Adolescent sleep duration and quality:
analyzing the conjoint associations of gaming, anxiety and depression

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Tiivistelmä – Referat – Abstract

Aims: Adolescent sleep is impacted by numerous biological, psychosocial and contextual factors. The sheer number of new elements capable of affecting adolescent sleep has grown steadily, most notably the amount of electronic devices available. In this adolescent-based sample, we first seek to characterize, and secondly investigate the relationship between gaming, and adolescent sleep, depression and anxiety.

Methods. Total of 1374 respondents, aged from 15 to 17 years of age, provided sufficient data in SleepHelsinki! Helsinki university research project. The associations between study parameters were analyzed using correlational comparisons and canonical correlations. Gender differences were also evaluated. The relationships between gaming, sleep, depression and anxiety were further studied using mediation model.

Results and Conclusions. In our study the adolescents sleep duration averaged 7:10 hours (SD 1:07) which is well under the recommended amount 8-9 hours of sleep per night. Severe restriction of less than 6 hours of sleep existed in 17.3% of respondents. Negative associations between sleep duration and sleep quality were established on depression, anxiety, chronotype, gaming and alcohol consumption. Positive connections were found between good self-control and sleep hygiene. Girls fared systematically worse than their male counterparts: significantly having more severe sleep restrictions, longer sleep onset latency, worse sleep hygiene and sleep quality. The gaming addiction score was found to mediate the effect of both depression and anxiety on total sleep time. The hours of gaming also mediated the effect of anxiety, but not depression. This study confirms many findings indicating both risk factors and protective factors regarding adolescent sleep. The gaming is established as an integral component when examining adolescent sleep – it should be studied in unison with particularly anxiety and depression symptoms.

Avainsanat – Nyckelord – Keywords

Adolescent, sleep, gaming, anxiety, depression

Säilytyspaikka – Förvaringställe – Where deposited

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Tiivistelmä – Referat – Abstract

Tavoitteet. Nuorten uneen nykypäivänä vaikuttavat lukuisat biologiset, psykososiaaliset ja kontekstuaaliset tekijät. Kontekstuaaliset tekijöistä tietotekniikan kehityksen myötä ovat tulleet elektroniset laitteet ja niiden moninaiset käyttömahdollisuudet, kuten pelaaminen. Tässä lopputyössä aluksi luokitellaan ja määritellään aineisto, jonka jälkeen tutkimme yhteyksiä nuorten nukkumisen, pelaamisen sekä masennus- ja ahdistusoireilun välillä.

Menetelmät. Helsingin yliopiston SleepHelsinki! tutkimusprojektin osana olleessa internetpohjaisessa kyselyssä selviteltiin uneen, terveyteen ja käyttäytymiseen liittyviä muuttujia. Kyselyn kokonaan suorittaneita vastaajia oli 1374, ikäväliltä 15 - 17 vuotta. Yhteyksiä kartoitettiin korrelaatiovertailuilla ja kanonisilla korrelaatiolla. Myös sukupuolen vaikutus selvitettiin. Pelaamisen ja unen, sekä ahdistus- ja msennusoireilun yhteyksiä selvitettiin lisäksi mediaatioanalyysillä.

Tulokset ja johtopäätökset. Tässä aineistossa nuorison keskimääräinen uniaika oli 7:10 tuntia (kh. 1:07), joka on selvästi alle suositusten (8-9 tuntia yössä). Vakava univaje on alle 6 tuntia unta yössä, tähän luokkaan kuului 17.3% vastaajista. Unen keston ja laadun kanssa negatiivisessa yhteydessä olivat masennus- ja ahdistusoireilu, kronotyyppi, pelaaminen ja alkoholin käyttö. Positiiviset yhteydet löytyivät hyvän unihygienian ja hyvän itsekontrollin kanssa. Tytöillä löydökset olivat systemaattisesti huonompia: tilastollisesti tytöillä oli enemmän vakavaa univajetta, pidemmät nukahtamisajat sekä huonompi unihygiena ja unenlaatu kuin pojilla. Ongelmallista pelaamista mittaavan kyselyn tulos välitti sekä masennus- että ahdistuoireilun tulosta kokonaisuniaikaan. Pelaamiseen käytetty aika välitti ahdistusoireilukyselyn tulosta, mutta ei masennusoirekyselyn tulosta. Tämä tutkimus vahvistaa monia nuorison unen riskitekijöihin ja suojaaviin tekijöihin viittaavia löydöksiä. Pelaamisen vaikutus nousee selvänä löydöksenä esiin arvioitaessa nuorison unta – sitä tulisi tutkia yhdessä erityisesti ahdistus- ja masennusoireilun kanssa.

Avainsanat – Nyckelord – Keywords

Nuoriso, uni, pelaaminen, ahdistus, masennus

Säilytyspaikka – Förvaringställe – Where deposited

Muita tietoja – Övriga uppgifter – Additional information

Contents

1. Introduction

In this thesis we examine the complex interrelationships between gaming, alcohol and sleep in adolescents. We will begin with reviewing the findings from current research. As the technology advances in an unprecedented speed, it is especially difficult to keep track of, and to evaluate all the factors affecting today's adolescents and their sleep. We review research defined protective and risk factors regarding adolescents sleep. Also briefly reviewed is the Biopsychosocial and contextual model of sleep in adolescence, and the model presenting potential impact of electronic media on sleep. The overall focus is on contextual factors, and especially in gaming, as defined by use of any game capable device (i.e. smartphone, videogame console, or computer).

1.1 Normal sleep delay in adolescence

Adolescence consists of the time period between ages 10 through 19. It marks the time in which a person's individual lifestyle and structures are initiated and evolved (Mak et al., 2014). National Sleep Foundation has guidelines which recommend 9 hours of sleep per night as optimal amount (Becker, Langberg, & Byars, 2015; Mak et al., 2014), and 8-9 hours as borderline sufficient during this developmental time (King, Delfabbro, Zwaans, & Kaptsis, 2014). Insufficient sleep is under 8 hours (Mak et al., 2014), and severe restriction of sleep can be considered when sleep time is less than 6 hours per night (Bartel, Gradisar, & Williamson, 2015). Lifestyle can be defined as a set patterns of behavior, based on one's personal characteristics, and socioeconomic and environmental factors (Mak et al., 2014).

Change in sleep patterns is considered normal part of adolescence. The most common is a general shift to later bedtimes, and more activity in the evening (Bartel et al., 2015; Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, & Grob, 2014). This delay in bedtimes and total sleep time is thought to be due to natural biological maturation, and due to the environmental factors (Arora, Broglia, Thomas, & Taheri, 2014; Lemola et al., 2014). For students this can results in sleep deprivation on weekdays and more sleeping on weekends. As for environmental factors, the most pronounced effect of late has been the somewhat dramatic increase in electronic media use; both in general, and before bedtime especially for pre-teens and adolescents. Adolescence is also considered to be time of heightened risk taking as the maturation of socio-emotional brain areas is somewhat lacking, thus ensuing in deficiency in cognitive control and excessive thrill-seeking (Smith, Gradisar, King, & Short, 2017). The average sleep time at age 16 is 8.1h, compared to 9.6h at age 11 and 11h at age 6 (Cain & Gradisar, 2010). Over time the total sleep duration also seems to decrease compared to previous generations; however, in controlled studies (Stanford sleep camp studies) where adolescent had the opportunity to sleep "enough", no differences in sleep duration was found in adolescents in different ages or pubertal stages (Cain & Gradisar, 2010); so there is definitely more than meets the eye in our research topic.

1.2 Sleep factors

A Biopsychological and contextual model of sleep has been proposed as an increasingly popular model for studying sleep in adolescence (Becker et al., 2015). It considers sleep to be interwoven result of biological psychosocial and contextual factors of adolescents' lives, both currently and across lifespan to date. The often referenced model is presented in Figure 1.

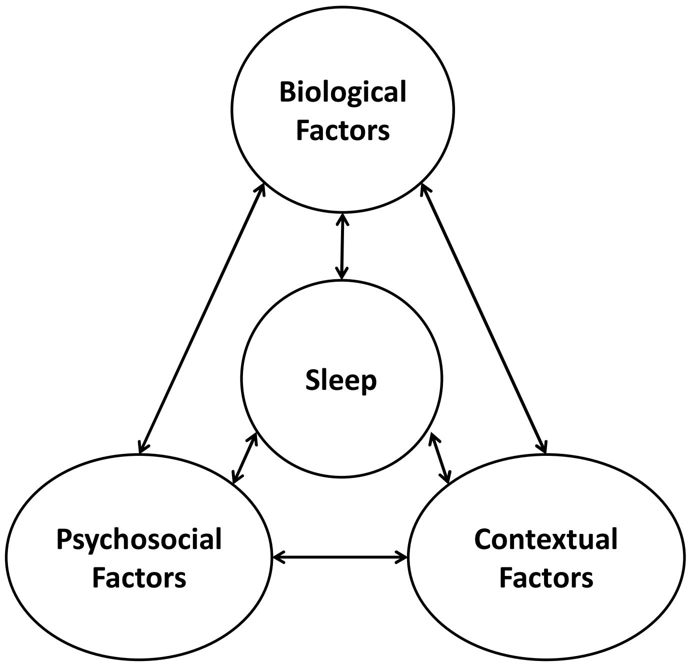

Figure 1. Biopsychosocial and contextual model of sleep in adolescence (Becker et al. 2015).

Biological factors include the aforementioned various biological changes and maturations during developmental stages including and leading up to adolescence. These changes have profound effect on sleep architecture. It has been proposed that some of the effects are slower accumulation of sleep pressure (i.e. the need to sleep), the general shift and preference to *eveningness* (a preference for later sleep-wake timing). One finding reported typical adolescent preference for summer sleep schedule to be from 3:00 to midday (Becker et al., 2015).

Psychosocial factors are thought to comprise of social relationships of family members, peers, and academic (school) environment. Mental health and psychological functioning are also included.

Family environment is integral in comprehending sleep factors; attachment style has also been considered to be integral. A noteworthy finding is that parents sleep quality has been found to correlate with adolescents sleep quality. Another finding proposes connection with eveningness and parent-teen conflicts. The parent set bedtime diminishes rapidly, and at age 13 it is merely 33%, and at 18 it is non-existent (Becker et al., 2015). *Contextual factors* are our topic of interest in this thesis, and we will review them more thoroughly. In general, contextual factor consists of the events or activities which take place close to bedtime, such as electronic media use and electronic media multitasking. Homework, extracurricular activities and possible employment are also included. Increasing amount of evidence links excessive homework with various sleep disturbances. Similar findings have been reported on part time employment, which results in shorter sleep duration, greater daytime sleepiness and sleep rebounds on weekends. Extracurricular activities in turn are linked with shortened sleep. It is important to bear in mind that some factors, such as peer contacts and extracurricular activities can also function as protective factors (Becker et al., 2015).

Protective and risk factors

In their meta-analysis Bartel, Gradisar & Williamson (2015) have reviewed protective and risk factors for adolescent sleep. They identified 20 factors from 41 articles included in final analysis. Three different measurements were required, Bedtime (BT), Sleep Onset Latency (SOL) and Total Sleep Time (TST) (Bartel et al., 2015). Systematic reviews show accumulating systematic evidence indicating that electronic media use during adolescence is connected most to later bedtimes, shorter total sleep, and sleep disturbances (Cain & Gradisar, 2010; Lemola et al., 2014).

The identified factors are listed in Table 1 (Bartel et al., 2015). Mean weighted R's in the table are correlations, where individual correlation within a study is weighted by the number of person in the same study. As factor increases bedtime becomes earlier, sleep onset latency lengthens and Total Sleep Time increases. Thus for instance, (good) sleep hygiene correlates with increase in total sleep time, earlier bedtime and shorter sleep onset latency. In this context, sleep hygiene can be defined as distinct set of behaviors that promote and support healthy sleep (Gradisar & Short, 2013).

Table 1.

Mean weighted r between protective/risk factors and Bedtime, Sleep Onset Latency and Total Sleep Time (Bartel et al., 2015).

		Mean weighted r's	
Variable	Total sleep time	Bedtime	Sleep onset latency
Tobacco	*-.183*	-.183	-.015
Computer use	*-.157*	*.148*	.040
Evening light	*-.138*	*.169*	-.029
Negative family environment	*-.133*	*.103*	*.243*
Alcohol	-.123	-.156	-.029
Caffeine	*-.116*	.074	-.015
Phone use	-.104	*.131*	.039
Internet use	-.087	*.212*	.080
Homework	-.076	.038	-.016
Work	-.062	.066	.010
Video gaming	-.059	*.120*	.031
Televisio	-.059	.041	.010
Extracurricular activity	-.054	-.049	-.025
Pre-sleep worry	-.030	.091	.137
Latitude	-.019	.099	.072
Time spent with peers	.014	-	-
Longitude	.070	-.097	.086
Physical activity	.118	**-.137**	-.081
Sleep hygiene	**.200**	**-.172**	**-.172**
Parenteset bedtime	**.218**	-.143	.014

note. bold = protective factors (i.e., factors where r < └.1 and CI does not overlap 0)
italicized = risk factors (i.e., factors where r > .1 and CI does not overlap 0).

To summarize, earlier bedtime was associated with good sleep hygiene and physical activity; later bedtime with evening light, internet use, computer use, phone use and video gaming (Bartel et al., 2015). Sleep onset latency correlated also with good sleep hygiene, and reversely with negative family environment (Bartel et al., 2015) Sleep duration was related to good sleep hygiene and parent-set bedtimes and decreased sleep duration was related to tobacco use, computer use, evening light, caffeine use and negative family environment (Bartel et al., 2015). In conclusions, good sleep hygiene was related to all three parameters: Total Sleep Time, Sleep Onset

Latency, and Bedtime. The breakdown of technology types showed only computer use to be related to less total sleep, however all media use resulted in later bedtime, albeit in small effects.

Electronic Medias Effect on Sleep

It is fair to say that electronic media has thoroughly pervaded modern life, especially in the case of adolescents. An often cited source of National Sleep Foundation's surveys in 2006 and 2011, reports almost all adolescents (97%) having one or more electronic device in their bedrooms, and 95% using electronic media within an hour before bed (Becker et al., 2015; Bruni et al., 2015). In their systematic literature review Hale & Gaun explored the adolescent sleep quality associated with screen time. Screen time is considered an environmental (contextual) source, as opposed to biological and psychosocial causes. Their review included 67 studies (of which 8 were also in Bartel, Gradisar & Williamson's meta-analysis) with same parameters: Bedtime (BT), Sleep Onset Latency (SOL) and Total Sleep Time (TST) (Hale & Guan, 2015). At this point it should be noted that screen time is becoming somewhat blurred concept. For instance, when using a mobile device, one can spend dubious amounts of time waiting for a certain response, or checking for new messages/mails etc. which there is none. Self-reported screen time also has its problems due to multiscreening: added total time for different sources have been found to exceed reported screen time use, which clearly indicates habit of using multiple screens, and the difficulty of reporting correct viewing amount for each screen and for total use (Mak et al., 2014). The self-report format still seems to be the most common method of research, due to its low cost and convenient way to reach large sample sizes.

The adverse effect of *television viewing* prior bedtime has been widely studied, with consistent findings indicating prolonged Sleep Onset Latency, Delayed Bedtime and decreased Total Sleep Time (Cain & Gradisar, 2010). In Hale & Gaun's review (2015), in 78% of the studies examined television watching was associated with either delayed bedtime or shortened total sleep time (Hale & Guan, 2015). An interesting finding in Bartel, Gradisar & Williamson's (2015) meta-analysis was that TV in itself - whilst considered a passive source - was not found to affect sleep adversely, at least in comparison to interactive screen sources. However, Hale & Guan's (2015) more in-depth look into some of the studies revealed similar conclusions as Bartel et al.: the adverse effects are mediated by multi-screen action and the presence of television in the bedroom (Bartel et al., 2015; Hale & Guan, 2015). As not all studies have shown deleterious consequences, the proposed explanation is the sedentary effect which TV can provide before bedtime; it can help de-arouse adolescents as a preparation for sleep (Gradisar & Short, 2013).

In Hale & Guan's review (2015) c*omputer use* related to shortened total sleep time in all studies examined; however more in-depth comparison is difficult due to the wide array of questions and definitions used (Hale & Guan, 2015). *Video gaming*, as defined as some form of screen based game playing, was associated with detrimental effect to TST and delayed bedtime in 81% of the studies analyzed. Common moderators were the age of the participant and the day of the week; effects were stronger on older participants and on weekends (Hale & Guan, 2015). The findings are somewhat in contrast with the Bartel et al. (2014) meta-analysis that reported no significant connections with video-games and total sleep time. A more consistent finding in both reports is delayed bedtime. *Mobile devices* were related to at least one detrimental sleep outcome in 83% of the studies, with three studies demonstrating no association. Common association was to wither decreased Total Sleep Time or delayed Bedtime. Adverse connections were also found between perceived tiredness (Hale & Guan, 2015). The rapid development of mobile phones and their increased capabilities is sure to be one source of inconsistencies in reported findings.

Multiscreening i.e. using various screen sources simultaneously was reported to have significant association with decreased Total sleep time in 8 of the 9 reviewed articles. The trend of "screen-stacking" is likely to increase due the swift development of devices. A recent finding suggested that as much as half in evening television viewers are simultaneously using another screen, such as mobile phone or laptop (Hale & Guan, 2015). A population-based study on Norwegian population indicated an increased risk of Sleep Onset Latency when using multiple devices. The Odds ratio (a measure of association between an exposure and an outcome) for sleep deficiency for multitasking with 2-3 devices was 1.5, and for four devices or more 1.75 in contrast of using only one device. The Odds ratio for sleeping less than five hours was from 2.2 to 2.8, in contrast to using only one device (Hysing et al., 2015). One study suggested an estimation for the proportion of multiscreening: 30%, based on discrepancies between total screen time and total calculated device screen time (Mak et al., 2014). *Social networking* is often not distinguished from computer use or mobile device use. In one instance where such differentiation was made, results showed greatest decrease in sleep duration for those who often/usually use social networking services before bedtime. The reduction in Total Sleep Time was almost 1 hour (Arora et al., 2014).

1.3 Health related complaints

For most mammals, sleep is a paramount health factor, one which has potential to be greatly influenced by various environmental, intrinsic and extrinsic factors and addictions (Paiva, Gaspar, & Matos, 2015). Physical activity and screen viewing are other common lifestyle patterns which greatly affect adolescent health and well-being (Mak et al., 2014). Although the importance of sufficient amount of sleep and physical activity is well-established, in many countries the majority of adolescents fall below recommended level (Mak et al., 2014). The era of technology has brought its own challenges: the term techno-stress has emerged, to describe stress reactions in relation to computer and media use (Thomée et al., 2012). Sleep deprivation has been studied both experimentally and epidemiologically for decades. The consensus is that overall sleep deprivation strongly impairs human functioning.

Regarding mental health, it would seem that sleep problems do not predispose to any one specific mental health problem, but rather introduce the risk for a range of mental health outcomes, defined as multifinality in developmental psychopathology (Becker et al., 2015). One study, which strength was longitudinal design, found prospective connections between computer use and several mental health outcomes; though many inconsistencies existed as well. It also proposed that some associations are enhanced in interaction with mobile phone use (Thomée et al., 2012). However, direct connections have also been studied between sleep problems and anxiety, and between sleep problems and depression, specifically. In a study examining reciprocal associations between shortened sleep and anxiety disorders, consistent short sleep predicted increased anxiety disorders while baseline anxiety was controlled; however baseline anxiety disorder did not predict shortened sleep (Roberts & Duong, 2017). In another study, subjective sleep disturbance was found to prognosticate the development of generalized anxiety disorder (Cox & Olatunji, 2016). Well-known connection between sleep problems and depression was examined in one study with statistical causal-discovery algorithms: in minor depression/dysphoria, depression did not cause sleep problems to a same degree as sleep problems produced depression (Rosenström et al., 2012).

In one study sleep deprivations correlation with various physical health complaints were evaluated (Paiva et al. 2015). Sleep deprivations were linked with reduced health-related quality of life, and with perceived health-related quality of life as well as perceived physical and mental health. The study also established connections with sleep deprivation and headaches, fatigue, irritability, nervousness, dizziness and neck and shoulder pains. Researchers also reported earlier findings in which bedtimes are associated with various health hazards, such as depression, accidents, various pains, anxiety, tantrums and headaches. (Paiva et al., 2015).

Another study focused on videogame addiction, sleep deprivation, obesity and cardio-metabolic deficits (Turel et al. 2016). Curtailed sleep was negatively associated with obesity, and researchers suggest sleep curtailment as possible full mediator between videogames, obesity and the associated cardio-metabolic deficits; which is in-line with several meta-analyses they have reviewed. (Turel, Romashkin, & Morrison, 2016) .

Lemola et al. (2014) examined smartphone use versus regular mobile phone use, and it's associations with sleep disturbances and depressive symptoms. Due to their compact size and usability when lying down, smartphones are especially convenient to use when already in bed. For both sleep disturbance and depression the abundant electronic media use can be identified as a predisposing factor. Smartphone was linked to more media use in the evening in contrast to adolescents with a regular mobile phone.

Electronic media use had a negative effect on sleep duration, and negative effect on sleep overall, which in turn resulted in more depressive symptoms *(Lemola et al., 2014).* However, no differences in total sleep difficulties or depressions symptoms were found between groups, which points to an interpretation that emphasizes the importance of *when*, *how much* and *how often* electronic devices are used (Lemola et al., 2014). Another study pointed out a relevant fact regarding any kind of mobile phone in bedroom: adolescents who reported being woken up at least sporadically by incoming calls or text messages were markedly more tired than their counterparts, who were never woken up by phone activity (Cain & Gradisar, 2010).

In sum, technology use resulting in sleep curtailment can be identified as one indirect driver of poor physiological health and with perceived poor condition. Alternate explanations include pressure from school and budging social life, which can as well deteriorate health and well-being (Paiva et al., 2015)

1.4 Video gaming, video game addiction and alcohol consumption

An interesting focus has been the effect of video gaming on sleep. Considered being a prevalent form of entertainment for boys in western industrialized countries, boys have been systematically reported playing more than girls (Thomée et al., 2012), and at least 75% of boys report playing video games every week (King et al., 2013). Pre-sleep video gaming has been linked with various detrimental effects on sleep. Cross sectional research reveal later bedtimes on school nights and weekends, less total sleep, increased sleep onset latency, later wake-up times and greater daytime sleepiness, and heightened physiological arousal; however experimental studies have been scarce (Gradisar & Short, 2013; Weaver, Gradisar, Dohnt, Lovato, & Douglas, 2010; Wolfe et al., 2014). Documented risks also include video game addiction, aggressive behavior, attention problems, depression and anxiety, reduced empathy and impaired social functioning (King et al., 2013). Another aspect to acknowledge is accessibility, defined as the number of (game capable) devices adolescent has access to. Accessibility has been named as strong predictor for the amount of time an adolescent spends to play video-games (Smith et al., 2017). Longitudinal study has indicated connections with pathological gaming and predicted higher levels of depression, anxiety, social phobia and poor school performance (Thomée et al., 2012). Video game addiction can be defined as maladaptive psychological dependency. This results in impaired normal functioning, and can lead to detrimental effects on individuals health and social functioning; one estimation places 2-30% of gamers with serious addiction indicating symptoms (Turel et al., 2016). Persistent pattern of maladaptive Internet video-gaming has been included in the appendix of DSM-5 as internet gaming disorder since May 2013 (King et al., 2014). It is suggested, that pathological use disposes to greater risks of sleep-related problems than non-pathological use (King et al., 2014)

Video games and sleep

The specific relationship on video game playing and subsequent night's sleep has been the focus in several interesting recent studies (Wolfe et al. 2014; King et al. 2012; Weaver et al. 2010). Experimental studies are paramount in establishing cause-and-effect relationships between video games and sleep (King et al., 2013). In a study of single night video-game use significant correlations were found between time spent video gaming, and with sleep and sustained attention (Wolfe et al., 2014). Sleep duration had also significant negative correlation with sustained attention, but not with working memory (Wolfe et al., 2014). Weaver et al (2010) also had control group that watched DVD prior bedtime, versus playing a 3rd person shooter game. Significant differences were observed between groups on sleep onset latency, subjective estimation of sleepiness and in cognitive alertness. No effect between groups were observed in physiological arousal or in sleep architecture (Weaver et al., 2010).

King et al. (2012) compared prolonged gaming sessions with a regular gaming sessions in a cohort of regular video gamers with no reported sleep difficulties. They argue, that low level of exposure used in some studies (less than 60 minutes) may be insufficient level of exposure (King et al., 2013); similar statements have been made regarding the level and experience of gamer (Lemola et al., 2014). In this study participants had two testing sessions, one week apart, with 50 minutes and up to 2,5 hours of gameplay (Warhammer 40k: Space Marine!); along with sleep diary before and between sessions. Moderate effect size was observed for total sleep time, decreased sleep efficiency and for subjective sleep on-set latency. Despite moderate effect size, no statistical significance was found. Measured in minutes or as percentage spent in sleep phase, slow wave sleep had also small effect, and REM sleep almost moderate effect (King et al., 2013). Participants reported lower satisfaction levels in gaming after shorter session; after shorter sessions the desire to game more (for 37 min.) was more than twice than after a long session, a finding that/which could indicate that there is unlikely to be any efficient self-limiting models in place to control gaming length (King et al., 2013).

In summary, as prolonged video-gaming results in reduced sleep time, one can conclude that long-term or subsequent nights gaming is likely to result in cognitive and health deficits associated with persistent sleep reduction. Accumulating evidence suggests video gaming especially affects Bedtimes, Sleep Onset Latency and Total sleep Time (Gradisar & Short, 2013).

Gaming addiction and alcohol

A very under researched area affecting adolescent sleep quality is the combined effect of problematic video gaming and alcohol use. Regular alcohol use and binge drinking emerge in adolescence, along with other risk taking behaviors, such as substance use (Touitou, Touitou, & Reinberg, 2016). Problematic Video Gaming (PVG) (preferred naming as we are focusing on adolescents instead of pathological gaming) is often viewed as risky behavior, with various problems associated with it (van Rooij et al., 2014). Also an abundant amount of cross-sectional data has linked eveningness and later bedtimes with greater at-risk alcohol consumption and greater bingeing (Hasler et al., 2017). One of the very few longitudinal studies on the subjects suggests that eveningness can predict escalation in alcohol use; thus sleep timing may be more emphatically linked to substance use than other factors affecting adolescent sleep (Hasler et al., 2017).

The aforementioned internet gaming disorder (IGD) remains the only uniformly used measure for gaming addiction. In one study similarities were found between Internet gaming disorder and alcohol use disorder, notably in trait impulsivity and response inhibition (Choi et al., 2014). Modest proposal is that neurocognitive characteristics may overlap in these addictive disorders (Choi et al., 2014; van Rooij et al., 2014). However, focusing on one specific game type has been considered premature, as game types often overlap as much as 63% (van Rooij et al., 2014).

The co-occurrence of problematic video gaming and substance use (substance use defined as alcohol use, smoking cigarettes or use of cannabis) has been the focus of very few studies, even though substance use and video gaming is rather common among adolescents today (van Rooij et al., 2014). One study reported 92.1% teens playing video games and 17.7% having problematic use of video games; substance consumption was frequent in 19.8%, and 8.3% having problematic use of substances (Coëffec et al., 2015); which is in line with literature. Problematic video gaming is most often, but not by any means exclusively, associated with online multiplayer games. Generally boys are more prone to play multiplayer online games (60%) than girls (14%), and problematic gamers were also more frequently boys (5%) than girls (1%); thus gender plays evident role (van Rooij et al., 2014).

More or less systematic findings state those playing regularly are reported using significantly more alcohol, and those with problematic video game use started substance use earlier; however research on the subject has reported controversial findings (Coëffec et al., 2015; Desai, Krishnan, Cavallo, & Potenza, 2010). For instance, in girls, gaming was found to correlate with not drinking at all. (Desai et al., 2010). One study focusing on the co-occurrence of problematic video gaming and substance, use reported problematic video gaming associated with four times more likely with online gaming than regular gaming. Also alcohol drinkers were twice as likely to score high on problematic video gaming. (van Rooij et al., 2014) In the same study, high problematic video game use was linked with more psychosocial problems, depressive mood and higher substance use. Again, this study provides some evidence for the underlying vulnerabilities that make adolescents susceptible and predisposes to both forms of risky behavior (van Rooij et al., 2014).

With most of the data being cross-sectional by nature, it cannot be determined how reported interactions between alcohol, problematic video game use and psychosocial problems work. Problematic video gaming, according to literature, is probably an outcome as well as the cause: psychosocial problems often result in preference of online interactions, and greater amounts of gaming in turn can lead to increased depression, anxiety and lower school performance (van Rooij et al., 2014). Currently, health-correlates with gaming and its relationships with alcohol use or depression remain incompletely understood; also the effect of gender on both gaming and its clinical correlates is inadequately understood (Desai et al., 2010).

1.5 Potential Mechanisms

All three meta-analyses discussed above identify key operating mechanisms. *Time* displacement is simply/straightforwardly more time in front of screens equals less available sleep time. *Physiological and psychological arousal* results due to the content of the media, and as a results of social interaction. Lastly, the *effect of light* on both general alertness and circadian rhythm (Bartel et al., 2015; Cain & Gradisar, 2010; Hale & Guan, 2015). These are in line with the often referenced model first proposed by Cain & Gradisar (2010) in their review of electronic media use and sleep in school-aged children and adolescents. In a thorough assessment of the role of technology on sleep hygiene and environment, Gradisar & Short (2013) review the model and potential mechanisms explaining the relationship between sleep and technology. The model is presented in Figure 2.

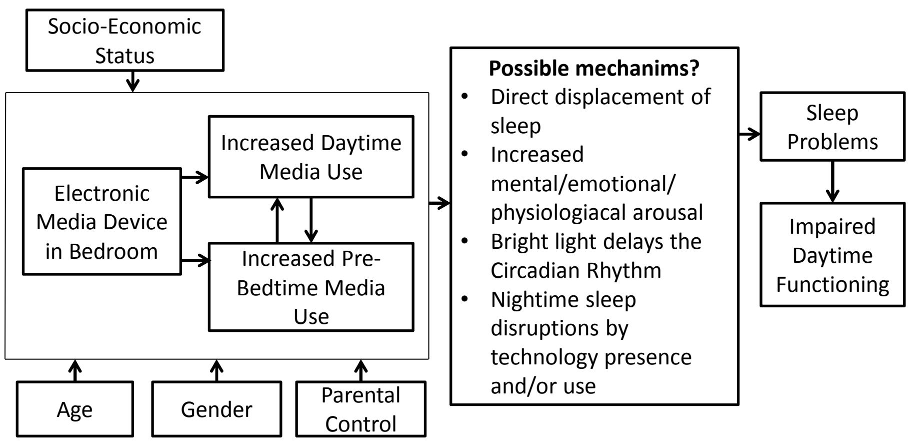

Figure 2. A Graphical representation of the potential impact of electronic media on sleep (Cain et al. 2010; Gradisar et al. 2013).

The displacement mechanism is somewhat straightforward in its impact on delayed bedtime, however its ability to explain why technology use would prolong Sleep Onset Latency remains inadequate (Gradisar & Short, 2013). Arousal is quite a plausible mechanism in impeding Sleep Onset Latency and also directly shortening sleep. This would be a particularly potential mechanism in younger adolescents, when combined with developmentally inappropriate material, such as suspenseful, violent or adult content. Amounting evidence is indeed pointing in the direction of content being an important factor in this mechanism (Gradisar & Short, 2013). Although generally accepted, the effect of light has not been directly examined. Firstly, the technology device would have to be able to except sufficient amount of light, on proper luminosity/intensity, for long enough time and on right wavelength. Secondly, the combination with ambient light levels is always unique. Modern technology devices can have light-saving modes or are generally radiating low-intensity light, so more research is needed to verify the potential of this mechanism (Gradisar & Short, 2013). While reviewing the model on potential mechanisms Gradisar & Short (2013) added sleep interruption as a potential mediating mechanism. In an everyday example the adolescent could be already in bed, perhaps just fallen asleep, when incoming message/email/notification results in awakening. This interruption can require response, which can lead to waiting for response's response etc. In one study, as many as 1 in 5 were woken by incoming message 1-4 times per month and 1 in 10 was woken at least once a week. While sleep interruptions can also happen spontaneously, the availability of technology can then turn the break in sleep into technology use, instead of an attempt to resume sleep. It has been reported that as many as 35% of those that are awake during night engage in some form of electronic media use. Inherently this has been made possible by access to various devices directly or almost directly from bed (Gradisar & Short, 2013).

Moderating factors

Moderating factors presented in the model: age, gender, parental control and socio-economic status (SES) have also been increasingly studied (Gradisar & Short, 2013; Paiva et al., 2015; Smith et al., 2017). accumulating age in adolescence results in more cell phone use, especially after lights out, more electronic devices in the bedroom, and more screen time (Gradisar & Short, 2013). The gender differences are quite well established. Boys generally are likely to play more video games and have a game console in their bedroom (Cain & Gradisar, 2010; King et al., 2014). They also use more internet, computers and have more screen time compared to girls; who are more likely listen to music and use cell phones (Gradisar & Short, 2013; Hysing et al., 2015). Markedly computer use has shown inconsistent findings (Gradisar & Short, 2013). Gender differences seem to emerge in the transition between preadolescence and adolescence (Bruni et al., 2015). Uniform findings regarding SES show associations between higher SES and less media use. Adolescents with higher SES (background) also have less overall screen time, and are less likely to have television in bedroom, or to use TV or computer as a sleep aid (Gradisar & Short, 2013). Another consistent findings is better sleep quality, greater ease of falling asleep and greater total sleep time (Gradisar & Short, 2013; Hasler et al., 2017). Parental control, it has been suggested, may co-vary with electronic media use and with sleep. A common method for parental limit setting is set bed times and supervised times and amount of media use. A proposed view states that diminished or total lack of parental control may lead to excessive technology use and increased sleep problems, such as bed resistance and less total sleep (Gradisar & Short, 2013; Smith et al., 2017) Parental regulation has been shown to be helpful, as various studies show parental set bedtimes associated with longer sleep duration (Bartel et al., 2015). According to previous studies, parental regulation is rare or non-existent at 75% of the time (Smith et al., 2017).

The proposed mediating mechanisms between health problems and/or depressive symptoms is at least partly mediated by the sleep disturbances, with or without other sleep difficulties; but no so much by total sleep duration (Lemola et al., 2014; Turel et al., 2016). The proposed models are often based on the theoretical model propose by Cain and Gradisar (2010), as presented earlier in Figure 2.

Mediating the effect of video games

The proposed mechanisms that impair sleep and results from video gaming specifically, focus on the stimulating nature on video games. As one is constant interaction with the screen, it can result in increased mental, emotional and physiological arousal (King et al., 2013; Smith et al., 2017; Weaver et al., 2010). They can also include heightened activity and arousal due to emotional bond to your character. Common practice in today's video games are unlockable content and "achievements", which can also lead to prolonged gaming sessions and investment; as unlocking content and completing achievements become purpose in themselves. Often mentioned cognitive processes include decision-making, problem-solving and memory use are thought to result in cognitive alertness; and therefore in difficulty of "shutting off" when one is in bed (Arora et al., 2014). Online gaming can bring its unique factors, such as being awake to play in certain time with players from different time zones, or the need to participate in time-constrained challenges, which again can be tied to entirely different time zone (Gradisar & Short, 2013).

A model has been proposed of how aspects of gaming predict adolescent sleep (Smith et al., 2017). The key component is defined as duration, which directly affects bedtime and thus sleep. Precursor is defined as Accessibility, and supporting mechanisms as Flow, Risk and Parent regulation. The proposed model is in figure 3 (Smith et al., 2017).

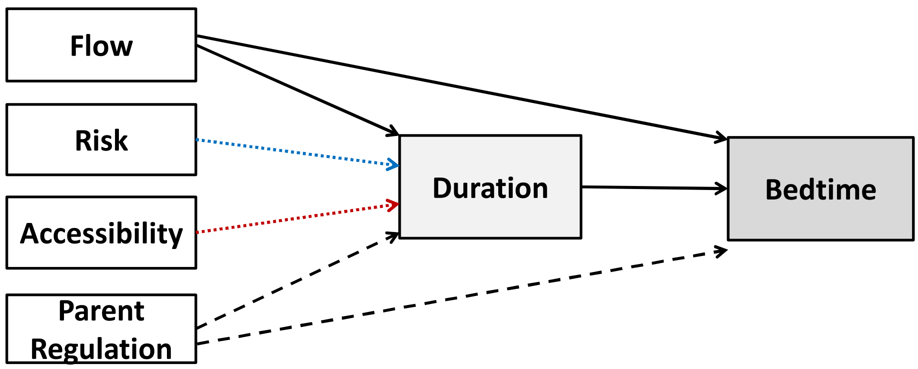

Figure 3. Aspects of gaming predicting adolescent sleep and the mediator of this relationship. Risk = perceptions of negative consequences of risk taking; Flow = Flow states experienced whilst playing computer games; Accessibility = number of devices owned; Parent regulation = monitoring and rule setting about media use. Taken from Smith et al. (2017). Blue dotted line = no significant correlation on duration, correlation on bedtime. Red dotted line = correlation with duration, but not with bedtime. Solid line = significant relationship. Dotted line = non-significant relationship (Smith et al., 2017).

In their test for the model, Smith et al. found Risk variable correlating significantly with bedtime, but not with gaming duration. Accessibility correlated significantly with duration, but not with bedtime; thus neither qualifying as mediator. The effect of parental regulation on bedtime did not depend on the time spent on video games; however, the connection between Flow and bedtime was partially mediated by duration, direct link with flow and bedtime was also found (Smith et al., 2017). In conclusion, flow states and parental regulation are proposed as two key areas through which adolescent sleep is possibly affected by gaming, and through which potential protective influence could be administered (Smith et al., 2017).

1.6 Shortcoming in current research and future directions

General limitations of the analyzed studies come mainly from self-report format, using various questionnaires. This method is vulnerable to common generally acknowledged shortcomings, such as method, bias and memory difficulties. Another limitation is the often unavailable *time of device use*, as day-time use is sure to differ at least to some extent from pre-sleep and nighttime use. The total time spent on a particular device is not necessarily in direct relation to its effect on sleep; screen utilization patterns and characteristics are equally important in determining which kind of use is most disruptive to sleep. Multifunctionality device effects vs. single purpose device effect comparisons are often omitted. Computers and mobile phones are great inventions, however multifunctionality can result in prolonged use due to distractions and "too many" possibilities.

The acute shortage of validated and reviewed questionnaires assessing use of modern electronic screen devices is problematic. On positive note this has led to the development and use of new instruments; however the use of completely new instrument makes comparison of results difficult. Also for instance, in Bartel et al. (2015) meta-analysis, 36% of exclusions in first phase were due to no relevant variables measured. Publication bias should also not be forgotten as journals often favor studies that show "significant" findings in contrast to those studies presenting negative findings or "no results".

The correlational nature of cross-sectional studies greatly limits causal interpretations. Various explanations can be offered for why discerned associations would not indicate causality. Reverse causality could exist in a form that those in need of less sleep or having sleep difficulties due to other reasons, choose to use screen devices as means to pass time or to find sleep more easily. More detailed analyses are also required for confounding factors, which can be associated with both increased screen device use and sleep curtailments. Such confounding factors could be, for example low physical activity or social isolation. Hale & Guan (2015) report only nine out of 67 studies having adept measurements for timing of observations, a paramount prerequisite, which can help in assessing the direction of causality.

More studies employing longitudinal observations are needed, especially those with verified and quantitative measures of sleep, and using multivariate statistics for models and causal factors. Studies that control SES, age and parental control are also needed. Participants' selection has many limitations as well, and these often seem to be a "pre-selected" group with defined problems or another enrollment reason, which limits ecological validity and the applicability of findings to broader adolescent population. In all experimental studies the use of other media during gaming, such as smartphone was apparently restricted, so multiscreen test condition remains an unexplored area.

Researchers have been commendably outlining priorities for future research. More experimental studies are called for better establishing causal links between sleep and electronic media. Attempts should be made to test the mechanisms mediating the effect of electronic media use to sleep. Researchers should strive to stay up-to-date on device development as well as services and their contents used by adolescents (Cain & Gradisar, 2010).

1.7 The current study

The strength of this study is the comprehensive amount questionnaires, which are widely used in the research of adolescent sleep. Whilst sleep parameters and their correlates are well established, little is known conjoint effect and underlying mechanism. The PSQI, MCTQ and ASHS together provide a very comprehensive view into the participants sleep. It is often argued that sleep is best studied not in isolation or in a controlled laboratory environment, but in the context of everyday life (in situ) (Roenneberg et al., 2015). Problematic video game use is assessed with Gaming addiction scale (GAS) and Problematic alcohol use with the alcohol use disorders identification test (AUDIT-C). With the additional instruments of General anxiety disorder questionnaire (GAD), Self-Control Scale SCS, and Beck Depression index (BDI), we can go further than just analyzing the individual effects of problematic video game use or alcohol use in relation to adolescent sleep. Thus our research questions are defined as follows:

> #1 Research question is to identify and describe our sample of Finnish adolescents, and measure the strength of previously established research associating sleep with gaming variables, sleep quality variables and mental well-being variables.
>
> #2 Research question is to test whether mediation effect occurs, that is, whether the effects from mental well-being variables (Independent Variables) are carried by gaming variables (Mediating Variables) to Sleep Variables.

Mediation has been studied on how different aspects of video gaming affect adolescent sleep (Smith et al., 2017), but – to our knowledge – not whether gaming itself could act as mediating variable for underlying issues. Thus this study seeks to add more on how adolescent gaming affects sleep behavior while also accounting the interaction of depression and anxiety symptoms.

2. Methods

2.1 Procedure

SleepHelsinki! –study is a Helsinki university research project, intended to produce new information regarding sleep, sleep disturbances and to find new ways to help adolescents with sleep problems or difficulties managing circadian / healthy sleep rhythm. The data in this study is from the first phase initiated in September 2016. The first phase consisted of an online survey inquiring adolescent's sleep, health and behavior. The survey took approximately 30 minutes to complete. All participants were from 15 to 17 years of age. Total of 1411 adolescents (19% of the invited 7539) participated in the on-line survey, of which 1374 provided valid responses.

2.2 Participants

Table 2 presents the key variables for this study. From Sleep variable analyses, we omitted those working shift-work (39 participants), as that would have distorted sleep variable calculations; this is also instructed in assessing the Munich ChronoType Questionnaire results (Roenneberg, Wirz-Justice, & Merrow, 2003). Mean age was approximately 16 years and 10 months, with standard deviation of approximately seven months. Respondents differed in gender in favor of females (34.2% boys, 65.8% girls, $p<.001$). Highest parental education level was also inquired to give indication of socioeconomic status. Only 1.9% of participants reported low education level (minimum compulsory education), 23.6% reported middle level (education beyond minimum level) and majority of 74.4% reported upper education level (university level degree for either parent).

2.3 Measures and questionnaires

Pittsburgh Sleep Quality Index

Pittsburgh Sleep Quality Index is a validated questionnaire to inspect sleep-wake patterns. The questionnaire consists of 19 self-reported questions and optional 5 questions rated by partner. Self-reported questions are used to score 7 sleep components, and global score.

Table 2.

Descriptive statistics for study variables.

Category	Variable	Freq. / Mear	Perc. / std.	Range	p-value
Gender					
	Boy	457	34.2%		<0.001
	Girl	878	65.8%		
	Age in late adolescence	16.85	0.58	15.75-17.88	
Highest parental education					
	low	26	1.9%		
	middle	305	23.6%		
	upper	962	74.4%		
Sleep Statistics					
	Total Sleep Time	7.17	1.12	3-12	NS
	Time of going to bed on workday	22.54	1.76		<0.001
	Time of going to bed on freeday	23.93	1.96		<0.001
	Sleep Onset Latency	17.53	14.79		<0.01
	Wakeup on workday	6.78	0.95		<0.001
	Wakeup on freeday	10.26	1.64		<0.001
	Wakeup Latency	0.28	0.22		<0.05
	Sleep midpoint difference	2.54	1.25		<0.01
	Chronotype	4.97	1.69		<0.001
	Absolute social jetlag	2.45	1.10		<0.01
Questionnaires					
	Pittsburgh Sleep Quality Index	6.54	3.43	0-20	<0.001
	Adult Sleep hhygiene Scale	4.57	0.54	2.37-6.00	<0.001
	Gaming Addiction Scale	31.49	13.81	8-105	<0.001
	Beck Depression Inventory	11.78	9.85	0-55	<0.001
	Generalized Anxiety Disorder	4.97	4.93	0-21	<0.001
	Alcohol Use Identification Test	2.35	2.54	0-10	NS
	Self-Control Scale	122.14	18.96	67-175	<0.001

Note. In sleep statistics, time is displayed in hours. P-values mark significance in differences between genders, values obtained from t-test or $\chi 2$ test.

Component scores are Subjective Sleep Quality, Sleep Latency, Sleep Duration, Habitual Sleep Efficiency, Sleep Disturbances, Use of Sleep Medication and Daytime Dysfunction (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Global score is the sum of seven component scores, each having maximum score of 3 and global score having maximum of 21. Impaired sleep is considered when global score is more than five, thus lower score indicates better sleep quality (Buysse et al., 1989). Buysse et al. (1989) state cut-off score providing sensitive and specific measure of sleep quality, thus indicating good validity. The Cronbach's α is 0.83 for PSQI components indicating good internal homogeneity (Buysse et al., 1989). Validation study reported global score mean of 7.4, median of 6.0, and standard deviation of 5.1 (Buysse et al., 1989). In sum, PSQI can be considered psychometrically reliable and valid instrument.

Adolescent Sleep Hygiene Scale

This often used self-report measure aims to evaluate how adolescents apply theoretically important sleep practices for optimal sleep. The 28-item instrument is answered on a six-point scale (from (1) always to (6) never) (LeBourgeois, Giannotti, Cortesi, Wolfson, & Harsh, 2005; Storfer-Isser, Lebourgeois, Harsh, Tompsett, & Redline, 2013). Respondents are inquired about sleep practices and behaviors during the past month last six months. 28 quantitative items are used to calculate 9 subscale scores, and the total sleep hygiene score is calculated from the means of the subscale scores. Conceptual domains are physiological (5 items), cognitive (6), emotional (3), sleep environment (4), daytime sleep (1), substances (2), bedtime routine (1), sleep stability (4), and bedroom sharing (2) (LeBourgeois et al., 2005; Storfer-Isser et al., 2013). Along with Total sleep hygiene score, lowest and highest quintile (20%) are sometimes reported, distinguishing poor and good adolescent sleep hygiene scores (Storfer-Isser et al., 2013). Psychometric evaluation has found somewhat acceptable internal consistency, with Cronbach's α 0.80; and subscales ranging from 0.46 to 0.74 (LeBourgeois et al., 2005).

The Munich ChronoType Questionnaire

Self-report instrument developed by Roenneberg et al, The Munich ChronoType Questionnaire has been used since 2000 to measure chronotype and social jetlag (Roenneberg et al., 2003). Chronotype is the propensity for sleep at particular time during the 24h clock, as well as presenting the behavioral expression of individual circadian rhythms. Social jetlag is a concept which encompasses misalignment of biological and social time, and the discrepancy between workdays and free days (Roenneberg et al., 2015, 2003). For example, late chronotypes amass sleep debt during the workweek, for which they need to compensate on free days by extending total sleep time by several hours; however it bears to keep in mind that chronotype does not refer to sleep duration but to sleep phase, specifically (Roenneberg et al., 2003). MCTQ makes clear distinction between workdays and free days. This enables us to calculate chronotype estimates based on midpoint sleep parameters. The underlying assumption states that sleep timing specifically on free days is influenced by circadian clock, and workdays by social needs; this is evident in total sleep time and sleep midpoint variables, which differ significantly for workdays and free days (Roenneberg et al., 2015)The derived variable for chronotype is continuous, with properties similar to normal distribution (Roenneberg et al., 2015). As recommended by Roenneberg et al. (2015) we calculated the chronotype and defined late and early chronotype as quintiles (25%).

Mid-sleep points, weekly sleep loss and absolute social jetlag time were estimated as well (Roenneberg et al., 2015). Chronotype presents sleep midpoint as well when sleep duration on free days is shorter than sleep duration on workdays. When sleep duration is longer (the usual case) on free days, the chronotype is mid-sleep point minus the difference of sleep duration on free days and average weekly sleep duration divided by two (Roenneberg et al., 2003). With our sample being adolescents, it is noteworthy to report that chronotype development is still towards delaying, and it turns to advancing earlier in men (19.5 years) than in women (21 years).

Gaming Addiction scale

Problematic gaming behavior was assed using *Finnish version/Finlandized* translation of the 21-item Gaming Addiction Scale. Considerable disagreement still exist on the term addiction, as the tem is not used by clinical psychologist, it is the most common among research publications (Lemmens, Valkenburg, & Peter, 2009). 21 Items are thought to represent seven DMS-based criteria for game addiction defined by previous research, with 3 items each forming a specific criterion. (1) Salience is used to describe when playing a game becomes the foremost activity, and dominates ones thinking, feelings, and behavior. (2) Tolerance is a process where playing games builds up to eventually occupying more and more time. In (3) Mood modification game engagement is subjectively assessed, it can also include the calming and soothing effect related to escapism. In (4) Withdrawal the unwanted physical and emotional effects occur as result of lessened or interrupted gaming. (5) Relapse is propensity of shifting back to earlier patterns of game play. (6) Conflict includes all interpersonal strife emanating from excessive gaming. (7) Problems: displacement problems as the addiction takes the space over normal motions of life. (Brunborg, Hanss, Mentzoni, & Pallesen, 2015; Lemmens et al., 2009).

Polythetic format requires respondents to answer at least 3 on 5-point Likert scale, to more than half of the questions. With the 7-item version the monothetic format is also used, which requires endorsement of all the items. In the validation study using 7 item version, 9.4% of respondents met polythetic criteria and 2.3% had at least at one point experienced all of the seven items

(Lemmens et al., 2009). Following Lemmens et al. 2009, we calculated total score and polythetic criteria. We also used classification from Brunboirg et al. (2015), in which the 7-item version is used to distinguish addicted gamers (7 items met), problem gamers (4-6 items met) and no-problem gamers (fewer than 4 items) (Brunborg et al., 2015).

Self-Control Scale

The adolescents' ability for self-control is arguably still very much developing. The ability to inhibit impulses, and on the other hand to persevere on daily rhythm can have important effect on sleep management, alcohol use and on controlling one's video-gaming. Theoretical ground involving the notable component of deficient self-control is thought to underlie majority of social and personal problems. Notably, high self-control is related to absence of alcohol-related problems, which holds true for adolescents as well (Tangney, Baumeister, & Boone, 2004). The self-control scale assesses individual differences in traits of self-control. It consists of 36-items rated on 1 to 5 –point scale, from (1) not at all like to (5) very much like me. This gives possible range of 36 to 180 for the total sum score, with higher score indicating better self-control. Cronbach's alphas for internal consistency and test-retest reliability were both 0.89 (Tangney et al., 2004). In sum, SCS is viable tool in assessing adolescents ability to interrupt unwanted behavior and refrain from acting on temptations, as well as ability to initiate wanted behavior (De Ridder, De Boer, Lugtig, Bakker, & van Hooft, 2011).

Generalized Anxiety Disorder Questionnaire

One of the more common mental disorders, generalize anxiety disorder, was screened for symptoms with GAD-7. The brief 7-item tool is considered valid and efficient for screening GAD and to assess its severity, with the internal consistency considered to be very good (Cronbach's α = 0.92) (Spitzer, Kroenke, Williams, & Löwe, 2006). The items inquire symptoms over the last 2 weeks, with scale ranging from 0 (not at all) to 3 (nearly every day), thus maximum score is 21. Mild anxiety is considered with a total score of 5, and moderate anxiety and possible diagnosis with score of 10 or more. 15 points represent severe anxiety (Spitzer et al., 2006). Following Spitzer et al. (2006), we calculated the total score, and the cutoff score of 10 (or more) points. Sensitivity is then 89% and specificity is 85% (Spitzer et al., 2006).

Alcohol Use Disorder Identification Test

A short 3-item version of Alcohol Use Disorder Identification Test (AUDIT-C) was used to assess adolescents drinking habits and alcohol consumption. This brief screening test is considered valid test to assess active alcohol use or heavy drinking (Bradley et al., 1998). Questions inquire how many times respondents have had alcohol during the past year, how many drinks is typically consumed when drinking, and lastly, how often 6 or more drinks have been consumed on one occasion. All questions are scaled to 0-4 scale, with scores the summed to obtain total score within 0 to 12 range (Bradley et al., 1998). Heavy drinking is often associated with alcohol related problems, and thus the last questions inquiring how often 6 or more drinks is consumed, is considered effective screening question on its own right. Researchers reported cutoff score of 4 having decent sensitivity of 86% and specificity of 72%. The 3-item short format had comparable performance to 10-item format in detecting heavy drinking and/or active alcohol use or dependence (Bradley et al., 1998). Thus, following Bradley et al. (1998) we calculated the total score and the cutoff score of 4 points. It should be noted that in this survey, the final question inquired how often 5 or more drinks were consumed in a single session, rather than 6 or more.

Beck Depression Inventory

Beck Depression Inventory (BDI-II) is often considered standard tool for assessing depression status. 21-items are rated on a 0 to 3 scale, thus giving the maximum total score of 21 (Beck, Steer, & Garbin, 1996). The acquirement of total score is rather simple, however the deeper interpretation of the results is more complex, and the result in itself is indicatory only, with final assessment up to clinician. BDI–II manual reports cutoff scores based on ROC analyses: the total score of 1-13 indicates no depression, 14-19 indicates mild depression, 20-28 moderate depression, and score of 29-63 severe depression (Beck et al., 1996). Internal consistency reliability can be considered commendable with Cronbach's α of 0.91 (Sprinkle et al., 2002). Using the predefined cutoff scores, we calculated the cutoff point for moderate or severe depression, and the total score of the sample.

2.4 Missing values analysis

The original data consisted of 1374 participants. The software used for was SPSS22-24. The missing value analysis within SPSS includes list-wise, pairwise, EM and regression estimation for missing values. Additionally, missing values can be analyzed with charts and graphs. The amount of missing values was quite low, 1-7 on average for variables that were essential for analyses, such as average amount of daily sleep or wake-up time. However, when a variable such as total sleep time was inquired in separate questions, first the hours and then the minutes, total of 219 – 344 participants had omitted minutes. These values were considered zeroes. Similar occurrences were treated in similar way.

“Impossible values” were somewhat consistent as well. For example, Total Sleep Time per any given day cannot exceed 24 hours, while responses ranged originally from 3 to 270 hours. It was required to establish limits for such illogical outliers that existed on data. The lowest amount that was excluded was 14 hours of sleep per day on average. The lowest value, 3 hours per night was considered plausible. For the average wake-up time, the boundary was set to 18:00. For average bedtime the limit was 12:00 (in the next day).

At this point, variable values were found missing from total of 32 participants. These were then coded as system missing in SPSS. We also excluded participants who were shift working from average statistics, as this would severely skew and distort values such as average waking time, bedtime, and total sleep time. The amount of such participants amounted 39. No Participants were completely removed at any point.

Measure and questionnaires consisted from 3 to 36 variables. Each was explored with Missing values analysis tool for the amount of missing values and possible patterns. Little’s MCAR test is very commonly used for testing whether cases are missing completely at random. If such is the case, and the amount of missing values is not very high, this can be considered safe. The hypothesis is of course the same, and should the test value be non-significant, one can rather safely assume that missingness does not matter for the analyses (Little, 1988). Then we can use list-wise control for all the analyses. The values and the results of Little’s MCAR test are presented in Table 3. According to the results, more in-depth examination should be done on variables of The Munich Chronotype Questionnaire and Gaming Addiction Scale.

The Munich Chronotype Questionnaire: Careful examination of the data revealed logical symmetry: when participant had omitted data from hours outdoor per weekday variable , it was more often than not also missing from hours outdoor per weekend variable. One worthy consideration could state, that person did not go outdoors, either on weekdays or weekend, and omitted the question altogether.

Table 3.

Missing values on questionnaires and Littles MCAR test p-value.

Questionnaire	Missing values	Little's MCAR p-value
Pittsburgh Sleep Quality Index	0-1	.980
Adolescent Sleep Hygiene Scale	0	na
The Munich ChronoType Questionnaire	1 - 70	.049*
Gaming Addiction scale	25 - 33	.000***
Self-Control Scale	2 - 14	.196
Generalized Anxiety Disorder Questionnaire	2 - 8	.073
Alcohol Use Disorder Identification Test	6 - 10	.348
Beck Depression Inventory	110	na

note. ***. P-value is significant at the 0.001 level (2-tailed). *. P-value is significant at the 0.05 level (2-tailed). Missing values: The minimum and maximum value of the missing data. Little's MCAR p-value: significant results indicates, that the data is not missing at random, and should be examined. Little's MCAR test missing: Adolescent Sleep Hygiene Scale did not contain any missing values. Beck Depression inventory did not contain individual variables.

Gaming Addiction Scale: examining the data revealed that data was indeed not missing at random. The participant had either omitted all questions, or responded to all the questions until at certain point omitted all the remaining questions. However, the total number 33 is rather low, 2.4% of the total data. We can hypothesize, that certain participants felt that this portion of the total questionnaire was not applicable to them, as would be also indicated by their style to answer to certain point, after which they would again judge that this does not apply to them, thus omitting all the remaining questions.

Beck Depression Index: data was missing from 110 participants, and 110 scored 0, each group equaling 8.2% of respondents. In the upper extreme, only one single participant was present from each score from 48 to 55 (maximum score). In order to further explore the construct of these two groups, analysis of variance was used to measure them against Total Sleep Time and Generalized Anxiety Disorder score. Chi-square test was used the asses gender ratio. The results are displayed in Table 3. The group scoring zero from BDI has significantly higher Total Sleep time (F 19.33, p. <0.001), and also significantly lower GAD score (F 57.85, p. <0.001). The zero-score group has 59.1% boys, while the data has 34.2% boys (X^2 36.40, p. <.001)

Table 4.

F-tests and Chi-square test for Beck Depression Inventory score groups

BDI response	TST				GAD				Gender		
group	N	Mean	std.	F-value	N	Mean	std.	F-value	Girls	Boys	X^2
M a.	106	7.15	1.16	19.33***	110	4.15	4.63	57.85***	66	44	36.34***
0 b.	107	7.77	0.75		110	0.45	1.15		45	65	
1 c.	1090	7.11	1.08		1115	5.47	4.97		767	348	

Note. Beck Depression Inventory score groups: a) Missing values group. b) zero score group. c) from 1 to maximum value group. ***Value is significant at p. <.001 level.

2.5 Descriptive statistics

Essential descriptive statistics from the questionnaires data for gender are presented in Table 5. Total sleep time for study population was 7:10 hours, with standard deviation of 1:07 hours. Boys slept slightly longer on average than girls, no statistical significance. 17.3% of participants slept less than 6 hours per night, girls (18.8%) more often so than boys (14.2%), with statistical significance (Pearson χ2 4.45, p. <.05).

Average Bedtimes on workdays (schooldays) and free days (weekends) were 22:32 and 23: 56, respectively. In this study the difference was 1:23 hours with standard deviation of 1:57 hours. Boys went to bed later on both school and free days, with statistical significance (F 18.83, p. <.001 and F 56.19, p. <.001, respectively). Sleep onset Latency was 17:32 minutes; more than two minutes more for girls, with mediocre statistical significance (F 6.85, p. <.01). Wake-up times on schooldays averaged 6:47 (SD 0:57) and on free days they averaged 10:16 (SD 1:38). Boys woke up later on both school and free days, with statistical significance (F 43.17, p. <.001 and F 22.37, p. 001, respectively). The difference between on wake-up times on schooldays and free days was rather striking, 3:28 hours with standard deviation of 1:34 hours. Wake-up latency was 0:17 hours; more than two minutes more for girls, with weak statistical significance (F 6.19, p. <.05).

Sleep midpoint difference between schooldays and free days was 2:32 hours (SD 1:15) with not much difference between genders (F 9.89, p. <.01). The average chronotype was 4:58 (SD 1:41), with boys having average chronotype 27 minutes later than girls (F 17.66, p. <.001). Absolute social jetlag averaged 2:27 hours, with boys having 11 minutes more absolute social jetlag than girls (F 8.56, p. <.01).

Table 5.

Means, standard deviations, and gender differences for the study variables

	All			Girls			Boys					
Characteristics	Mean	Median	std.	Mean	Median	std.	Mean	Median	std.	F / χ2	p value	Sig.
Total Sleep time	7.17	7.25	1.12	7.13	7.17	1.08	7.24	7.33	0.99	3.12	.078	NS
Less than 6h. of sleep per night a)	17.3%			18.8%			14.2%			4.46	.035	<0.05
Time of going to bed on workday	22.54	22.3	1.76	22.4	22.2	1.67	22.81	23	1.63	18.83	.000	<0.001
Time of going to bed on freeday	23.93	24	1.96	23.65	23.3	1.97	0.47	24	1.8	56.19	.000	<0.001
Sleep Onset Latency	17.53	15	14.79	18.28	15	14.97	16.07	13.5	14.34	6.85	.009	<0.01
Wakeup on workday	6.78	6.5	0.95	6.67	6.45	0.97	7.02	7	0.97	43.17	.000	<0.001
Wakeup on freeday	10.26	10	1.64	10.11	10	1.57	10.55	10.3	1.73	22.37	.000	<0.001
Wakeup Latency	0.28	0.25	0.23	0.30	0.26	0.22	0.26	0.22	0.23	6.19	.013	<0.05
Sleep midpoint difference	2.54	2.4	1.25	2.46	2.35	1.21	2.69	2.5	1.32	9.89	.002	<0.01
Chronotype	4.97	4.74	1.69	4.81	4.46	1.78	5.26	5.16	1.47	17.66	.000	<0.001
Absolute social jetlag	2.45	2.36	1.10	2.39	2.23	1.06	2.57	2.49	1.19	8.56	.003	<0.01
Pittsburgh Sleep Quality Index	6.54	6	3.43	6.95	6	3.54	5.74	5	3.04	38.89	.000	<0.001
PSQI poor sleep quality a)	53.5%			62.0%			43.1%			29.85	.000	<0.001
Adult Sleep Hygiene Scale	4.57	4.62	0.54	4.50	4.55	0.55	4.70	4.79	0.50	45.29	.000	<0.001
ASHS lowest quintile a)	(20%)			23.2%			13.5%			18.32	.000	<0.001
ASHS highest quintile a)	(20%)			16.7%			26.5%			18.49	.000	<0.001
Game Addiction Scale Score	31.49	25	13.81	27.25	22	11.14	39.71	38	14.75	301.68	.000	<0.001
GAS polythetic criterion b)	8.5%			3.3%			18.9%			95.53	.000	<0.001
Beck Depression Inventory	11.78	9	9.85	13.32	10	10.38	8.28	6	7.44	67.51	.000	<0.001
BDI Moderate or Severe depression c)	18.8%	c		23.4%			8.3%			36.76	.000	<0.001
Generalized Anxiety Disorder	4.97	4	4.93	6.03	5	5.08	2.87	2	3.84	198.70	.000	<0.001
GAD Moderate or Severe anxiety d)	17.8%			23.6%			6.5%			71.56	.000	<0.001
Alcohol Use Disorder Identification Test	2.35	1	2.54	2.27	2	2.41	2.53	1	2.79	3.09	.079	NS
AUDIT-C 4 or more e)	30.4%			28.6%			33.8%			4.00	.046	<0.05
Self-Control Scale	122.14	123	18.96	120.43	121	19.47	125.55	126	17.43	22.64	.000	<0.001

Note. : a) Percentages and Pearson's Chi-Square test statistic; b) more than half of items met according criteria and Pearson's Chi-Square test statistic; c) more than 20 p. on index and Pearson's Chi-Square test statistic; d) more than 10 p. on index and Pearson's Chi-Square test statistic; e) 4 or more points and Pearson's Chi-Square test statistic. P value represents significance in differences between genders. Values are obtained from F-tests for continuous variables and χ2-tests for categorical variables.

Sleep hygiene was evaluated with adolescent sleep hygiene scale. Our study produced total score of 4.57 (SD 0.54). Boys scored slightly higher than girls (F 45.29, p. <.001). In our sample lowest quintile had proportionally more girls, and vice versa in highest quintile (Pearson $\chi 2$ 18.32, p. <.001 and 18.49, p. <.001). Pittsburgh Sleep quality index for this sample was 6.54 (SD 3.43), girls averaging somewhat higher than boys (F 38.89, p. <.001) and thus having lower overall sleep quality. Poor sleep quality indication was found on staggering 53.5% of adolescents.

Gaming questionnaires

Game Addiction Scale identified 8.5% as problematic gamers, according to polythetic criterion. Using the 7-item short version, 1.2% were identified as addicted gamers, and 9.0 as problematic gamers. Boys (18.9%) met the criteria significantly more often than girls (3.3%) (Pearson $\chi 2$ 95.53, p. <.001). 32% of respondents played for more than two hours, and 5 % played for more than five hours. Of those who reported not gaming at all, 90% were girls; however, in 1 hour or less gaming category 71% of respondents were girls as well. The gender ratio differed statistically (Pearson $\chi 2$ 325.38, p. <.001).

Mental Well-being questionnaires

Beck Depression Inventory questionnaire was used to measure depression symptoms. Total score for our sample was 11.78, with standard deviation of 9.85. Girls scored significantly higher scores on depression index (F 67.51, p. <.001). Total of 18.8% of participants obtained scores indicating moderate or severe depression. Girls (23.4%) obtained such score more often than boys (8.3%) (Pearson $\chi 2$ 36.76, p. <.001). Generalized Anxiety Disorder score averaged 4.97, with standard deviation of 4.93. Total of 17.8% of participants obtained scores indicating moderate or severe anxiety. Girls (23.6%) obtained such score more often than boys (6.5%) (Pearson $\chi 2$ 71.56, p. <.001).

Other questionnaires

For Alcohol Use Disorder Identification Test (AUDIT-C), total mean was 2.35 points, with standard deviation of 2.54. Screening criterion was met on 30.4% of respondents, with very borderline statistical significance indicating more boys meeting the criteria than girls. For Self-Control Scale this sample population had mean of 122.14 and standard deviation of 18.96; with indication of boys scoring somewhat higher than girls (F 22.64, p. <.001).

2.6 Statistical analyses

First, to describe the data and to provide overview how the Total Sleep Time variable is affected, we used SPSS to provide bar graphs by questionnaire levels for both boys and girls. This simultaneously provides interaction effect plot with heights of the bars. Statistical significance was tested with the UNIANOVA procedure, with specifically requesting interaction effect statistics. Additional graphics were produced describing the absolute amount participants by gender for the Hours of Gaming and for the Gaming Addiction Scale variables. Finally, the Beck Depression Inventory and the Generalized Anxiety Disorder scores were contrasted by the Hours of Gaming variable, again for both genders, with similar interaction effect testing.

Secondly, correlational comparisons were conducted for study variables. The well-established variables in analyzing adolescent sleep are total sleep time (TST), sleep onset latency (SOL and Bedtime (BT) (Bartel et al., 2015; Hale & Guan, 2015). For correlational studies these were considered as outcome variables. The result of circadian misalignment, social jetlag, is also considered an outcome variable in this study (Roenneberg et al., 2015). For predictive variables we used total score of all the questionnaires, MCTQ Chronotype, the gender and the amount of hours spent on video-games. Correlational calculations between the predictive and outcome variables were made for boys and girls separately. Additionally, partial correlations were performed to establish the individual effect of gaming variables (Gaming addictions scale score and the hours of gaming), and then what is considered as mental well-being variables (Generalized Anxiety Disorder and Beck depression Inventory questionnaires).

We then use canonical correlations, to analyze relationships between two sets of variables. Canonical correlations are suitable for describing the data, and best utilized when independent variables can be theoretically hard to distinguish (Tabachnick & Fidell, 2007). In doing so we seek to distinguish meaningful grouping of variables and how they interact.

As a final analysis, we conducted mediation testing. In mediation additional variable is considered to mediate the effect of Independent Variable (IV) has on the Dependent Variably (DV), either in perfect mediation on in partial mediation. The underlying theory proposes that the effects of IV on behavior are mediated by various transformational processes internal and specific to mediating variable. Mediating variable explains how IV results or takes internal psychological significance on the DV. The basic model assumes that both mediator and IV affect (correlate) the DV, and also IV affects the mediator (Baron & Kenny, 1986a).

We adopt the four-step model on testing mediation, as proposed by Baron & Kenny (1986). In SPSS, this can be easily achieved with PROCESS macro, written by Andrew F. Hayes. We then applied Sobel's test to results to test the significance of the results. The figure 4 will show the required steps and calculated regression coefficients. In first step, it is required to establish the significant connection with IV and DV which is coefficient c. In following step, we test the connection between IV and MV (a), and MV and DV (b). In two last steps, we test connection with both IV and MV explaining DV, in which case the coefficient b should be statistically significant, and coefficient c' should be somewhat reduced. Additional step can include the test whether the mediation is complete, or partial; as is expected in this case.

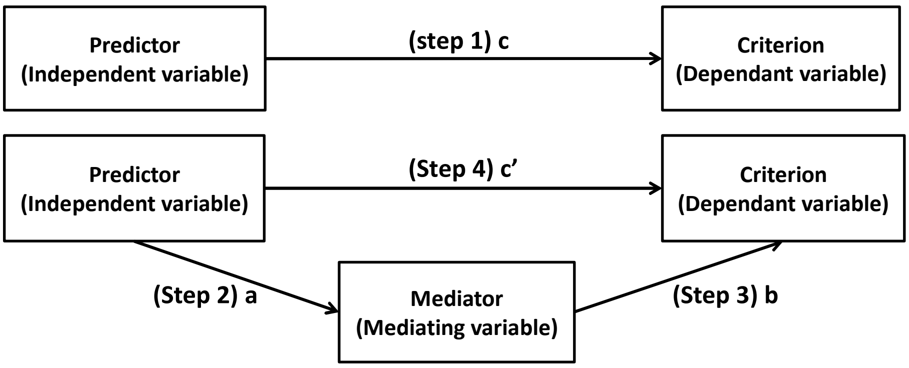

Figure 4. Theoretical model and steps for testing mediation (Baron & Kenny, 1986b).

The strength of mediation can be assessed with said Sobel's Test. Sobel's test is used to estimate whether a mediator carries the influence of an Independent variable to a dependent variable (Baron & Kenny, 1986a; Hayes, 2009; Hayes & Rockwood, 2017). Sobel's test can be calculated from the t-values, or from raw (unstandardized) regression coefficients and standard errors. Some criticism has been put forth regarding Sobel's test. It's assumptions of sampling distribution of the indirect effect tends not to be fulfilled, also it has been suggested that one should use it as supplementary test only (Hayes, 2009). Also, Type I error is prone to increase with multiple comparisons (Cafri, Kromrey, & Brannick, 2010). Alternative, more suitable tests include empirical M-test and bootstrapping.

In short, the more preferred bootstrapping treats the obtained sample as a representation of the larger population, and generates an empirical representation of the sampling distribution on the indirect effect. These are then resampled predefined number of times to emulate the original sampling process (Hayes, 2009) In our analyses we use Sobel's test as supplementary method, and as main effect we use PROCESS Macro's bootstrapping method, which inherently has the highest power and best Type I error control (Hayes, 2009). PROCESS macro calculates the upper and lower limits, which one can consider as the confidence interval. Then all we need to do, is to determine whether zero is in the interval. If zero is no present, we can be confident that the mediation effect (the indirect effect) is different from zero (Hayes & Rockwood, 2017).

Defining variables

Testing mediating and moderating effects is best suited for longitudinal studies, however with clear and rationalized assumptions of the directions of correlations, it can used in multiple situations. As per our research hypothesis, amount of time spent gaming or problematic gaming behavior might better explain the effects of underlying problems, such as anxiety or depressions might have on sleep variables, thus acting as a mediating variable.

As per our research hypothesis, we define the score of the Generalized Anxiety Disorder Questionnaire and the score of the Beck Depression Index (GAD score and BDI score) as Independent Variables. The Gaming Addiction Scale score (GAS score) and the hours spent gaming (Gaming time) are defined as Mediating Variables, and finally the Total Sleep time (TST) and Pittsburgh Sleep Quality Index score (PSQI score) are considered as Dependent Variables. It should be noted, that Gaming time variable is not strictly interval scaled, (but rather ordinal scaled), however for now we have good grounds to treat it as if it were continuous scaled.

SPSS 24 was used to calculate raw (unstandardized) regression coefficients for c, a, b and c'; as demonstrated in figure 6. Additional package for SPSS, PROCESS Macro was used to calculate R^2 for mediation effect, and to obtain t-values (which were used to calculate Sobel's test), and Lower-Limit Confidence Interval (LLCI) and Upper-Limit Confidence Interval (ULCI). For Bootstrapping, we used 5000 bootstrap samples with Bias Corrected CI method and 95% confidence levels.

3. Results

3.1 Sleep Graphs by questionnaire levels with interaction effect

Figure 5 displays how the Total Sleep Time variable affected by the total scores of the questionnaires. The height of the bars also displays the profile plot of the interaction effect, indicating whether the independent variables differ depending on the level of the other variable. Statistically significant interaction effect occurred only in Figure 5 a) Total Sleep Time by Beck Depression Inventory levels. $F(3,1116) = 3.578$, $p < .05$. For boys, the total sleep time seems to be affected only in the "severe" score group, in girls the decline in total sleep time is more linear. No other interactions in Figure 4 from b to f were statistically significant. Both "mental well-being" variables, the BDI and the GAD score indicate sleep curtailment with more severe scores. Both variables measuring overall sleep quality, the PSQI and ASHS scores indicate very clearly how good scores are associated with increased total sleep time (PSQI scale was inverted for this picture, higher score would normally indicate poorer sleep quality). The SCS score behaves similarly, with better score being associated with increased total sleep time. AUDIT-C score shows interesting result, boys have higher mean score in every group and more sleep in every group.

Figure 6 displays the effect of gaming variables on total sleep time, the distribution between hours of gaming and the gaming addiction scale scores, and the means scores of the BDI and the GAD by hours of gaming levels. Figures 6 a) and b) show similar phenomenon, boys have more sleep while scoring higher in the Gaming Addiction Scale questionnaire, and more sleep while spending more time gaming. There is no statistical interaction effect, thus the effect of the dependent variables are similar in different levels of the variables. In figure 6 c) the girls are vast majority in no gaming at all and gaming less than an hour a day groups, and then boys are majority the 2-3 hours of gaming per day and the latter groups (girls: 911, boys: 459). Similar effect can be observed in Figure 6 d): girls are majority in no gaming at all group, and boys are majority in all other groups (girls: 913, boys: 461). In Figure 6 e) girls score systematically higher BDI scores while time spent gaming increases, there is no interaction effect though; in f) we have similar effect with GAD score, again with no interaction effect.

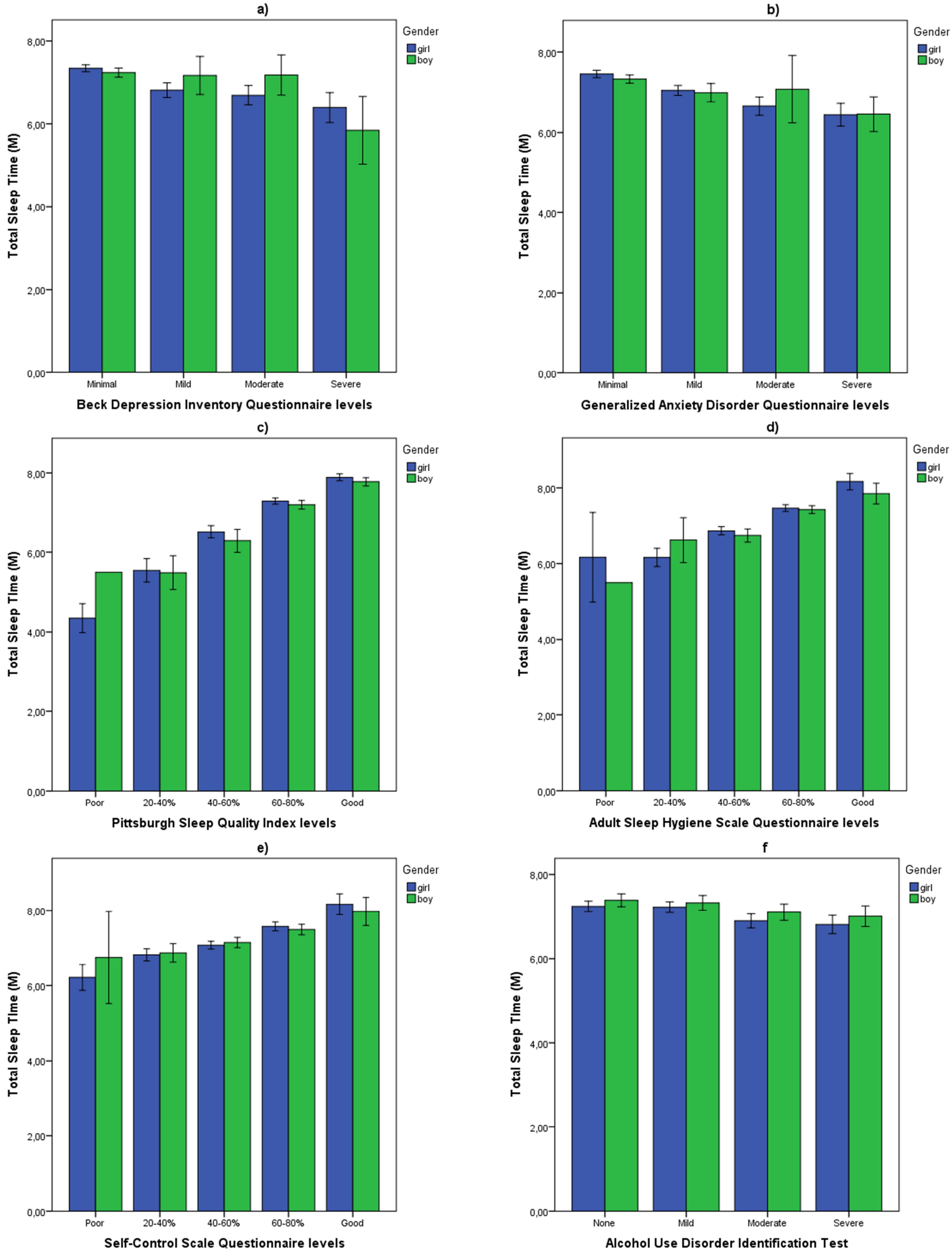

Figure 5. Sleep Graphs by questionnaire levels. The height of the bars is also profile plot of the interaction effect. a) Total Sleep time by BDI Levels. Statistically significant interaction $F(3,1116) = 3.58$, $p. < .05$. b) Total Sleep time by GAD levels. No statistically significant interaction $F(3,1334) = 1.29$. c) Total Sleep time by PSQI questionnaire levels. No statistically significant interaction $F(3,1332) = 0.76$. d) Total Sleep time by ASHS levels. No statistically significant interaction $F(3,1332) = 1.92$. e) Total Sleep time by SCS levels. No statistically significant interaction $F(3,1330) = 0.92$. f) Total Sleep time by AUDIT-C levels. No statistically significant interaction $F(3,1272) = 0.12$.

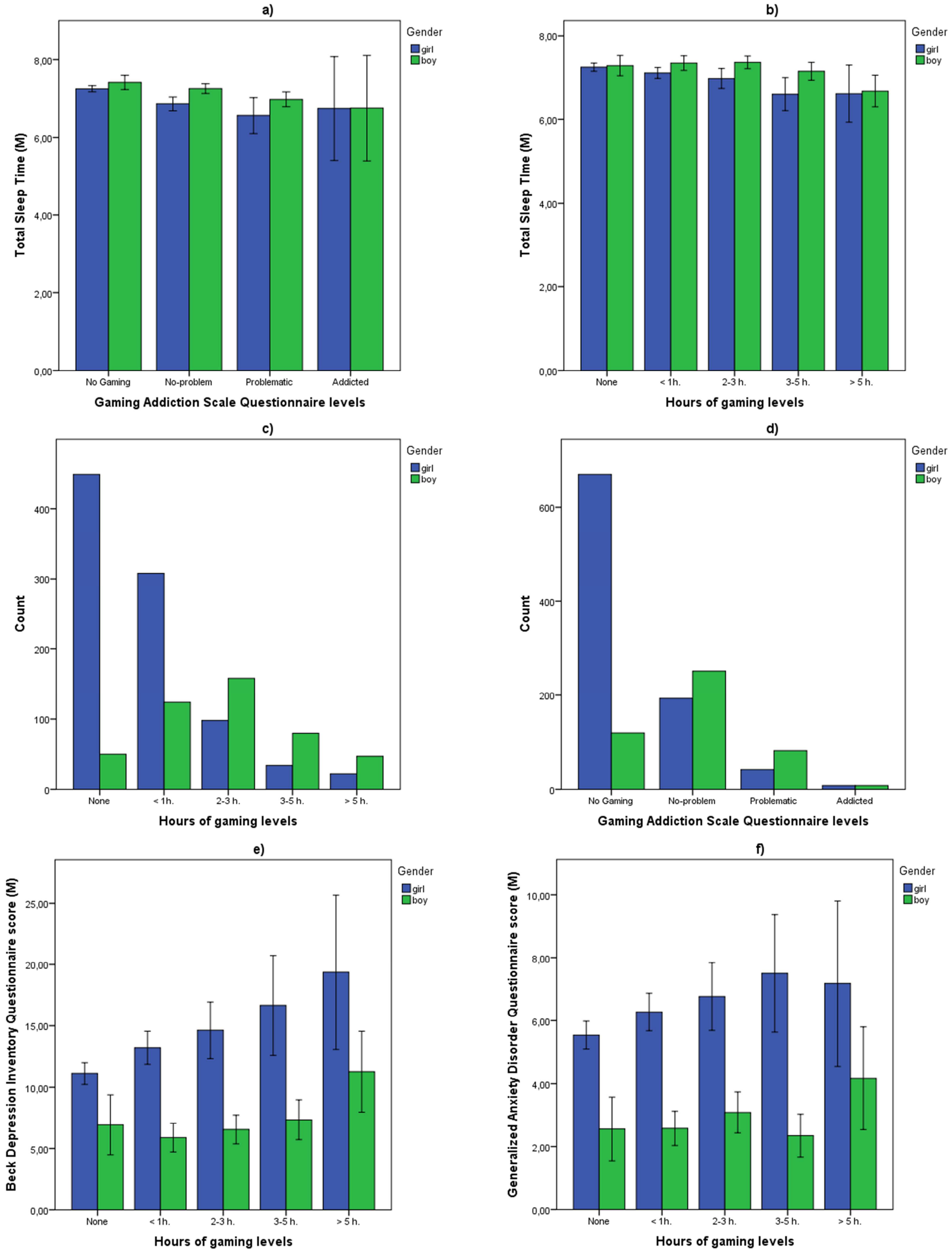

Figure 6. a) Sleep graphs and gaming variable graphs. For total sleep time graphs and DBI and GAD graphs the height of the bars is also profile plot of the interaction effect. a) Total Sleep time by GAS Levels. No statistically significant interaction F(3,1334) = 1.03. b) Total Sleep time by amount of gaming. No statistically significant interaction F(4,1328) = 1.24. c) Distribution of respondents by amount of gaming. d) Distribution of participants by GAS levels. Count refers to absolute amount of participants. e) BDI score by amount of gaming No Statistically significant interaction F(4,1248) = 1.42. f) GAS score by amount of gaming. No statistically significant interaction F(4,1360) = 0.91.

3.2 Correlational comparisons

Table 6 presents results from correlational analyses. Total sleep time correlated significantly with all predictor variables (Pearson's correlation p. <0.01, p. <0.05 for gender). Sleep Onset Latency correlated significantly with all predictors besides Game addiction Scale (GAS) and the time spent playing video games (Pearson's correlation p. <0.01, p. <0.05 for AUDIT-C). Bedtime correlated significantly with all predictors besides BDI and GAD scores (Pearson's correlation p. <0.01). Social Jetlag was found to correlate significantly with all predictors besides Generalized anxiety disorder questionnaire (Pearson's correlation p. <0.01). Between predictor variables, gender variable had significant correlations with mental well-being variables (BDI- & GAD scores, Pearson's correlation p. <0.01) and with gaming variables (GAS score & hours of gaming, Pearson's correlation p. <0.01). Mental well-being variables BDI and GAD correlated significantly with all other predictor variables, besides hours of gaming (Pearson's correlation p. <0.01). Of the gaming variables Gaming Addiction scale (GAS) correlated significantly with other predictor variables (Pearson's correlation p. <0.01), however the hours of gaming correlated weakly with GAD score Pearson's correlation p. <0.05) and moderately only with Self-Control Scale score (Pearson's correlation p. <0.01).

Table 6.

Correlations between sleep variables and predictor variables.

Measures	TST	SOL	BT	SJL	Gender	BDI	GAD	AUDIT-C	GAS	Hours	PSQI	ASHS	SCS
Total Sleep Time													
Sleep Onset Latency	-.255**												
Bedtime	-.296**	0.027											
Social Jetlag	-.291**	.063*	.311**										
Gender	.054*	-.071**	.200**	.081**									
BDI score	-.324**	.240**	-.034	.089**	-.238**								
GAD score	-.314**	.240**	-.023	.053	-.305**	.781**							
AUDIT-C score	-.151**	.059*	.131**	.292**	0.055	.090**	.134**						
GAS score	-.119**	.037	.183**	.129**	.427**	.177**	.093**	-.067*					
Hours of gaming	-.098**	.033	.217**	.155**	.465**	.032	-.065*	-.059*	.677**				
PSQI score	-.657**	.522**	.112**	.204**	-.168**	.609**	.583**	.235**	.139**	.040			
ASHS score	.465**	-.234**	-.138**	-.357**	.176**	-.489**	-.509**	-.417**	-.128**	-.033	-.619**		
SCS score	.377**	-.229**	-.146**	-.265**	.128**	-.533**	-.511**	-.378**	-.197**	-.040	-.522**	.622**	
MCTQ Chronotype	-.370**	.192**	.524**	.731**	.212**	.117**	.112**	.318**	.265**	.323**	.345**	-.438**	-.333**

Note. *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). BDI = Beck Depression Inventory, GAD = Generalized Anxiety Disorder, AUDIT C = Alcohol Use Identification Test, GAS = Gaming Addiction Scale, PSQI = Pittsburg Sleep Quality Index, ASHS = Adult Sleep Hygiene Scale, SCS = Self-Control Scale, MCTQ = Munich ChronoType Questionnaire.

Table 7.

Correlations between sleep variables and predictor variables for girls.

Variables a.	TST	SOL	BT	SJL	BDI	GAD	AUDIT-C	GAS	Hours	PSQI	ASHS	SCS
Total Sleep Time												
Sleep Onset Latency	-.269**											
Bedtime	-.262**	.023										
Social Jetlag	-.299**	.061	.237**									
BDI score	-.353**	.241**	-.005	.122**								
GAD score	-.340**	.254**	.015	.076*	.773**							
AUDIT-C score	-.152**	.089**	.120**	.355**	.158**	.173**						
GAS score	-.174**	.044	.026	.062	.338**	.235**	-.069*					
Hours of Gaming	-.135**	.043	.095**	.122**	.167**	.099**	-.008	.595**				
PSQI score	-.670**	.548**	.111**	.191**	.627**	.597**	.242**	.239**	.152**			
ASHS score	.472**	-.239**	-.145**	-.382**	-.496**	-.504**	-.445**	-.236**	-.174**	-.593**		
SCS score	.390**	-.221**	-.145**	-.304**	-.552**	-.503**	-.413**	-.266**	-.134**	-.504**	.631**	
MCTQ Chronotype	-.327**	.209**	.442**	.718**	.150**	.184**	.350**	.203**	.250**	.345**	-.508**	-.411**

Note. **. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level. a. Gender = girl; N = 863 - 827, 754 for BDI score and 687 for MCTQ Chronotype. BDI = Beck Depression Inventory, GAD = Generalized Anxiety Disorder, AUDIT C = Alcohol Use Identification Test, GAS = Gaming Addiction Scale, PSQI = Pittsburg Sleep Quality Index, ASHS = Adult Sleep Hygiene Scale, SCS = Self-Control Scale, MCTQ = Munich ChronoType Questionnaire.

Table 8.

Correlations between sleep variables and predictor variables for boys.

Variables b.	TST	SOL	BT	SJL	BDI	GAD	AUDIT-C	GAS	Hours	PSQI	ASHS	SCS
Total Sleep Time												
Sleep Onset Latency	-.214**											
Bedtime	-.448**	.082										
Social Jetlag	-.295**	.085	.425**									
BDI total score	-.225**	.220**	.107*	.085								
GAD total score	-.236**	.170**	.116*	.102*	.742**							
AUDIT C total score	-.163**	.017	.130**	.194**	.013	.136**						
GAS total score	-.141**	.123**	.261**	.163**	.343**	.334**	-.140**					
Hours of Gaming	-.149**	.128**	.243**	.153**	.174**	.078	-.218**	.606**				
PSQI Global score	-.631**	.452**	.250**	.290**	.493**	.481**	.268**	.250**	.109*			
ASHS total score	.441**	-.195**	-.258**	-.375**	-.388**	-.445**	-.426**	-.232**	-.062	-.642**		
SCS total score	.335**	-.226**	-.252**	-.234**	-.456**	-.496**	-.356**	-.325**	-.081	-.532**	.575**	
MCTQ Chronotype	-.497**	.211**	.580**	.753**	.257**	.219**	.272**	.201**	.275**	.492**	-.476**	-.326**

Note. **. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level. b. gender = boy; N = 430-440. 336 for BDI score, 380 for MCTQ Chronotype. BDI = Beck Depression Inventory, GAD = Generalized Anxiety Disorder, AUDIT C = Alcohol Use Identification Test, GAS = Gaming Addiction Scale, PSQI = Pittsburg Sleep Quality Index, ASHS = Adult Sleep Hygiene Scale, SCS = Self-Control Scale, MCTQ = Munich ChronoType Questionnaire.

Tables 7 and 8 represent correlational comparisons for girls and boys respectively. Notably the GAS score and the amount of time spent on video games correlated significantly for both genders, however the GAS score did not correlate with Sleep Onset Latency or with Bedtime for girls, and the hours of gaming did not correlate with Sleep Onset Latency for boys. The hours of gaming correlated with AUDIT-C score for boys (r. -.218, p. <0.001), but not for girls. Also, the hours of gaming did not correlate with sleep hygiene (ASHS) or Self-control (SCS) for boys, but did so for girls (r. -.174 & r. -.134, p. <0.001). For boys BDI and GAS scores correlated weakly with bedtime (r. -.107 & r. -.116, p. <0.05), but not so for girls.

As per our hypothesis, we wanted to examine the relationship of gaming and sleep variables while controlling previously determined predictor variables. Thus For further analysis, we controlled variables measuring mental well-being (GAD, BDI), substance use (AUDIT-C), self-control traits (SCS), and sleep quality measures (ASHS and PSQI). This partial correlation allows us to examine if the relationships between outcome variables and predictor variables is affected by additional variables, which are considered outside variables.

Tables 9 and 10 display the results of these analyses. When controlling for variables, the relationships to sleep parameters markedly diminish. For girls, the Total Sleep Time no longer correlated with the GAS score nor with the hours of gaming. The Sleep Onset Latency however became statistically significant (r. -.085, p. <0.05). For boys, the Total Sleep Time was no longer significant with either the GAS score nor with the hours of gaming. The Sleep Onset Latency behaved similarly with the Total Sleep time, and was no longer significant. Interestingly TST and SOL did not correlate anymore for boys.

Table 9.

Partial correlations for sleep and gaming variables by gender.

	Girls					Boys				
Variables	TST	SOL	BT	SJL	GAS	TST	SOL	BT	SJL	GAS
Total Sleep Time										
Sleep Onset Latency	.190**					.085				
Bedtime	-.270**	-.085*				-.439**	-.037			
Social Jetlag	-.213**	-.023	.170**			-.155**	-.006	.369**		
GAS total score	-.047	-.085*	.032	.024		-.018	-.043	.168**	.132*	
Hours of Gaming	-.061	-.006	.083*	.091*	.582**	-.060	-.070	.207**	.161**	.606**

Note. **. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level. GAS = Gaming Addiction Scale score. Controlled variables: Beck Depression Inventory score, Generalized Anxiety Disorder score, Alcohol Use Identification Test total score, Pittsburg Sleep Quality Index score, Adult Sleep Hygiene score, Self-Control Scale score. N = 693 for girls; N = 306 for boys.

Table 10.

Partial correlations for sleep, anxiety and depression variables by gender.

	Girls					Boys				
Variables	TST	SOL	BT	SJL	GAD	TST	SOL	BT	SJL	GAD
Total Sleep Time										
Sleep Onset Latency	.160**					.082				
Bedtime	-.284**	-.066*				-.443**	-.043			
Social Jetlag	-.227**	-.014	.173**			-.168**	-.010	.350**		
GAD total score	-.167**	-.088*	-.098*	-.150**		.161**	-.074	-.068	-.114*	
BDI total score	-.171**	-.140**	-.140**	-.078*	.606**	.133*	-.002	-.051	-.147**	.610**

Note. **. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level. GAD = Generalized Anxiety Disorder, BDI = Beck Depression Inventory. Controlled variables: Alcohol Use Identification Test total score, Pittsburg Sleep Quality Index score, Adult Sleep Hygiene score, Self-Control Scale score.Gaming Addiction Scale score, Hours of gaming. N = 693 for girls; N = 306 for boys.

In further partial correlations analysis, we controlled same variables with added GAS score and hours of gaming, to see how Generalized Anxiety Disorder and Beck Depression Inventory score would behave. In contrast to controlling gaming variables, GAD and BDI remained statistically significant in relation to Total Sleep Time after controls (Girls: r .167; r .171, p. <0.001, Boys: r .161; r .133, p. <0.001,). For girls, Sleep Onset Latency and Bedtime remained significant as well (SOL: r -.088 p. <0.05; r .140 BT: r -.095 p. <0.05; r .140, p. <0.001), but interestingly not so for boys. In sum, controlling for variables diminished the effect of gaming variables, but not the effect of "mental well-being" variables, the GAS and BDI score. Clear gender differences were also present.

3.3 Canonical correlations

From Figure 7, we can then interpret how the two sets of variables behave in the first canonical equation. Whilst not necessary, we consider the first set of 5 variables as independent variables, and the second set of 4 variables as the dependent variables. The increase of BDI and GAD score and the decrease of ASHS and SCS score with the late chronotype can be described as behavior of the canonical variate V1. This in turn is strongly associated (r .647) with the behavior of canonical variate U1, which is characterized by a decrease in Total Sleep Time, and increase of GAS score, Sleep Onset Latency and AUDIT-C score. The canonical variate V1 extracts 47.1% of the variance, and the canonical variate U2 extracts 31.3% of the variance. All canonical equation pairs are presented in table 11.

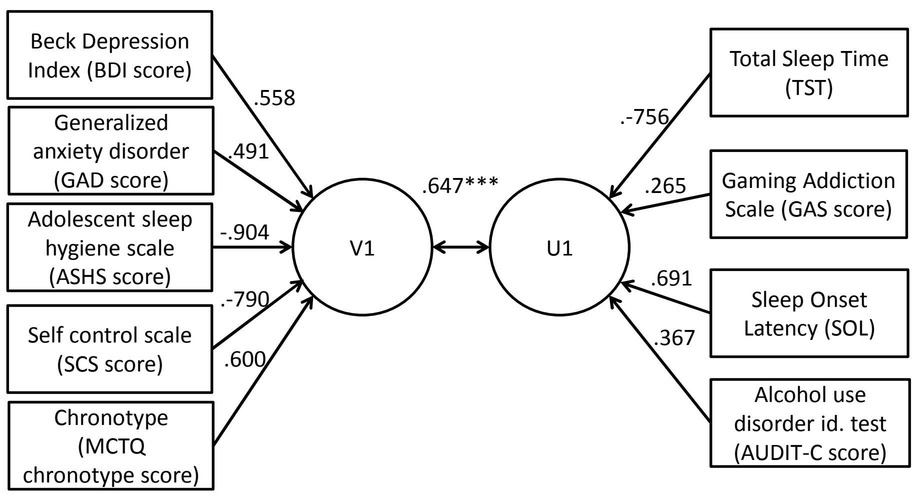

Figure 7. Canonical correlations between two sets of variables for the first canonical equation. The canonical correlation between two sets is significant .647 (p <. 001). The arrows represent canonical loadings, which can be interpreted as Pearson's product moment correlation coefficients. From the total variance of the first set of variables, the V1 extracts .471. From the total variance of the second set of variables, U1 extracts .313.

Table 11.

Canonical equations, correlations and loadings, with proportion of variance explained.

		Canonical equation pairs (4 total)			
	Correlation	.624***	.235***	.151***	.084
Variables & canonical loadings for the first set.	BDI score	.56	-.82	.10	.11
	GAD Score	.49	-.62	-.11	.35
	ASHS score	-.90	.04	.38	-.16
	SCS score	-.79	.04	-.46	-.40
	Chronotype	.60	.20	.10	-.70
	proportion of variance explained	.471	.218	.078	.162
Variables & canonical loadings for the second set.	Total Sleep Time	-.76	.43	.33	.37
	Sleep Onset Latency	.37	-.58	-.02	.73
	GAS score	.27	-.27	.88	-.29
	AUDIT-C score	.70	.68	.01	.24
	proportion of variance explained	.313	.264	.220	.202

Note. *** Correlation is significant at .001 level. BDI = Beck Depression Inventory, GAD = Generalized Anxiety Disorder, ASHS = Adult Sleep Hygiene Scale, SCS = Self-Control Scale, GAS = Gaming Addiction Scale, AUDIT-C = Alchol Use Disorder Identification Test.

The linear combinations of variables created for canonical correlations are, of course, optimized for the first canonical equation; which we have already interpreted. The often challenging task is to discern meaningful interpretation for the rest of the pairs of canonical variates, which might often not be plausible. (Tabachnick & Fidell, 2007). The second canonical equation seems to emphasize the Beck Depression Index score and the Generalized Anxiety Disorder score of U1, with lower Total Sleep Time and increase of Sleep onset Latency, and the increase of AUDIT-C score. The third equation seems to stress the high ASHS score and decrease of SCS score, with the major increase of GAS score. The last pair highlights the late chronotype and lower SCS score with higher Sleep Onset Latency and increase in AUDIT-C score. While the first two equations display logical in plausible canonical correlations between variables, the meaningfulness of the interpretations of the last two equations is up to debate.

In sum, while the results of all the correlational comparisons can be interpreted in many ways, we can establish that outside variables effect the relationship of gaming variables (GAS total Score and hours of gaming per day) and sleep outcome variables. This gives direct support to our first research questions, and indicates that the effect that gaming has on sleep is not as straightforward as is sometime presented. We then proceed to examine more thoroughly with our second research hypothesis: The gaming mediates the effect of Generalized Anxiety Disorder (GAD) score and/or Beck's Depression Inventory (BDI) total score, through either problematic gamin, behavior, or through amount of time spent gaming.

3.4 Results of Mediation testing

Figure 8 displays the performed mediation analysis and regression coefficients for Total Sleep time with GAS score as a mediator. The regression coefficients for the third step (b) are modest, but statistically significant. The drop in regression coefficients in the fourth step (c') is very small, indicating partial moderation at best. The full results of mediation tests are presented in Table 12. LLCI and ULCI acquired by bootstrapping are of course not fixed, but can vary minimally between sampling. Unstandardized coefficients give the direction of regression coefficients, but should not be interpreted as such. Here we have calculated the Sobel's test from t-values instead of regression coefficients.

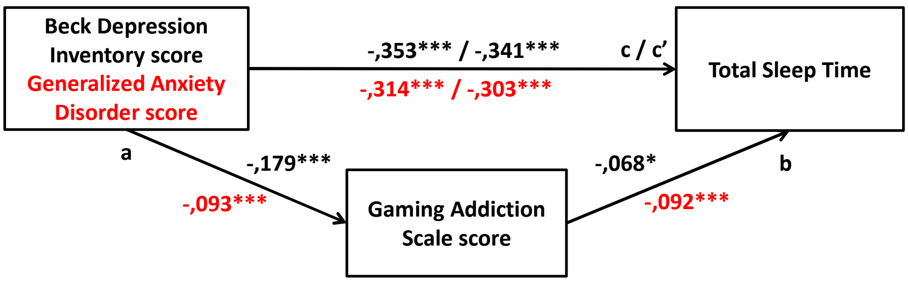

Figure 8. Regression coefficients with Gaming Addiction Score as a mediator from Beck Depression Inventory score and from Generalized Anxiety Disorders score to Total Sleep Time. *** p. <.001; * p. <0.05.

Table 12.

Mediation tests and Sobel's tests. Unstandardized coefficients acquired with SPSS regression analysis. PROCESS Macro was used to obtain R-squared and t-values with following settings: 5000 samples with Bias corrected CI method and 95% confidence intervals. Sobel's test value was calculated from t-values.

	Unstandardized coefficients				Sobel's	Bootstrap	R
Variables	c	a	b	c'	Test	LLCI - ULCI	squared
GAD score GAS score - TST	-.068**	.259***	-.007***	-.066***	.018a	-.0041; -.0005	0.006
BDI score - GAS score - TST	-.038**	.247***	-.005*	-.037***	.023a	-.0029; -.0001	0.011
GAD score - GAS score - PSQI score	.405***	.259***	.021***	.403***	.012a	.0020; -.0114	0.012
BDI score - GAS score - PSQI score	.218***	.247***	.010	.028***		-.0010; .0061	
GAD score - Gaming time - TST	-.068**	-.015*	-.113***	-.070***	.032a	.0003; .0039	0.005
BDI score - Gaming time - TST	-.038**	.001	-.096***	-.038***		-.0013; .0003	
GAD score - Gaming time - PSQI	.405***	-.015*	-.234***	.409***	.049a	-.0085; -.0005	0.005
BDI score - Gaming time - PSQI score	.218***	.001	.114	.218***		-.0003; .0024	

note. ***. Unstandardized regression coefficient is significant at the 0.001 level (2-tailed). **. Unstandardized regression coefficient is significant at the 0.01 level (2-tailed). *. Unstandardized regression coefficient is significant at the 0.05 level (2-tailed). a. Sobel's test is significant at the 0.05 level (2-tailed). GAD = Generalized Anxiety Disorder, BDI = Beck Depression Inventory, GAS = Gaming addiction Scale, TST = Total Sleep Time, PSQI = Pittsburg Sleep Quality Index.

The Gaming Addiction Scale score (GAS score) mediates the effect of both Generalized Anxiety Disorder Questionnaire score and the Beck Depression Index score (GAD score and BDI score) have on Dependent variable, Total Sleep Time (Sobel's test p. 0.018 and p 0.023, respectively). With Sleep Quality, defined as PSQI score, the effect remains as GAD score as IV (Sobel's test p. 0.012), but not for BDI score as IV (LLCI;ULCI -0.001; .0061). With Gaming time as mediating variable the paths from GAD score to TST and GAD score to PSQI score carried mediation effect (Sobel's test p. 0.032 and p. 0.049, respectively). The BDI score and Gaming time did not carry mediation effect to either IV, TST or PSQI score (LLCI; ULCI -0.013; .0003 and -.003; .0024, respectively).

Based on the analyses described above, we can with certain confidence state that the gaming variables mediate the effect of the Generalized Anxiety Disorder Questionnaire and the score of the Beck Depression Inventory to sleeping variables. The indirect effect is very low, however, and the majority of the effect is the direct effect. We can conclude that even though gaming variables are in direct effect regarding sleeping variables, one would do well to always consider them unison with other effects as well.

Addressing Type I Error

Type I error is bound to increase when we perform multiple analyses, as we have done here. With more inferences made, the more likely erroneous inferences are to occur (Cafri et al., 2010). The conservative approach to deal with this problem is the Bonferroni correction, in which we would multiply the p-values with the number of tests conducted. Here, we could argue, we have two sets of 4 tests. In our case this would be appropriate with the results of Sobel's test. We have however, calculated the results from the t-values obtained from bootstrapping method, and not from unstandardized coefficients and standard errors from regression analyses, thus Type I Error correction is not required (Hayes, 2009; Hayes & Rockwood, 2017).

4. Discussion

Adolescence is a time of increasing vulnerability for various sleep difficulties and sleep curtailments. From biological development and environmental factors to psychosocial and contextual factors, the range of contributing elements is vast. Sleep has paramount impact on both mental and physical well-being, as well as on one's ability to study and function normally (Paiva et al., 2015). The most profound change is probably the natural shift to later bedtimes and increased evening activity during adolescence (Bartel et al., 2015; Lemola et al., 2014). A phenomenon in its own right is the unmistakable increase in electronic media use, both in general and before bedtime, especially for pre-teens and adolescents (Bartel et al., 2015). The evaluation of contributing factors is therefore of utmost importance. Our leading research question was to attempt to verify associations between sleep outcome variables and affecting variables for approximately 17 year old Finnish adolescent sample.

Our results show that Finnish adolescents in this sample fall from the recommended optimal amount of sleep per night (9 hours) and from the sufficient amount of 8 hours as well (Becker et al., 2015; King et al., 2014; Mak et al., 2014). In our study, adolescents averaged 7 hours and 10 minutes (SD 1 hour and 7 minutes) of sleep. 17.3% met the criteria of under 6 hours of sleep, which is considered severe restriction in sleep (Bartel et al., 2015; Paiva et al., 2015). Having 6 hours or less sleep per night is often associated with depression and anxiety symptoms, lower self-esteem, and deficits in functioning and general health (Cox & Olatunji, 2016; Paiva et al., 2015; Roberts & Duong, 2017; Rosenström et al., 2012). In our study, the severe restriction on sleep duration group scored on average 5.1 points more on BDI, and 1.3 points more on GAD questionnaire.

The main findings from the meta-analysis regarding sleep duration include good sleep hygiene and parent-set bedtimes as promoting factors, and tobacco use, computer use, evening light, caffeine use and negative family environment as decreasing factors (Bartel et al., 2015). In our study, Total Sleep Time correlated negatively with the total scores of BDI-, GAD-, AUDIT-C- and PSQI questionnaires; and positively with the scores of ASHS- and SCS questionnaires. In meta-analysis from Bartel et al. (2015), parent set bedtime and good sleep hygiene were identified as the most important protective factors. In our study, Finnish adolescents had the mean ASHS score of 4.57. In comparison, LeBourgeois et al. (2017) studied American and Italian samples of adolescents with the mean age of 14 years and seven months (SD 1 year and seven months), and reported the ASHS total scores of 4.5 (SD 0.57) and 4.0 (SD 0.61), respectively (LeBourgeois et al., 2005). Our results are then in line with this previous research, as well as deductive reasoning: good sleep hygiene and good self-control promote good sleep; poor sleeping habits with problematic alcohol use and with depression and anxiety symptoms induce poor sleep duration.

In the same meta-analysis from Bartel et al. (2015), video gaming correlated mildly negatively with Total Sleep Time, and was identified as a risk factor only in correlation to a later bedtime (Bartel et al., 2015). According to our study, problematic gaming behavior (GAS score) was identified in 8.5% of participants, boys (18.9%) met the criteria significantly more often than girls (3.3%). The GAS score correlated with less total sleep (r -.119, p.<.01), with sleep onset latency (r. 037 p = ns.) and most clearly with later bedtime (r .183, p.<.01). The hours of gaming behaved similarly in all accounts: TST (r -.98, p. <.01), SOL (r. 033 p = ns.) and BT (r .217, p.<.01). Thus we have very similar findings with Bartel et al. (2015), with additionally identifying problematic gaming behavior and the hours of gaming as a risk factor to a total sleep time as well. This is in line with accumulating evidence suggesting video gaming especially affects Bedtimes, Sleep Onset Latency and Total sleep Time (Gradisar & Short, 2013). This is also in line with Hale & Guan's (2014) systematic literature review on screen time. The gaming was associated with delayed bedtime and shorter sleep time in 81% of the reviewed articles (Hale & Guan, 2015). The often recommended amount of gaming (and television viewing) is two hours per day (Cain & Gradisar, 2010), in our sample 32% played for more than two hours, and 5% played for more than five hours. Of those whose Gaming Addiction Scale score indicated problematic gaming, 79% (98) played at least 2 hours, of those identified as addicted, 94% (15) played at least 2 hours.

The relationship between sleep quality and gaming remains mostly an unexplored area. In Hale & Guan's (2014) review, only three articles had specifically targeted sleep quality and gaming, and of those three, one reported significant negative correlation between sleep quality and gaming, and two had found no significant associations. In our study, the GAS score was associated with poor sleep quality (PSQI) and with poor sleep hygiene (ASHS). The hours of gaming was not, however, significantly correlated with either sleep quality or sleep hygiene. We can conclude that while problematic gaming and the hours of gaming are naturally highly correlated, the hours of gaming are not always nor necessarily associated with self-reported problematic gaming. The question remains how capable self-report questionnaires are in capturing problematic gaming behavior. Another issue is the difficulty of estimating overall time spent on gaming when one is using multiple devices, i.e. computer for longer sessions and smartphone for multiple shorter sessions.

When controlling for other variables, the associations of Gaming Addiction Scale and Hours of gaming with sleep variables diminished for both genders, and only for the boys the association with bedtime remained significant. In a similar analysis, the associations of Beck Depression Inventory and Generalized Anxiety Disorders scores, however, remained significant: for girls, associations with all sleep variables (Total Sleep Time, Sleep Onset latency, Bedtime) remained significant, and for boys the connections with Total Sleep Time remained significant. The increase in the amount of time spent gaming and in the score of the Gaming Addiction Scale impacted more clearly the scores of the Beck Depression Inventory and the Generalized Anxiety Disorder questionnaires for girls than it did for boys (Figure 5), although no significant interaction effect was found. The interaction effect was, however, present when assessing how the Beck Depression Inventory score was associated with the Total Sleep Time, indicating that the effect is different for girls than it is for boys. This notion is supported by results of partial correlations. Boys, in contrast, seem to be affected less by the more time spent gaming, until the more than 5 hours category, suggesting perhaps a habituation effect. In sum, we conclude that the independent effect that the GAS and BDI scores have on sleep variables is thus stronger, which gives support to our second research question on the mediating effect of gaming.

Pathways examining aspects of gaming in relation to sleep have been studied in mediation analyses. The connection between Flow state and Bedtime was found to be partially mediated by duration of gaming, and a direct link with Flow and Bedtime was also found (Smith et al., 2017). We sought to expand this avenue and analyzed whether gaming itself would mediate the underlying effect of anxiety or depression to sleep duration. The Gaming Addiction Scale score was found to mediate the effect of both the Generalized Anxiety Disorder Questionnaire score and the Beck Depression Inventory score on Total Sleep Time. The effect of anxiety was also mediated to sleep quality, measured by the Pittsburgh Sleep Quality Index. The hours of gaming acted as a statistically significant mediator as well for anxiety, to both Total Sleep Time and sleep quality. The large number of omitted answers (8.1%) and similar amount of null total score answers (8.1%) in the BDI questionnaire might explain why only anxiety was statistically significant in all analyses. To our knowledge, no similar mediation analyses have been attempted before. The result are, however, in line with previous findings stating associations between sleep and anxiety, and between sleep and depression: consistent short sleep has predicted increased anxiety disorders (Roberts & Duong, 2017), and sleep problems have been found to predict depression (Rosenström et al., 2012). With direct associations and mediating effects confirmed, researchers would do well to study sleep problems and gaming with anxiety and depression in mind as well. This is supported by our earlier notion stating that the hours of gaming are not always indicating problematic gaming behavior, nor being necessarily cause for concern. Here we have examined the root effect of the BDI and the GAS scores; however other underlying issues worthy of research could also better decode this phenomenon.

5. Conclusion

In this thesis we wanted to analyze the interrelationships between sleep variables and quality, and between comprehensive arrays of questionnaires from SleepHelsinki! –study. The scores of Sleep hygiene and sleep quality questionnaires are strongly associated with sleep parameters (Total Sleep Time, Sleep Onset Latency and Bedtime) followed by the scores Depression and Anxiety questionnaires. SleepHelsinki! –study included Game Addiction Scale and hours of gaming categorical variable. Rather than accept the gaming variables as independent agonist to sleep variables, we sought to define them as mediator or outcome variables. Canonical correlations give preliminary support to our notion that gaming variables are most likely both independent and dependent variable in context of our study.

The results of this study suggest that adolescents today would very likely benefit from sleep hygiene and sleep quality education. The association between Total Sleep Time and depression and anxiety scores remained significant for both genders even after controlling for other variables, which are the scores of Gaming Addiction scale, Self-Control Scale, The Munich ChronoType Questionnaire, Pittsburgh Sleep Quality Index, Adolescent Sleep Hygiene Scale, Alcohol Use Disorder Identification Test and the hours of gaming. For girls the statistical significance remained with all sleep variables, including the Sleep Onset Latency and the Bedtime, but not so for boys. This suggests that sleep can be enhanced for both genders by addressing anxiety and depression well-being as well; and additional benefit can be obtained especially regarding adolescent girls sleep.

The associations between gaming and sleep appear to be complex. When controlling for other previously mentioned other variables, only the connection with bedtime remained significant, and only for boys. Thus based on our results, more beneficial would be to address problematic gaming and the amount spent gaming together with mental well-being. In whole we concur with Becker et al., (2015): rather than wrestling with one particular factor or optimal amount of sleep, conditions should be optimized that adolescents would spontaneously sleep as much as they want. Future research should verify our notion of gaming variables having both independent effect, and also acting as mediator for underlying solemn effects from depression and anxiety. We then call for longitudinal research design, to assess the interrelationships between sleep variables, mental well-being variables and gaming variables.

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