Narrative review of health-related factors of video games and electronic sports

Revisión narrativa sobre factores relacionados con la salud en los videojuegos y deportes electrónicos

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Abstract

The aim of the present work was to analyse empirical evidence regarding physiological effects, performance and health in relation to video game and electronic sports players. A narrative review of existing scientific literature was performed on the state of the issue regarding to factors associated with physiology, performance and health in the context of video games and electronic sports. Principal findings indicated elevated levels of five hormones, high systolic blood pressure and increased heart rate. In the case of exergaming, favourable outcomes emerged for some ergogenic aids, brain activation, cognitive,

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sensorimotor and corticospinal performance, strength, balance, cardiovascular capacity, and social and psychological wellbeing. However, eSports can cause eye fatigue, myofascial syndrome, tendinosis, musculoskeletal pain/syndromes, consumption of unhealthy food, sugary drinks, stimulants and doping substances, sleep disturbance and heart rate variation. Causes, symptoms, characteristics and relationships underlying Internet gaming disorder (IGD) and addiction to video games and electronic sports were also determined. In conclusion, the positive health impact of engaging in electronic sports and video games is noted, however, measures must target electronic sports players in order to avoid the negative effects of excessive video game use.

Keywords: eSport, videogames, exergaming, physical health, physiology, addiction.

Resumen

El objetivo de este trabajo fue analizar la evidencia empírica sobre los efectos fisiológicos, rendimiento y salud de jugadores de videojuegos y deportes electrónicos. Se realizó una revisión narrativa de la literatura científica sobre el estado de la cuestión de factores asociados a la fisiología, rendimiento y salud en videojuegos y deportes electrónicos. Los resultados mostraron importantes hallazgos en los niveles de cinco hormonas, alta presión arterial sistólica y mayor frecuencia cardíaca; en los exergaming se mostraron resultados favorables con algunas ayudas ergogénicas, activación cerebral, rendimientos cognitivo, sensoriomotor y corticoespinal, fuerza, equilibrio, capacidades cardiovasculares y bienestar social y psicológico; los eSports pueden suscitar fatiga ocular, síndrome miofascial, tendinosis, dolores/síndromes musculoesqueléticos, consumo de comida insana, bebidas azucaradas, estimulantes o sustancias dopantes, afectar el sueño y variar la frecuencia cardiaca; y se determinaron las causas, síntomas, perfiles y relación del trastorno por juego en Internet (IGD) con la adicción a los videojuegos y deportes electrónicos. Como conclusión, es destacable el impacto positivo de la práctica de deportes electrónicos y videojuegos en distintos aspectos de la salud y se deben adoptar medidas con los jugadores de deportes electrónicos para evitar los efectos negativos de un uso excesivo de videojuegos.

Palabras clave: eSport, videojuegos, exergaming, salud física, fisiología, adicción.

Introduction

The relationship between health and videogames has been the subject of public debate and academic research (Ferguson, 2007). Previously

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conducted studies have related the use and abuse of videogames with negative effects, such as sedentary behaviour (Santaliestra-Pasías et al., 2013), aggressive behaviour (Anderson & Dill, 2000) and risk of injury or chronic pain (Mcgee & Chiu, 2021; Sekiguchi et al., 2018). In addition, one of the main concerns around the health of video gamers is that they will experience behavioural problems such as addiction (World Health Organization, 2020), despite this actually affecting only a small number of gamers (Kuss & Griffiths, 2012; Weinstein, 2010). This being said, evidence exists of the positive effects of videogames at a physical, cognitive, motivational, emotional and social level (Granic et al., 2014).

The disparity of existing evidence is due to the changing nature of videogames and gamers over recent years and continuous motivational evolution (Dale & Green, 2017). In this sense, when intertwining motivation, together with leisure and entertainment, with competition, denominated "electronic sports" or "eSports", a factor to consider in relation to videogames (Adachi & Willoughby, 2011), the psychological demands entailed are more similar to those found in sport. Whilst competitions date back to 1972, eSports have evolved, over the last decade, to be set apart from video games (Pedraza-Ramírez et al., 2020).

Despite psychological differences (García-Lanzo & Chamarro, 2018), no clear consensus exists on the health of gamers (Yin et al., 2020), although in an attempt to improve their health and extend their careers, eSports professionals tend to engage in physical activity (Giakoni-Ramírez et al., 2022). Whilst exergaming is oriented towards physical exercise, it is not classified as eSports because it lacks a competitive structure (Sween et al., 2014).

Thus, in light of the growing boom in videogames and electronic sports, the present narrative review is novel in its bid to shed light on the relevant physiological effects and health outcomes. In this way, the main aim was to examine empirical evidence of physiological effects, performance and health in individuals who engage in videogames and electronic sports. The narrative review is divided into two sections. The first considers the physiological effects of playing and performance regarding videogames and electronic sports at a recreational and competitive level. The second section considered effects on physical health and the potential development of addiction.

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Method

Articles gathered from the databases and repositories Web of Knowledge, Scopus, Dialnet, Google Scholar, ORCID and ResearchGate were reviewed. The following keywords were used: "eSport", "addictions", "adicciones", "videogame", "videojuego", "performance", "computer game", "physiology", "salud", "healthy", "exergaming", "gamer". The following search criteria were applied: articles, review articles, books and doctoral thesis completed between 2000 and 2023. Inclusion criteria stipulated that, for inclusion, articles had to present studies that dealt with videogames and/or electronic sports and considered the physiological effects of performance at a recreational and competitive level, health-related effects and addiction development. After running the search, 107 research studies were selected that met the aim of the narrative review.

Results

Physiological effects of playing videogames and electronic sports

Physiological response

Studies on hormone response have focused on cortisol levels (Mendoza et al., 2021; Schmidt et al., 2020), testosterone (Oxford et al., 2010), DHEA, androstenedione and aldosterone (Gray et al., 2018). Emotions have been shown to be relayed as two pleasant and two unpleasant emotions prior to engaging in a videogame (Behnke et al., 2022). On the other hand, when creating a videogame, emotions have been analysed from a dynamic standpoint harnessing multiple components (Leitão et al., 2020). Lipid profiles have also been considered in children (Manousaki et al., 2020), as has cardiorespiratory fitness and cardiometabolic risk in children and adolescents (Tornquist, et al. 2022).

Regarding to cortisol, pre-competition levels, subjective importance of the match and cognitive anxiety were higher in expert eSports players (Mendoza et al., 2021). On the one hand, prior to and following a game session, cortisol levels increased during the game, as a function of whether videogames players experienced victory or defeat, in such a way that winners reported low-to-moderate levels and greater anxiety (Mendoza et al., 2021). On the other hand, an increase in cortisol has

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been seen prior to a tournament, with levels remaining significantly higher immediately afterwards (Oxford et al., 2010).

With regards to testosterone, higher values have been revealed immediately after a game in individuals who most contributed to winning points, whilst average testosterone levels were significantly higher immediately after a match in individuals whose team defeated an external team in a tournament in which they formed part of the ingroup (Oxford et al., 2010). Reductions in aldosterone were also found to be associated with the length of play against others, being positively correlated with increased testosterone, DHEA and androstenedione. In contrast, cortisol has been found to not be negatively related with changes in testosterone, with reductions being more related with the number of matchups played (Gray et al., 2018).

Findings reveal that pleasant and unpleasant emotions do not influence cardiac efficiency when compared to control conditions and that individuals with greater reactivity to cardiac output performed better (Behnke et al., 2022). Further, emotions arise out of the interaction between assessment, expression, motivation and physiology, with the coming together of these resulting in subjective feeling (Leitão et al., 2020). Also of note, obsessive passion has been found to predict negative consequences, although it also predicted better performance in online competitions (Bertran & Chamarro, 2016).

Concerning to assessment of lipid profile in children, no independent association was found between playing videogames/computer games and the lipid profile after adjusting for adiposity and other covariates (Manousaki et al., 2020). Further, high screen time, due to playing videogames, computer use and television viewing, and low cardiorespiratory fitness were related with high systolic blood pressure (Tornquist et al., 2022).

Finally, a higher heart rate was found to be associated with higher ratings when it came to perceiving a game that was about to be played as a challenge (Kätsyri et al., 2013a), in addition to winning more points and the belief that they are better than other more experienced players (Maciej et al., 2020). Also, a first-person shooting game produced a greater change in maximum heart rate (Sousa et al., 2020).

Cognitive performance

When it comes to assessment of aspects related to the brain, males were mostly examined (De Las Heras et al., 2020; Ding et al., 2018; Giboin et al., 2021; Gong et al., 2019; Hyun et al. 2013), with the exception of

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a study conducted by Tartar et al. (2019). The first cited study revealed that *eSports* are related with plasticity of central executive functions and default mode areas. In the second study, multi-player videogames set in battlefields were found to be associated with cognitive capacities including tracking multiple objects, concentration and visuospatial awareness, and personality traits such as conscientious, with this potentially being due to training effects. On the other hand, in individuals without pathologies, regular and prolonged play was found to be related with volume changes in the prefrontal and parietal cortex, which was, in turn, associated with cognitive flexibility (Hyun et al. 2013). In addition, consumption of inositol-stabilized arginine silicate, nooLVL®, may improve executive functioning in *gamers* during play via improved accuracy, decision making and reaction time (Tartar et al., 2019).

With regards to cerebral and physiological aspects, ergogenic aids were examined in three research studies. In one such study, nooLVL® intake increased vigour-energy and decreased rage (Tartar et al., 2019). In a second study, the energy drink *ReloadTM* was found to have no effect on either mental performance, specifically, attention, reaction time and working memory, or physical performance, specifically, handgrip strength and finger tapping speed (Thomas et al., 2019). Finally, in the third study, 3 mg/kg of caffeine was found to improve accuracy and simple reaction time for hitting (Sainz et al., 2020). On the other hand, the use of hypoxia was found to increase the number of errors committed in the discrimination of angles/distances, increasing levels of anxiety and stress and impinging intellectual working, thinking and performance in general, despite it potentially producing benefits for routine operations based on responses to simple signals (Tambovtseva & Sechin, 2019). Further, following an *eSports* session involving two types of games, first-person shooting and MOBA, it was concluded that both types of games reduced inhibitory control and accuracy of executive functioning, suggesting that increased activation of the sympathetic nervous system may be at play (Sousa et al., 2020).

Concerning to sensorimotor performance and corticospinal characteristics related with action videogames, greater corticospinal excitability has been observed, with varying relationships emerging with reaction time and intracortical inhibition, which could potentially mask excitatory and topographic differences (Giboin et al., 2021).

Finally, a brief intense cardiovascular exercise, prior to gaming, improved accuracy, the capacity to eliminate targets and positive affective state (De Las Heras et al., 2020).

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The brain during electronic sports competitions

Brain activation is associated with the win-lose binomial (Kätsyri et al., 2013b) and, given recent interest in transcranial random noise stimulation (tRNS), effectiveness of this approach in relation to learning and performance of a complex task was examined (Chenot et al., 2022). Another study examined neuronal desensitisation in relation to a violent videogame (Goodson et al., 2021).

The first study mentioned reported that brain activation was greater when winning and upon achieving victory. Further, prefrontal ventromedial cortex and dorsal striatum responses were found to be stronger for winning when subjects were winning against another human being (Kätsyri et al., 2013b). Next, a group subjected to high definition tRNS showed more improvements over the long-term than a comparison group receiving simple definition tRNS, as they tended to learn more quickly and performed better against simulated groups (Chenot et al., 2022). Finally, in contrast to the aforementioned potential harmful effect of playing violent videogames, no hormonal desensitisation was uncovered (Goodson et al., 2021).

Physical health and addiction to videogames and electronic sports

Physically active videogames

Active video gaming or exergaming is the combination of gaming and physical exercise (Gao et al., 2016), with the aim of perforating screen time with exercise that is performed in a fun way (Best, 2013; Höchsmann et al., 2016; Simons et al., 2015). The perception of enjoyment may be a crucial factor for promoting exergaming as an alternative to generic physical activity, as this may provoke greater adherence (Feltz et al., 2014; Lee et al., 2017; Schättin et al., 2022) and increase daily physical activity in individuals with sedentary lifestyles (Best, 2013; Gao et al., 2016; Simons et al., 2015). Further, it can be used to improve physical abilities in older individuals and patients with cardiac diseases, obesity, Parkinson's and osteoporosis (Agmon et al., 2011; Höchsmann et al., 2016; Hurkmans et al., 2011; Maranesi et al., 2022; Rezaei et al., 2022). In this sense, greater strength and improved balance helps to prevent falls and improve cardiovascular fitness (Agmon et al., 2011; Martin-Niedecken et al., 2021; Schättin et al., 2022; Vernadakis et al., 2012) and executive function (Huang, 2020; Moret et al., 2022). It may also lead to greater connection between family members, especially between grandparents and grandchildren, which seems to drive to better social and psychological wellbeing (Wollersheim et al., 2010).

Effects on physical health

Sedentary behaviour was found to be associated with a greater risk of premature death and health complications (Silva et al., 2016), however, regular exergaming may help to attenuate this (Best, 2013; Gao et al., 2016; Höchsmann et al., 2016; Martin-Niedecken et al., 2021). In this sense, competing and spending a large amount of time each day engaged in eSports (three to ten hours/day) may be harmful (Bonis, 2007; DiFrancisco-Donoghue et al., 2022), with eye strain, neck and back pain, myofascial syndrome and tendinosis all being more common amongst gamers (Kaczmarek et al., 2022; Silva et al., 2016; Zapata et al., 2006). Notably, adolescents exhibit a high prevalence of musculoskeletal pain/ syndromes (Queiroz et al., 2018), with 42.6% of eSports gamers reporting that they suffer from some type of musculoskeletal pain (Lindberg et al., 2020) with, specifically, 36% reporting wrist pain, 32% hand pain and 31% back pain. This being said, only 2% reported requiring medical assistance to deal with this pain (DiFrancisco-Donoghue et al., 2019).

In young overweight individuals, excessive screen time increases sedentary behaviour and the consumption of unhealthy foods and sugary drinks (Smith et al., 2021). Additionally, playing videogames may affect sleep and heartrate variability (Ivarsson et al., 2013), especially in the case of e-games players, due to long playing hours. This also goes hand in hand with greater consumption of stimulants, such as caffeine, and doping substances, such as dextroamphetamine (Holden et al., 2018). Likewise, engaging in videogames for longer than three hours a day, combined with the sporting aspect, may increase the risk of suffering injuries to the elbow and shoulder joints (Sekiguchi et al., 2018).

Addiction to videogames and electronic sports

Videogames may produce negative effects in 8-14% of gamers (Choo et al., 2010) and, whilst little evidence is available about addictions to

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electronic sports (Chen & Bu, 2022), interest has grown over the last twenty years with regards to disordered online game use (Choi et al., 2018; Mao, 2021; Paulus et al., 2018). Interest is mainly born out of the fact that excessive engagement in electronic sports can turn into internet gaming disorder (IGD). According to Maldonado-Murciano et al. (2022), the main causes of IGD are depression, anxiety, childhood trauma, authoritarian parenting, negligent parenting, permissive parenting, the male sex and the parent's job, amongst others (Buiza-Aguado et al., 2018; Choi et al., 2018; Gonzálvez et al., 2017). Symptoms of IGD include reduced sleep time, obesity, raised blood pressure, low high-density cholesterol, high triglycerides, high insulin resistance (Turel et al., 2016), worrying about the game, withdrawal syndrome, greater tolerance (need for greater commitment to the game), inability to cut down on game time, dropout from other activities, continuing to play despite the associated problems, lying to relatives, using games to alleviate negative mood states and loss of work or sentimental relationships (American Psychiatric Association, 2013). It is also important to note that IGD increases when more than one device is used, such as a mobile telephone and a computer, leading, as a result, to greater depression, anxiety and substance abuse disorders (Paik et al., 2017).

In consideration of the aforementioned causes and symptoms, the combination of variables inherent to IGD were examined in a sample of gamers who were subsequently classified according to different profiles (Colder & Kardefelt-Winther, 2018; Martín-Fernández et al., 2017). In the case of the former citation, this corresponded to 2.2% of gamers being assigned to the IGD class, 63.5% to the normative class, 7.3% to the engaged class and 23.6% to the concerned class (Colder & Kardefelt-Winther, 2018). In contrast, Martín-Fernández et al. (2017) identified two profiles with one being characterised by few IGD symptoms and the other, comprising a small number of individuals, describing severe IGD symptoms. Given that gamers with IGD may have the same neurocognitive and social deficiencies as methamphetamine users, IGD is considered to be an addiction (Jiang et al., 2020).

Addiction risk is significantly greater in children, in individuals with poor academic performance and in those who prefer online multiplayer games (Wang et al., 2014), with worse addiction being associated with average amount of weekly time spent playing, frequency with which money is spent on games and length of time spent on games, lack of family harmony and absence of close friendships (King et al., 2020;

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Meduna et al., 2020). Likewise, diminished happiness and altered time perceptions whilst playing have been found to be the variables with the most predictive power in terms of addiction (Hull et al., 2013).

Nonetheless, a degree of controversy exists, given that DSM-V diagnostic criteria (American Psychiatric Association, 2013) do not separate multiplayer online role-playing games (MMORPG) from gambling, games of chance, pornography and other types of addictions associated with the Internet (Carbonell, 2014; Griffiths et al., 2016; Šincek et al., 2017). For this reason, inclusion of IGD in the International Classification of Diseases is being considered (Aarseth et al., 2017) as a means to improving assessment and understanding of the symptoms discussed above (Faust & Prochaska, 2018; Király et al., 2015; Maldonado-Murciano et al., 2022).

Discussion

The aim of the present study was to examine existing empirical evidence of the physiological, performance and health effect of videogame and electronic sports players. Hormone response, brain activation, cardiovascular reactivity, pleasant-unpleasant emotions, performance parameters, anxiety, heart rate and lipid profile have all been examined, increasing knowledge regarding the impact of some videogames and electronic sports on the human body and the interactions that take place within it. Nonetheless, the relatively small sample size represents a limitation of the present review (Chenot et al., 2022; Giboin et al., 2021; Kätsyri et al., 2013a; Kätsyri et al., 2013b; Leitão et al., 2020; Maciej et al., 2020; Oxford et al., 2010), as does inconsistency in the videogames chosen for examination (e.g. FIFA 19, Space Fortress, *BZFlag*, *Counter-Strike: Global Offensive* and *Unreal Tournament* 2004) (Behnke et al., 2022; Chenot et al., 2022; Kätsyri et al., 2013a; Maciej et al., 2020; Oxford et al., 2010), predominance of the male sex (Behnke et al., 2022; Chenot et al., 2022; De Las Heras et al., 2020; Ding et al., 2018; Giboin et al., 2021; Gong et al., 2019; Gray et al., 2018; Hyun et al., 2013; Kätsyri et al., 2013a; Kätsyri et al., 2013b; Maciej et al., 2020; Oxford et al., 2010) and failure to specify sex distribution in a sample of 630 individuals (Manousaki et al., 2020). Likewise, included studies present numerous differences in terms of sample split, actual playing time, inclusion of computers as an

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assist, procedure and the baseline characteristic data available on gamers. This makes it impossible to, not only, generalise findings to a larger number of individuals, bigger range of videogames and females but, also, prevents comparisons and conclusions from being made with the aim of establishing more meaningful and robust parameters, which would favour the development of intervention guidelines and/or pertinent measures. In any case, the reviewed published research provides a reference base upon which increasingly comprehensive advances can be made in this field of knowledge. This will be essential given the growing number of gamers (Jonasson & Thiborg, 2010).

Performance assessment in gamers has focused on aspects pertaining to human development and equilibrium, however, as is the case in the leisure setting, research into *eSports* is still in the preliminary stages (Reitman et al., 2020) and the demands of gamers must be investigated in order to optimise their health and performance outcomes (Thomas et al., 2019). Indeed, certain psychological, neurophysiological and perceptual motor parameters are starting to be prioritised over physical parameters, given that professional and high performance gamers are physically active, engaging in around 1.08 hours of physical exercise in 5.28 overall hours of training (Kari et al., 2019). In this sense, anxiety appears to have a greater impact on performance than physiological excitation (cortisol and heart rate variability) (Schmidt et al., 2020), whilst some nutritional supplements, i.e. new inositol-stabilized arginine silicate, nooLVL®, and caffeine, may improve executive function and perceptual motor skills (Sainz et al., 2020; Tartar et al., 2019). This being said, it must be born in mind that another supplement, *ReloadTM*, did not lead to any type of mental or physical improvement (Tambovtseva & Sechin, 2019). Consequently, it is possible to identify the association between some videogames, three nutritional supplements and certain psychological, neurophysiological and perceptual motor parameters. In conclusion, future research is urged, not only, to continue to consider variables with an already growing research base but, also, to examination the combination of variables, recruit larger samples, include more females, standardise variables and videogames, and examine potential psychomotor implications for neuromotor development, physical and affective-social health, and management of leisure and free time.

The adaptive effect of *eSports* on human development may be as demanding at a cognitive and physical level as traditional sports (Gong et al., 2019), making it, potentially, a suitable tool for cognitive, cerebral, educational (Boot, 2015; Latham et al., 2013) and physical research. However, in contrast to the improvement seen in executive function (Cain et al., 2012; Colzato et al., 2010; Glass et al., 2013; Hyun et al., 2013), its impact at a physical level appears to be more convoluted, given its predominant use of the upper body at the expense of other parts of the body, together with long periods of sitting during matches. For this reason, *gamers* may be more active than the population average, bearing in mind that no less than 95% of gamers engage in physical exercise through participation in traditional sports (Hebbel-Seeger, 2012) and are, therefore, physically active (Kari et al., 2019). Further, given that continuous engagement in exergaming improves health (Best, 2013; Gao et al., 2016; Höchsmann et al., 2016; Martin-Niedecken et al., 2021), game design should be personalised in order to modulate intensity, duration and the skills targeted for improvement (Moret et al., 2022; Williams & Ayres, 2020). In addition, in both eSports and videogames, potential associated risks should be considered, such as the consumption of unhealthy foods (Simons et al., 2015), strain injuries due to excessive screen time (Pourmand et al., 2017; Stavrinos et al., 2009; Stavrinos et al., 2011), and overuse injuries due to excessive repetition of a determined movement (Cowley & Minnaar, 2008; Sparks et al., 2009; Tripette et al., 2014).

With regards to addictions, whilst obsessive use of videogames and eSports may emerge in 8-14% of gamers (Choo et al., 2010), for those who do not experience negative symptoms, gaming may bring some benefits. Potential benefits include reduced stress, improved problem solving techniques, greater coordination, greater capacity for critical thinking, social skills, greater attention span and greater team working capacity, amongst others (Abedini et al., 2012; Saquib et al., 2017; Shi et al., 2020). Further, in the case of gamers who do not experience IGD, there is growing evidence to suggest that emotional intelligence and social support may be preventive factors (Dang et al., 2019; Tham et al., 2020). Nevertheless, gamers with IGD may confuse pleasure and happiness when associating their affective states to videogames (Gros et al., 2020). As a result, they may be less likely to engage in cognitive reappraisal and more likely to repress their emotions (Yen et al., 2017). In this regard, high levels of cognitive reappraisal and inability to suppress emotions was shown to be related with depression, anxiety and hostility amongst gamers with IGD. Thus, the development of interventions targeting emotional intelligence in gamers with IGD may help to nullify

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negative symptoms. Likewise, given the scarcity of research examining videogame addiction from a multi-factorial standpoint, it would be of great interest to conduct studies that examine the combination of gamer profiles and conceive personalised interventions.

Conclusions

In conclusion, a notable increase in publications on factors related with human physiology, performance and health is highlighted, which provides increasingly comprehensive knowledge in relation to videogames, eSports and human beings. Specifically, with regards to physiological effects and performance, levels of the hormones cortisol, testosterone, aldosterone, DHEA and androstenedione were found to be altered, depending on the point in the match at which measurements were made. On the other hand, high systolic blood pressure was found to be related with low cardiorespiratory fitness and excessive screen time. Further, higher heart rate was positively associated with performance and favourable outcomes were uncovered in relation to some ergogenic aids, brain activation and cognitive, sensorimotor and corticospinal parameters. In relation to physical health, the physical activity engaged in during exergaming improves strength, balance and cardiovascular capacity, whilst also benefiting social and psychological wellbeing when engaged in with family members. On the other hand, eSports can lead to eye strain, myofascial syndrome, tendinosis, musculoskeletal pain/syndromes, and consumption of unhealthy food, sugary drinks and stimulants or doping substances, in addition to affecting sleep and heart rate. Finally, an in-depth look was taken of the causes, symptoms and profiles inherent to IGD and its relationship with addiction to videogames and electronic sports. This addiction, despite debate around DSM-V diagnostic criteria and the potential inclusion of IGD in the International Classification of Diseases, was characterised in accordance with two personality types regarding susceptibility and other relevant variables.

Limitations and future perspectives

Limitations of the present work include the predominance of males in included samples, use of different videogames by individual research studies, failure to specify the sex distribution in a sample of 630 individuals, non-standardised sample split and research setting, different research settings, non-controlled actual playing times, variable inclusion of computers as assists and different availability of baseline characteristic data for gamers. These limitations prevent generalisation of findings. Further, the growing nature of the sector, which is growing out of step with the rate at which research is being conducted, makes it difficult to examine many of the findings obtained in a number of studies and slows knowledge transfer. Likewise, challenges exist to evaluating the effects of videogame use in different countries, given variations in the degree of digitalisation between locations. Thus, the limitations highlighted here should be addressed through future lines of research.

To this end, future studies are urged, not only, to consider the factors discussed above, but, also, to consider additional aspects more broadly, for instance, by examining the impact of attention span, concentration and other psychological variables, in addition to variables pertaining to executive brain functions, potential psychomotor outcomes, motor skills and physical capacities, physical and affective-social health, management of leisure and free time, and educational outcomes, amongst others.

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