



Faculty of Cognitive Sciences and Human Development

**THE IMPACT OF EXERGAMING AND PHYSICAL ACTIVITY ON MOTOR
SKILLS AND EXECUTIVE FUNCTION AMONG CHILDREN WITH AUTISM
SPECTRUM DISORDER : A COMPREHENSIVE REVIEW**

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Bachelor of Science with Honours (Cognitive Science)

2022

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BSc Hons (CogSc) 2022

UNIVERSITI MALAYSIA SARAWAK

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THE IMPACT OF EXERGAMING AND PHYSICAL ACTIVITY ON MOTOR SKILLS AND EXECUTIVE FUNCTION AMONG CHILDREN WITH AUTISM SPECTRUM DISORDER: A COMPREHENSIVE REVIEW

NUR NABIHAH BINTI NAZRI

**This project is submitted
in partial fulfilment of the requirements for a
Bachelor of Science with Honors
(Cognitive Science)**

**Faculty of Cognitive Science and Human Development
UNIVERSITI MALAYSIA SARAWAK
(2022)**

The project entitled 'The Impact of Exergaming and Physical Activity on Motor Skills and Executive Function Among Children with Autism Spectrum Disorder: A Comprehensive Review.' was prepared by Nur Nabihah Binti Nazri and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honors (Cognitive Science).

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ACKNOWLEDGMENTS

In the name of Allah, The Almighty, the Most Forgiving and Merciful.

Allah is worthy of all praise and blessings for giving me the opportunity to be able continue my study for undergraduate degree in Bachelor of Science with Honors (Cognitive Science). I thank Allah for all the opportunities, challenges, and determination that bring this final year project to come into fulfilment. I had gained a lot of knowledge over the journey, not only academically but also practically. Our grateful hearts go out to the Holy Prophet (Peace be upon him), whose life has offered as a continuing encouragement for us.

First, I would like to extend my heartiest gratitude to Associate Professor Dr Julia Lee Ai Cheng, my supervisor for Final Year Project, for her guidance, supervision and most significantly, for non-stop giving us motivation despite of her hectic schedule. Having Dr Julia as my supervisor had been a real joy and privilege. Besides, I'd would like to give special thanks to my esteemed examiners, Associate Professor Dr Fitri Suraya Binti Mohamad Hapni Joblie and Madam Ross Azura Binti Zahit for provided me with constructive comments and input on my Final Year Project. I have chosen this moment to express my appreciation for their contributions.

Aside from that, my family members also deserve my heartfelt gratitude who had supported me and always encouraged me for not giving up. I'd also like to express my sincere gratitude to all my colleagues who have supported me and been with me through ups and downs of my bachelor's degree journey, especially my friends under Dr Julia's supervision, for being able to share the knowledge and helping each other.

May Allah bless all the above-mentioned with success and respect throughout all their lives.

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LIST OF ABBREVIATION

ASD: Autism Spectrum Disorder

FMS: Fundamental motor skills

MS: Motor skills

EF : Executive Function

ABSTRACT

Autism spectrum disorder (ASD) has become more frequent, it has become a major public health concern. This frightening trend emphasises the need to develop an appropriate approach to cope with the growing population. ASD is a neurodevelopmental disorder that causes speech delays as well as social and communication impairments that resulting in repetitive behaviour and narrowed interests obstruct academic and social participation. One of the three critical and distinguishing characteristics of ASD is repetitive behaviour. Children with ASD can engage, socialise, perform, and acquire in their own special ways. Individuals with ASD have a broad range of cognitive ability when it comes to problem-solving and thinking. Some people with ASD need a lot of assistance in their everyday life, while others just require a little. Physical exercise (PA), particularly moderate to vigorous physical activity (MVPA), is good for the body and has been demonstrated in studies to have considerable health benefits. In several studies, MVPA has been found to assist children with ASD develop their cognitive, emotional, physiological, and behavioural functioning. Children with ASD may benefit from PA because it improves their motor skills and executive function. Furthermore, exergaming, or active video games, maybe a safe and low cost form of exercise for adolescent and children with ASD since they are more enjoyable than conventional physical activities, which may impact treatment adherence. This paper will focus on the comprehensive review of “Executive functions (EF)” and “Motor Skills (MS)” affected by doing physical activity and exergaming. The ranged of the age of children with ASD for this study is generally between 5 to 12 years old. This review will provide an in-depth summary of the impact of exergaming and physical activity on the executive function and motor functions of children with ASD, published from 2000 to 2022.

Keywords: Physical activities, executive function, exergaming, motor skills, autism spectrum disorder, Kinect, early childhood intervention, video games, swimming, dance-dance revolution, Makoto arena, SPARK.

ABSTRAK

Gangguan Spektrum Autisme (ASD) telah menjadi lebih kerap, ianya telah menjadi kebimbangan kesihatan awam yang paling utama. Trend yang menakutkan ini menekankan keperluan untuk meningkatkan pendekatan yang sesuai untuk menghadapi populasi yang semakin meningkat .ASD adalah gangguan perkembangan saraf yang menyebabkan kelewatan pertuturan serta gangguan sosial dan komunikasi yang mengakibatkan tingkah laku berulang dan minat yang menyempit menghalang penyertaan akademik dan sosial. Salah satu daripada tiga ciri kritikal dan membezakan ASD adalah tingkah laku berulang. Kanak -kanak dengan ASD boleh melibatkan diri, bersosial, melakukan, dan memperoleh dengan cara istimewa mereka sendiri. Individu yang mempunyai ASD mempunyai pelbagai keupayaan kognitif ketika menyelesaikan masalah dan pemikiran. Sesetengah orang yang menghidap ASD memerlukan banyak bantuan dalam kehidupan seharian mereka, sementara yang lain hanya memerlukan sedikit. Latihan fizikal (PA), terutamanya aktiviti fizikal yang sederhana dan kuat (MVPA), adalah baik untuk badan dan telah ditunjukkan dalam kajian untuk mempunyai manfaat kesihatan yang besar. MVPA telah ditunjukkan dalam banyak ujian untuk membantu kanak -kanak dengan ASD meningkatkan fungsi intelektual, emosi, fisiologi, dan tingkah laku mereka. Dengan melakukan PA, ia boleh memberi kesan kepada kemahiran motor dan fungsi eksekutif kanak -kanak dengan ASD. Selain itu, permainan video yang aktif, atau aktif, juga boleh dianggap sebagai bentuk latihan murah dan selamat untuk kanak-kanak dan remaja dengan ASD, kerana mereka lebih menyeronokkan daripada aktiviti fizikal tradisional, yang boleh mempengaruhi pematuhan rawatan. Makalah ini akan memberi tumpuan kepada kajian komprehensif mengenai "Fungsi Eksekutif (EF)" dan "Kemahiran Motor (MS)" yang terjejas dengan melakukan aktiviti fizikal dan permainan video. Julat umur kanak -kanak yang menghidap ASD untuk kajian ini berusia antara 5 hingga 12 tahun. Ulasan ini akan memberikan ringkasan literatur yang mendalam tentang kesan aktiviti permainan video dan aktiviti fizikal terhadap fungsi eksekutif dan fungsi motor kanak-kanak menghidap ASD, yang diterbitkan dari tahun 2000 hingga 2022.

Kata kunci: aktiviti fizikal, fungsi eksekutif, exergaming, kemahiran motor, gangguan spektrum autisme, kinnect, campur tangan awal kanak-kanak, permainan video, berenang, revolusi tarian tarian, Makoto Arena, Spark.

CHAPTER ONE

INTRODUCTION

Autism Spectrum Disorder (ASD) is a broad term that encompasses a wide range of neurodevelopmental impairments that manifest clinically throughout early childhood. The condition affects almost four times as many boys as it does girls (Belmonte MK, 2004). Autism is becoming more common throughout the world, with one out of every 200 children being diagnosed with the condition. ASD is a long-term developmental disorder characterised by social communication difficulties and restricted and repetitive behaviours, interests and hobbies. In recent years, ASD has become much more common. Now, 0.76 percent of the world's population is thought to have it. Early on, many children with autism demonstrate sensory and motor deficits (Baranek GT, 2002). Peer communication is challenging for people with ASD, mostly because of a lack of understanding of other people's behaviours. Besides, autism has become one of the most common neurodevelopmental diseases in children, making it challenging for caregivers to keep up with the concurrent increase in service demands. Children with ASD may have difficulty performing fundamental routines and specialised tasks (Mahdi et al., 2018). A significant issue of ASD is motor impairment (Macdonald M et al., 2014). It might make it challenging to engage in physical activity (Nadia R. Azar, 2016). People with ASD may find it hard to do physical activity because of problems like getting along with peers and other people and having trouble communicating.

Physical activity (PA) generally defined as any activity that involves the consumption of skeletal muscle energy and the execution of fundamental motor skills (FMS). Planned, systematic, and repetitive exercise that raises the heart rate above resting levels is included in PA. It also involves daily activities that require bodily activity. On a long-term basis, everyone benefits from PA. Regular PA in children is significant not just for ensuring a healthy body weight but also for a variety of physiological and psychological advantages. PA has recently been proposed to help young children improve their motor skills. In 4–6-year-old pre-schoolers, PA has been found to increase motor and cognitive skills, particularly in terms of concentration, memory, attitude, and academic achievement (Lang et al., 2010; Zeng et al.,2017).

To enhance PA among children with autism, a variety of strategies or treatments must be applied. Low motor skills in people with ASD may make participation in PA and sports more challenging (J. Cairney, 2006). Therefore, it is much better to schedule all PA in a quiet, non-crowded place (Groft-Jones M, 2006). FMS that requires movement (e.g., hopping and running), manipulating or control of an object (e.g., throwing and catching), or balance (e.g., shifting and stabilizing) are crucial for the development of future complex motor skills (MS) and contributes to children's cognitive, social development and physical (Rafie Milajerdi et al., 2021). Although it is widely suggested for young people to participate in recreational activities such as playing, sports, hobbies, and social engagements, Children with ASD are considerably more likely to participate in passive play and unhealthy behaviors and are less likely to involve in structured leisure activities such as sports on a random basis. Besides, recent research evaluated the effects of aquatic training on personal activity and aquatic skill in children with autism spectrum disorder with healthy controls, showing that these treatments potentially help children with ASD enhance their physical fitness and motor skills.

Next, Executive function (EF) is a set of cognitive control processes primarily supported by the prefrontal cortex that regulates lower-level processes (e.g., perception, motor responses). It thus enables self-regulation and self-directed behaviour toward a goal, allowing us to break habits, make decisions and assess risks, plan for the future, prioritise and sequence our actions, and cope with novel situations (Miyake et al., 2012). It has been proposed that EF is linked to motor difficulties in children. Executive functions include working memory, monitoring, inhibition, mental flexibility, planning, and starting and controlling the action (Chan et al., 2008). EF deficiencies, such as cognitive flexibility, have been observed in individuals with ASD. EF develops from early childhood into adulthood (Best, 2010). Without adequate EF, adults and children might say or even do unusual or inappropriate things, obstructing positive social connections. These skills are also important in a range of contexts, such as emotional management and self-directed learning, both of that can help youngsters achieve academic achievement (Baxter et al., 2015). Numerous studies have found that children with ASD struggle with basic and higher-order EF skills. Children with ASD may have low participation rates in physical exercise because their motor and executive functioning problems make it more challenging for them to engage.

Exergaming, also known as active video gaming, is a growing trend in the fitness, education, and health industries. It's described as digital games that require physical movement. This makes for an active gaming experience that can be used as a form of physical activity (PA). Exergames have been shown to improve cognitive function in children with ASD in several studies. The behavioral and cognitive performance of 12 school-aged children with ASD improved after they engaged in an exergame intervention called Dance Dance Revolution (DDR), with reduced repetitive behavior and improved EF. Similarly (Hilton et al., 2014). Exergames have also shown to be effective as therapeutic methods in children with different problems, according to other studies. Videogames (such as Wii and Kinect) are popular and engaging to children with ASD (K. Durkin, 2010). The active gaming industry has exploded in size over the last ten years, and it may provide new ways to get more exercise on a regular basis. Nintendo, Wii, Xbox Kinect, and PlayStation (among others) are now reasonably inexpensive and widely utilised in homes and communities, allowing a rising percentage of the general public, as well as people with ASD, to participate. Kinect is one of the exergaming tools that assist in practising the motor and EF skills of individuals with ASD. Regarding EF, research indicated that after an 8-week intervention, exergaming resulted in substantial increases in performance on a test of mental flexibility in typically developing preschool children compared to routine PA (Xiong et al., 2019). This review will focus on the impact of physical activity on motor skills and the impact of exergaming towards executive function among children with ASD.

RESEARCH OBJECTIVES

In this study, the impact of physical activity and exergaming on children with ASD's motor skills and executive function were looked at. In this study, the following objectives are discussed in detail:

- i.** To study the impact of physical activity towards motor skills among children with ASD.
- ii.** To study the impact of exergaming towards executive functioning among children with ASD.

RESEARCH QUESTIONS

The above discussion raises the following research questions:

- i.** Does doing physical activity can give impact toward motor skill among children with ASD?
- ii.** Does doing exergaming can give impact toward executive function among children with AS

CHAPTER TWO

METHOD

The method used in this research to find data, papers, journals, and e-books mostly through the most reliable search engines such as Research Gate, NCBI, PubMed, Scopus, Google Scholar, Jstore, Science Direct and SpringerLink using the keywords, 'exergaming', 'physical activity', 'executive function', 'motor skills' and 'autism spectrum disorder'. Bibliographies of chosen publications were used to locate another research. Articles were divided into findings and conclusions to examine trends and gaps in the literature. Scholarly literature from 2000 to 2022 is selected for analysis and review to provide a more detailed picture of children with ASD relevant to the research objectives and research questions above mention. The UNIMAS Library App (PeTARY) may also be used to find materials, such as papers written by UNIMAS alumni and journals. The papers gathered and evaluated are sorted and organized in two comprehensive tables (Table I and Table II). The findings were divided into two categories: the impact of physical activity on ASD children's motor skills and the impact of exergaming on ASD children's executive function.

Table I : Literature Search for The Impact of Physical Activity towards Motor Skills among Children With ASD.

Article	Type	Age	Findings
Aksay et al., (2014)	Experimental study	Children with ASD (n=33)	" In children with ASD, a daily 50-minute exercise program involving a delimited exercise area and the display of cartoons can positively impact their performance and motor skills" Aksay and Gullu concluded.
Catama et al., (2016)	Experimental study	12 children with ASD	The motor intervention programmed includes improvements in locomotor and fine motor skills, as well as other fitness characteristics like body balance, coordination, flexibility, and handwriting dexterity. There has been a considerable change because of the intervention programmed. Gross and fine motor abilities are developed by physical activities such as walking in different directions, throwing, and catching objects such as a ball.
Dong et al., (2021)	Experimental study	N=21	The experimental group's FMS gains on ball skills and locomotor were considerably more significant than the controls' immediately after the programme. These individuals continued to improve on locomotor at the 2-month follow-up.
Duronjic et al., (2010)	Experimental study	5 children with ASD Age range: 62-81 months	Eight week of exercise programs measure using "Movement Assessment Battery for Children" (M-ABC). Enhances their children with ASD gross motor skills. Should o physical activity twice a week.

Hasani et al., (2020)	Pre/Post-test design	8-11 years old	The Brininx-Oresetsky Test (BOT) and a program called "I can have physical literacy" (ICPL) as well as Sport, Play, and Active Recreation for Kids (SPARK) were used as evaluation tools. According to the findings, the experimental ICPL and Spark groups exhibited improved MS.
Leah Ketcheson et al., (2016)	Experimental study	4-6 years old children	Has demonstrated a significant improvement in well health and locomotor skills during eight weeks of intervention. The experiment has been handled for the total of 8 weeks. The activities such as ball control and locomotor activities has been conducted.
Najafabadi et al, (2018)	Quasi-experimental	28 kids between 5 and 12 years old with ASD.	The study's primary purpose was to determine how successful a SPARK program was in improving the motor and social abilities of children with ASD. The SPARK program, which was used in this study, improved children's motor (balance and coordination) and social interaction abilities with ASD. The treatment group showed substantial gains in static and dynamic balance and bilateral coordination compared to the control group. The SPARK program's play component (stability and displacement) may have been intensive and focused enough on the current study to enhance motor skills in children with ASD.
Oliveira et al., (2021)	Experimental study	5-10 years old	The Participation and Environment Measure-Children and Youth (PEM-CY) was used to evaluate participation results, while the Timed Up and Go, Timed Up and Down Stairs, Test of Gross Motor Development-2nd edition, and Pediatric Balance Scale

			were used to assess motor skills. Resulting in the outcome of 30 children with ASD classified mild to moderate.
Sarabzadeh et al., (2019)	Experiment study	N=18 6-12 years old	Children with ASD took part in a six-week Tai Chi Chuan programme (Improved in focus, internal signals, and stability) that included 18 sessions of 60 minutes each give positive improvement in ball skills and balancing performance.
Yilmaz et al., (2004)	Individual (Case Study)	Not mentioned	Speed, agility, balance and power ratings improved, as did hand grip, lower and upper extremities muscular strength, flexibility, and cardiovascular fitness. The behavior of autistic and stereotypical people have also changed: One-hour observations revealed that "swinging" had declined from seven to five minutes, "spinning" had decreased from two to zero minutes, and echolalia had decreased from 4 to 2 minutes.
Wuang et al.,	Experimental	N=60 6 and 8 years old	10-week simulated developmental horse-riding program. improved motor performance and sensory integrative functions post-intervention that were sustained for at least 6 months

Table II : Literature Search for The Impact of Exergaming towards Executive Function among Children With ASD.

Article	Type	Age	Findings
Anderson-Hanley et al., (2011)	Experimental study	Not mentioned	Researchers discovered improvements in behavioral and cognitive performance, particularly a decrease in repetitive behavior and an increase in EF, after 12 school-aged children with ASD played the exergame Dance Dance Revolution.
Anderson-Hanley et al., (2011)	Experimental study	Not mentioned	Before and after each task, repeated behaviors and executive function were evaluated. Repetitive behaviors decreased slightly after the exergaming conditions, and the Digits Backwards score improved compared to the control condition.
Anderson-Hanley et al., (2011)	Quasi-experimental	Not mentioned	In the second pilot research, ten more teenagers did a 20-minute about of intense cybercycling. When compared to the control condition, both exergames conditions demonstrated a significant decrease in repetitive behaviors and an improvement in executive functioning
Edwards et al., (2017)	Case-control study	6-10 years old	The Xbox Kinect is used as a testing platform for children with ASD in this case study. Exergames may not provide enough opportunities for participants with ASD to acquire genuine motor skills. However, following the exergaming session, self-perceived abilities improved dramatically.

Hilton et al., (2014)	Experimental analysis	Not mentioned	<p>Study examined at how a 30-session pilot "Makoto arena" training intervention, which is a light and sound speed-based exergame, impacted speed performance, executive functioning (EF), and MS in children with ASD who were in school. Some EF and motor scores were linked in a way that was statistically significant, showing that there is a link between the two domains. The average amount of time it took participants to respond kept going up (effect size = 1.18). Working memory, meta-cognition, and strength and agility in the motor domains all got a lot better. According to the results, exergaming, especially the Makoto arena, could be helpful for children with ASD who have motor and executive functioning (EF) problems.</p>
Rafiei Milajerdi et al., (2021)	Not mentioned	6-10 years old	<p>WCST to assess EF. Children with ASD play Kinect Tennis for 24 sessions. These results suggest that exergaming may help improve EF because it challenges cognitive systems.</p>

CHAPTER THREE

FINDINGS

The Impact of Physical Activity towards Motor Skills among Children With ASD.

There are several ways in which children with ASD might benefit from engaging in physical activity to improve their motor skills. These are ten articles were relevant to the topic (Yilmaz et al., 2004; Duronjic et al., 2010; Leah Ketcheson et al., 2016; Catama et al., 2016; Aksay et al., 2014; Najafabadi et al., 2018; Oliveira et al., 2021; Dong et al., 2021; Sarabzadeh et al., 2019; Hasani et al., 2020).

Physical exercise is vital in preserving health in individuals with neurodevelopmental disorders, and the benefits of physical activities for children with ASD have been studied (Piteti et al., 2007). Several studies have also studied longer-term exercising as a possible treatment for ASD. Physical activities have been demonstrated to enhance many of the deficiencies and obstacles that children with ASD endure. Physical activity in preschool children is gaining popularity since young children are at a vital stage in developing motor skills and abilities. Practicing physical activity in early childhood is thought to help develop motor skills. The study also indicated that participation in physical activity allows children with ASD to experience a fun activity with their peers and to develop critical interpersonal skills (Srinivasan et al., 2014). Moreover, numerous studies showed that physical activity has a few benefits linked to psychosocial well-being, sleep, academic performance, cognitive function, and mental health.

According to (Aksay et al., 2014; Catama et al., 2016; Duronjic et al., 2010; Hasani et al., 2020; Najafabadi et al, 2018).The studies found that, the children with ASD improve in their gross and fine motor skills after doing some physical activities . Aksay et al., (2014) found that a daily 50-minute exercise program involving delimited exercise area and the display of cartoons can positively impact their MS and performance of children with ASD. Besides, the motor intervention programmed includes improvements and FMS as well as other fitness characteristics like body balance, coordination, flexibility and handwriting dexterity. The changes occurred based on the intervention programme. Gross and fine motor abilities developed by physical activities such as walking different directions, catch objects such as ball and throwing

(Catama et al., 2016). Moreover, Duronjic et al., (2010) in their experimental study found the eight week of exercise programme using “Movement Assessment Battery for Children”(M-ABC) that significantly enhances gross motor skill of children with ASD. The children need to do physical activity at least twice a week. Next, Hasani et al., (2020) found that the The Brininx-Oresetsky Test (BOT) and a program called "I can have physical literacy" (ICPL) as well as Sport, Play, and Active Recreation for Kids (SPARK) were used as evaluation tools. According to the findings, both activities exhibited improved MS. Furthermore, 28 kids between 5 and 12 years old with ASD found in the quasi-experimental done by Najafabadi et al., (2018). The study's primary purpose was to determine how successful a SPARK program was in improving the motor and social abilities of children with ASD. The SPARK program, which was used in this study, improved children's motor (balance and coordination) and social interaction abilities with ASD. The treatment group showed substantial gains in static and dynamic balance and bilateral coordination compared to the control group. The SPARK program's play component (stability and displacement) may have been intensive and focused enough on the current study to enhance motor skills in children with ASD. Based on the above findings can be said that physical can give impact on motor skills by improving fine and gross MS.

Apart from that, physical activity can also give impact on motor skills by improving locomotor skills. Locomotor skills are an important group of gross motor skills. Two studies found that physical activities can improve in locomotor skills (Leah Ketcheson et al., 2016; Dong et al., 2021). According to Leah Ketcheson et al., (2016), in their experimental study found that children with ASD age range 4 to 6 years old has demonstrated significant improvement in well health and locomotor skills during eight weeks of intervention. The experiment has been handled for the total of 8 weeks. The activities such as ball control and locomotor activities has been conducted. Meanwhile, Dong et al., 2021 found that the experimental group's FMS gains on ball skills and locomotor were considerably more significant than the controls' immediately after the programme. These individuals continued to improve on locomotor at the 2-month follow-up.

Last but not least, an experimental study done by Sarabzadeh et al., (2019) Children with ASD that took part in a six-week Tai Chi Chuan programme (Improved in focus, internal signals, and stability) that

included 18 sessions of 60 minutes each. Improve in balance performance and ball skills. All of the findings prove that physical activity give positive impacts toward motor skills among children with ASD.