Article

A cross-sectional study on extensive gaming in adolescents

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Abstract

Background: Extensive gaming and the consequences thereof is frequently reported from child and adolescent psychiatry and school health care. The behavior is associated with compulsion, psychiatric and physical symptoms, impaired cognitive development, and poorer school performance. This phenomenon has been described as an emergent health issue for men and little is known about its potential gender-specific characteristics. The aim of this study was to explore extensive gaming among male and female adolescents and to investigate whether the frequency of often feeling low, often feeling anxious, self-reported ADHD, self-reported ASD, being satisfied with one's own general health, poor sleep, loneliness, and having tried smoking, alcohol, and/or other substances differed among those with and without extensive gaming.

Design and Methods: This study was based on data collected through a public health survey distributed in 2016 to pupils in 9th grade of primary school and in second grade of secondary school, including a total of 13498 participants. The association between extensive gaming and different factors was estimated among male and female respondents separately.

Results: Roughly 30% of the male and 5% of the female respondents were categorized as extensive gamers. Extensive gaming was associated with a higher prevalence of poor sleep and a lower prevalence of being satisfied with one's own health among boys and (to a higher degree) among girls.

Conclusions: Altogether, our results contribute to the impression that extensive gaming is more heavily related to subjective health complaints among female than male adolescents.

Introduction

Internet gaming disorder (IGD) receives increasing amount of attention and has relatively recently been formally acknowledged.[1-3] The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) identifies IGD as a condition requiring additional research and clinical experience before inclusion as a formal disorder while the 11th revision of the International Classification of Diseases (ICD 11) includes gaming disorder, defined as a gaming behaviour in sufficient severity to cause significant impairment in areas of function.[1,3]

Despite an increasing recognition theoretically, scientifically as well as formally,[1-5] disagreements remain in the IGD research field that still lacks consistency regarding terminology, diagnostic cut-off and accordingly both prevalence rates and comorbidity estimates.[6,7] However, most research agree on a pathological potential in the behaviour and the reports on negative health consequences are numerous.[7-10] Gaming disorder has been associated with depression, anxiety, low self-esteem, sleeping disorder, loneliness and low social competence but also to the neuropsychiatric conditions attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD).[4,8,9,11-13] Some scholars argue that the gaming itself might not be the issue, but the time spent that occur at the expense of other beneficial activities.[9] The number of hours spent on gaming have been shown to be associated with both the development of game addiction but also to independently increase the probability of adverse health consequences such as depressive symptoms.[14-16]

Most research report on a male predominance in IGD and the phenomenon has been described as an emergent health issue for men.[4,5,17-19] Boys in general are known to spend more time on gaming than their female peers and they are overrepresented among the minority that exhibits gaming problems.[4,5,17,20] Time spent on gaming has been reported as a risk factor for IGD,[5,15,16] but whether the time spent constitute a greater increase in risk for boys than for girls remains uncertain. Previous research suggests that the motives for gaming differ between gender, as male gamers are more likely to engage in gaming for social motives whereas female gamers are more likely to do so as a coping mechanism.[16] IGD apparently shows differences between boys and girls but female gaming, sex differences in gaming and potential gender-specific health correlates are poorly understood.

We explored the frequency of extensive gaming among Swedish male and female adolescent pupils and investigated

Significance for public health

Extensive gaming is associated with compulsion, psychiatric and physical symptoms, impaired cognitive development and poorer school performance. This phenomenon has been described as an emergent health issue for men and little is known about its potential gender-specific characteristics. The aim of this study was to explore extensive gaming among Swedish male and female adolescent pupils and to investigate whether the frequency of often feeling low, often feeling anxious, self-reported ADHD, self-reported ASD, being satisfied with one's own general health, poor sleep, loneliness, and having tried smoking, alcohol, and/or other substances differed among those with and without extensive gaming. The attention and interest of problems related to gaming in media, institutions such as schools, social services and other health institutions are huge. Our findings are clinically relevant in screening and treatment of both male and female adolescent problem gamers.

whether the frequency of the suspected associated factors differed among those with and without extensive gaming.

Specifically, we used a large sample of Swedish pupils from primary and secondary school to investigate if those with and without extensive gaming differed in the frequency of often feeling low,[1,2] often feeling anxious,[3] self-reported ADHD,[4] self-reported ASD,[5] being satisfied with one's own general health,[6] poor sleep,[7] loneliness, and having tried[8] smoking,[9] alcohol, and/or[10] other substances. The frequency of suspected associated factors was explored, stratified by gender.

Design and Methods

This study uses data collected from a public health survey that was distributed in 2016 to pupils in 9th grade in primary school and in 2nd grade of secondary school. Distribution covered all 33 municipalities in Skåne, a region in the south of Sweden (although most primary schools in Lund municipality did not participate in the survey), with a response rate of 77% in 9th grade and 73% in 2nd grade. The survey's primary purpose was to investigate the current health, way of life, and various social factors among Swedish adolescents, and was provided by Region Skåne in cooperation with the municipal association of Skåne. It was answered anonymously. All participation was voluntary, all measures were based on self-report, and all questions were described as optional. Claesdotter-Knutsson *et al.,* used the same study sample and health correlates to explore problematic gambling (2021, submitted manuscript) and extensive smartphone use (2021, submitted manuscript).

Measures

Extensive gaming

Respondents were asked to rate on a 4-point scale ("none", "less than 1 hour", "1-3 hours", "more than 3 hours") how much time they spent on gaming (using either a computer or a gaming console) every day. A new binary variable labelled "Extensive gaming" was created in which more than three hours of gaming was categorized as "yes" and all other responses as "no".

Associated factors

Based on clinical experience combined with previous research outlined in the introduction we chose to investigate a wide range of suspected associated factors. These factors were related to general well-being, mental health, and various adverse or risk-taking behaviors. Using the available survey data, we created new, binary variables in order to examine the frequency of each factor.

Respondent's psychological health was assessed using two questions from the Health Behaviour in School-Aged Children Symptom Checklist, both with separately verified satisfactory test-retest reliability.[21] Respondents rated, on a five-point scale ("about every day", "more than once a week", "about every week", "about every month", "rarely or never"), how often they had "felt low" and "anxious/worried" during the past six months. We created two new binary variables, labelled "Often feeling low" and "Often feeling anxious", where those who answered "about every day" or "more than once a week" were categorized as "yes" and all others as "no".

Several questions on long-term somatic or psychiatric disorders were included in the survey. Respondents were asked whether they had "ADHD or ADD" and "Autism/Asperger's syndrome", and based on their answers two new binary variables, labelled "ADHD" and "ASD", were created, where those who affirmed ADHD/ADD or ASD were categorized as "yes" and all others as "no".

Respondents' general health status was assessed, on a five-point scale ("very good", "rather good", "neither good nor poor", "rather poor", "poor"), with the Self-Rated Health instrument (Eriksson *et al.*, 2001). A new binary variable labelled "Satisfied with health" was created, with those answering "very good" or "rather good" classified as "yes" and all others as "no".

Respondents rated, on a three-point scale, how many hours a night they usually slept on weekdays ("less than 7 hours", "7-9 hours", "more than 9 hours"). Based on their answers we created a new binary variable, labelled "Poor sleep", with those answering "less than 7 hours" classified as "yes" and all others as "no".

Respondents rated, on a four-point scale ("have no close fried", "have one close friend", "have two close friends", "have several close friends"), whether they presently have a close friend with whom they can talk in confidence about almost any personal matter. We created a new binary variable, labelled "Loneliness", with those answering "have no close friend" classified as "yes" and all others as "no".

The survey included several questions about smoking, alcohol habits, and other substance use. We created three new binary variables, labelled "Tried smoking", "Tried alcohol", and "Tried other substances", with affirming of any kind of frequency classified as "yes" and all other responses as "no".

Statistical analysis

We used the R statistical programming language, version 4.0.4 for all statistical analysis,[22] along with several functions from the R package tidy verse for intermediate data processing.[23] A fully Bayesian approach to statistical analysis was used, which has a clear advantage over frequentist approaches in that it facilitates genuine probabilistic statements about estimated parameters.[24] We used the R package brms,[25] which provides an interface between R and the Stan probabilistic programming language to specify Bayesian models.[26] Specifically, we used Bayesian binomial regression models with weakly informative priors centered around zero, providing moderate regularization while still having minimal impact on obtained estimates,[27] in order to assess whether the frequency of a suspected associated factor was different among those with and without extensive gaming. Finally, we used the R package emmeans for post-processing results.[28]

Estimated group differences are presented as estimated median absolute percentage differences and associated odds ratios along with 95% highest density intervals (HDIs) presented within square brackets. The 95% HDI may be interpreted such that it has a 95% probability of actually containing the values inside it.[29] Furthermore, we used the region of practical equivalence (ROPE) approach to determine whether an estimated difference was of practical and/or clinical importance.[29] Specifically, we considered an estimated difference of at least 5% (in either direction) as the minimal difference for "practical equivalence", and if the 95% HDI was not beyond this cutoff, we deemed the results as uncertain in terms of practical and/or clinical importance.

Results

Sample characteristics

Around thirty percent of boys in both 9th grade of primary school and 2nd grade of secondary school were classified as extensive gamers, whereas for girls the corresponding percentage was around five percent in both grades (see Table 1 for additional details). The frequency of having poor sleep emerged as the largest and most robust difference between those with and without

extensive gaming, followed by satisfaction with one's own health. For several other variables the differences between the two groups were robustly above zero, although the estimated differences were not, with 95% probability, at least +/- 5% or larger.

Boys in 9th grade of primary school

Among boys in 9th grade of primary school, we found that 37% (N=532) of boys with extensive gaming were classified as having poor sleep, compared to 23.7% (N=698) of those without extensive gaming, with an estimated difference of 13.3% [10.9%, 15.8%] and a corresponding odds ratio of 1.89 [1.68, 2.11]. Although the estimated differences did not, with 95% probability, exceed the prespecified ROPE, boys with extensive gaming were also less satisfied with their own health and reported a higher frequency of loneliness than those without extensive gaming. Full details are presented in Table 2 and Figure 1A.

Girls in 9th grade of primary school

Among girls in 9th grade of primary school, we found that those with extensive gaming were robustly and substantially less satisfied with their own health compared to those without extensive gaming [66.5% [N=181 compared to 86.1% (N=3295)], with an estimated difference of -19.5% [-24.4%, -14.8%] and a corresponding odds ratio of 0.32 [0.25, 0.39]. Furthermore, the difference in frequency of poor sleep between those with [52.7% (N=154)] and without [35.4% (N=1430)] was also both substantial and robust, with an estimated difference of 17.4% [12.4%, 22.3%] and a corresponding odds ratio of 2.04 [1.65, 2.47]. Finally, girls with extensive gaming reported higher frequencies of ADHD, ASD, loneliness, and having tried smoking and other substances than those without extensive gaming, but these estimates did not, with 95% probability, exceed the ROPE. Full details are presented in Table 3 and Figure 1B.

Table 1. Frequency of extensive gaming, based on data collected in southern Sweden in 2016.

	Number of respondents	Valid responses (%)	Extensive gaming (%)	No extensive gaming (%)
Boys in 9th grade of primary school	4609	4401 (95.5)	1442 (32.8)	2959 (67.2)
Girls in 9th grade of primary school	4497	4363 (97)	293 (6.7)	4070 (93.3)
Boys in 2nd grade of secondary school	3945	3756 (95.2)	1054 (28.1)	2702 (71.9)
Girls in 2nd grade of secondary school	3955	3847 (97.3)	201 (5.2)	3646 (94.8)

Table 2. Extensive gaming and associated factors among boys in 9th grade of primary school, based on data collected in southern Sweden in 2016.

	N.	Extensive gaming %	No extensive gaming %	% Diff. [95% HDI]	OR [95% HDI]
Often feeling low	4227	9.4 (N=131)	8.1 (N=230)	1.3 [-0.2%, 2.9%]	1.18 [0.96, 1.41]
Often feeling anxious	4215	7.8 (N=108)	6.9 (N=195)	0.8 [-0.6%, 2.3%]	1.13 [0.9, 1.37]
Satisfied with health	3941	89.6 (N=1169)	95.4 (N=2515)	-5.7 [-7.3%, -4.2%]	0.42 [0.33, 0.51]
ADHD	4221	3.4 (N=48)	2.5 (N=70)	0.9 [0%, 1.9%]	1.39 [0.98, 1.85]
ASD	4221	2.6 (N=37)	2 (N=57)	0.6 [-0.2%, 1.4%]	1.31 [0.87, 1.79]
Poor sleep	4378	37 (N=532)	23.7 (N=698)	**13.3 [10.9%, 15.8%]**	1.89 [1.68, 2.11]
Loneliness	4360	10.4 (N=149)	7.7 (N=226)	2.7 [1.2%, 4.3%]	1.39 [1.14, 1.65]
Tried smoking	4225	32 (N=445)	30.9 (N=875)	1.1 [-1.3%, 3.6%]	1.05 [0.94, 1.18]
Tried alcohol	4284	57 (N=805)	56.1 (N=1612)	0.8 [-1.7%, 3.5%]	1.03 [0.93, 1.15]
Tried other substances	4167	6.9 (N=96)	6.4 (N=177)	0.6 [-0.7%, 2%]	1.1 [0.87, 1.34]

Diff., estimated difference; OR, odds ratio; HDI, highest density interval. Estimated differences that, with 95% probability, are above the prespecified cutoff for practical equivalence are highlighted in bold.

Table 3. Extensive gaming and associated factors among girls in 9th grade of primary school, based on data collected in southern Sweden in 2016.

	N.	Extensive gaming %	No extensive gaming %	% Diff. [95% HDI]	OR [95% HDI]
Often feeling low	4270	22 (N=63)	23.8 (N=947)	-1.9 [-5.9%, 2.4%]	0.9 [0.69, 1.12]
Often feeling anxious	4262	19.2 (N=55)	19.4 (N=770)	-0.2 [-4%, 3.9%]	0.99 [0.75, 1.26]
Satisfied with health	4098	66.5 (N=181)	86.1 (N=3295)	**-19.5% [-24.4%, -14.8%]**	0.32 [0.25, 0.39]
ADHD	4229	6.4 (N=18)	2.8 (N=110)	3.5 [1.2%, 5.9%]	2.34 [1.38, 3.38]
ASD	4216	5 (N=14)	0.8 (N=31)	4.1 [2.1%, 6.3%]	6.54 [3.3, 10.38]
Poor sleep	4336	52.7 (N=154)	35.4 (N=1430)	**17.4 [12.4%, 22.3%]**	2.04 [1.65, 2.47]
Loneliness	4336	12.4 (N=36)	5.6 (N=226)	6.7 [3.5%, 9.9%]	2.37 [1.67, 3.15]
Tried smoking	4277	42 (N=121)	32.3 (N=1287)	9.7 [4.8%, 14.6%]	1.52 [1.22, 1.84]
Tried alcohol	4315	54.8 (N=159)	55.5 (N=2233)	-0.6 [-5.6%, 4.4%]	0.97 [0.78, 1.17]
Tried other substances	4250	7.3 (N=21)	4.4 (N=173)	2.9 [0.4%, 5.5%]	1.71 [1.08, 2.42]

Diff., estimated difference; OR, odds ratio; HDI, highest density interval. Estimated differences that, with 95% probability, are above the prespecified cutoff for practical equivalence are highlighted in bold.

Boys in 2nd grade of secondary school

Our findings among boys in 2nd grade of secondary school largely mirrored those of boys in 9th grade of primary school. Of those with extensive gaming, 48.4% (N=506) were classified as having poor sleep and 84.3% (N=805) reported being satisfied with their own health, compared to 39.3% (N=1058) and 92.9% (N=2244) among those without extensive gaming, respectively, with estimated differences of 9.1% [6.2%, 12.1%] (corresponding odds ratio of 1.45 [1.28, 1.63]) for poor sleep and -8.6% [-10.8%, -6.5%] (corresponding odds ratio of 0.41 [0.33, 0.49] for being satisfied with their own health. Those with extensive gaming also reported a higher frequency of often feeling low, ADHD, and ASD, but these estimates did not, with 95% probability, exceed the ROPE. Full details are presented in Table 4 and Figure 1C.

Girls in 2nd grade of secondary school

Again, findings among girls in 2nd grade of secondary school were similar to those observed among girls in 9th grade of primary school. 62% (N=124) of those with extensive gaming were classified as having poor sleep, compared to 43.9% (N=1594) of those without extensive gaming, with a robust and substantial estimated difference of 18.1% [12.4%, 24.1%] and a corresponding odds ratio of 2.09 [1.58, 2.62]. Furthermore, 71.1% (N=128) of those with extensive gaming were satisfied with their own health, compared to 82.9% (N=2802) of those without extensive gaming, again with a robust and substantial estimated difference of -11.7%

[-17.3%, -6.1%] and a corresponding odds ratio of 0.51 [0.37, 0.66]. In addition, girls in 2nd grade of secondary school classified as extensive gamers also reported higher frequencies of ADHD, ASD, and loneliness, as well as *lower* frequencies of having tried smoking and alcohol. Still, these estimates did not, with 95% probability, exceed the ROPE. Full details are presented in Table 5 and Figure 1D.

Discussion

This study used a large, representative sample of Swedish adolescent pupils and found that extensive gaming, defined as spending more than three hours on computer and/or console gaming daily, was relatively prevalent among boys (~30% of respondents), especially when compared to girls (~5% of respondents). Furthermore, extensive gaming was robustly associated with a substantially higher prevalence of poor sleep and a substantially lower prevalence of being satisfied with one's own health. Our findings showed that the prevalence of poor sleep was between ~9% to ~18% *higher* among those with extensive gaming, whereas the number of respondents reporting that they were satisfied with their own general health was between ~6% to ~20% *lower* among those with extensive gaming. Overall, differences were greater among girls than among boys. In addition, several suspected associated factors differed reliably from zero between those with and without extensive gaming. Although these estimates were, overall, relative-

Table 4. Extensive gaming and associated factors among boys in 2nd grade of secondary school, based on data collected in southern Sweden in 2016.

	N.	Extensive gaming %	No extensive gaming %	% Diff. [95% HDI]	OR [95% HDI]
Often feeling low	3644	13.4 (N=138)	10.9 (N=285)	2.4 [0.4%, 4.5%]	1.26 [1.03, 1.5]
Often feeling anxious	3645	10.3 (N=106)	9.3 (N=243)	1 [-0.8%, 2.9%]	1.12 [0.89, 1.35]
Satisfied with health	3370	84.3 (N=805)	92.9 (N=2244)	**-8.6 [-10.8%, -6.5%]**	0.41 [0.33, 0.49]
ADHD	3637	4.2 (N=43)	2.2 (N=58)	2% [0.9%, 3.1%]	1.93 [1.31, 2.61]
ASD	3636	5.3 (N=54)	1.4 (N=36)	3.8 [2.7%, 5.1%]	3.97 [2.64, 5.5]
Poor sleep	3739	48.4 (N=506)	39.3 (N=1058)	**9.1 [6.2%, 12.1%]**	1.45 [1.28, 1.63]
Loneliness	3732	8.4 (N=88)	7.2 (N=194)	1.1 [-0.5%, 2.8%]	1.17 [0.92, 1.43]
Tried smoking	3598	55.4 (N=560)	57.1 (N=1478)	-1.7 [-4.7%, 1.4%]	0.93 [0.82, 1.05]
Tried alcohol	3650	81.8 (N=843)	83.5 (N=2188)	-1.7 [-3.9%, 0.6%]	0.89 [0.75, 1.04]
Tried other substances	3537	17.8 (N=177)	16.6 (N=421)	1.2 [-1.1%, 3.6%]	1.09 [0.92, 1.27]

Diff., estimated difference; OR, odds ratio; HDI, highest density interval. Estimated differences that, with 95% probability, are above the prespecified cutoff for practical equivalence are highlighted in bold.

Table 5. Extensive gaming and associated factors among girls in 2nd grade of secondary school, based on data collected in southern Sweden in 2016.

	N.	Extensive gaming %	No extensive gaming %	% Diff. [95% HDI]	OR [95% HDI]
Often feeling low	3788	28.1 (N=56)	27.9 (N=1003)	0.1 [-5.3%, 5.5%]	1.01 [0.75, 1.28]
Often feeling anxious	3795	25.8 (N=51)	22.3 (N=801)	3.4 [-1.7%, 8.7%]	1.21 [0.89, 1.55]
Satisfied with health	3560	71.1 (N=128)	82.9 (N=2802)	**-11.7 [-17.3%, -6.1%]**	0.51 [0.37, 0.66]
ADHD	3767	8.2 (N=16)	3.1 (N=111)	5 [1.8%, 8.2%]	2.75 [1.58, 4.09]
ASD	3767	5.1 (N=10)	0.6 (N=23)	4.3 [1.9%, 6.9%]	8.15 [3.27, 13.7]
Poor sleep	3829	62 (N=124)	43.9 (N=1594)	**18.1 [12.4%, 24.1%]**	2.09 [1.58, 2.62]
Loneliness	3839	12.1 (N=24)	4.8 (N=175)	7.1 [3.3%, 11%]	2.69 [1.7, 3.75]
Tried smoking	3756	44.6 (N=86)	52.8 (N=1883)	-8.3 [-14.2%, -2.2%]	0.72 [0.55, 0.9]
Tried alcohol	3780	74.7 (N=145)	82.2 (N=2949)	-7.4 [-12.7%, -2.2%]	0.64 [0.47, 0.83]
Tried other substances	3715	13.4 (N=25)	11.3 (N=399)	2 [-2.2%, 6.2%]	1.21 [0.79, 1.67]

Diff., estimated difference; OR, odds ratio; HDI, highest density interval. Estimated differences that, with 95% probability, are above the prespecified cutoff for practical equivalence are highlighted in bold.

ly modest, with median estimated differences below 5%, they represent factors that may be worthy of further research.

Poor sleep was the only variable shown to be consistently associated with extensive gaming. Both male and female extensive gamers in both 9th grade of primary school and in 2nd grade of secondary school showed a robust overrepresentation of poor sleep. Previous research seems to agree on the association between poor sleep and screen time in general but also to extensive gaming specifically.[30,31] The fact that insufficient sleep is associated with both mental health problems and poor academic performance makes this relationship particularly clinically relevant.[31,32] The overrepresentation was consistently greater among the extensively gaming girls (the estimated difference in the prevalence of poor sleep among extensive vs. non-extensive gamers were 13% and 9% for boys and 17% and 18% for girls). Whether female gender strengthens the adverse effect of gaming on sleep quality is to our knowledge not previously investigated and the relationship deserves further exploration.

Lee et al. showed that the prevalence of depressive symptoms, suicidal behaviour and being bullied increased steadily with increas-ing time spent on video games increased among female adolescents while the male adolescents showed the same tendency but not to the same extent.[20] Concordant with the results presented by Lee at al. our study showed that female extensive gamers were consistently less likely to be satisfied with their general health status. The male extensive gamers in 2nd grade of secondary school showed the same pattern to a lesser degree.

Marmet et al. reported on an association between game addiction and addiction to tobacco, alcohol and illicit drugs among adult men.[33] The extensive gaming girls in 9th grade of primary school showed a significantly greater prevalence of individuals who report-ed that they had ever tried both cigarettes and other substances, though not robustly so. This association was not seen among their male peers or in 2nd grade of secondary school. The female gamers in 2nd grade of secondary school showed an almost opposite pattern with a significantly reduced prevalence of individuals with the experience of both cigarettes and alcohol, still not robustly. Reasonably, an experience of cigarettes and other substances represent a more severe risk-taking behaviour the younger you are, as there is evi-
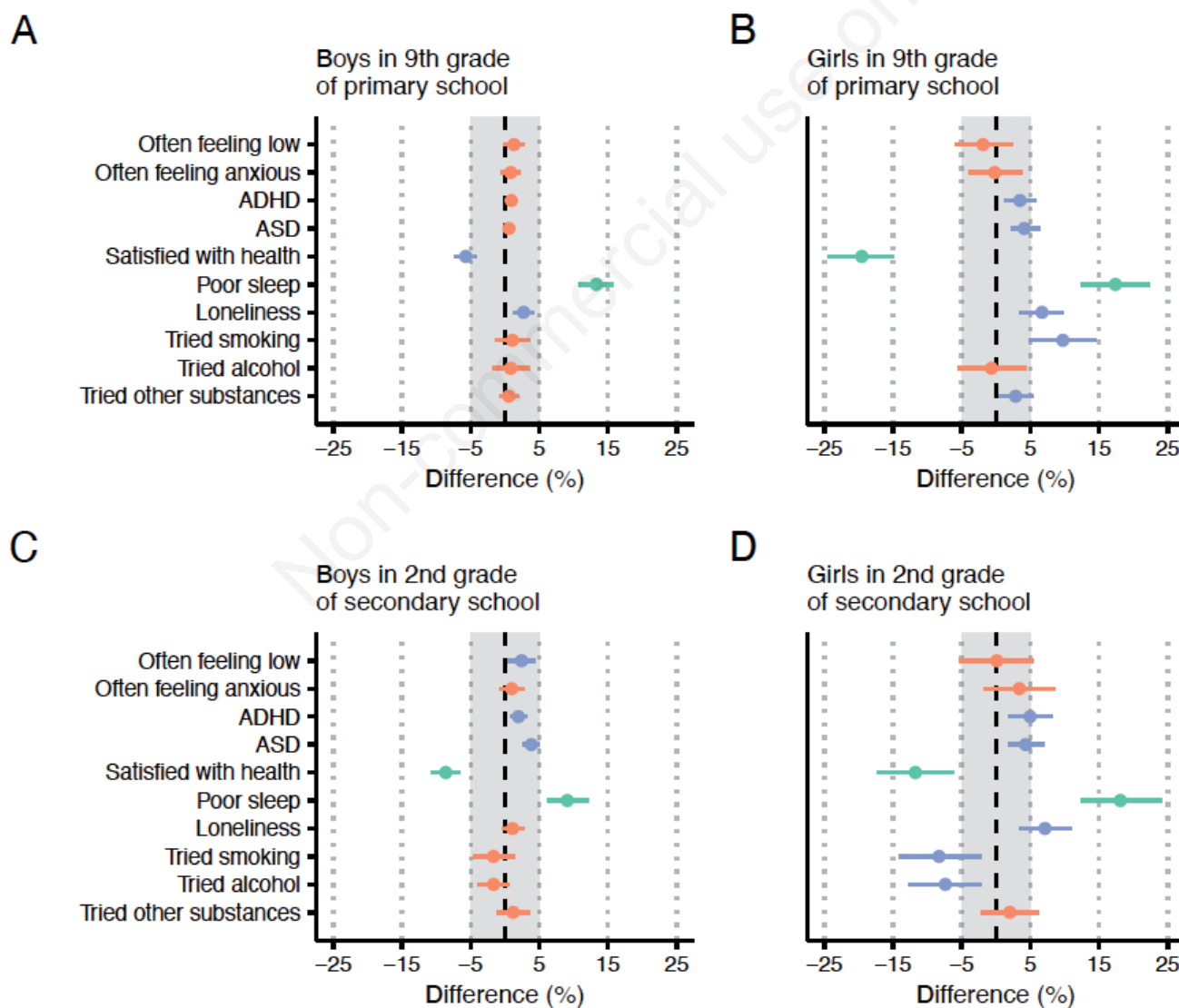

Figure 1. General health status in A) boys in 9th grade of primary school; B) girls in 9th grade of primary school; C) boys in 2nd grade of secondary school; D) girls in 2nd grade of secondary school.

dence that these kinds of behaviour are more common later in adolescence than early in adolescence.[34,35] One could further argue that you would expect that a majority of the respondents in 2nd of secondary school should report a lifetime experience of either alcohol or cigarettes,[34,35] possibly as part of a social and exploratory behaviour. If that was true, the lack of such experience seen among the extensive gaming girls in 2nd of secondary school could be considered deviating and possibly as a part of the increased degree of loneliness also seen in this group. The estimated differences were modest but noteworthy and deserves additional exploration.

ADHD is a heterogeneous childhood neurodevelopmental disorder with persistent symptoms of hyperactivity, inattention and impulsiveness that impair functioning in multiple settings.[1] The condition is recognized as relatively common in childhood with an estimated worldwide prevalence of 5 per cent (36, 37). DSM-5 lists ADHD as a comorbidity of IGD,[1] and the condition has repeatedly been reported as associated with both addictive and problematic gaming.[7,8,38] In our material, both the female and the male extensive gamers showed a disproportionate high prevalence of ADHD in 2nd of secondary school while the association was seen only among the girls in 9th grade. Yen *et al.* reported on ADHD as more heavily related to internet addiction among females than males and perhaps this applies for extensive gaming as well.[39]

Autism spectrum disorder (ASD) is a persistent and impairing neurodevelopmental disorder with an early onset.[40] ASD is one of the most common developmental disabilities, characterized by deficits in social interaction, communication and stereotypic behaviour.[41] Previous research describes an association between ASD and gaming, suggesting a greater risk for pathological game use among ASD individuals.[11] Furthermore, it has been hypothesized that the behavioural phenotype of ASD make ASD individuals more vulnerable for problematic gaming but also that an extensive gaming might aggravate ASD related difficulties, such as social capacity or educational success, perhaps as a consequence of the displacement of time that could be spent on social or educational activities.[12] The research on potential gender discrepancies is scarce at best and a great proportion appears to focus on boys with autism only.[4,11] Interestingly, in our material, the female extensive gamers in both grades showed an overrepresentation of self-reported ASD. ASD was also more common among male gamers in 2nd of secondary school but not in the 9th grade of primary school. The relationship and potential consequences thereof need to be further examined to be fully understood and whether girls with autism could be more vulnerable for pathological gaming than boys, is a relevant question for future research to answer.

Problem gaming is usually described as an introvert behaviour and addictive gaming has been coupled to both loneliness, social phobia and low social competence.[7,8] Both the male and the female extensive gamers in 9th grade of primary school were concordantly more likely to report that they had no close friend at all. In 2nd grade of secondary school, only the extensively gaming girls were more likely to report on the absence of a close friend. Our results suggest that the female extensive gamers are more likely to be lonely than the male extensive gamers. Such gender bound discrepancy could not easily be found in the literature and warrants additional investigation.

These results should be considered within the limitations of the present study. The measures we used for this study were all based on self-reported data and the accuracy could be limited by recall bias. The generalizability could be limited by diverse motivation to engage in answering questionnaires among different groups.[42] Also, the current study presents cross-sectional data, which precludes conclusions of causality; this would require longitudinal investigation.

With these limitations in mind, the present study explores a large, representative and population-based material with a relatively high response rate limiting the risk of selection bias. Also, the Bayesian approach facilitates genuine probabilistic findings and the application of the ROPE procedure as a guide to determine which effects may be of clinical and/or practical importance offer further robustness to our findings.

Conclusions

The current study provides an exploration of extensive gaming in a large representative sample of adolescents. Extensive gaming was found robustly associated with a substantially higher prevalence of poor sleep and a substantially lower prevalence of being satisfied with one's own health. Other associated factors varied by gender and age as well as regarding robustness and size of the estimated difference. Altogether, our results contribute to an impression that extensive gaming is more heavily related to subjective health complaints among female than male adolescents.

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