Effects of Exergames Executive Function and Physical Activity in Young Autistic Groups

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Abstract: *The Autism Spectrum Disorder (ASD) is a common developmental disorder of the nervous system characterized by difficulties in social interaction, communication, and repetitive behaviors. Fine, gross motor disorders and social difficulties are the main obstacles for autistic people to perform traditional physical activities. Exergames are video games that increase the amount of physical activity in people with ASD, improve motor and cognitive abilities, and enhance executive function. This paper reviews the origin of exergames and their effects on executive function, energy expenditure and exercise intensity in young ASD groups. Finally, the paper discusses the problems encountered in the experiment of commercial exergames. In the future, the exergame should be designed to meet the characteristics of ASD groups.*

Keywords: *Exergame, ASD, Executive Function, Physical Activity*

1. Introduction

Autism Spectrum Disorder(ASD), one of the pervasive developmental disorders, is a developmental disorder of the nervous system[1]. The main symptoms are social disorder, communication disorder, narrow interest and repetitive behavior. Autism affects 1 in 100 people worldwide[2]. In 2010, the prevalence of autism among children in the United States was about 1.34%[3]. The Ministry of Health and Welfare of Taiwan, China, released the number of people with autism in the third quarter of 2023, a total of 20,251 people[4].

Children with ASD face many difficulties in performing traditional physical activities[5]. 80%-90% of ASD patients have motor disorders[6], which are manifested as poor control of the large muscles of the upper and lower limbs, incoordination of movements, poor sensitivity, and abnormal muscle tone. However, regular physical activity has many benefits for children with ASD, including weight control, reduced repetitive behaviors, self-harming behaviors, hyperactive behaviors, and improved cognitive function, physical energy expenditure, reaction speed, and cardiorespiratory function[6-8].

Exergames are electronic games that require physical participation. For children with ASD, somatosensory play is currently a relatively safe, low-cost, attractive, multi-sensory stimulation, and can increase energy expenditure of physical activity. The purpose of this study is to sort out the specific effects of exergames on improving executive function and physical activity in young ASD patients based on proven experiments, and to give suggestions on the problems in the use of exergames in children with ASD.

2. The emergence and development of exergames

Arcade games are early exergames, which are mainly controlled by sensors and infrared accelerometers[9]. Nintendo is the first person who originated the modern exergames. In 1983, Nintendo released the "Red and White Machine", which was the prototype of exergames[10].

In 2004, SONY took the lead in launching the EYE TOY, a motion-sensing control device for exergames, connecting the EYE TOY with the Play Station2(hereinafter referred to as PS2) to recognize player movements through computer vision and gesture recognition[11]. In 2010, a motion controller for the SONY PS3, the device can detect changes in wrist angles and movements in all directions[12-13]. In 2010, Microsoft introduced the Kinect, a motion sensing peripheral for the Xbox360 that included cameras for facial and motion recognition, depth sensors, and a microphone for speech recognition.

Through infrared scanning of the room and recognition of human movements[14], players can operate the game without any handheld devices.

In 2006, Nintendo launched the home game console Will, along with the game controller "Will Remote", which contains Bluetooth, gyroscope, accelerometer and other technologies, and can sense the device pointing and human body movement[10]. In 2007, Nintendo launched another external device "Will Fit", which can measure players' weight and balance ability through pressure sensing principle, and has more than 40 kinds of fitness games for players to choose[15]. In 2017, Nintendo officially released the "Nintendo Switch" (Switch), which includes a high-precision vibrator and infrared camera[16].

3. Effects of exergames on physical activity and executive function in young autistic groups

3.1 Influence of exergames on physical activity of young autistic groups

Movement disorders, sedentary videogaming (SVG), and drug side effects are important factors for the reduction of physical activity in children with ASD[17-19]. Compared to traditional physical activities, children with ASD show greater pleasure and motivation in somatosensory play[20-22].

Brandy E.[23] after 6-week *exergame* intervention for obese ASD children, the waist-to-hip ratio and triceps skin fold thickness of the children slightly decreased; There is a downward trend in weight. After one year of Will game intervention by Kathleen et al.[24], BMI and physical fitness (standing long jump, cardiopulmonary function, sit-ups and 10 x 50m return run) of the intervention group were significantly better than those of the control group. This evidence suggests that somatosensory play is a viable way to control weight and increase physical activity in children with ASD.

According to the survey[25], the daily MVPA activity of children with ASD is only 25 points, which is far from the daily physical activity recommendation of WHO for people with disabilities. Therefore, it is very important to find a way to improve the exercise intensity of ASD patients. Several studies have shown that the intensity of motion sensing games can reach moderate to vigorous levels. Daphne et al.[20] used Xbox Kinect360 to compare energy expenditure and percentage of time spent moderate-to-vigorous physical activity over a 20-minute period between SVG, motion-sensible games, and Energy expenditure at 4.5METS pace and percentage of time spent at moderate-to-vigorous physical activity (%MVPA), the result shows walking > Motion game >SVG. This suggests that exergames can be an important means of increasing the amount of daily physical activity. Zachary C. et al. also demonstrated that the MVAP% of motion sensing games is higher, and in terms of exercise intensity, running >Will motion sensing games > walking[26]. Compared with traditional sports, exergames are more interesting and enjoyable, and children with ASD are more active in participation and more conducive to long-term persistence.

Virtual tasks can improve the accuracy of real tasks[27-28]. This shows that the practice of exergames is helpful to the learning of real motor skills. The 8-week Kinect intervention improved the movement quotient (QM) and movement age (IM) of children with ASD, and the improvement of QM was conducive to the improvement of children's movement performance, and the results showed that the speed and balance ability of children with ASD were significantly improved[29]. In terms of motor skills, Hilton.[30] After 30 Makoto Arena interventions, children with ASD showed significant improvements in strength and agility. In two other studies[31-32], somatosensory play improved balance, flexibility, speed, strength, coordination, agility, and other physical qualities in children with ASD. In another study by Hilton.[6] Makoto Arena increased reaction speed in children with ASD. Some studies[9][33] show that exergames do not significantly improve motor skills, which may be caused by inconsistent assessment methods and shortly experimental period.

3.2 Effects of exergames on executive function in young autistic groups

3.2.1 Definition of executive function

"Executive function" first appeared in the study of prefrontal cortex injury, which resulted in a series of neuropsychological defects, such as difficulties in cognition, decision making, working memory, inhibition and work monitoring[34]. Most studies have identified working memory, cognitive flexibility, and cognitive inhibition as core components of executive function.

3.2.2 Improvement of executive function by exergames in young autistic groups

Due to impaired inhibitory control and cognitive flexibility[35], autistic patients usually exhibit repetitive and stereotypical behaviors. Studies have shown that exergames can improve executive

function and thus reduce repetitive behaviors in children with ASD. Anderson-Hanley's experiments showed that after 20 minutes of somatosensory play, people with autism had significantly less repetitive behavior; Daekook M. et al.[36] measured the repetitive behavior of children with ASD after 8 weeks of intervention and found that the repetitive behavior of children in the intervention group was significantly improved. Another study showed that children with ASD experienced a significant decrease in purposeless physical activity after 12 sessions of somatosensory play over a 6-week period[37]. The reasons for the reduction of repetitive stereotyped behavior may be related to fatigue after exercise[38] and the similarity between physical movements and stereotyped behaviors.

Executive function is the basis of metacognition, and the improvement of metacognition can optimize the output of executive function. After 30 Makoto Arena interventions, metacognitive index and overall complex executive ability were significantly improved[40][10], and the ability of working memory initiation, planning, organization and problem solving were improved in children with ASD. Inhibition control, cognitive flexibility and emotional regulation were improved to some extent. After 12-week somatosensory play intervention, inhibition, working memory and flexibility of ASD children were significantly improved, and the improvement of inhibition and flexibility was more sustained than that of traditional PE class[38]. Daekook M.et al. 's study found that exergames could significantly improve the executive function of children with ASD, and the experimental group showed more significant improvement in executive function than the control group[39]. Studies have shown that single-human exergames can improve children's executive function more[40]. This may be due to the additional social skills in cooperative exergames, the cognitive monitoring of peers and other loads that distract the attention of children with ASD, thus reducing executive function performance.

The development of motor and executive function is identical[32], and the development of motor brain area is positively correlated with the development of executive function[41]. The improvement of executive function in ASD children after somatosensory play may also be due to the changes in cognitive function, brain physiological structure and brain nerve caused by exercise. During exercise, blood flow to the brain increases and oxygen and nutrients in the brain are improved; Abilities related to cognitive function, such as working memory, task switching, and attention, are trained to improve executive function. In addition, studies have shown that exercise changes certain brain regions that are important for learning and memory, as shown by the up-regulation of IGF-1, VEGF, BDNF and other growth factors; Moreover, norepinephrine produced during exercise is positively correlated with performance of executive function[42].

4. Exergames suitable for autistic groups

At present, the exergames on the market are designed for normal people, and almost no games are designed for ASD people. ASD people will encounter many obstacles in the use of games, and the following aspects should be considered when designing games for this group.

Environmentally, the game should be played in an empty room to avoid other things that attract children's attention[43]. In terms of hardware, projectors and non-contact motion capture devices should be selected. In terms of software, game design should take into account game rules, difficulty, action design, game scene, etc. The rules should be as concise as possible; long text introductions can be boring and frustrating for children with ASD. At the level, it should be divided according to the QM and exercise intensity of the ASD group, and the duration of the game should not be too long to avoid the boredom of ASD children[44]. In the design of movement, the intensity, difficulty and common repetitive behavior should be considered. In terms of exercise intensity, a single upper or lower limb action should be set first to be mastered by the player, and mixed upper and lower limb actions should be added in subsequent games to ensure that the exercise intensity reaches medium or above[32]. In terms of game stimulation, only one stimulus is retained in the primary game scene as far as possible, and new stimuli are introduced while retaining the original stimulus with the increase of game progression. In terms of the number of players, designing single-player games[40], additional stimulation in multiplayer games will reduce the attention of children with ASD.

5. Conclusions

Current studies have proved that exergames can improve the amount of physical activity and exercise intensity in young ASD groups, improve QM and executive function, enhance balance, agility, strength, speed and other motor abilities, and significantly improve executive function, repetitive behavior,

metacognition and other abilities. Moreover, exergames are easy to get started and hardly require time to adapt. This means is more interesting and attractive than traditional sports. Therefore, exergames can be used as a supplement to traditional sports to increase the group's interest in sports, gradually transition to traditional sports, improve basic motor skills, and thus develop a life habit of independent sports.

Current studies on the effects of exergames on physical activity and executive function of ASD population have some problems, such as too small sample size, uneven male-female ratio, insufficient staffing of researchers, and insufficient activity space. As a result, the research results are not universal and difficult to promote.

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