the method of choice to assess pathological Internet use at the time the study was conducted, today there are advanced questionnaires, covering the DSM-5 criteria. Furthermore, generalized problematic Internet use could be measured, addressing a deficient self-regulation in any kind of Internet use (Caplan, 2010). For this purpose, the well validated generalized problematic Internet use scale (GPIUS) could be applied for instance (Caplan, 2002; Fioravanti et al., 2013). Another limitation is the cross-sectional design, the results are only a momentary assessment, therefore, future research should conduct longitudinal assessments.

In future research, the here described continuum from excessive to pathological Internet use could be compared to the continuum of other addictive disorders, e.g. substance abuse. To get a deeper understanding of the disorder, neurobiological mechanisms of pathological Internet use could be investigated in the context of the continuum. Finally, such a dimensional approach could provide a valuable contribution, to design preventive strategies and optimized treatments.

CRediT authorship contribution statement

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5). American Psychiatric Pub.

Balázs, J., Miklósi, M., Keresztény, Á., Hoven, C. W., Carli, V., Wasserman, C., Apter, A., Bobes, J., Brunner, R., Cosman, D., Cotter, P., Haring, C., Iosue, M., Kaess, M., Kahn, J.-P., Keeley, H., Marusic, D., Postuvan, V., Resch, F., … Wasserman, D. (2013). Adolescent subthreshold-depression and anxiety: Psychopathology, functional impairment and increased suicide risk. Journal of Child Psychology and Psychiatry, 54(6), 670–677.

Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. F. (1996). Comparison of Beck Depression Inventories-IA and-II in Psychiatric Outpatients. *Journal of Personality Assessment, 67*(3), 588–597.

Billieux, J., Flayelle, M., Rumpf, H.-J., & Stein, D. J. (2019). High involvement versus pathological involvement in video games: A crucial distinction for ensuring the validity and utility of gaming disorder. *Current Addiction Reports, 6*(3), 323–330.

Bohnert, M., & Gracia, P. (2020). Emerging Digital Generations? Impacts of Child Digital Use on Mental and Socioemotional Well-Being across Two Cohorts in Ireland, 2007–2018. *Child Indicators Research, 14*(2), 629–659.

Caplan, S. E. (2002). Problematic Internet use and psychosocial well-being: Development of a theory-based cognitive–behavioral measurement instrument. *Computers in Human Behavior, 18*(5), 553–575.

Caplan, S. E. (2010). Theory and measurement of generalized problematic Internet use: A two-step approach. *Computers in Human Behavior, 26*(5), 1089–1097.

Caplan, S. E., & High, A. C. (2006). Beyond excessive use: The interaction between cognitive and behavioral symptoms of problematic Internet use. *Communication Research Reports, 23*(4), 265–271.

Carli, V., Durkee, T., Wasserman, D., Hadlaczky, G., Despalins, R., Kramarz, E., … Kaess, M. (2013). The association between pathological Internet use and comorbid psychopathology: A systematic review. *Psychopathology, 46*(1), 1–13.

Carli, V., Wasserman, C., Wasserman, D., Sarchiapone, M., Apter, A., Balazs, J., … Hoven, C. W. (2013). The saving and empowering young lives in Europe (SEYLE) randomized controlled trial (RCT): Methodological issues and participant characteristics. *BMC public health, 13*(1). https://doi.org/10.1186/1471-2458-13-479.

Colder Carras, M., & Kardefelt-Winther, D. (2018). When addiction symptoms and life problems diverge: A latent class analysis of problematic gaming in a representative multinational sample of European adolescents. *European Child & Adolescent Psychiatry, 27*(4), 513–525.

Costello, E. J., Mustillo, S., Erkanli, A., Keeler, G., & Angold, A. (2003). Prevalence and development of psychiatric disorders in childhood and adolescence. *Archives of General Psychiatry, 60*(8), 837–844.

Durkee, T., Carli, V., Floderus, B., Wasserman, C., Sarchiapone, M., Apter, A., … Wasserman, D. (2016). Pathological Internet Use and Risk-Behaviors among European Adolescents. *International Journal of Environmental Research and Public Health, 13*(3), 294. https://doi.org/10.3390/ijerph13030294.

Durkee, T., Kaess, M., Carli, V., Parzer, P., Wasserman, C., Floderus, B., & Wasserman, D. (2012). Prevalence of pathological Internet use among adolescents in Europe: demographic and social factors. *Addiction (Abingdon, England), 107*, 2210–2222.

Dworak, M., Schierl, T., Bruns, T., & Struder, H. K. (2007). Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. *Pediatrics, 120*(5), 978–985.

Fioravanti, G., Primi, C., & Casale, S. (2013). Psychometric evaluation of the generalized problematic internet use scale 2 in an Italian sample. *Cyberpsychology, Behavior, and Social Networking, 16*(10), 761–766.

Fisher, R. J., & Katz, J. E. (2000). Social-desirability bias and the validity of self-reported values. *Psychology & Marketing, 17*(2), 105–120.

Gardner, M., & Steinberg, L. (2005). Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. *Developmental Psychology, 41*(4), 625–635.

Gentile, D. A., Bailey, K., Bavelier, D., Brockmyer, J. F., Cash, H., Coyne, S. M., …, Markle, T. (2017). Internet gaming disorder in children and adolescents. Pediatrics, 140, S81-S85.

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., … Rapoport, J. L. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. *Nature Neuroscience, 2*(10), 861–863.

González-Bueso, V., Santamaría, J. J., Fernández, D., Merino, L., Montero, E., & Ribas, J. (2018). Association between Internet gaming disorder or pathological video-game use and comorbid psychopathology: A comprehensive review. *International Journal of Environmental Research and Public Health, 15*(4), 668.

Goodman, R., Meltzer, H., & Bailey, V. (1998). The Strengths and Difficulties Questionnaire: A pilot study on the validity of the self-report version. *European Child & Adolescent Psychiatry, 7*(3), 125–130.

Hurrelmann, K. (1990). Health promotion for adolescents: Preventive and corrective strategies against problem behavior. *Journal of Adolescence, 13*(3), 231–250.

Jackson, S., & Goossens, L. (Eds.). (2020). Handbook of adolescent development. Psychology Press.

Jessor, R. (1991). Risk-behavior in adolescence: A psychosocial framework for understanding and action. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine, 12*(8), 597–605.

Kaess, M., Durkee, T., Brunner, R., Carli, V., Parzer, P., Wasserman, C., … Wasserman, D. (2014). Pathological Internet use among European adolescents: Psychopathology and self-destructive behaviours. *European Child & Adolescent Psychiatry, 23*(11), 1093–1102.

Kessler, R. C., Amminger, G. P., Aguilar-Gaxiola, S., Alonso, J., Lee, S., & ??st??n, T. B. (2007). Age of onset of mental disorders: A review of recent literature. *Current Opinion in Psychiatry, 20*(4), 359–364.

Konrad, K., Firk, C., & Uhlhaas, P. J. (2013). Brain development during adolescence: Neuroscientific insights into this developmental period. *Deutsches Ärzteblatt International, 110*(25), 425–431.

Kuntsche, E., Kuntsche, S., Thrul, J., & Gmel, G. (2017). Binge drinking: Health impact, prevalence, correlates and interventions. *Psychology & health, 32*(8), 976–1017.

Machimbarrena, J. M., González-Cabrera, J., Ortega-Barón, J., Beranuy-Fargues, M., Álvarez-Bardón, A., & Tejero, B. (2019). Profiles of problematic internet use and its impact on adolescents' health-related quality of life. *International Journal of Environmental Research and Public Health, 16*(20), 3877.

Orben, A. (2020). Teenagers, screens and social media: A narrative review of reviews and key studies. *Social Psychiatry and Psychiatric Epidemiology, 55*(4), 407–414.

Orben, A., & Przybylski, A. K. (2019). Screens, Teens, and Psychological Well-Being: Evidence From Three Time-Use-Diary Studies. *Psychological Science, 30*(5), 682–696.

Orben, A., & Przybylski, A. K. (2020). Teenage sleep and technology engagement across the week. PeerJ, 8, e8427.

Przybylski, A. K., Weinstein, N., & Murayama, K. (2017). Internet gaming disorder: Investigating the clinical relevance of a new phenomenon. *American Journal of Psychiatry, 174*(3), 230–236.

Rabe-Hesketh, S., Skrondal, A., Pickles, A. (2004). Generalized multilevel structural equation modeling. Psychometrika, 69, 167-190.

Remschmidt, H. (2013). Mental health and psychological illness in adolescence. *Deutsches Ärzteblatt International, 110*(25), 423–424.

Ryding, F. C., & Kaye, L. K. (2018). "Internet addiction": A conceptual minefield. *International Journal of Mental Health and Addiction, 16*(1), 225–232.

StataCorp (2015) Stata: Release 14. Statistical Software. StataCorp LLC, College Station, TX.

Szász-Janocha, C., Vonderlin, E., & Lindenberg, K. (2019). Die Wirksamkeit eines Frühinterventionsprogramms für Jugendliche mit Computerspiel-und Internetabhängigkeit: Mittelfristige Effekte der PROTECT+ Studie. *Zeitschrift für Kinder-und Jugendpsychiatrie und Psychotherapie.*

Tokunaga, R. S. (2016). An examination of functional difficulties from Internet use: Media habit and displacement theory explanations. *Human Communication Research, 42*(3), 339–370.

Tokunaga, R. S. (2017). A meta-analysis of the relationships between psychosocial problems and internet habits: Synthesizing internet addiction, problematic internet use, and deficient self-regulation research. *Communication Monographs, 84*(4), 423–446.

Tokunaga, R. S., & Rains, S. A. (2010). An evaluation of two characterizations of the relationships between problematic Internet use, time spent using the Internet, and psychosocial problems. *Human Communication Research, 36*(4), 512–545.

Wartberg, L., Durkee, T., Kriston, L., Parzer, P., Fischer-Waldschmidt, G., Resch, F., … Kaess, M. (2017). Psychometric properties of a German version of the Young Diagnostic Questionnaire (YDQ) in two independent samples of adolescents. *International Journal of Mental Health and Addiction, 15*(1), 182–190.

Wasserman, D., Carli, V., Wasserman, C., Apter, A., Balazs, J., Bobes, J., … Hoven, C. W. (2010). Saving and empowering young lives in Europe (SEYLE): A randomized controlled trial. *BMC Public Health, 10*(1). https://doi.org/10.1186/1471-2458-10-192.

Wasserman, D., Hoven, C. W., Wasserman, C., Wall, M., Eisenberg, R., Hadlaczky, G., ... & Carli, V. (2015). School-based suicide prevention programmes: the SEYLE cluster-randomised, controlled trial. The Lancet, 385(9977), 1536-1544.

World Health Organization. (2018). International classification of diseases for mortality and morbidity statistics (11th Revision). Retrieved from https://icd.who.int/browse11/l-m/en.

World Health Organization, & Centers for Disease Control and Prevention, CDC. (2013). Global school-based student health survey (GSHS).

Young, K., Pistner, M., O'mara, J., & Buchanan, J. (1999). Cyber disorders: The mental health concern for the new millennium. *CyberPsychology & Behavior, 2*(5), 475–479.

Young, Kimberly. S. (1998). Internet Addiction: The Emergence of a New Clinical Disorder. *CyberPsychology & Behavior, 1*(3), 237–244.

Zajac, K., Ginley, M. K., Chang, R., & Petry, N. M. (2017). Treatments for Internet gaming disorder and Internet addiction: A systematic review. *Psychology of Addictive Behaviors, 31*(8), 979–994.

Zung, W. W. K. (1971). A Rating Instrument For Anxiety Disorders. *Psychosomatics, 12*(6), 371–379.