Problematic gaming behaviour and health-related outcomes: A systematic review and meta-analysis

AUTHORS

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ABSTRACT

This systematic review and meta-analysis aimed to investigate the interplay between problematic gaming behaviour and health-related outcomes at different developmental stages. A total of 50 empirical studies met the specified inclusion criteria, and a meta-analysis using correlation coefficients was used for the studies that reported adverse health implications regarding the impact of problematic gaming behaviour on depression, anxiety, obsessive–compulsive disorder and somatisation. Overall, the results suggested that problematic gaming behaviour is significantly associated with a wide range of detrimental health-related outcomes. Finally, the limitations of this review alongside its implications were discussed and considered for future research.

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Introduction

Over the last decade, video games have increasingly become an integral aspect of individuals' leisure activities and everyday life. Videogame playing is highly prevalent among young people worldwide according to several reports. In Europe, it has been estimated that approximately 25 per cent of the entire European population aged between 16 and 64 years played video-games at least once a week in 2012 (Interactive Software Federation of Europe (ISFE), 2012). Moreover, the latest data from the EU Kids Online (2014) have shown that online gaming among European children and adolescents from seven European countries aged between 9 and 16 years has significantly increased from 16 per cent in 2010 to 28 per cent in 2014.

There are currently several approaches adopted by researchers to characterise addictive engagement with videogames. Previous research has relied on inconsistent and non-standardised frameworks to define problematic gaming behaviour (PGB). For example, parallels were established between the pathological gambling diagnostic criteria, generalised Internet addiction (IA) and/or substance use disorder (King et al., 2013; Kuss et al., 2017a; Pontes and Griffiths, 2014). This diagnostic approach has been used by researchers because it was believed that the way of determining whether behavioural addictions were addictive was to compare them against clinical criteria for other established drug-ingested addictions (Griffiths, 1996; Pontes and Griffiths, 2014).

Notwithstanding the recent ongoing conceptual debates surrounding PGB (e.g. Griffiths et al., 2016; Griffiths and Pontes, 2014; King et al., 2013; Kuss et al., 2017a; Petry et al., 2015), the American Psychiatric Association (APA) included Internet Gaming Disorder (IGD) as a potential disorder warranting further research in Section III of the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; APA, 2013). In terms of its definition and diagnosis, IGD comprises a behavioural pattern encompassing persistent and recurrent engagement with both online and offline games, leading to significant impairment or distress over a 12-month period (APA, 2013). Thus, IGD may be indicated when a per-son endorses at least five out of the nine following criteria: (1) a preoccupation with games; (2) withdrawal symptoms when gaming is taken away; (3) tolerance, resulting in the need to spend increasing amounts of time engaged in games; (4) unsuccessful attempts to control participation in games; (5) loss of interest in previous hobbies and entertainment as a result of, and with the exception of, games; (6) continued excessive use of games despite knowledge of psychosocial problems; (7) deceiving family members, therapists or others regarding the amount of gaming; (8) the use of games to escape or relieve negative moods and (9) jeopardising or losing a significant relationship, job or education or career opportunity because of participation in games (APA, 2013).

The assessment of PGB has been extensively researched, and the inclusion of IGD in the DSM-5 has facilitated more research examining the quality and implications of the phenome-non. Several reviews and empirical studies investigating the psychometric assessment of IGD were conducted (see King et al., 2013; Pontes and Griffiths, 2014, 2015b). Due to the ongoing debate and unofficial

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status of IGD as a bona fide addiction (Kuss et al., 2017ab; Saunders et al., 2017), the term PGB was adopted throughout this study.

Although video gaming is mostly regarded as a beneficial entertainment leisure activity, there is a large body of research illustrating the potential links between PGB, negative social outcomes and poor psychological health including, but not limited to, greater levels of lonel-ness (Haagsma et al., 2012), increased anxiety (Peng and Liu, 2010), greater levels of depres-sion (Pontes and Griffiths, 2016), lower academic achievement and conduct problems (Brunborg et al., 2014), higher incidence of sleeping problems (Achab et al., 2011; Dworak et al., 2007; Lam, 2014), decreased offline social support (Kaczmarek and Drążkowski, 2014), reduced decision-making ability (Pawlikowski and Brand, 2011), greater attentional bias (Jeromin et al., 2016), lower psycho-social well-being (Lemmens et al., 2011), decreased happiness (Hull et al., 2013) and other negative psychosocial outcomes (see Kuss and Griffiths, 2012b).

Conversely, evidence on the positive effects of healthy gaming abounds in the literature. For instance, moderate gaming has been found to be associated with relaxation and stress reduction (Snodgrass et al., 2011). Connolly et al. (2012) reported the potential contribution of gaming to enhancing learning processes and the development of a wide range of cognitive skills. Additionally, further studies demonstrated that both competitive and cooperative gaming can significantly reduce stress levels (Roy and Ferguson, 2016), leading to augmented creative performance (Yeh, 2015) and decreased levels of loneliness and social anxiety (Martončik and Lokša, 2016).

Notwithstanding this, there is plenty of research on the harmful addictive effects videogames can have, though these studies are not without drawbacks. Thus, there are still questions that remain to be addressed and specific areas warranting further research in this context. Previous reviews on PGB focused on identifying key limitations in terms of etiology and predictors (Kuss and Griffiths, 2012a), prevalence rates (Ferguson et al., 2011) and assessment (King et al., 2013; Pontes et al., 2017). Further research highlighting the under-lying neuropsychological mechanisms of PGB has been conducted (e.g. Forrest et al., 2016; Pontes and Griffiths, 2015a). Finally, the links between personality and PGB have also been extensively investigated (Griffiths et al., 2015).

There is still a paucity of evidence allowing researchers to grasp a solid understanding of the negative health implications emerging from PGB. Thus, the main aim of this study is to systematically review the existing evidence on PGB and its associated cross-cultural health-related outcomes to ascertain the health impacts of PGB on adolescents, young adults and adults. Thus, this study can contribute to both promoting and shaping future evidence-based research practices and inform prevention, education and treatment of PGB.

Throughout this study, health was defined as a state of complete physical, social and mental well-being (World Health Organisation (WHO), 1946). In turn, positive mental health was defined as including elements of emotional (i.e. affect/feeling), psychological (i.e. positive functioning), social (i.e. relationship with others), physical and spiritual (i.e. sense of meaning and purpose in life) well-being (Barry and Friedli, 2008). Research has also shown that internalising and

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externalising behaviours can negatively impact health (Achenbach, 1991). A number of determinants affecting the health or well-being of individuals can be organised according to the WHO framework at the psychological level (emotional health or control, ability to concentrate or nervousness, life satisfaction, self-efficacy and stress level), social level (feeling of loneliness, social connections and relationships with peers and family) and physical level (changes in sleeping, physical complaints, injuries and level of physical activity). Based on these operational definitions, positive health-related outcomes imply a functional state whereby psychological, social and biological aspects of mental and physical health and well-being are in harmony within individuals.

Methods

Search strategy

The review process was conducted in accordance to the guidelines of the Centre for Reviews and Dissemination (CRD, 2008) for systematic review and meta-analysis. Systematic literature searches were conducted in the following electronic databases: Scopus, Ovid MEDLINE, PsycARTICLES and CINAHL to retrieve studies published between January 2005 and June 2016. The search strategy was generated with the help of a Research Support Librarian using the following terms: MeSH video games, MeSH behaviors addictive ('computer gam*' OR 'video gam*' OR 'Internet gam*') AND (problem* OR compulsive OR 'addict*' OR patholog* OR dependen) AND (health OR 'well-being' OR wellbeing OR welfare OR 'quality of life' OR 'life satisfaction' OR effect OR impact OR outcome OR physical OR psychological OR mental OR social OR eating OR 'food consumption' OR diet OR sleep OR activity OR fitness OR exercise OR cardiorespiratory OR obesity OR overweight OR pain OR musculoskeletal OR body OR discomfort OR loneliness OR friendship OR relation-ship OR communication OR fatigue OR stress OR ailment OR depression OR anxiety OR mood OR somatic OR psychosomatic OR symptom OR disorder).

Study inclusion and exclusion criteria

In order to be suitable for review, studies had to (1) include participants older than a mean age of 12.5 years; (2) assess PGB based on all or some of the core criteria suggested by King et al. (2013; i.e. withdrawal, loss of control and problems referring to personal relationships and school or work difficulties); (3) assess the association between PGB and at least one health-related physical, psychological and/or social health outcome; (4) have a prospective, cross-sectional and/or retrospective longitudinal study design; and (5) be published in a peer-reviewed journal in English. Studies were not eligible for review if they (1) had reported the participants' mean age below 12.5 years; (2) had an experimental (e.g. randomised con-trolled trial (RCT)) or a single-case study (N = 1) design; (3) were focused exclusively on the therapeutic aspects of digital gaming (i.e. educational or serious games interventions); (4) were focused on gambling behaviours (e.g. online poker, roulette, etc.); (5) were unpublished dissertations, thesis studies and/or conference papers;

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(6) were not published in a peer-reviewed journal; (7) had a focus on other technological addictions (e.g. IA); (8) had investigated the impact or interactions of videogaming on the players' neurobiological or cognitive functioning and (9) focused on aggression effects.

Quality and risk bias assessment

The checklist created by the Joanna Briggs Institute (JBI, 2014) was adopted and modified to evaluate the quality and risk bias across all studies (see Supplement A). This checklist is appropriate for examining both cross-sectional and longitudinal studies, and a list of key objective criteria were selected (seven for cross-sectional studies and nine for longitudinal studies) that allowed for a comprehensive assessment of the quality and risk bias of the studies. These criteria included, for instance, the consecutive or random participant sampling means employed (sampling bias), the eligibility criteria of the participants provided (selection bias), identified confounding factors (bias in analysis), adequate measures of PGB and health factors employed (measurement bias), clear description of the study characteristics provided (reporting bias) and appropriate analysis employed (bias in analysis). A scoring system was used to determine the quality of each study whereby a score of 0 corresponded to the item not being present, a score of 0.5 corresponded to the item being present with some limitations and a score of 1 corresponded to the item being present. Based on this scoring system, the studies being assessed could obtain a maximum of 7 points for cross-sectional studies and 9 points for longitudinal studies, and scores ranged from 0 to 7 or 9 points, with greater scores suggesting higher quality of the study being reviewed.

Analysis

A meta-analysis was conducted with the data that were statistically and methodologically homogeneous using STATA 11.2 (StataCorp, 2009). The meta-analysis was performed when a health-related factor had at least three independent effect size estimates. Correlation coefficients (r) were used to determine the effect size for the meta-analysis. In cases where other forms of effect size statistics were reported (i.e. mean differences, odd ratios, etc.), these were converted to correlation coefficients utilising standard formulae (Borenstein et al., 2009). Moreover, random effects models were used to examine how the effect ratios (i.e. symptoms of depression and anxiety in PGB) differed between the participants' age subgroups. The symptoms of depression and anxiety in PGB were included in the analysis because there were three or more estimates available (to be valid moderator) in each developmental category, and the subgroup analyses of other health-related outcomes were there-fore not conducted. The studies included in the analysis were categorised into different develop-mental stages based on the following age groups: childhood and adolescence (12–18 years), young adults (18–28 years) and young adults to older adults (over 18 years). Random effects models were used to assess overall effect sizes because of the underlying assumption of heterogeneity between samples. The effect sizes were interpreted according to Cohen's (1992) recommendations whereby a correlation of 0.09 or less indicated a null effect, 0.10 a small effect, 0.30 a medium effect and 0.50 a large effect. I-squared (I^2) and Q-statistic values were computed to determine the degree of heterogeneity among the effect sizes. I^2 statistic ranges from 0 to 100 per cent were adopted, whereby I^2 values of 25 to 50 percent were

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described as low, 50–75 per cent moderate and 75 per cent or greater high dispersal (Higgins et al., 2003). The presence of publication bias was assessed by inspecting funnel plots and conducting Egger's test ($p < 0.05$; Sterne et al., 2001) for the factors when there were three or more independent estimates available.

Results

Search results

The study selection process (Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) by Moher et al., 2009, Supplement B) yielded a total of 2,203 studies. Of these, 1890 were identified in Scopus, 174 in MEDLINE, 87 in CINAHL, 49 in PsycArticles and 3 from other sources. To ensure reproducibility, the selection of studies was carefully documented using RefWorks® (CRD, 2008). The duplicates (n = 30) from four databases were eliminated (CRD 2008). Moreover, two researchers (N.M. and M.K.) independently screened the titles and abstracts of the studies retrieved (n = 2,173) and available full texts (n = 116). As a result, a total of 50 studies met the inclusion criteria. Key information from included studies with regard to year of publication, country/countries of participants, study design, sample sizes, gender of participants, assessment tools utilised to investigate PGB and associated health-related outcomes, in addition to methodological considerations (e.g. type of analysis, effects and effect size estimates), were extracted into a Word document. A total of 32 studies could not be included in the quantitative analyses due to insufficient data.

Descriptive characteristics of the included studies

Of all 50 studies (summarised in Supplement C) selected for review, 5 used a longitudinal design, while the majority were cross-sectional (i.e. 45 studies). Most studies were published from 2010 onwards (90%, 45 populations). The majority of the study populations came from Europe (19 populations, 73,285 participants), eight were from South-East Asia (8441 participants), five were from the America (3,154 participants), nine from the Western Pacific Regions (19,264 participants) and seven were multicultural samples (25,286 participants). The participants' age varied from 12 to 88 years. Of all 50 studies, 30 included adolescents only or young adults (12–25 years), with 22 studies focused mainly teen-agers (12–18 years). Sample sizes across all 50 studies ranged from 110 to 23,533 participants. With regard to gender, three studies used male-only samples, and 18 studies included mostly male participants (i.e. over 60% male). Where reported, the proportion of females in the studies ranged from 3 to 65 per cent.

Assessment of PGB

A variety of PGB assessment tools were utilised throughout all 50 studies (see Supplement C), including the Gaming Addiction Scale (GAS; Lemmens et al., 2009, 12 populations), the IGD criteria (DSM-5; APA, 2013, 2 populations) and the Young's Internet Addiction Scale (IAT; Young, 1996, 9 populations). Approximately half of the studies (n = 27) adopted the criteria for

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pathological gambling (Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev.; DSM-IV-TR); APA, 2000) to assess PGB. Furthermore, PGB was assessed using modified criteria for substance use disorder (DSM-IV-TR, APA, 2000, 2 populations or International Classification of Diseases-10 (ICD-10), WHO, 1993, 2 populations) and IA (other than Young's criteria (e.g. Compulsive Internet Use Scale (CIUS; Meerkerk et al., 2009), Chen's Internet Addiction Scale (Chen et al., 2003), 8 populations). Finally, nine studies (17%) used miscellaneous criteria to assess PGB.

Assessment of health-related and well-being outcomes

Of the 50 included studies, 46 reported data on psychological factors, whereas 17 focused on psychological health factors. In 19 studies, measures of social factors were included, and in 18 studies, data on physical health-related factors were reported (see Supplement D). The most commonly adopted health-related tools were the Rosenberg's Self-Esteem Scale (RSES; Rosenberg, 1965, 5 populations), the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997, 3 populations), the Beck Depression Inventory I or II (BDI; Beck et al., 1961, 1996, 3 populations), the Satisfaction With Life Scale (SWLS; Diener et al., 1985, 3 populations) and the Hospital Anxiety and Depression Scale (HADS; Zigmond and Snaith, 1983, 2 populations). Personality factors were usually assessed using the Five-Factor Model (Big-Five Inventory (BFI-10); McCrae and Costa, 1987, 2 populations; Five-Factor Inventory (NEO-FFI); Costa and McCrae, 1992, 2 populations)].

Quality and risk bias of the studies

Quality and risk of bias assessments were con-ducted for all studies reviewed (see Supplement A). The mean Joanna Briggs Institute Checklist score was 4.9 (range = 2–7) for cross-sectional and 5.8 (range = 5–7) for longitudinal studies. The degree of risk of bias across the reviewed studies was also scrutinised. Accordingly, 41 (82%) studies were considered low risk relating to all risks of bias (scores ≥4). Furthermore, 16 studies (32%) sampled their participants using randomisation techniques, whereas in 38 studies (76%), participants' eligible criteria were defined by researchers. This assessment showed that most of the studies (n = 39; 78%) employed validated measures of health-related factors. Out of all 50 reviewed studies, 38 (76%) assessed PGB on a continuum whereby total scores obtained were used to indicate the severity of PGB. In 29 studies (58%), confounding factors were identified and accounted for health effect estimates. A total of 36 studies (72%) provided adequate descriptions of participants' characteristics. Finally, 42 studies (84%) conducted appropriate analyses in health-related effect size estimates.

PGB: health-related outcomes

Psychological health-related outcomes. A number of psychological health factors were found to be associated with PGB. Overall, depression and anxiety were the most commonly associated outcomes (see Supplement C). More specifically, a total of 8 studies (i.e. Brunborg et al., 2014; Desai et al., 2010; Király et al., 2014; Li et al., 2011; Papay et al., 2013; Peng and Liu, 2010; Strittmatter et al., 2015; Van Rooij et al., 2011) found PGB to be positively associated with

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depression alone, while 11 studies (i.e. Andreassen et al., 2016; Bouna-Pyrrou et al., 2015; Kim et al., 2016b; Lehenbauer-Baum et al., 2015; Lemos et al., 2016; Mentzoni et al., 2011; Müller et al., 2015; Son et al., 2013; Starcevic et al., 2011; Van Rooij et al., 2012; Vukosavljevic-Gvozden et al., 2016) found PGB to be associated with both depression and anxiety.

Additionally, PGB was found to be positively associated with the following outcomes: attention-deficit hyperactivity disorder (ADHD; Andreassen et al., 2016), psychoticism (Starcevic et al., 2011), obsessive–compulsive disorder (OCD; Andreassen et al., 2016; Kim et al., 2016b; Starcevic et al., 2011; Vukosavljevic-Gvozden et al., 2016), obsessive passion disorder (Lafreniere et al., 2009) and general psychiatric distress (Király et al., 2015; Rikkers et al., 2016). One study (Li et al., 2011) reported that gamers exhibiting greater actual-ideal self-discrepancy and depression were more likely to present with higher levels of escapism and PGB symptoms. Additionally, a total of six studies reported that PGB was associated with lower levels of quality of life or life satisfaction (Festl et al., 2013; Lehenbauer-Baum et al., 2015; Lemmens et al., 2015; Mentzoni et al., 2011; Montag et al., 2011; Scharkow et al., 2014).

Several studies also reported PGB to be associated with greater impulsivity (Kim et al., 2016b; Walther et al., 2012), poorer self-control (Kim et al., 2008), increased attention deficit (Andreassen et al., 2016; Gentile, 2009; Müller et al., 2015; Walther et al., 2012), hyperactivity (Baer et al., 2012; Rikkers et al., 2016; Strittmatter et al., 2015), concentration prob-lems (Kim et al., 2016b), augmented self-dis-crepancy (Kwon et al., 2011), lower self-esteem (Festl et al., 2013; Lemmens et al., 2015; Papay et al., 2013; Van Rooij et al., 2012; Walther et al., 2012), impaired life skills (Baer et al., 2012) and low school well-being (Rehbein and Baier, 2013). Wan and Chiou (2006) reported that dissatisfaction concerning safety, love, belonging, self-esteem and self-actualisation were key risk factors for PGB. Similarly, Wu et al. (2013) reported that needs for autonomy, competence and relatedness were inversely associated with PGB.

The relationship between PGB and personal-ity factors was also established in this review. Accordingly, neuroticism was the most observed trait related to internalising problems and psychological health through the feeling of unpleasant emotions (e.g. anxiety, depression). It was found that neuroticism was negatively linked to PGB (Lehenbauer-Baum et al., 2015; Mehroof and Griffiths, 2010; Montag et al., 2011; Peters and Malesky, 2008). By contrast, Wang et al. (2014) did not find an association between PGB and neuroticism.

Social health–related outcomes. Regarding social health factors, it was found that PGB was mostly associated with problems in interfamily relationships (Jeong and Kim, 2011), familial harmony (Rikkers et al., 2016; Wang et al., 2014), social integration at school (Rehbein and Baier, 2013), parent–child attachment and parental rearing attitudes (Kim and Kim, 2015) and social self-efficacy (Rehbein et al., 2010; Walther et al., 2012). Additionally, shyness (Peng and Liu, 2010), social phobia (Lehen-bauer-Baum et al., 2015), decreased openness (Wang et al., 2015) and interpersonal difficul-ties (Baer et al., 2012; Festl et al., 2013; Kim et al., 2008; Müller et al., 2015; Rikkers et al., 2016; Strittmatter et al., 2015) were positively associated with PGB. Furthermore, social self-efficacy in the virtual world and preferences for online interactions correlated positively

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with PGB (Collins and Freeman, 2013; Jeong and Kim, 2011; Porter et al., 2010). Finally, PGB was found to be associated with greater levels of loneliness (Kim et al., 2016b; Lemmens et al., 2015; Van Rooij et al., 2012; Walther et al., 2012).

Physical health–related outcomes. Physical health outcomes were assessed in 13 studies. Accordingly, PGB was found to be associated with experiences of physiological symptoms such as somatisation (Kim et al., 2016b; Müller et al., 2015; Starcevic et al., 2011), shifts in the autonomic nervous system (Coyne et al., 2015) and plasma catecholamine responses (Kim et al., 2016a). Additionally, PGB was found to be associated with decreased levels of physical activity (Henchoz et al., 2016; Montag et al., 2011) and hand and wrist pain (Gentile, 2009). A recent study (Kim and Kim, 2015) found that PGB induced cardiovascular stress reaction in gamers, leading to a decrease in plasma catecholamine norepinephrine (NE) and epinephrine (Epi) levels over time. A 1-year longitudinal study (Coyne et al., 2015) found that changes in physiological indicators (i.e. sympathetic and parasympathetic nervous system activities) were associated with PGB because decreased respiratory sinus arrhythmia (RSA) withdrawal alterations in response to specific tasks were associated with greater severity of PGB. Finally, PGB was also reported to be associated with sleep problems in several studies (Achab et al., 2011; Kim et al., 2016a; Rehbein et al., 2010).

Meta-analysis

Of all 53 studies and all health-related outcomes reviewed, depression, anxiety, OCD and somatisation were found to be sufficient for a meta-analysis to be conducted. A total of 33 effect sizes were included in the quantitative analysis.

The analysis of the association between PGB and depression yielded a total of 14 effect sizes, and the average effect size obtained was 0.26 (0.20–0.30, with a 95% confidence interval (CI), $p < 0.0001$) with an I2 value of 98 per cent (see Supplement document E). As for the analysis of anxiety in PGB, a total of 1^2 effect sizes were computed, and the average effect size obtained was 0.28 (0.19–0.37, with 95% CI, $p < 0.0001$) with an I^2 value of 98.3 per cent (see Supplement document D).

A total of four effect sizes for OCD were computed, and the average effect size obtained was 0.40 (0.22–0.59, with a 95% CI, $p < 0.0001$) with an I^2 value of 99 per cent, whereas a total of three effect sizes were computed for somatisation with the average effect size of 0.40 (0.20–0.59, with a 95% CI, $p < 0.0001$) with an I^2 value of 97.3 per cent (see Supplement F).

The effect sizes for depression and anxiety symptoms in PGB in different age groups were also computed (see Supplement F). More specifically, children and adolescents presented with lower effect sizes for depression and anxiety in comparison to young adults (age of 18– 28 years) and young adults to older adults (over 18 years).

Overall, the results of the meta-analysis highlighted the key role played by the following health-related factors in PGB: depression, anxiety, OCD and somatisation. However, statistically significant (Q test, $p < 0.05$) and high ($I^2 > 75\%$) heterogeneity in the effect sizes were found.

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Analysis of the funnel plots showed considerable heterogeneity in the effects, but no significant risk of publication bias across all studies reviewed. The Egger test results ranged between $p = 0.244$ and 818 (see Supplement F).

Discussion

This study aimed at identifying the most relevant, adverse health-related outcomes associated with PGB. In order to achieve this aim, a systematic review was conducted using a total of 50 studies. Overall, the findings provided new insights showing how PGB negatively impacts psychological, social and physical health.

This review provides robust evidence of the overall significant negative links between PGB and health-related outcomes, especially in the psychological health domain, which is in line with previous studies (Fuster et al., 2016; Greitemeyer and Mügge, 2014; King et al., 2013; Pontes & Griffiths, 2015c, 2016; Pontes et al., 2016; Pontes et al., 2017; Saunders et al., 2017). This was the first study quantifying the correlations between PGB and specific health indicators, such as depression, anxiety, OCD and somatisation. The meta-analysis showed that these health correlates had an average small-to-medium effect size. Adverse health-related effects in PGB were generally heterogeneous ($I^2 > 75\%$; Higgins et al., 2003). Regarding the age-related findings, depression and anxiety symptoms yielded a medium effect size in young adults or adults, whereas the effect size was small in the group of adolescents. Future research should examine the role of develop-mental factors in the relationship between risk factors of PGB as this may help designing efficacious intervention programmes.

Although many studies investigated associated psychological health-related outcomes in PGB, recent studies (e.g. Baer et al., 2012; Collins and Freeman, 2013; Festl et al., 2013; Jeong and Kim, 2011; Lee and Leeson, 2015) examined distinct underlying interpersonal mechanisms of PGB (e.g. family harmony and functioning, social support online and offline and social activities with peers and friends). Socioemotional factors such as social capabili-ties (e.g. Peng and Liu, 2010; Rehbein et al., 2010; Walther et al., 2012), personal character-istics (Charlton and Danforth, 2010; Peters and Malesky, 2008) and loneliness (e.g. Kim et al., 2016b; Lemmens et al., 2015; Van Rooij et al., 2012) were also implicated in PGB. Based on the findings obtained, it can be argued that social and interactive schemes in videogames may motivate gamers to seek more social inter-actions within videogames as opposed to real-life interactions. This assumption has also been recently corroborated by recent empirical studies evaluating the social nature of video games and PGB (Pontes, in press). Furthermore, external stressors (e.g. problems in family function) may lead to a greater risk of PGB.

In terms of physical health–related outcomes linked to PGB, it was found that the most frequently reported outcomes were alterations in physical functioning such as somatisation (e.g. Kim et al., 2016b; Müller et al., 2015) and sleep disturbances (Achab et al., 2011; Kim et al., 2016a; Rehbein et al., 2010). Furthermore, preliminary evidence emerged suggesting that PGB may contribute to

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a lack of physical activity (Henchoz et al., 2016; Rehbein et al., 2010) even though this relationship is not causal (Mentzoni et al., 2011). This assumption is plausible given that videogames can jeopardise engagement in physical activities leading to sedentary behaviour (Rideout et al., 2010).

A small amount of studies investigated changes in PGB symptoms longitudinally (Rehbein and Baier, 2013; Scharkow et al., 2014; Van Rooij et al., 2011). Previous research found that PGB is unstable due to spontaneous remission. More specifically, studies have found that up to 50% of individuals may recover naturally (e.g., Gentile et al., 2011; Scharkow et al., 2014). By contrast, further longitudinal evidence found a high degree of consistency in PGB symptoms (Gentile et al., 2011; Rehbein and Baier, 2013). Although problematic pat-terns of technology can occur at young ages (Andreassen, 2015), the stability and long-term influences of PGB are not so well understood. Additional longitudinal data are required to unravel the temporal patterns and directionality of PGB symptoms in relation to adverse health correlates.

Previous work has shown that the level of severity in terms of gaming time and harmful engagement differs between PGB individuals (Griffiths et al., 2016). Moreover, high video-game engagement indicates a less severe problem compared to PGB (Brunborg et al., 2013) as time spent gaming is not necessarily associated with the health-related problems in gamers' lives (Brunborg et al., 2014). The strengths of this study included a search strategy used that focused on studies employing the core PGB criteria, making this review and analysis highly comparable in contrast to PGB studies based on game duration or inconsistent assessment criteria.

Notwithstanding this, potential limitations in this study need to be acknowledged. First, only reports published in English were reviewed, implying that potential relevant studies may have been inadvertently over-looked. Second, the results reported are largely cross-sectional, thus not allowing causal inferences regarding PGB and health-related outcomes. Additionally, sampling bias may have occurred as most participants across the studies reviewed were recruited from online gaming forums and social networking sites. Third, there was significant variability in the measurement of PGB and health-related outcomes, and most studies defined PGB and health-related outcomes based upon participants' self-report, potentially introducing response bias or socially desirable responding. Moreover, most studies employed inconsistent cut-off to determine PGB, and only a few studies employed the new IGD frame-work from the DSM-5 to assess the behaviour. Fourth, due to heterogeneity of the data obtained, it was impossible to examine the overall effect sizes for all relevant health out-comes. Finally, most of the studies reviewed included male-only samples, and thus, future studies should include more female participants to ascertain specific gender-related differences in PGB.

Future longitudinal studies evaluating the direction of the causal relationship between PGB and changes in health-related factors should be conducted to further corroborate the findings reported here. Additionally, research on PGB should adopt a socio-ecological approach (i.e. individual, gaming culture, relationship, community and societal level) as it may enhance the understanding of PGB.

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Taken together, to the best of authors' knowledge, this is the first study that has systematically reviewed key adverse health– related outcomes linked to PGB. The findings obtained suggested that health-related factors such as depression, anxiety, OCD and somatisation were strongly associated to PGB, further highlighting the need for PGB assessment in young people with high-risk profiles for behavioural problems. In this context, developing further preventive initiatives in respect to PGB may be beneficial. Such initiatives should be targeted to the psychosocial characteristics of individuals at risk for PGB in a holistic way. Finally, the development of prevention and treatment programmes should include activities that build social competence and the skills to handle stress.

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