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Impact of Individual, Competitive, and Team-Based Exergames on Cognitive Function and Distress in School-Aged Children with Developmental Disorders

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Abstract

Exergames are becoming increasingly significant in rehabilitation, medical care, and therapy that emphasize individuals. The purpose of the current study was to compare how school-aged children with intellectual disabilities responded cognitively and anxiously to cooperative, competitive, and solo activities. This pretest-posttest randomized controlled trial inquiry involved three groups. Recruitment and assignment of thirty children with developmental impairments to the Cooperative Game Group (CGG), Competitive Game Group (CmGG), and Solitary Game Group (SGG) took place. For eight weeks, the exergame program was carried out twice a week. Measures of the program's outcomes, such as anxiety and behaviours, were taken both before and after it. The differences between the groups were compared using a one-way ANOVA, while changes within the groups were examined using a paired sample t-test. While all groups exhibited a considerable improvement in memory, attention, and visual special ability, the CGG and CmGG had a significantly higher level of attention than the SGG. Furthermore, the language was significantly improved ($p<0.05$) only in the CGG. The CGG was the only one to show significant improvements in all anxiety subscales when compared to the CmGG. Notably, the CGG showed significant gains in the subscales measuring general anxiety disorder, separation anxiety, and obsessive-compulsive disorder (p0.05). Only social phobia was improved in the CmGG, whereas worries of physical harm, social phobia, and general anxiety were improved in the SGG. According to this research, competitive and cooperative games can be utilized to enhance cognitive capacities, and for kids with developmental impairments, cooperative games can be the most useful way to lower anxiety when compared to other game genres.

Keywords: *Exergames, One-way ANOVA, Cooperative games, Competitive games, Solitary games, Anxiety*

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1. Introduction

1.1. Children dealing with developmental challenges

A group of medical disorders known as developmental disabilities are brought on by deficiencies in the physical, cognitive, learning, linguistic, or behavioural domains. These problems typically begin at a very young age during the developmental stage and can impact daily activities, while they typically persist throughout a person's lifespan [1]. Attention-Deficit/Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), Cerebral Palsy (CP), Obsessive-Compulsive Disorder (OCD), Intellectual Disorders (ID), and learning problems are among the conditions commonly diagnosed as developmental disabilities [1][2]. A recent statewide population-based study indicates a continuous rise in the frequency of developmental impairments among children in Hungary [3].

Many individuals with developmental disorders share common features such as impairments in cognitive functions, social interaction, communication, and behavioural patterns. Cognitive impairment is one of the hallmarks of deficits in children with developmental disabilities [4]. Numerous areas are impacted, including planning, reasoning, memory, concentration, and problem-solving skills. Furthermore, social interaction deficit is another major feature that defines individuals with ASD, while available literature affirms its presence in individuals with other types of developmental disabilities. It is reported to be present in approximately 75% of individuals with ID [5], and 50-60% of those with ADHD [6], and is highly present in individuals with OCD [7]. Generally, social interaction deficits result in limited opportunities for participation in social activities with family and peers, acceptance by others, and classroom performances. In many cases, restricted participation in social activities leads to social isolation and an increase in anxiety.

Anxiety is a serious issue for both children and their families, and it is heightened in children with developmental disabilities. It is linked to feelings of fear and bewilderment, tension, autonomic nervous system activity, and potentially negative impacts on abilities, output, and functionality [8]. Therefore, anxiety can lead to a lack of control over behaviours and routines, which is commonly referred to as restricted behaviour and interest [9]. Moreover, evidence points to anxiety as the cause of behavioural problems such as bed-wetting, nail-biting, and thumb-sucking, known as repetitive behaviours. However, these symptoms tend to be reduced by the reduction of anxiety and the creation of a calm environment [10]. While some adults and typically developing children may benefit from in-person therapies, the majority of children with developmental disabilities struggle with verbal communication and may require an alternative method. Given the critical role that games play in a child's healthy development, it is possible to employ games to establish a setting conducive to socialization, cognitive skill development, and anxiety reduction. On the other hand, various game types may affect kids differently.

1.2. Exergames and developmental disabilities

Exergames have recently become increasingly important in the fields of healthcare and rehabilitation for improving health conditions, including but not limited to physical activity, chronic diseases, and behavioural conditions. Exergame is an arrangement of the words "exercise" and "game" and is used to describe a way of improving health using video games that require being active or exercising [11]. Exergames are considered particularly attractive to children with developmental disabilities as they generally can be anticipated with less surprising events, while the difficulty, frequency, and pace of the games can be directly

controllable [12][13]. Over the last decade, the increased interest in exergames in the healthcare and rehabilitation field led to an increase in the game market, making it difficult to choose an adequate game for children with developmental disabilities.

Games vary in many aspects, such as content, rules (e.g., strategy, chance, or dexterity), and context [14]. The characteristic that reports the social implication of a particular game that impacts children's social behaviour is its context of play. Gaming context is the interconnection of the player and his goals in a game. There are three common types of games: cooperative, competitive, and solitary. Collaborative games sometimes referred to as cooperative games, need players to play as a team against other players or enemy characters.

Conversely, competitive games pit players against one another and guarantee that a winner will lose to a loser. Games that are played by one person alone have separate goals, meaning that a player's success or failure has no bearing on the actions of other participants. For therapeutic purposes, cooperative games are the most studied by researchers. Studies on normal developing children showed that cooperative games promote children's prosocial acts and more physical contact [14][15]. Moreover, children with developmental disabilities may show positive changes in behavioural outcomes during cooperative games. According to Mitchell's research on teaching methodologies [16], encouraging children to play together as a team can improve their social skills. Though peer interaction can be difficult and demanding, the previously mentioned studies on cooperative games did not discuss how much peer interaction throughout the game may affect the players' anxiety levels. To understand how cooperative games impact kids with developmental disabilities, especially in terms of anxiety effects, more research is necessary. Studies on competitive and solitary behaviours in children with developmental disabilities have often concentrated on how they affect limited and repetitive behaviours, physical activity, cognitive function, and social skills [17][18]. However, there is insufficient data to determine how playing solitary and competitive video games affects anxiety levels, particularly in kids with developmental disabilities. Previous studies that compared the effects of different game genres on anxiety and cognition in kids with developmental disabilities or looked at the effects of workout games have not been done. Furthermore, it would be interesting to find out which solo, cooperative, and competitive games help children with developmental difficulties feel less anxious and sharper.

Thus, this study aimed to investigate how school-aged children with developmental impairments' levels of anxiety and cognition were affected by cooperative, competitive, and solitary games. It is anticipated that the results of this study will offer proof of the kind of game that works well to enhance cognitive function and lessen anxiety in kids with developmental disorders. Additionally, this study might point the way for future investigations into creating personalized exergames for kids with developmental disabilities. This study contends that by fostering more interplay amongst children, cooperative games would significantly improve cognition and lower anxiety levels compared to other game types.

2. Methods

2.1. Research design

This study was carried out using a randomized controlled trial pretest-posttest design with three groups. After being randomly assigned to one of three groups, participants engaged in a

four-week intervention. The participant's parents or legal guardians' written informed consent was obtained.

2.2. Participants

Local social welfare organizations serving people with special needs were the source of participant recruitment. The research was recommended to children by social workers and their parents. Thirty kids, ranging in age from six to sixteen, took part in the study. The parents of each child attending the special education school attested to their diagnosis, which included ASD (60%), ADHD (10%), ID (17%), and OCD (13%).

The inclusion criteria included not having any problems with vision, hearing, or following basic instructions, having a developmental impairment diagnosis or displaying some of its symptoms. Children with severe genetic disorders (such as Down syndrome), those who were unable or unwilling to follow the instructor's instructions, and those who needed assistance standing up were also considered exclusion criteria. The study's flow diagram is shown in [Figure 1].

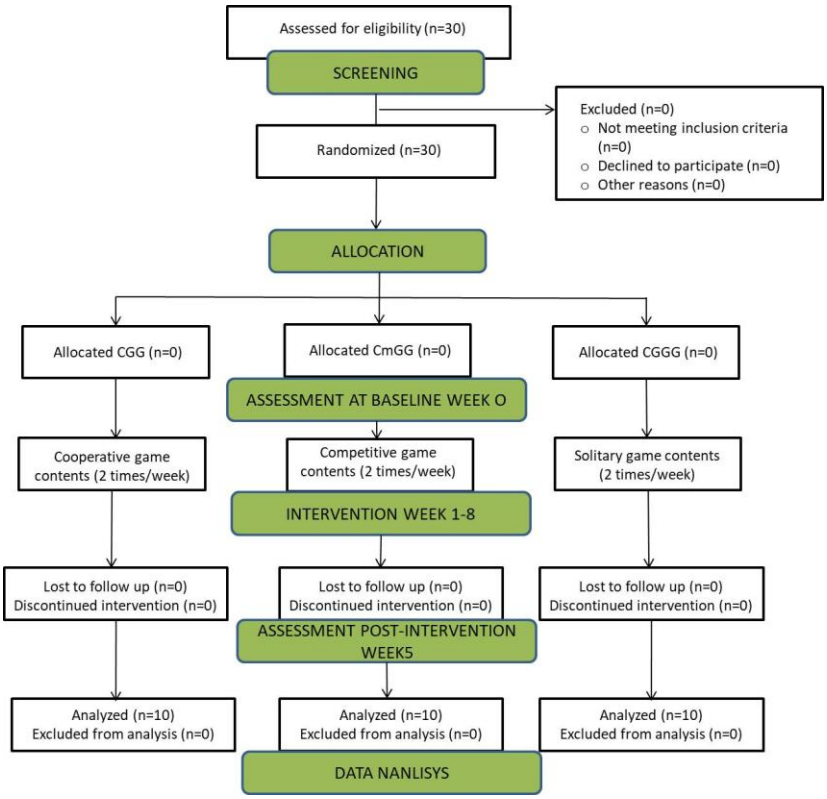

Figure 1. Study flowchart

2.3. Randomization

The three groups—the Competitive Game Group (CmGG), the Solitary Game Group (SGG), and the Cooperative Game Group (CGG)—were assigned to participants at random. An impartial investigator created thirty cards in three distinct colours for the allocation. Participants were asked to select one card out of thirty enveloped cards. Using their cards as a

guide, they were divided into one-to-one groups (green for the CGG, black for the CmGG, and blue for the SGG). The kinds of games that were played in the various group sessions were hidden from the participants.

2.4. Outcome measurements

(1) Cognition

Several cognitive functions were measured in the current study using the computerized cognitive assessment program. A popular tablet-based cognitive test in clinics is the CoSAS-S. It assesses six distinct cognitive domains: language, orientation, visual perception, memory, attention, and high-level cognition. The CoSAS-S comprised 29 items that required 10 to 15 minutes to finish. With an intra-class correlation coefficient of 0.93 ($p < 0.001$; 95% CI = 0.82–0.97) between two raters, it has been reported to have outstanding inter-rater reliability [19]. A higher score corresponds to a higher level of cognitive function; the score runs from 0 to 100.

(2) Anxiety

The Spence Children's anxiety levels were assessed using the Children's Anxiety Scale-Parent (SCAS-Parent). An established psychological questionnaire that is frequently used to measure child anxiety overall is called the SCAS-Parent, and parents of children fill it out. Good test-retest reliability and internal consistency of its psychometric features have been demonstrated in earlier research [20][21]. It consists of 38 items that evaluate specific symptoms of anxiety and one non-scored item. The 38 items measure the following six subscales of anxiety: agoraphobia, separation anxiety disorder, generalized anxiety disorder, obsessive-compulsive disorder, physical injury fear, and social anxiety. On a four-point scale (0 = never, 1 = occasionally, 2 = often, and 3 = usually), parents were asked to rate how frequently their children display anxiety symptoms. When the scores were added together, the greater score denoted a higher degree of experienced anxiousness.

2.5. Exergame programs

Participants included in this study were allocated to the CGG group (n=10), CmGG group (n=10), and SGG group (n=10). After recruitment and allocation of participants into different groups, the pre-intervention measurements were conducted, including the collection of personal information of participants and completion of cognitive and anxiety evaluations. Each participant engaged in two 30-minute sessions throughout the eight-week training program. The exergame programs were run in a sizable training area utilizing a KINECT sensor and the UINHEALTH game software. The games were played in pairs by participants assigned to the CGG and CmGG groups. The difficulty of the games progressively increased based on the participants' performance. If one partner performed worse than the other in the preceding session—with a difference greater than 25%—the pairings matching was modified. After each session, participants in the SGG group played the games alone, with the difficulty level progressively rising.

Each group in this study was assigned to play one of two games, which were played throughout every session. The CGG group played two games: a cooperative tennis match using two rackets per player and a farm protection game with two players assuming colleagues' roles. To finish the party, players must work together to accomplish the two games. The CmGG group played a game of balloon boxing and basketball ball shooting in which they had to compete against one another and report their scores independently. The

SGG group's members engaged in solitary vehicle races and soccer striker games, with their scores reflecting their unique abilities. Before beginning the activities, a recorded video tutorial gave instructions. During the games, the gadget provided both visual and auditory feedback, displaying the phrases "Perfect," "Great," "Good," and "Miss" on the screen. The system includes a management interface that allows health providers to monitor each participant's progress and a user interface that displays the game's contents. The management interface's data were safely stored on a computer drive and utilized to analyze the participants' development.

2.6. Data analysis

IBM Corporation's SPSS statistics software version 26.0 for Windows (Armonk, NY) was utilized for the statistical study. All outcome measures' means and standard deviations were provided in descriptive statistics. The Shapiro-Wilk test was used to confirm the data's normal distribution and parametric tests were employed in the data analysis. To examine the differences between the pre- and post-intervention within the groups, a paired sample t-test was used. A one-way ANOVA was run to compare the differences between the three groups, and the post hoc Bonferroni test was employed to assess the differences between them. A significant threshold of $p < 0.05$ was established.

3. Results

3.1. Demographic information

Best [30] presented the participant's demographic information. Twenty people finished the exergame program—22 boys (73%) and eight girls (27%). There were no dropouts or follow-up losses. The study group's ages in the CCG, CmGG, and SGG were 12.40±1.34, 12.63±1.14, and 12.25±1.28, respectively, to the mean and standard deviation. Only two participants in the CGG and one in each of the CmGG and SGG were in elementary school, whereas most were in primary school.

[Table 1] below displays the outcome of the cognitive function both within and between groups. The within-group analysis revealed improvements in the CGG's language, visual perception, memory, and attention subscales, with $p<0.05$. Nonetheless, there were no discernible gains in high-level orientation or orientation between the pretest and post-test scores ($p = 0.074$ and 0.081, respectively). Memory, attention, and visual perception substantially improved with $p<0.05$ in both CmGG and SGG outcomes. On the other hand, neither group demonstrated statistically significant gains in the high-level cognitive, orientation, or language subscales ($p>0.05$).

Table 1. Comparison of cognition before and after the intervention within and between groups

Variables		CGG (n=10)	CmGG (n=10)	SGG (n=10)
Orientation	Pretest	9.50±1.50	9.60±1.64	10.20±1.87
	Post-test	10.40±2.63	10.10±2.13	10.80±2.53
	P-value (t-test)	0.081	0.096	0.051
Memory	Pretest	8.30±1.63	6.80±1.68	7.10±1.19
	Post-test	9.40±2.63	7.50±1.58	8.20±1.93
	P-value (t-test)	0.032	0.045	0.024
Attention	Pretest	10.00±0.81	10.10±0.73	9.90±0.87
	Post-test	12.20±0.63	12.40±0.96	10.80±1.54
	P-value (t-test)	<0.001[a]	<0.001[b]	0.041[a,b]
Visual perception	Pretest	11.70±1.49	10.60±1.26	10.90±1.44
	Post-test	12.20±1.22	11.40±1.43	11.70±1.61
	P-value (t-test)	0.015	0.037	0.029
Language	Pretest	11.20±1.22	11.20±1.61	11.90±0.99
	Post-test	12.90±1.85	11.50±1.95	12.30±1.33
	P-value (t-test)	<0.001[a,c]	0.496[c]	0.309[a]
High-level cognition	Pretest	14.00±0.94	13.90±0.99	13.90±1.19
	Post-test	15.10±1.33	14.20±0.91	14.40±1.64
	P-value (t-test)	0.074	0.343	0.299

Data are expressed as mean±standard deviation: a indicates a significant difference between CGG and SGG, b significant difference between CmGG and SGG, c significant difference between CGG and CmGG, CGG: Cooperative game group, CmGG: Competitive game group, SGG: Solitary game group.

Variations were noted across many subscales in the comparison between groups. Initially, notable distinctions in attention were pointed out between the CGG and SGG, as well as between the CmGG and SGG ($p<0.05$), but not between the CGG and CmGG ($p>0.05$). Additionally, notable distinctions were noted in the language subscale between the CGG and CmGG and the CGG and SGG ($p<0.05$). The other cognitive subscales showed no differences between the groups ($p>0.05$).

Table 2. Comparison of anxiety levels before and after the intervention within and between groups

Variables		CGG (n=10)	CmGG (n=10)	SGG (n=10)
Panic attack and agoraphobia	Pretest	5.10±0.73	5.10±0.73	4.90±0.87
	Post-test	4.20±1.13	4.70±0.82	4.30±1.33
	P-value (t-test)	0.019	0.223	0.140
Separation anxiety	Pretest	5.00±1.15	5.20±1.61	4.90±0.99
	Posttest	3.80±1.12	5.00±1.76	4.50±1.26
	P-value (t-test)	0.003[c]	0.443[c]	0.104
Physical injury fears	Pretest	4.50±1.50	5.30±1.16	4.20±1.87
	Post-test	3.30±1.25	4.90±1.44	3.80±1.75
	P-value (t-test)	0.018	0.309	0.037
Social Phobia	Pretest	6.70±1.49	4.60±1.43	5.90±1.44
	Posttest	5.40±1.64	3.70±1.16	4.90±1.28
	P-value (t-test)	0.013	0.041	0.023
Obsessive-compulsive	Pretest	7.80±1.03	6.80±1.68	7.10±1.19
	Post-test	6.30±0.94	6.60±1.89	6.40±1.07
	P-value (t-test)	0.003[c]	0.555[c]	0.066
General anxiety disorder	Pretest	8.00±0.94	7.90±0.99	7.90±1.19
	Post-test	6.10±1.19	7.60±0.30	6.90±1.66
	P-value (t-test)	0.001[a]	0.434[a]	0.042

Data are expressed as mean±standard deviation, [c] indicates a significant difference between CGG and CmGG, CGG: Cooperative game group, CmGG: Competitive game group, SGG: Solitary game group.

[Table 2] below shows the outcome of the anxiety score as determined by the SCAS-Parent. First, a substantial decrease in all six anxiety subscale scores in the CGG with $p<0.05$ in the within-group study was seen. Only the "social phobia" subscale in the CmGG showed a significant improvement ($p=0.041$), with the other five subscales showing no meaningful changes ($p>0.05$). According to the SGG, there were significant differences between the pre- and post-intervention scores on the "physical injury fears," "social phobia," and "general anxiety disorder" subscales ($p=0.037$, $p=0.023$, and $p=0.042$, respectively). With $p>0.05$, there were no significant differences seen in the other subscales.
Second, there were significant differences ($p<0.05$) between the CGG and the CmGG in the “separation anxiety," "obsessive-compulsive," and "general anxiety disorder" subscales when comparing the two groups. On all subscales with $p>0.05$, no statistically significant differences were found between the CGG and SGG or between the CmGG and SGG.

4. Discussions

The purpose of the current study was to compare how school-aged children with developmental disabilities responded cognitively and anxiously to cooperative, competitive, and solo activities. The results show that while language increased only in the CGG, memory, attention, and visual perception greatly improved in all groups, regardless of the game type. The results showed that playing competitive and cooperative games improved attention more than playing solitary games and that playing cooperative games was the only strategy that affected language. The study's findings regarding anxiety revealed that only cooperative games significantly differed from competitive games in terms of the separation anxiety, obsessive-compulsive, and general anxiety disorder subscales, which were all positively impacted by games. In lonely games, physical injury, general anxiety fear, and social phobia all improved, but only social phobia did in competitive games.

The children's cognitive abilities were all positively benefited by cooperative, competitive, and solitary games, particularly in memory, attention, and visual perception. This outcome is consistent with earlier research that employed exergames and verified gains in cognitive abilities, such as memory, attention, and different visiospatial processing domains [22][23][24][25]. Exergames are a well-known explanation for this phenomenon, combining mental and physical demands [26]. They put more strain on the brain and have high degrees of neural plasticity because they mentally and physically excite the brain. Furthermore, playing exergames requires mental abilities like creativity, reasoning, and emotion, all of which may support different facets of cognition. Interestingly, compared to solo games, cooperative and competitive games had stronger effects on attention. The games' design and content explain this. Youngsters who played competitive and cooperative games had their rivals and partners in the same physical space, which may have improved their focus on both the physical surroundings and the games themselves. To effectively finish the cooperative games, players had to focus on both their partners' and their performance. Conversely, players of the competitive game have to pay close attention to compete and try to outsmart their rivals. On the other hand, people who play alone games only need their concentration to focus on the performance of the game.

Cooperative games were the only kind of games that positively impacted the language subscale, and the results were superior to those of competitive and solitary games, even though all game types had positive effects on memory, attention, and visual perception in children with developmental disabilities. This study found that children who played cooperative games were more likely to be socially involved and needed to communicate more

verbally to win than kids who played solo or competitive games. A prior study that employed video games to improve cooperation, social, and communication skills lends credence to this argument [27]. The authors confirmed that linguistic and social abilities may be enhanced by players actively participating in games where they exchange ideas and discuss them.

All anxiety subscales were better by cooperative games, while only physical injury concerns were improved by competitive games. General anxiety, social phobia, and physical injury fears were all improved by lonely games. Generally speaking, anxiety symptoms are linked to low self-esteem and a lower quality of life. The cooperative activities in this study featured tasks requiring reciprocal communication, which has been shown to improve cognition in children with developmental impairments through cooperation. In addition, to name a few, it lessens anxiety, panic, fear, and uneasiness. Engaging in socially active activities promotes social stability and reciprocal support, which improves psychological safety and lessens anxiety symptoms. The findings are corroborated by a previous study showing that social interaction improves mental health in general [28].

Also, aside from the social phobia subscale, the competitive games had no beneficial effects on the anxiety subscales. Playing competitive sports can be mentally taxing and demanding, which can contribute to anxiety and poor mental health in kids with developmental impairments. It can also cause low self-esteem and low confidence. Furthermore, a prior study found that negative behaviours are influenced by thoughts of failure and low self-esteem and are linked to stress, anxiety, and depression [29].

Three of the six subscales in the current study (physical injury worries, social phobia, and general anxiety disorder) improved when participants played solitary games. One kind of anxiety is content terror in strange places and among strangers. The results imply that an opponent player may be a cause of heightened anxiety when compared to a teammate. But playing video games reduced the need for social connection, failure-related anxiety, and stress. The scenario could be explained by the fact that children are better able to regulate their surroundings and their behaviour without the assistance of an adult. They also had less psychological strain since they could play the game at their speed, without regard for other players, and merely focused on achieving their own goals without fear of criticism or falling short of others.

4.1. Advantages and practical implications

There are several advantages and implications to this study. First, to minimize selection bias, a randomized controlled trial design was employed with three groups to assess how different game types may alter children's cognitive and anxiety levels with developmental difficulties. Secondly, to minimize performance bias, each session was conducted independently, and participants were blinded to the differences. Finally, the program's eight weeks and sixteen sessions may be deemed adequate to compare the effects of various game genres.

4.2. Limitations and future research

Even with all of the aforementioned advantages, this study has certain drawbacks. Initially, although every participant was aware that they attended school and that their educational attainment was documented, it was unable to accurately gauge their cognitive abilities, which could potentially restrict the applicability of our results. Secondly, there were only 30 participants in total, with 10 individuals in each group, making the overall number of participants in this study limited, because of the COVID-19 pandemic, a significant number

of subjects could not be included in this study. To quantify the intervention program in future studies, including a larger sample, offering the effect size, and specifying the p-value would be interesting. In addition, a long-term follow-up needs to be examined to assess the program's continuity.

5. Conclusion

The current study aimed to assess how school-aged children with developmental disabilities responded cognitively and anxiously to cooperative, competitive, and solitary exergames. According to the results, all kinds of games can help with cognitive function, particularly with memory, concentration, and special visual skills, but only cooperative games can help with verbal communication. Furthermore, compared to lonely games, competitive and cooperative games can be used to successfully increase attention span. When it comes to reducing anxiety, solo games come in second place, whereas cooperative games may not benefit kids with developmental problems. Exergames are the main tool used to help school-aged children with young children with developmental disabilities improve a variety of skills. They are a multifaceted intervention strategy. However, the kind of games chosen should be carefully considered in light of the child's requirements and circumstances. Further research should be conducted to get more proof of the long-term impacts of the various gaming genres.

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