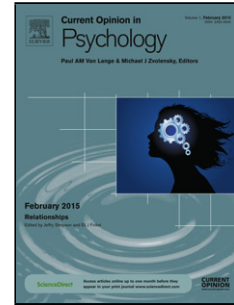


Journal Pre-proof

Delineating adaptive esports involvement from maladaptive gaming: a self-regulation perspective

Damien Brevers (Conceptualization) (Methodology) (Writing - original draft), Daniel L King (Writing - review and editing), Joël Billieux (Conceptualization) (Writing - review and editing)



PII: S2352-250X(20)30137-8

DOI: <https://doi.org/10.1016/j.copsyc.2020.07.025>

Reference: COPSYC 1053

To appear in: *Current Opinion in Psychology*

Please cite this article as: { doi: <https://doi.org/>

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2020 Published by Elsevier.

Delineating adaptive esports involvement from maladaptive gaming: A self-regulation perspective

Damien Brevers¹, Daniel L. King², Joël Billieux^{3,4}

¹ Institute for Health and Behaviour, Department of Behavioural and Cognitive Sciences, University of Luxembourg, Esch-sur-Alzette, Luxembourg

² College of Education, Psychology, & Social Work, Flinders University, Australia

³ Institute of Psychology, University of Lausanne, Lausanne, Switzerland

⁴ Centre for Excessive Gambling, Lausanne University Hospitals (CHUV), Lausanne, Switzerland

* **Corresponding author:** Brevers Damien, PhD, Institute for Health and Behaviour, Department of Behavioural and Cognitive Sciences, University of Luxembourg, Esch-sur-Alzette, Luxembourg, e-mail: damien.brevers@uni.lu

Abstract

The last decade has witnessed the rise of electronic sports (esports), yet little is known about how involvement in intensive esports relates to self-regulatory processes, such as executive functioning (EF). In this paper, we review the evidence on EF in problematic and non-problematic video-game use. We also consider research on EF in traditional sports athletes, as well as in “exercise addiction.” The focus of the review is on two core components of EF, namely response inhibition and cognitive flexibility. The available evidence suggests that EF is a reliable marker for indexing specific types of sport and video-gaming expertise, but does not appear to consistently delineate maladaptive from adaptive video-game involvement.

Future research avenues on EF that characterize esports players are suggested to advance this area.

Keywords: esports; self-regulation; executive functioning, response inhibition; cognitive flexibility

Introduction

Electronic sports, or *esports*, refer to organized, competitive forms of video-games that can be played individually or in a team and viewed by spectators either in-person or via streaming services [1]. With the advance in digital technologies, there has been an exponential worldwide increase in the popularity of esports and an increased number of national and international tournaments [1,2]. Along with this increased involvement in esports, the world has been introduced to a new generation of esports players, including some who, like elite athletes, receive (high) income through prize monies, sponsorship, and celebrity endorsements [2].

There have been some claims that the development of esports may promote dysfunctional gaming practices (i.e., gaming disorder, GD [3]). In 2019, GD was recognized as a condition by the World Health Organization and included in the 11th edition of the International Statistical Classification of Diseases and Related Health Problems (ICD-11). As defined in the ICD-11, one of the central features of GD is loss of control over gaming, which involves an inability to regulate the duration of gaming sessions or the context in which they take place [4-6]. Nevertheless, it has been suggested that GD criteria may not distinguish harmful from adaptive esports involvement [••7]. Moreover, little is known about how esports practice (e.g., strenuous training, disappointment after low performances, boredom [••8,9]) relates to players' self-regulation capacities. In particular, intensive esports involvement might

impact on daily-life executive functioning (EF), which plays a pivotal role in the voluntary pursuit and attainment of life goals [10].

The present paper aims to discuss how EF has the potential to delineate GD from adaptive esports involvement. Indeed, while both adaptive and problematic gaming may involve intensive video-game use (e.g., in terms of time commitment), one is adaptive (peak esports performance) and one is maladaptive and constitutes a mental condition (GD). Here we focused on two core EF processes, namely response inhibition (i.e., the ability to stop a response that has been initiated but has become inappropriate or unwanted; [11]) and cognitive flexibility (i.e., the ability to successfully adapt to a constantly changing environment; [12]). We selected these two constructs from the available evidence that advances their crucial role in the characterization of impulsive (a failure to suppress addiction-related behaviors) and compulsive (an inability to shift behaviors toward healthy and functional areas of life) components of addictive disorders [13,14]. We start by reviewing the evidence regarding EF in problematic and non-problematic video-game use. We next review the evidence regarding EF in sport athletes and in the debated construct of “sport addiction” or “exercise addiction.” In light of these findings, we then propose research avenues for a better understanding of EF in esports players and to avoid the conflation of adaptive and maladaptive intensive video-game involvement.

2. EF in GD population, gamers, and athletes

2.1. Response inhibition

2.1.1. GD population. In GD research, response inhibition has been measured by using the Stroop task, the go/no-go task (GNGT), and the stop-signal task (SST). Meta-analyses have highlighted that individuals with GD exhibit lower inhibitory control in the Stroop task and the GNGT [15,16]. Nevertheless, the main literature on the GNGT shows that between-group

differences do not necessarily hold when controlling for response speed [17]. Put differently, response inhibition can be affected by response speed (i.e., “go” trials for GNGT, “congruent” trials for the Stroop task; for a brief task description, see **Table S1** in *supplementary materials*). This aspect is especially relevant because significant reaction time differences (increased or decreased speed) have been frequently observed between individuals with IGD and matched-control participants (e.g., [17-19]). However, to the best of our knowledge, none of these studies controlled (at an individual or a group level) for the effect of reaction time on response inhibition outcomes.

In contrast to the Stroop task and the GNGT, the SST allows for the estimation of response inhibition independently of categorization speed on “go” trials through the computation of the stop-signal reaction time (SSRT; slower SSRT indicates lower efficiency of response inhibition; see also **Table S1**). When relying on the effect sizes reported by two recent meta-analyses (studies undertaken before May 2016 in [15]; before October 2017 in [16]), it appears that GD is linked to a decrease in SST performance. However, one meta-analysis focused on SST response accuracy (e.g., “go” response on “stop” trials) rather than on SSRT [15]. The other reported SST performance across five studies, but it is not clear which SST index was used to compute effect sizes [16]. Specifically, one study did not report SSRT [21]; two studies reported lower response inhibition (i.e., slower SSRT), but in a sample of individuals with problematic Internet use (i.e., not GD-specific [22]), or in a sample of problem gamblers with problematic Internet use (again, not GD-specific [23]); and the two remaining studies did not observe a significant response inhibition (i.e., SSRT) difference between GD and matched-controls (playing Internet games less than 2h/day [24,25]).

We found four additional studies that reported response inhibition (indexed by SSRT on the SST) in individuals with GD [26-29], which were not included in the above-

mentioned meta-analyses. Three studies did not observe a significant difference between the GD (treatment seeking in [28]) and the control groups (non-gamers in [27,28]; frequent gamers in [26]). Only Wang and colleagues [•29] reported lower response inhibition in a sample of treatment-seeking adolescents with GD compared with that in matched non-gamer controls. Overall, when reviewing the effect size and statistical power of studies that have reported SSRT (see **Table S2**), it is unclear whether GD is associated with a decrease in response inhibition.

2.1.2. Gamers. Two studies did not observe a significant SSRT difference between highly involved players in “first-person shooter” games (FPS; this game type requires the player to rapidly react to fast-moving visual/auditory stimuli) and non-gaming matched controls ([30,31]; see **Table S2**). Interestingly, when comparing different groups of video-game players, Deleuze et al. ([•32]; see **Table S2**) highlighted that FPS players exhibited lowered response inhibition on the SST compared with players who favored massively multiplayer online role-playing games and with multiplayer online battle arena players. These results remained significant when taking into account the potentially confounding effect of demographics, time played per week, impulsivity traits, depression, and IGD symptoms. Hence, these findings suggest that regular video-game practice may modulate response inhibition ability.

2.1.3. Athletes. Elite athletes (i.e., young athletes who perform at high-levels of competition or professional adult athletes) exhibit higher response inhibition (i.e., faster SSRT on the SST) than do non-athletes (see **Table S2**). Notably, these enhanced patterns of response inhibition vary according to the level of sport expertise, with elite-level athletes displaying better response inhibition than amateur or recreational athletes do (see **Table S2**).

Interestingly, better response inhibition has been highlighted in sports that involve direct contact with an opponent (soccer, handball, fencing, taekwondo; [33-37]), but not in sports

that do not involve direct physical contact with the opponent (volleyball, badminton; [38-40]). Hence, response inhibition ability seems to differ according to the type of sport expertise.

Few studies have been reported on inhibitory control in exercise and sport “addiction,” possibly because this addiction construct is poorly operationalized and defined [41-42], or because there are few treatment-seeking cases, as compulsive physical exercise is mostly viewed as a by-product of eating disorders [43]. Yet, we identified a study that provides preliminary evidence that “exercise addicts” present decreased inhibitory control (but as assessed with a go/no-go task) when compared with regular exercisers and non-exercisers [44].

2.2. Cognitive flexibility

2.2.1. GD population. Cognitive flexibility may be operationalized as the ability to shift response sets to a previously irrelevant dimension (i.e., attentional set-shifting), or to adjust choices with changes in contingencies (i.e., reversal learning). The most widely used neuropsychological tasks for the evaluation of attentional set-shifting are the Wisconsin Card Sorting Test (WCST) and the Intra-/Extra-Dimensional Set-Shifting Task (ID/ED; see **Table S1** for an overview). Reversal learning can be assessed with the Probabilistic Reversal Learning Task (see also **Table S1**).

Attentional set-shifting and reversal learning have been examined in GD by Banca and colleagues [45]. Their study found that individuals with GD were less effective in reversal learning, but not in attentional set-shifting compared with matched-control participants. Another case-control study did not observe a significant difference in attentional set-shifting performance between individuals with GD and matched-control participants [25]. Han et al. [46] examined attentional set-shifting in a group of individuals with GD with

comorbid major depressive disorder, a GD group without depressive symptoms, and a group of controls. These authors found that performance on ID/ED was lower in the GD group with a major depressive disorder compared with that in the GD group without depression and the control group, signaling the importance of taking into account the impact of a comorbid depressive disorder on EF.

2.2.2. Gamers. Numerous studies have shown that video-game players (especially FPS players) are faster than non-players in switching between tasks (i.e., decreased “switch cost” during response mapping tasks; for a review, see [47,48]). Yet, these results should be considered cautiously because they might have been overestimated and subjected to publication bias [49]. However, no study has specifically examined attentional set-shifting and reversal learning across different levels or types of video-game expertise.

2.2.3. Athletes. A decreased “switch cost” effect has also been consistently reported in elite athletes (for a meta-analysis, see [50]). Surprisingly, little is known regarding reversal learning and attentional set-shifting abilities among elite athletes. The two only studies that we identified report that attentional set-shifting ability (measured with the WCST in [51], and with the ID/ED in [52]) increases in terms of sport expertise.

We failed to identify any study that has investigated cognitive flexibility in individuals who are “exercise addicts.” As explained earlier, this might be due to controversies and inconsistencies regarding the operationalization of this condition and/or the reduced number of treatment-seeking cases.

3. Perspectives and research avenues

3.1. The need for individualized approaches

The above findings suggest a number of research directions to examine how EF operates among esports players. Of particular importance is the observed modulatory effects of

comorbid GD psychopathology (e.g., depressive symptoms), as well as of the types of video-game and sport expertise on EF.

Overall, these findings call for applying a person-centered analytic approach to the study of EF in esports. Such an approach would allow one to map patterns of EF to specific profiles of esports players (e.g., differing in esports subgenre, level of performance, or motives to play; [53]). For example, a study by Wang et al. [29] used cluster analysis to show that, despite significant between-group differences, more than 70% of a sample with GD symptoms presented intact inhibitory control (assessed by the SST). A similar approach also allowed improvement in the understanding of the complex links and interrelations between specific patterns of problematic video-game use (e.g., [54,55]). Another method is to combine case-control studies (intergroup approach) with complementary profile analyses (intragroup approach). By using such a method in a sample of treatment-seeking gamblers, Billieux et al. [56] showed that only 40% of the patients presented with an *abnormally low* pattern of response inhibition, despite significant between-group differences with non-gamblers. Hence, such an analytic approach will allow matching of practical indexes of EF that characterize esports players (e.g., using quintiles to identify levels of performance: impaired, low, mild, high, outstanding) to GD symptoms.

3.2. Using an ecological index of EF

Although laboratory tasks offer sensitive measures of EF, they are also characterized by limited ecological validity. For instance, these tasks present a low correlation with EF performance in natural settings among patients with neurological and developmental disorders [57]. Another potential methodological issue is that the response modalities pertaining to computerized EF tasks mimic those of video gaming (e.g., to push left/right computer keys on go trials of the SST), implying a potential transfer from video-game expertise to the computerized assessment of EF. For instance, lower response inhibition

performance in FPS players [•32] might reflect adaptive adjustment to video-game expertise, but not a decreased ability in response inhibition per se. This aspect is of key importance for esports, which links strategic actions to fast, accurate finger-key actions under stressful competitive environments.

Laboratory tasks should thus not serve as the sole source for estimating EF in video-gamers and esports players. For instance, in individuals with attention-deficit/hyperactivity disorder, EF can be reliably assessed with the Barkley Deficits in Executive Functioning Scale (BDEFS [58]; see **Table S3** for examples of items from each subdimension of the scale). Potential advantages to self-rating of EF include the ecological validity and predictive capacity in relation to daily life impairment [59]. Indeed, the BDEFS correlates with measures of comorbid disorders (e.g., major depression) and predicts impairment or deviant behaviors in daily living (e.g., antisocial acts), as well as occupational functioning, better than EF tasks do [59]. Another interesting aspect of the BDEFS is that it can also be completed by someone who knows the individual well. Hence, applying this procedure to esports players should allow parents and/or trainers to help their children/athletes in self-regulating their video-game use on a daily life basis (see also [60]).

The examination of EF in esports would thus benefit from a comparable line of research aiming to offer a more comprehensive understanding of both the maladaptive and adaptive features of competitive video-gaming. This goal could be operationalized through the creation of items that tap into daily-life self-regulatory challenges encountered by esports players (e.g., personal hygiene, screen time, sleep, diet, esports betting; [•61-62]) and by examining their ability to face such situations (see **Table S3** for an illustration). Comparable front-loaded phenomenological approaches have already been used to better grasp key psychological processes involved in sport performance (e.g., precompetitive emotional states [63]), or to provide qualitative understandings of engagement in new types of digital conduct

(e.g., binge-watching of TV series [•64], social media use [•65]). These ratings of EF should also be particularly relevant when adopted throughout the stages of the esports career (e.g., initiation, development, mastery, and discontinuation) in order to inform about the main pathways and challenges encountered during a career in esports [••8,66].

4. Conclusion

Given the constantly growing popularity of esports and related activities, it is urgent to identify markers that delineate adaptive high involvement in video games from problematic involvement. Yet, based on our review of the literature, pathological involvement in video gaming is a heterogeneous condition that is not necessarily associated with EF deficits. Moreover, available research shows that specific games (and sport expertise) differentially impact EF, which raises questions regarding whether the studies have taken game genre into account. Our view is that the similarities and specificities of video-gaming and rule-based competitive sports call for new lines of research on EF. Exploring this question is crucial if we are to develop a gaming-specific theoretical and practical understanding of how these key self-regulatory processes unfold among esports players. This line of research should lead to the development and funding of innovative educational and intervention programs and to the spread of these actions to parents, young adult peers or siblings, teachers, and esports coaches.

CRedit author statement

Damien Brevers: Conceptualization, Methodology, Writing - Original draft preparation and Editing. **Daniel King:** Writing - Reviewing and Editing. **Joël Billieux:** Conceptualization, Writing - Reviewing and Editing.

Authors' contributions

DB and JB wrote the manuscript. DLK provided critical input and revisions. The manuscript's content was discussed and approved by all authors.

Declaration of interests

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

Conflicts of interest

DB, DLK, and JB declare no conflict of interest.

Journal Pre-proof

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- of outstanding interest

References

1. Hamari J, Sjöblom, M: **What is eSports and why do people watch it?** *Internet Res* 2017, **27**:211-232.
2. Funk DC, Pizzo AD, Baker BJ: **eSport management: Embracing eSport education and research opportunities.** *Sport Manag Rev* 2018, **21**:7–13.
3. Chung T, Sum S, Chan M, Lai E, Cheng N: **Will esports result in a higher prevalence of problematic gaming? A review of the global situation.** *J Behav Addict* 2019, **8**:384-394.
4. World Health Organization, 2019. *ICD-11 for Mortality and Morbidity Statistics*. Retrieved from: <https://icd.who.int/browse11/l-m/en#/http://id.who.int/icd/entity/1448597234> 2019.
5. Billieux J, Potenza M, Maurage P, Brevers D, Brand M, King D: **Cognitive Factors associated with Gaming Disorders.** In *Cognition and addiction: A researcher's guide from mechanisms towards interventions*. Edited by Verdejo-Garcia A. MA: Elsevier Academic Press; 2020:221-230.
6. Brand M, Young KS, Laier C, Wölfling K, Potenza MN: **Integrating psychological and neurobiological considerations regarding the development and maintenance of specific Internet-use disorders: an Interaction of Person-Affect-Cognition-Execution (I-PACE) model.** *Neurosci Biobehav* 2016, **71**:252-266.

- 7. Nielsen RKL, Karhulahti Veli-Matti: **The Problematic Coexistence of “Internet Gaming Disorder” and Esports.** *Proceedings of FDG’17, Hyannis, MA, USA, August 14-17, 2017*, 4 pages. *This work mapped each GD criterion to the phenomenological understanding of e-sport (how it is played and its requirements) and revealed that it is currently unclear whether DSM criteria can distinguish e-sport involvement from IGD.*
- 8. Salo M: **Career Transitions of eSports Athletes: A Proposal for a Research Framework.** *Int J Gam Comp-Mediat Simul* 2017, **9**:22–32. *This paper provides an insightful research framework for the adoption of a lifespan approach on e-sport career trajectories.*
- 9. Yin K, Zi Y, Zhuang W, Gao Y, Tong Y, Song L, Liu Y: **Linking Esports to health risks and benefits: Current knowledge and future research needs.** *J Sport Health Sci* 2020, <https://doi.org/10.1016/j.jshs.2020.04.006>
- 10. Diamond A: **Executive Functions.** *Annu Rev Psychol* 2013, **64**:135–68.
- 11. Verbruggen F, Aron AR, Band GP, Beste C, Bissett PG, Brockett AT, et al: **A consensus guide to capturing the ability to inhibit actions and impulsive behaviors in the stop-signal task.** *eLife* 2019, **8**:e46323. *This paper provides state-of-the-art guidelines for measuring motor response inhibition with the stop-signal task.*
- 12. Brown VJ, Tait DS: **Attentional Set-Shifting Across Species.** *Curr Top Behav Neurosci* 2016, **28**:363–95.
- 13. Odlaug BL, Chamberlain SR, Kim SW, Schreiber LRN, Grant JE. **A neurocognitive comparison of cognitive flexibility and response inhibition in gamblers with varying degrees of clinical severity.** *Psychol Med* 2011, **41**:2111–9.
- 14. Rochat L, Maurage P, Heeren A, Billieux J: **Let’s open the decision-making umbrella: A framework for conceptualizing and assessing features of impaired decision making in addiction.** *Neuropsychology Review* 2019, **29**:27-51.

15. Argyriou E, Davison CB, Lee TTC: **Response Inhibition and Internet Gaming Disorder: A Meta-analysis.** *Addict Behav* 2017, **71**:54–60.
16. Ioannidis K, Hook R, Goudriaan AE, Vlies S, Fineberg NA, Grant JE, et al: **Cognitive deficits in problematic internet use: meta-analysis of 40 studies.** *Br J Psychiatry* 2019, **20**:1–8.
17. Zhao X, Liu X, Zan X, Jin G, Maes JHR: **Male Smokers' and Non-Smokers' Response Inhibition in Go/No-Go Tasks: Effect of Three Task Parameters.** *PLoS ONE* 2016, **11**:e0160595.
18. Cai C, Yuan K, Yin J, Feng D, Bi Y, Li Y, et al: **Striatum morphometry is associated with cognitive control deficits and symptom severity in internet gaming disorder.** *Brain Imag Behav* 2016, **10**:12–20.
19. Dong G, Shen Y, Huang J, Du X: **Impaired error-monitoring function in people with internet addiction disorder: an event-related fMRI study.** *Euro Addict Res* 2013, **19**:269–75.
20. Littel M, van den Berg I, Luijten M, van Rooij AJ, Keemink L, Franken IH: **Error processing and response inhibition in excessive computer game players: an event-related potential study.** *Addict Biol* 2012, **17**:934–47.
21. Choi JS, Park SM, Lee J, Hwang JY, Jung HY, Choi SW, et al: **Resting-state beta and gamma activity in internet addiction.** *Int J Psychophysiol* 2013, **89**:328–33.
22. Li H, Zou Y, Wang J, Yang X: **Role of stressful life events, avoidant coping styles, and neuroticism in online game addiction among college students: a moderated mediation model.** *Front Psychol* 2016, **7**:1–11.
23. Chamberlain SR, Redden SA, Leppink E, Grant JE: **Problematic internet use in gamblers: impact on clinical and cognitive measures.** *CNS Spectr* 2017, **22**:495–503.

24. Choi JS, Park SM, Roh MS, Lee JY, Park CB, Hwang JY, et al: **Dysfunctional inhibitory control and impulsivity in internet addiction.** *Psychiatry Res* 2014, **215**:424–28.
25. Lim J-A, Lee J-Y, Jung HY, Sohn BK, Choi S-W, Kim YJ, et al: **Changes of quality of life and cognitive function in individuals with Internet gaming disorder.** *Medicine* 2016, **95**:e5695.
26. Deleuze J, Nuyens F, Rochat L, Rothen S, Maurage P, Billieux J. **Established risk factors for addiction fail to discriminate between healthy gamers and gamers endorsing DSM-5 Internet gaming disorder.** *J Behav Addict* 2017, **6**:516–24.
27. Irvine MA, Worbe Y, Bolton S, Harrison NA, Bullmore ET, Voon V: **Impaired decisional impulsivity in pathological videogamers.** *PLoS ONE* 2013, **8**:e75914.
28. Kim Y-J, Lim JA, Lee JY, Oh S, Kim SN, Kim DJ, et al: **Impulsivity and compulsivity in Internet gaming disorder: A comparison with obsessive-compulsive disorder and alcohol use disorder.** *J Behav Addict* 2017, **6**:545–53.
- 29. Wang L, Tian M, Zheng Y, Li Q, Liu X. Reduced loss aversion and inhibitory control in adolescents with internet gaming disorder. *Psychol Addict Behav* 2020, **34**:484–96. *This research used the stop-signal task and employed cluster analysis to examine response inhibition in individuals with gaming disorder.*
30. Colzato LS, van den Wildenberg WPM, Zmigrod S, Hommel B: **Action video gaming and cognitive control: playing first person shooter games is associated with improvement in working memory but not action inhibition.** *Psychol Res* 2013, **77**:234–9.
31. Steenbergen L, Sellaro R, Stock A-K, Beste C, Colzato LS: **Action Video Gaming and Cognitive Control: Playing First Person Shooter Games Is Associated with Improved Action Cascading but Not Inhibition.** *PLoS ONE* 2015, **10**:e0144364.

- 32. Deleuze J, Christiaens M, Nuyens F, Billieux J: **Shoot at first sight! First person shooter players display reduced reaction time and compromised inhibitory control in comparison to other video game players.** *Comp Hum Behav* 2017, **72**:570–6. *This research provides an accurate assessment of response inhibition according to the type of videogaming expertise.*
- 33. Brevers D, Dubuisson E, Dejonghe F, Dutrieux J, Petieau M, Cheron G, et al: **Proactive and Reactive Motor Inhibition in Top Athletes Versus Nonathletes.** *Percept Mot Skills* 2018, **125**:289–312.
- 34. Heppe H, Zentgraf K: **Team Handball Experts Outperform Recreational Athletes in Hand and Foot Response Inhibition: A Behavioral Study.** *Front Psychol* 2019, **10**:971.
- 35. Huijgen BCH, Leemhuis S, Kok NM, Verburch L, Oosterlaan J, Elferink-Gemser MT, et al: **Cognitive Functions in Elite and Sub-Elite Youth Soccer Players Aged 13 to 17 Years.** *PLoS ONE* 2015, **10**:e0144580.
- 36. Verburch L, Scherder EJA, van Lange PAM, Oosterlaan J: **Executive functioning in highly talented soccer players.** *PLoS ONE* 2014, **9**:e91254.
- 37. Verburch L, Scherder EJA, Van Lange PAM, Oosterlaan J: **Do Elite and Amateur Soccer Players Outperform Non-Athletes on Neurocognitive Functioning? A Study Among 8-12 Year Old Children.** *PLoS ONE* 2016, **11**:e0165741.
- 38. Chen J, Li Y, Zhang G, Jin X, Lu Y, Zhou C: **Enhanced inhibitory control during re-engagement processing in badminton athletes: An event-related potential study.** *J Sport Health Sci* 2019, **8**:585–94.
- 39. Meng F-W, Yao Z-F, Chang EC, Chen Y-L: **Team sport expertise shows superior stimulus-driven visual attention and motor inhibition.** *PLoS ONE* 2019, **14**:e0217056.

40. Liao K-F, Meng F-W, Chen Y-L: **The relationship between action inhibition and athletic performance in elite badminton players and non-athletes.** 2017, Available from: <http://rua.ua.es/dspace/handle/10045/69572>
41. Szabo A: **Addiction, Passion, or Confusion? New Theoretical Insights on Exercise Addiction Research From the Case Study of a Female Body Builder.** *Eur J Psychol* 2018, **14**:296–316.
42. Szabo A, Griffiths MD, de La Vega Marcos R, Mervó B, Demetrovics Z: **Methodological and Conceptual Limitations in Exercise Addiction Research.** *Yale J Biol Med* 2015, **88**:303–8.
43. Dittmer N, Jacobi C, Voderholzer U: **Compulsive exercise in eating disorders: proposal for a definition and a clinical assessment.** *J Eat Disord* 2018, **6**:42.
44. Huang Q, Huang J, Chen Y, Lin D, Xu S, Wei J, et al: **Overactivation of the Reward System and Deficient Inhibition in Exercise Addiction.** *Med Sci Sports Exerc* 2019, **51**:1918–27.
45. Banca P, Harrison NA, Voon V: **Compulsivity Across the Pathological Misuse of Drug and Non-Drug Rewards.** *Front Behav Neurosci* 2016, **10**:154.
46. Han DH, Kim SM, Bae S, Renshaw PF, Anderson JS: **A failure of suppression within the default mode network in depressed adolescents with compulsive internet game play.** *J Aff Dis* 2016, **194**:57–64.
47. Bediou B, Adams DM, Mayer RE, Tipton E, Green CS, Bavelier D: **Meta-analysis of action video game impact on perceptual, attentional, and cognitive skills.** *Psychol Bull* 2018, **144**:77–110.
48. Nuyens FM, Kuss DJ, Lopez-Fernandez O, Griffiths MD: **The Empirical Analysis of Non-problematic Video Gaming and Cognitive Skills: A Systematic Review.** *Int J Ment Health Addiction* 2019, **17**:389–414.

49. Hilgard J, Sala G, Boot WR, Simons DJ: *Overestimation of Action-Game Training Effects: Publication Bias and Salami Slicing*. *Collabra Psychol* 2019, **5**:30.
50. Scharfen H-E, Memmert D: **Measurement of cognitive functions in experts and elite athletes: A meta-analytic review**. *App Cogn Psychol* 2019, **33**:843–60.
51. Han DH, Kim BN, Cheong JH, Kang KD, Renshaw PF: **Anxiety and attention shifting in professional baseball players**. *Int J Sports Med* 2014, **35**:708-713.
52. Vaughan RS, Edwards EJ: **Executive function and personality: The moderating role of athletic expertise**. *Pers Individ Diff* 2020, **161**:109973.
53. Bányai F, Griffiths MD, Demetrovics Z, Király O: **The mediating effect of motivations between psychiatric distress and gaming disorder among esports gamers and recreational gamers**. *Comp Psychiat* 2019, **94**:152117.
54. González-Bueso V, Santamaría JJ, Oliveras I, Fernández D, Montero E, Baño M, et al: **Internet Gaming Disorder Clustering Based on Personality Traits in Adolescents, and Its Relation with Comorbid Psychological Symptoms**. *Int J Environ Res Public Health* 2020, **26**:17.
55. Jeong H, Yim HW, Jo S-J, Lee S-Y, Lee HK, Gentile DA, et al: **Gaming patterns and related symptoms in adolescents using cluster analysis: Baseline results from the Internet User Cohort for Unbiased Recognition of Gaming Disorder in Early Adolescence (iCURE) study**. *Environ Res* 2020, **182**:109105.
56. Billieux J, Lagrange G, Van der Linden M, Lançon C, Adida M, Jeanningros R: **Investigation of impulsivity in a sample of treatment-seeking pathological gamblers: a multidimensional perspective**. *Psychiatry Res* 2012, **198**:291–6.
57. Wood RL, Liossi C: **The ecological validity of executive tests in a severely brain injured sample**. *Arch Clin Neuropsychol* 2006, **21**:429–37.

58. Barkley RA, Murphy KR: **The Nature of Executive Function (EF) Deficits in Daily Life Activities in Adults with ADHD and Their Relationship to Performance on EF Tests.** *J Psychopathol Behav Assess* 2011, **33**:137–58.
59. Barkley RA, Fischer M: **Predicting Impairment in Major Life Activities and Occupational Functioning in Hyperactive Children as Adults: Self-Reported Executive Function (EF) Deficits Versus EF Tests.** *Developmental Neuropsychology* 2011, **36**:137–61.
- 60. Nielsen RKL, Kardefelt-Winther D: **Helping Parents Make Sense of Video Game Addiction.** In *Video Game Influences on Aggression, Cognition, and Attention*. Edited by Ferguson CJ, Cham: Springer International Publishing. 2018:59-69. *This chapter develops insightful rationales for examining videogaming involvement without being forced into a framework of addiction.*
61. Abarbanel B, Johnson MR: **Esports consumer perspectives on match-fixing: implications for gambling awareness and game integrity.** *Int Gambl Stud* 2019, **19**:296–311.
62. DiFrancisco-Donoghue J, Balentine J, Schmidt G, Zwibel H: **Managing the health of the eSport athlete: an integrated health management model.** *BMJ Open Sport Exerc Med* 2019, **5**:e000467.
63. Jones MV, Lane AM, Bray SR, Uphill M, Catlin J: **Development and validation of the sport emotion questionnaire.** *J Sports Exerc Psychol* 2005, **27**:407-431
- 64. Flayelle M, Maurage P, Billieux J: **Toward a qualitative understanding of binge-watching behaviors: A focus group approach.** *J Behav Addict* 2017, **6**:457–71. *This study employed a focus-group approach to better understand the phenomenological characteristics of TV series watching.*

- 65. Brevers D, Turel O: **Strategies for self-controlling social media use: Classification and role in preventing social media addiction symptoms.** *J Behav Addict* 2019, **8**:554–63.

This study employed a naturalistic-qualitative approach for finding commonly employed self-control strategies in relation to social media use.

- 66. Smithies TD, Toth AJ, Conroy E, Ramsbottom N, Kowal M, Campbell MJ: **Life After Esports: A Grand Field Challenge.** *Front Psychol*

2020, **11**:<https://doi.org/10.3389/fpsyg.2020.00883>

Journal Pre-proof