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The Effect of Physical Activity on Children's Logical-Mathematical Intelligence

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ABSTRACT: Research between physical activity and cognitive work in children is still relatively rare and inconsistent, even though children's motor development and cognitive learning are related to positive effects on academic work. This study aims to determine the increase in mathematical logical intelligence of early childhood through physical activity. This is action research. This type of research was a sequential exploratory design. Data analysis in this study used a combined quantitative and qualitative analysis (Mix Method). The results showed increasing logical mathematics intelligence in DKI Jakarta's childhood. The initial assessment results showed that the average value of the child's logical mathematics intelligence was 28 and then increased to 57 in the final assessment of cycle 1 and continued to increase to 78 in the final assessment of cycle 2. Physical activity learning with games strategies increasing the logical mathematics intelligence in childhood in Jakarta Kindergarten. Future research is expected to examine more childhood intelligence with many respondents.

Keywords: early childhood, physical activity, logical-mathematics intelligence

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1 INTRODUCTION

Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure. There is already a lot of evidence showing that physical activity is beneficial to the health of children and adolescents, such as better cognitive and mental health and a more positive self-concept, such as being more confident and optimistic about carrying out daily activities and improving academic results. at school. Higher levels of physical activity in adolescence are positively related to success in education and the world of work. It can be concluded that physical activity can be of personal and social benefit (Bunketorp Käll et al., 2015; Human & Services, 2016)

Research on the human and non-human brains shows that physical activity has acute and long-lasting effects on the structure and function of the central nervous system. Physical activity is also thought to enhance child development through its effects on brain systems that underlie cognition and behavior. Some evidence suggests that physical activity affects cognitive function, for example, influencing the management of energy metabolism and synaptic plasticity(Plasticity is a trait that indicates the capacity of the brain to change and adapt to functional needs). Recent research supports that physical activity can affect executive function. Executive function can be described as a higher-order, up-and-down thought process closely related to frontal brain activity, to produce intentional behavior flexibly and efficiently. In general, the executive function is known as a multidimensional structure. Although there is ongoing debate regarding the elements of executive function, the general opinion is that executive function includes flexibility, goal setting and planning, attention and memory systems, such as working memory and inhibition control (Deer et al., 2020; Shi et al., 2022; Stillman et al., 2016; Zulherma & Suryana, 2019).

Children and adolescents are at the stage of peak cognitive development. The level of executive function development during this period is critical for academic achievement, physical health, mental health, and social adaptation, which all influence achievement in reading and mathematics. Several studies have shown that physical activity at school is positively related to increased focus and working time. Physical activity can improve children's cognitive, emotional, and behavior so that they can improve academic achievement. However, the findings between the relationship between physical activity and cognitive work in children are still relatively rare and inconsistent even though children's motor development and cognitive learning have a positive effect on academic achievement. This shows that the physical growth, motor development, and cognitive development of children are interrelated. Many cognitive skills, such as visual-spatial and memory, contribute to learning arithmetic. Therefore, including physical activity in mathematics lessons can influence emotional experiences and be beneficial for children's mathematical logic work(Daly-Smith et al., 2018; Grieco et al., 2017; Hajar et al., 2019; Owen et al., 2016).

However, based on theoretical and field observations, more and more school-age children spend most of their time in sedentary/sedentary activities, both at school and

outside of school/children's free time. There are even parents who support their children to prioritize academics rather than extracurriculars such as physical exercise or sports. Because the attitude of these parents makes children less optimistic about physical activity and underestimates physical activity (Sember et al., 2020). Other problems such as less than 20% of children in the world are physically active for 60 minutes or more than recommended every day, one example is less than half of children in the United States meet the guidelines for 30 minutes of physical activity and in Indonesia the level of physical fitness at the elementary school, junior high school, and senior high school levels, it is in the very poor category. Whereas childhood inactivity has been shown to have detrimental effects, not only on children's physical and mental health but also on children's cognitive work and academic achievement. Several previous studies have raised this topic, but it is still on a local scale, the research has not covered areas in Indonesia and has not covered many sample criteria. So that researchers are interested in researching this in the research area in Jakarta, Indonesia to get updates regarding the relationship between physical activity and logical mathematics intelligence. It is hoped that this research can provide education and open people's mindsets so that they can balance academic achievement and physical activity in children.

2 THEORETICAL STUDY

2.1 *Physical Activity*

WHO defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement including during leisure time, transportation to and from places, or as part of one's job. Moderate and vigorous-intensity physical activity improves health. Popular ways to be active include walking, cycling, wheeling, sports, active recreation, and play, and can be done at every skill level and for everyone's enjoyment. Regular physical activity has been shown to help prevent and manage non-communicable diseases such as heart disease, stroke, diabetes, and some cancers. Physical activity also helps prevent hypertension, maintain a healthy weight, and improve mental health (Janssen & LeBlanc, 2010; Organização Mundial de Saúde, 2022).

WHO recommends physical activity for the following age categories for children under 5 years of age. Within 24 hours of the day, infants (less than 1 year) should: be physically active several times a day in various ways, especially through interactive floor-based play; the more the better. For those who are sedentary, this includes at least 30 minutes of tummy time throughout the day while awake; should not be stretched for more than 1 hour at a time (e.g., stroller, highchair, or strapped to a caregiver's back); Screen time is not recommended. When sedentary, engaging in reading and storytelling with caregivers is encouraged; and have good quality sleep for 14-17 hours (age 0-3 months) or 12-16 hours (age 4-11 months), including naps.

In a 24-hour day, children aged 1-2 years should spend at least 180 minutes in various types of physical activity of any intensity, including moderate to vigorous intensity

physical activity, spread out throughout the day; the more the better; not being held for more than 1 hour at a time (stroller/pram, highchair, or strapped on a caregiver's back) or sitting for long periods. For children aged one-year, sedentary screen time (such as watching TV or videos or playing computer games) is not recommended. For those aged 2 years, screen time should not exceed 1 hour; the less the better. When sedentary, engaging in reading and storytelling with caregivers is encouraged; and have good quality sleep for 11-14 hours, including naps,

Within a 24-hour day, children aged 3-4 years should spend at least 180 minutes in any type of physical activity of any intensity, of which at least 60 minutes is moderate to vigorous intensity physical activity, spread throughout the day; the more the better; not being held for more than 1 hour at a time (stroller/pram) or sitting for long periods. Screen time should not exceed 1 hour; the less the better. When sedentary, engage in reading and storytelling with caregivers); push; and have 10-13 hours of good quality sleep, which may include naps, with regular bedtime and wake times. For more information World Health Organization. physical activity guidelines, sedentary behavior, and sleep for children under 5 years of age. Children and youth ages 5-17 should do at least an average of 60 minutes per day of moderate to vigorous intensity, mostly aerobic physical activity, throughout the week. should combine vigorous-intensity aerobic activity, as well as activities that strengthen muscles and bones, at least 3 days a week. should limit the amount of time spent sedentary, particularly the amount of recreational screen time. Physical inactivity is one of the main risk factors for death from non-communicable diseases. Less active people have a 20% to 30% increased risk of death compared to moderately active people. In children and adolescents, physical activity improves physical fitness (cardiorespiratory and muscle fitness), cardiometabolic health (blood pressure, glucose, and insulin resistance), improving bone health, cognitive outcomes (academic work and executive function), mental health (reducing depressive symptoms); and reduce subcutaneous fat and internal organs (Organização Mundial de Saúde, 2022).

2.2 *Mathematical Logic Intelligence*

The relationship of physical activity to improving cognition and academic achievement in children and adolescents has been reported since 1997. In recent years, more than 200 studies have explored the relationship between physical activity and academic success in school-age children. Thus, it can be concluded that there is a significant positive relationship between physical activity and cognitive function in children. Several sports and brain experiments clearly show that regular physical activity changes certain brain structures and functions, especially in tests that require more executive function. This provides evidence on executive function, suggesting that exercise has the potential to induce altered vascularization, nerve growth, and synaptic transmission, thereby modifying thinking, decision making (Deer et al., 2020; Gomez-Pinilla & Hillman, 2013; Hildebrandt, 2018; Reikerås et al., 2017).

By doing a lot of physical activity the brain is increasingly stimulated and always active to think so that academic achievement also increases, which is associated with the

hormone BDNF (brain-derived neurotrophic factor). BDNF is a member of the neurotrophin growth factor family, which is related to the canonical nerve growth factor, a family that also includes nt-3 and nt-4/nt-5, a system that works in a person's learning, memory, and mental health. Physical exercise can affect how much of certain proteins are made in the brain. Specifically, levels of a protein called brain-derived neurotrophic factor (or BDNF for short) increase after exercise. It is this mindset that needs to be addressed so that misunderstandings do not occur on an ongoing basis which will affect the fate of the nation's children and education globally (Azman & Zakaria, 2022; Chaddock-Heyman et al., 2013; Colucci-d'amato et al., 2020; Miranda et al., 2019; Silakarma & Sudewi, 2019).

So far, systematic reviews have shown no indication that increased physical activity negatively impacts cognition or academic achievement. The overall effect of the different physical activities has a zero or small to moderate effect on academic achievement. Findings vary because of the diversity of cognitive domains and indicators of physical activity involved. Inconsistent results were observed across a few subjects, including mathematical intelligence, and reading. The relationship between physical activity and logical mathematics intelligence is more interesting. Indeed, logical mathematics intelligence has an irreplaceable position as a fundamental scientific discipline. In China, mathematical logic has become a compulsory subject in grades 1 to 12 and is a mandatory subject for taking the Senior High School/Senior High School entrance exams and college entrance exams, as this greatly supports the disciplines of science, engineering, and further learning practices. This explains why researchers pay more attention to logical-mathematical intelligence when exploring the relationship between physical activity and academic achievement(Beck et al., 2016; Fischer et al., 2020; Flores et al., 2023; Macdonald et al., 2020; Reikerås et al., 2017). Research has been conducted in the last two decades in several European, North American, and Australian countries to increase the amount of physical activity during school learning. Research not only modifies children's risk factors for cardiovascular disease. There is increasing evidence that physical activity has a positive effect on children's academic work, cognitive function, and behavior it is highly beneficial for academic work, especially in the mathematical logic (Andriyani et al., 2020; Aubert et al., 2021; Gao et al., 2018).

3 METHOD

This research uses the action research method, by combining qualitative and quantitative research (mix-method). Action research aims to improve the learning system to increase the logical mathematics intelligence of kindergarten-aged children (4 to 5 years old) through physical education. The subjects used in this study were all kindergarten classes in DKI Jakarta, totaling 23 children.

The action research model uses the Kemmis and Taggart models with two cycles (Krisiyanto, 2020). The steps as a spiral-shaped cycle include planning, action, observation, and reflection. If the first cycle has not been achieved, it will be continued to the next cycle so that the research objectives are achieved. The observation sheet

instrument for mathematical logic intelligence consists of 10 statements with the scale used being good (score 3), sufficient (score 2), and less (score 1). Data analysis in this study used a combined quantitative and qualitative analysis (Mix Method). The conceptual definition of logical mathematics intelligence is a child's ability related to sensitivity in seeking and finding patterns used to do arithmetic, abstract thinking, logical thinking, and scientific thinking. The operational definition is a score obtained from the results of children's observations about calculating by rote quickly, always asking critical questions, enjoying strategy games, explaining problems logically, doing trials, experimenting, results, and discussing.

4 RESULT AND DISCUSSION

4.1 *Result*

Preliminary assessment of logical-mathematical intelligence conducted in action research at Kindergartens in DKI Jakarta. Observations were carried out individually for 2 days by 3 observers, with 23 Kindergarten class children. Before the observation, the researcher conducted a debriefing for 2 observers to study the observation sheet together.

4.1.1 *Quantitative Result*

Table 1 shows that children's logical mathematics intelligence has increased in value to 57 from 28, out of 10 abilities in logical mathematics intelligence there is an average in the very good and good category. Based on the data above, it can be concluded that learning motor physical activity can improve children's logical mathematics intelligence.

Table 1. Initial Assessment and Final Assessment of Cycle 1 Logical-Mathematics Intelligence

Initial Assessment	Observation Aspect	Final Assessment Cycle 1
28%	**Average**	**57%**

Table 2 shows that children's logical mathematics intelligence has increased in value to 78 from 59, out of 10 abilities in logical mathematics intelligence there is an average in the very good and good categories. Based on the data above, it can be concluded that learning motor physical activity can improve children's logical mathematics intelligence.

Table 2. Initial Assessment of Cycle 1 and Final Assessment of Cycle 2 Logical-Mathematics Intelligence

Initial Assessment Cycle 1	Observation Aspect	Final Assessment Cycle 2
59%	**Average**	**78%**

4.1.2 *Qualitative Result*

At this stage, according to Miles and Huberman, what researchers do is examine all observation sheets, field notes, children's impressions, children's behavior, teacher opinions, and the results of informal interviews with parents. Of all the existing data, researchers take important data and ignore irrelevant data. The following are the results

of qualitative data. Learning physical motor activity can improve logical mathematics intelligence. Physical motor activity learning emphasizes play, which is the child's world. By playing, children will learn direct experience and will also have an impact on improving the quality of affection. Learning motor physical activity also has a positive impact on creating a quality learning process, such as: learning while playing, meaningful learning, fun learning, learning by doing, and constructive learning, learning like this is very suitable for the characteristics of early childhood, namely moving. Therefore, it has a high learning success rate because it is right on target.

In general, the benefits of learning physical motor activities felt by children, teachers, and parents include children knowing many things, increasing children's experience and vocabulary, children becoming brave and responsible, active, creative, smart, disciplined, and independent, and the teacher's insight can increase. In terms of lesson planning, the steps that need to be taken are to change the standard RKH into the form of RKH learning physical-motor activities by developing, enriching, and integrating conventional learning with the content of motor-physical activities including making games appropriate to the development of children's intelligence. The steps for learning motor physical activity need to be carried out step by step, with optimal teacher performance. Teachers need to understand the basic concepts of games, goals, methods, media, and how to play so that they can be applied starting from planning and implementing to evaluating learning physical motor activities. The internal factors of learning physical activity that need to be considered are the sequence of learning, the methods, and the media used, learning physical motor activity has its peculiarities because it requires a variety of methods and interesting media to stimulate optimal logical mathematics intelligence in children. External factors that need attention are the carrying capacity needed so that learning can be carried out and the difficulties that may arise. Teachers need to anticipate this.

4.2 *Discussion*

Qualitative improvements in logical mathematics intelligence are frequently asking questions, fast counting outside the head, enjoying strategy games, likes to compile categories, likes experimenting and high-order (logical) thinking processes to solve problems, and easily understanding causal relationships. Based on the results of the quantitative research, it was obtained data that logical mathematics intelligence increased significantly, namely the average initial assessment was worth 37, the final assessment of cycle one was worth 63 and the final assessment of cycle two was worth 82. This shows that learning through physical motor activity with play strategies can improve children's mathematical logic intelligence in DKI Jakarta Kindergarten. This is supported by previous research on cognitive improvement after being given physical activity treatment, as in the following studies. Children and adolescents who are physically active tend to be physically active during adulthood. Recent research also shows that physical activity can improve children's cognitive function and academic achievement in school.

Therefore, it is important to ensure that children and adolescents are involved in sufficient physical activity to support their current and future health conditions (Ha et al.,

2019). Regular participation in physical activity helps reduce health risks from childhood obesity and related chronic diseases. In addition, recent studies have shown that increased participation in physical activity affects cognitive function in children, including executive function (e.g., working memory and cognitive flexibility) and brain health. However, this study primarily targets older children and adolescents, while more evidence is needed to clarify the relationship between physical activity, health outcomes, and cognition during critical periods of child development, particularly early childhood (Vorkapic et al., 2021). One study suggested a significant effect of physical activity on motor skills (e.g., locomotor skills and object control skills) and cognitive development (i.e., language learning, academic achievement, attention, and working memory). No studies have found adverse effects from physical activity programs. Therefore, the authors conclude that physical activity is positively related to motor skills and cognitive development in preschoolers or early childhood (Gao et al., 2018; Tomaczkowski & Klonowska, 2020; Vorkapic et al., 2021).

Previous research also explained that there was a statistically significant relationship between the learning outcomes of Physical Education learning and students' mathematics learning outcomes, this shows that when students have sufficient health and appropriate physical exercise, students can participate in the learning process. Practice to develop the ability to think logically, critically think, and problem-solving the most to influence student motivation and learning outcomes. Consistent with the results of this study, teachers can improve academic achievement in mathematics by increasing students' motivation to be more active in carrying out physical and sports activities which improve student learning outcomes and improve students' emotional, cognitive, and psychological abilities. Besides that (Mahardika, 2021).

During the implementation of the action, it is inseparable from supporting and inhibiting factors. Supporting factors such as the cooperation of children to participate in learning activities. Children diligently participate in all activities, even learning physical motor activities with various playing strategies, children seem happy and enthusiastic in learning. This is shown by the impressions from the children at the time of parting that they wanted researchers to continue teaching them, the attitude of teachers who were open-minded, willing to learn, and willing to try harder to carry out planned learning both in terms of energy, mind, and time by having frequent discussions together. Researchers, carrying out learning to fill in quite a lot of observation and assessment sheets, is a very large contribution of the teacher to achieve the expected results in this study, namely increasing multiple intelligences in children, support in the form of motivation for teachers, changing schedules from the usual, and providing the necessary infrastructure (hall), providing a special time for learning physical activity motor. What stands out is the cooperative attitude of the school principal in the form of a positive response to the results of the research and following up by holding motor-physical activity learning for other class teachers.

The inhibiting factor in this study was the limited time due to only using school hours, namely 90 minutes, every meeting because after finishing the morning class, there was another class in the next class. This is felt to be quite short for various learning activities (teacher's explanations, examples, warm-up, individual play, group play, and evaluation). The impact is that teachers sometimes rush into teaching. The application of learning through motor-physical activity requires a larger room so that children are free to move, and activity plans can be carried out optimally, making game designs and applying them to complex daily activity plans.

The strength of this research is to find a model for learning physical motor activity with playing strategies. The results of this study exceed the previously targeted research objectives, namely that in addition to having an impact on the cognitive level it also has an impact on the affective and has a positive impact on the learning system. While the limitations of the research are that the research is carried out in a limited scope, with several children in one class at one kindergarten, and the research only applies games that develop one intelligence due to limited time and place of research.

So that further research is needed research in a broader scope to see the significance of the results on research subjects and can examine various intelligences of children. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results. that is, besides having an impact on the cognitive level, it also has an impact on the affective and has a positive impact on the learning system. While the limitations of the research are that the research is carried out in a limited scope, with a few children in one class at one kindergarten and the research only applies games that develop one intelligence due to limited time and place of research.

5 CONCLUSION

This study concludes that the logical mathematics intelligence of kindergarten-aged children in Jakarta can be improved through physical activity given by the teacher using play strategies. At the time of research, researchers provided learning media with a variety, varied and interesting, because the presence of media in learning is very important to determine the success of learning. After all, learning messages can be conveyed to children concretely, so they are more receptive to learning. This is by their current thinking stage, namely the concrete operational stage. Kindergarten teachers are expected to be able to apply motor-physical activity learning with play strategies in increasing the various potentials possessed by children. Further research requires research in a broader scope to see the significance of the results on research subjects and to be able to examine various types of children's intelligence. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results.

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