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## **A Potential Role of Physical Activity Intervention for Children with Autism Spectrum Disorder: A Study Protocol**

Noor Hasina Abd Rahman and Mariam Adawiah Dzulkifli  
*International Islamic University Malaysia*

### **ABSTRACT**

*Children with Autism Spectrum Disorder (ASD) commonly have difficulties with executive function abilities and motor skills that might complicate their learning. Literatures have shown on the possible role of physical activity to intervene the effects on the executive functions and motor skills. The present study is proposed to examine the executive functions (EF) and motor skills (MS) of children with ASD, and the possible role of physical activity intervention to affect the EF and MS of children with ASD. The relevant domains of EF which include inhibition ability, working memory, cognitive flexibility, and planning ability will be examined and compared between children with ASD who receive the physical activity intervention and those who do not. In addition, differences in gross motor skills will be compared between children with ASD who receive the physical activity intervention and those who do not. The data will be collected from children with ASD from the Department of Special Education under Ministry of Education Malaysia and Special Needs NGO centres in Selangor and Klang Valley, Malaysia (N=60). The children with the age range of 6-10 years old, bilingual in English and Malay and able to participate in physical activity or physical education class age range 6-10 years old will be targeted. All participants will be randomly and equally assigned into an experimental and a control group. The pre-intervention scores of executive functions will be obtained for both groups based on the Colour-Word Interference Test, Tower of Hanoi task and Number-Letter Sequencing Test. The scores of gross motor skills will be obtained from the Test of Gross Motor Development (TGMD-2). Then, the children in the experimental group will receive the physical activity intervention which is 15-20 minutes of jogging that will be conducted twice a week for 12 weeks period. Meanwhile, the children in the control group will not receive any intervention. After 12 weeks, the post-intervention scores for the executive functions and motor skills will be recorded again for both groups. Statistical analyses testing the effect of physical activity on EF will be conducted separately by using a 2 (Group: experimental vs control) x 2 (time: pre-test vs post- test) mixed ANOVA and testing the effect of physical activity on MS will be conducted by using a 2 (Group: experimental vs control) x 2 (time: pre-test vs post- test) mixed ANOVA as well. It is expected that children with ASD who undergo physical activity intervention will demonstrate significant increase in the executive function scores and motor skills scores compared to those who do not undergo the physical activity intervention. The study is expected to add to the current literatures on understanding the potential role of physical activity intervention for children with ASD in improving their executive function and gross motor skills and mechanisms to optimise their learning experience.*

**Keywords:** *Executive function, motor skills, physical activity intervention, ASD, children*

## INTRODUCTION

Autism spectrum disorder (ASD) is defined as a neurodevelopmental condition that is characterized by the deficits in social communication and interaction as well as restricted and repetitive patterns of behavior (American Psychiatric Association, 2000). Impairment in gross and fine motor skills, communication, imagination and social-cognitive are also commonly found in children with ASD (Coleman et al., 2008; Eposito et al., 2017).

The UNICEF (2014) included children with autism spectrum disorder (ASD) in the category of children with learning disabilities. Learning disabilities have been recorded as the most common type of disabilities among children in Malaysia (UNICEF, 2014). Even though the root cause of ASD is yet to be known (Ministry of Health Malaysia, 2014), the increasing statistics of children with ASD globally should be taken seriously. In general, according to Rigenbach and team (2015), the ratio of children with ASD are 1 in every 68 children specifically 1 in every 42 boys while 1 in every 189 girls. In Malaysia, there were only 30, 000 children with ASD that have registered, and it was estimated that there are more than 30, 000 children are yet to registered (Saori, 2018).

Several studies have reported that children with ASD have deficits in core components of executive function and in higher-order executive function (Weismer et al., 2018) particularly in the area of inhibitory control (Christ et al., 2011; Pelicano, Kenny et al., 2017), task shifting (Semrud-Clikeman et al., 2014), working memory (Pelicano et al., 2017; Semrud-Clikeman et al., 2014), planning and organization (Semrud-Clikeman et al., 2014). The executive function deficits are regarded as a central deficit in children with ASD (Craig et al., 2016).

Apart from executive function deficits, motor impairment also is commonly found in children with ASD (Schurink et al., 2012) specifically on gross and fine motor skills (Kopp et al., 2010), general motor incoordination (Green et al., 2009) and movement skills (Pan et al., 2016) which may be related to cognitive and physiological concerns (Song, 2013). In addition, some abnormal motor movements such as body rocking and repetitive hand flapping has also commonly been observed in children with ASD (Hattier et al., 2013; Ming et al., 2007). In one study by Lang et al., (2010), it was found that children with ASD have difficulties with balance, joint flexibility and speed compared to typically developing children. As a result of motor impairments, there are limited interaction of the child with the physical world during the developmental period (Fournier et al., 2010). A most comprehensive study was done by Staples and Reid (2010), whose study directly measured the motor skills of 25 school-aged children with ASD and typically developing children. Their study revealed that children with ASD exhibit significantly poorer locomotor and object control scores as compared to typically developing children. This signifies that developing a proficient motor skill in children with ASD is also vital because it provides them opportunity to engage with peers and provide the developmental benefits of physical activities (Pan et al., 2016). Generally, children's executive function and motor skills are interrelated (Diamond, 2000) as they develop in the same time span which range between 5 to 10 years (Anderson, 2002). Besides, executive function and motor skills also shares the same underlying brain structures that is dorsolateral prefrontal cortex which is responsible to execute the role of executive function and motor skills (Anderson, 2002; Diamond, 2000).

Several interventions have been studied in previous research to improve executive function in children with ASD. Among the studies in a review done by Wallace and colleagues (2016) are, Social Skills Training, Social Competence Intervention, Unstuck and On Target (UOT), Social Adjustment Enhancement Curriculum and Computer Based Intervention. Despite numerous interventions for improving executive function in children with ASD, many of research has a significant lack of methodological rigour (Wallace et al., 2016). Apart from the aforementioned studies, physical activity

intervention has also been found as a type of intervention that yield positive results on children's executive function. However, most of the past studies have been conducted on the typical developing children and children with Attention-Deficit Hyperactive Disorder (ADHD) (Tomporowski et al., 2008; Tan et al., 2016). Very few studies have focused on the children with ASD. There were also few studies that examine the effect of physical activity intervention on the executive function of children with ASD. Moreover, previous studies also provide less evidence in the specific executive function domains that were positively impacted by the physical activity intervention (Tan et al., 2016). Generally, there are inconsistencies in the domain of executive function that yield a positive result due to of physical activity intervention on children with ASD. For that matter, this proposed study is sought to include the four domains of executive function which are inhibition ability, working memory, cognitive flexibility, and planning ability as an attempt to provide a more holistic and comprehensive view on the effect of physical activity intervention on the executive function of children with ASD.

On the other hand, motor skills development in children with ASD is an area that is often being overlooked at and that makes it as an underrepresented area of early intervention for children with ASD (Ketcheson et al., 2016). According to Dowel et al., (2009), motor impairment has a significant impact on children with ASD to noticeable impairments of fundamental motor skills such as balance, coordination, gait, posture, and tone. However, a mild deficit in gross motor skills can cause the movement of children to be uncoordinated, clumsy, and inefficient (Ulrich, 2000) and unfortunately, children with ASD were found to experience greater clumsiness, motor coordination abnormalities, postural instability, and poor performance on standardized testing of motor functioning (Fournier, Hass, Naik et al., 2010). There are few existing interventions that have been done to improve children with ASDs' motor skills such as the sensory integration therapy (Baranek, 2002 as cited in Schaaf, Benevides et al., 2012), the interactive metronome training (Song, 2013) and physical activity intervention (MacDonald et al., 2012) which includes equine-assisted intervention (McDaniel Peters & Wood, 2017). Previous research has focused on different types of physical activity intervention in studying the effect of physical activity on different motor skills but not on the jogging intervention. This proposed study however would like to examine the effect of physical intervention specifically jogging activity for 12 weeks period on the gross motor skills that includes locomotion and object control as studies find that consistent practice can improves gross motor skills (Hadadi, 2018). Physical activity intervention is important as it was found to have a potential to improve not only motor skills in children with ASD but their overall development including cognitive development (Bremer et al., 2015).

According to Blijd-Hoogewys et al., (2014), executive function is an umbrella term for higher-order cognitive processes required to carry out complex goal-directed behaviours. In this proposed study, executive function will be investigate using four distinct cognitive processes namely inhibition ability, working memory, cognitive flexibility, and planning ability. Inhibition is defined as the ability to control attention, behaviour, thoughts, or emotion when there is a strong internal predisposition and external temptation (Diamond, 2013), and inhibition ability will be operationally measured in the current study based on Color-Word Interference Test scores. Working memory is defined as the ability to mentally hold and process information (Diamond, 2013). It will be operationally measured in the proposed study based on the Letter Number Sequencing Test scores. Meanwhile, cognitive flexibility is defined as the ability to change approaches to a problem and adapt to new rules or demands, as well as the ability to switch tasks (Diamond, 2013). The proposed study will measure cognitive flexibility using the Colour-Word Interference Test scores. The ability to identify and sort information to achieve a specific goal and optimise the execution of more complex tasks is defined as planning (Gross & Grossman, 2010). The proposed study operationally measures planning ability based on Tower of Hanoi task scores. Lastly, motor skills are defined as the combination of learned movement sequences that result in a smooth and efficient action to perform a specific task (Davis et al., 2011 as cited in Zeng et

al., 2017). Motor skills are operationally defined as Test of Gross Motor Development (TGMD-2) scores (Ulrich, 2000).

This proposed study is driven by five objectives. Firstly, to examine the differences in the inhibition ability of children with ASD who receive the physical activity intervention and children with ASD who do not receive the intervention. Secondly, to examine the differences in the working memory performance of children with ASD who receive the physical activity intervention and children with ASD who do not receive the intervention. Thirdly, to examine the differences in the cognitive flexibility of children with ASD who receive the physical activity intervention and children with ASD who do not receive the intervention. Next, to examine the differences in the planning ability of children with ASD who receive the physical activity intervention and children with ASD who do not receive the intervention. Lastly, to examine the differences in the motor skills specifically on gross motor skills of children with ASD who receive the physical activity intervention and children with ASD who do not receive the intervention. The proposed study will employ the following hypotheses:

Hypothesis One: Children with ASD who undergo jogging intervention will have a significant increase in the inhibition ability scores compared to children with ASD who do not undergo the physical activity intervention.

Hypothesis Two: Children with ASD who undergo jogging intervention will have a significant increase in the working memory performance compared to children with ASD who do not undergo the physical activity intervention.

Hypothesis Three: Children with ASD who undergo jogging intervention will have a significant increase in the cognitive flexibility compared to children with ASD who do not undergo the physical activity intervention.

Hypothesis Four: Children with ASD who undergo jogging intervention will have a significant increase in the planning ability compared to children with ASD who do not undergo the physical activity intervention.

Hypothesis Five: Children with ASD who undergo jogging intervention will have a significant increase in the gross motor skills compared to children with ASD who do not undergo the physical activity intervention.

## **METHOD**

The inclusion criteria for participants to participate in the proposed study are a) high-functioning children with ASD diagnosis based on the Diagnostic and Statistical Manual of Mental Disorders, 5th edition, text revision (DSM-V-TR) criteria b) Children with ASD who can understand and respond verbally in English or Bahasa Malaysia c) Children with ASD who are able to participate in physical activity or physical education class d) Age range from 6 -10 years old. Meanwhile the exclusion criteria are a) non-verbal children with ASD b) Children with ASD who are involved in jogging intervention. The targeted centers to reach the participants are Department of Special Education under Ministry of Education Malaysia, Permata Kurnia, Nasom, other Special Needs NGO centres in Selangor and Klang Valley.

An experimental study will be carried out with two groups: the experimental group (the group that will receive the jogging intervention) and the control group (the group without jogging intervention). Before participants receive intervention, a baseline will be established for all dependent

variables, including inhibition ability, working memory, cognitive flexibility, and planning ability, as well as gross motor skills of both experimental and control group. Following the collection of baseline data, the experimental group will be subjected to 24 jogging sessions as an intervention (jogging group) while the control group will not receive any intervention. After the 24 jogging sessions are completed, the scores of both experimental and control group in the executive function domains of inhibition ability, working memory, cognitive flexibility, and planning ability, as well as gross motor skills, will be recorded again.

Four different tests namely The Stroop Test, Wechsler Intelligence Scale for Children –IV (WISC-IV), Tower of Hanoi and Test of Gross Motor Development (TGMD-2) will be used in the proposed study. The Stroop Test was introduced by Stroop (1935) and was then highly used in study the cognitive function of children with ASD specifically their executive function. The Stroop Test consist of a word test, colour test and a colour-word interference test. However, for the purpose of study, only the colour-word interference test will be used. The Cronbach Alpha for the colour-word interference .73 (Golden, 1975). The colour-word interference test will be used to measure inhibition ability and cognitive flexibility. To measure the inhibition and cognitive flexibility, the participants will be required to switch in reading the words of colours and the name the actual colour of the printed words. The time taken in completing the task will be measured in the unit of second (s) (Homack, 2004). Higher scores indicating the participants have high inhibition ability (Homack & Riccio, 2004).

The WISC-IV was developed by Wechsler in 2003 to provide an overall measure of general cognitive ability, and measures of intellectual functioning in Working Memory, Verbal Comprehension, Perceptual Reasoning, and Processing Speed children aged 6 to 16 years (Gomez et al., 2016). The Letter Number Sequencing Test is one of the subscales in the WICV-IV and the Cronbach Alpha for this scale is .93 (Williams et al., 2003). In the proposed study, the Letter Number Sequencing Test will be used to assess the participants working memory in which there are 10 items that inclusive of three trials with same number of mixed letters and digits. The researcher will read the numbers and letters of which the participants will have to recall the letters in alphabetical manner and the number in ascending order. Lower scores indicate the difficulty in the participants' working memory. The total score and longest score will be measured.

Tower of Hanoi task is widely used in both normal and clinical participants sample to measure the executive function such as planning ability. The internal consistency analysis of the Tower of Hanoi has a very high split-half reliability of .87 and a Cronbach Alpha of .90 (Humes et al., 1997). Tower of Hanoi task will be used to assess the participants' ability in planning. The participants will be presented with two wooden based models which contain three equal sized rods. The researcher will present a model where there will be rings of different sizes that are stacked on the right rod. All the rings fit on the rod from the largest ring to smallest ring from bottom to top. The participants would then be required to arrange the rings in the same way as what had been presented by the researcher in different arrangement across the rods. The participants also must follow the following rules a) only one ring can move at a time; b) a bigger ring cannot sit on a smaller ring; c) the rings must stay on the rods if they are not in the participant's hand. The participants will be given 20 trials. The number of moves and time taken to complete the task will be measured.

The TGMD-2 was developed by Ulrich in 2000 to measure fundamental motor skills including locomotor skills (running, galloping, hopping, leaping, horizontal jumping, and sliding) and object control skills (striking a stationary ball, stationary dribble, catching, kicking, overhand throw, and underhand roll). One of the uses of TGMD-2 is to continuously evaluate the progress of a child with or

without disabilities in mastering the gross motor skills (Ulrich, 2000). The raw scores will be calculated by summing the totals from each of the two subtests. Motor quotients are a composite of the results from both the locomotor and object control subtests and will provide the most reliable score for the TGMD-2 (Ulrich, 2000). The Cronbach Alpha for this test is .98 (Ulrich, 2000).

Before the participants were assigned to experimental and control group, the informed consent with signed document and assent form will be acquired from the participants' parents as the participants are minor. A total of 60 children with ASD will be included in this proposed study. The children with ASD will be randomly assigned to experimental group and control group to ensure every participant has equal chance to receive the intervention. Children will be randomly assigned to experimental and control groups using simple randomization technique which is flipping a coin. The side of the coins (heads- control group, tails- experimental group) will determine the assignments of each child. Each group will comprise of 30 participants. The baseline scores of executive function will be obtained for both groups of children based on the Colour-Word Interference Test, Tower of Hanoi task and Number-Letter Sequencing Test before the physical activity intervention is introduced. The scores of gross motor skills will also be obtained through the scores of the Test of Gross Motor Development (TGMD-2) before the physical activity intervention is introduced.

Next, children in the experimental group will receive the physical activity intervention and the physical activity intervention that would be involved in the study is jogging which falls under aerobic and bone strengthening activities (National Heart, Lung and Blood Institute, n.d). As suggested by Nicholson et al., (2011), each session take approximately 15-20 minutes of which 12 minutes of jogging and followed by 5 minutes of cool down, walking and stretching. The time allocation is also essential as to reduce classroom removal time and the session will be conducted twice a week for 12 weeks. The jogging session will be conducted by the researcher and team member with the aid of class teachers. It will also be conducted in three different group. Each group will consist of 10 children with ASD. The children in the control group in contrast, will not receive any intervention.

After 12 weeks, the scores of executive function and motor skills will be obtained again for both experimental and control groups. The scores of executive function will be obtained through the Colour-Word Interference Test, Tower of Hanoi task and Number-Letter Sequencing Test for all the two groups of children. This is to investigate whether there are any differences in the executive function domains specifically inhibition ability, working memory, cognitive flexibility, and planning ability between children with ASD who receive the physical activity intervention and the children with ASD who do not receive such intervention. Next, the scores of gross motor skills will also be obtained again through the scores of the Test of Gross Motor Development (TGMD-2) as an attempt to investigate whether are there any changes in the gross motor skills between children with ASD who receive the physical activity intervention, children with ASD who do not receive such intervention. In assessing the pre and post intervention scores of all executive function domains as well as gross motor skills, individual assessment will be done. Each child with ASD will be brought to an empty classroom to score all the related domains.

The Statistical Package for Social Sciences (SPSS version 23.0) will be used to analyse the data in this study. To begin, all the data will be subjected to a data screening process to ensure that all the data could be used in the analysis. Missing values and outliers will be investigated as testing assumptions. To address the research questions for the proposed study, 2 (Group: experimental group vs control) x2 (time: pre-test vs post-test) mixed between-within subjects ANOVA will be conducted separately to examine the effect of jogging intervention on the inhibition ability, cognitive flexibility,



working memory, planning ability, and gross motor skills of children with ASD in the experimental and control groups.

Ethical approval will be obtained from IIUM Research Ethics Committee (IREC) and the child's assent practices will be obtained through their parents as the children are minor and below age 15. The researcher will ask the permission of the parents on behalf of their children participation in the study. The researcher will brief and explain to the parents about the roles of their children in the study. All information obtained in this study will be kept confidential and will be only used for academic purpose.

### **EXPECTED FINDINGS**

1. Children with ASD who undergo physical activity intervention will demonstrate significant increase in the inhibition ability compared to children with ASD who do not receive the intervention.
2. Children with ASD who undergo physical activity intervention will demonstrate significant increase in the working memory compared to children with ASD who do not receive the intervention.
3. Children with ASD who undergo physical activity intervention will demonstrate significant increase in the cognitive flexibility compared to children with ASD who do not receive the intervention.
4. Children with ASD who undergo physical activity intervention will demonstrate significant increase in the planning ability compared to children with ASD who do not receive the intervention.
5. Children with ASD who undergo physical activity intervention will demonstrate significant increase in the motor skills scores specifically on gross motor skills compared to children with ASD who do not receive the intervention.

Since there is limited study on the potential role of physical activity on the executive function of children with ASD, this study therefore aims to add on the current understanding of the effect of physical activity on the executive function of children with ASD. In addition, since the existing literatures also showed inconsistencies outcomes of the effect of physical activity intervention on the gross motor skills of the children with ASD, the proposed study may contribute on providing and adding evidence in understanding the effect of physical activity intervention on the gross motor skills of the children with ASD.

In term of the practical contribution, this proposed study might provide evidence and may serve as the basis for government, policy makers, teachers, and the family of the children in developing suitable interventions, curriculum, and support services for children with ASD in integrating the element of physical activity in the current system in improving their executive function and gross motor skills.

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