THE INFLUENCE OF PHYSICAL ACTIVITY ON MATHEMATICS LOGIC ABILITY EARLY CHILDHOOD

ABSTRACT: This study aims to determine the increase in mathematical logical intelligence of early childhood through physical activity. This is action research (action research). This type of research was a sequential exploratory design and the subjects used were all Kindergarten classes in DKI Jakarta, totaling 23 childhood (age 4 to 6 years). The assessment of mathematical logic intelligence uses a child's observation sheet instrument which was made by the author himself and has been consulted by experts and has been tested for reliability and validity. 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 results showed that there was an increase in mathematical logic intelligence in DKI Jakarta Kindergarten childhood. The results of the initial assessment showed that the average value of the child's mathematical logic 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. Kindergarten teachers are expected to be able to apply motor-physical activity learning with play strategies in increasing the various potentials possessed by childhood. Future research is expected to examine more in this study, namely intelligence with many subjects and research locations.

keywords: mathematical, childhood, kindergarten

1 INTRODUCTION

Physical activity is any body movement produced by skeletal muscles that results in energy expenditure, more confident and optimistic about carrying out daily activities, and improving academic results at school. Higher levels of physical activity in adolescence have been shown to be 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 effects on brain systems that underlie cognitive 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). Synaptic plasticity is the ability to change synaptic strength. Changes in strength include neurotransmitters. Neuroplasticity comprises a neurochemical basis that is important in learning and memory. Recent research supports that physical activity can affect executive function. Executive function can be described as a high-order, up-and-down thought process that is closely related to frontal brain activity. It is a process by which individuals coordinate different cognitive activities while performing cognitive tasks, with the aim of enabling individuals to achieve set targets and produce intentional behavior in a flexible and efficient manner. In general, the executive

Commented [3PP1]: Title needs to be revised because "logical-mathematics" is an intelligence, not an ability. This also has an impact on your supporting references, you must complete your references with Logical-mathematical intelligence variables.

although Logical-Mathematical Intelligence is the ability to analyze situations or problems logically, identify solutions, conduct scientific research, and easily complete logical/mathematical operations. but the equivalent word for the research variable, the phrase "Logical-Mathematical Intelligence" is "intelligence" not "ability"

We recommend changing the title to The Influence of physical activity on children's logical-mathematical intelligence

Commented [3PP2]: The correct abstract can be written in the following systematics:
1. Brief background (one sentence only) (make sure by the editor this background is research related, important, and clear)
2. research objectives
3. Brief method (location and sampling technique do not need to be abstracted)
4. Brief Research Results (Findings)
5. Short conclusion

Commented [3PP3]: this sentence should be moved to the method section

Commented [3PP4]: keywords need to be fixed, related to research variables, for example, "early childhood; physical activity; logical-mathematics intelligence"
function is known as a multidimensional structure. Although there is ongoing debate regarding the elements of executive function, the general consensus is that executive functions include flexibility, goal setting and planning, attention and memory systems (such as working memory), and control of inhibition. (Deer et al., 2020; Shi et al., 2022; Stillman et al., 2016; Zulhema & Suryana, 2019). Childhood 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 and mental health, and social adaptation, which in turn have been found to be related to 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 childhood's cognitive, emotional and behavior so that it can positively influence academic achievement. However, findings between physical activity and cognitive work in childhood are still relatively rare and inconsistent. Childhood's motor development and cognitive learning are associated with positive effects on academic work. This shows that physical growth, Motor development and cognitive development of childhood are interrelated. Many cognitive skills, such as visual spatial skills and memory skills contribute to the learning of arithmetic. Therefore, including physical activity in mathematics lessons can influence emotional experiences and be beneficial for childhood's mathematical logic work (Daly-Smith et al., 2018; Grieco et al., 2017; Hajari et al., 2019; Owen et al., 2016).

However, based on theoretical and field observations, more and more school-age childhood spend most of their time in sedentary/sedentary activities, both at school and outside of school/childhood's free time. There are even parents who support their childhood to prioritize academics rather than extracurriculars such as physical exercise or sports. Because the attitude of these parents makes childhood less optimistic about activities and physical exercise and underestimates physical activity (Sember et al., 2020). This is what is worrying for future generations. Because in fact it is precisely by doing a lot of physical activity that the brain is getting stimulated and is always active to think so that academic achievement also increases, 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. In particular, the level of a protein called brain-derived neurotrophic factor (or BDNF for short) increases 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 childhood and education globally. (Azman & Zakaria, 2022; Chaddock-Heyman et al., 2013; Colucci-D’amato et al., 2020; Miranda et al., 2019; Silakarma & Sudewi, 2019) Physical education lessons at school are the only opportunity to provide programmed physical activity while at school, and it is said that the role of physical activity while at school has not been sufficiently disseminated in most countries internationally, on average less than 20% of childhood are physically active for 60 minutes or more than recommended each day, one example is that less than half of childhood in the United States meet the 30-minute guideline of physical activity while studying at school. Based on the opinion of the World Health Organization or WHO, childhood aged 6 to 17 years must do at least 60 minutes of moderate to vigorous physical activity every day. (Organização Mundial de Saúde, 2022) (Organization, 2020). Childhood inactivity has been shown to have detrimental effects, not only on childhood’s physical and mental health but also on childhood’s cognitive and academic performance. To deal with today's low levels of physical activity in childhood, research has been con-
ducted in the last two decades in several European, North American, and Australian
countries to increase the amount of physical activity during schooling. Research not only
modifies childhood's cardiovascular disease risk factors, but increasing evidence shows
that physical activity does not have a negative effect on childhood's academic work, cog-
nitive function, and behavior, in fact it is very beneficial for academic work, especially in
mathematical logic. (Andriyani et al., 2020; Aubert et al., 2021; Gao et al., 2018). There
have been several studies that have addressed this topic, but they are still on a local scale,
the research has not covered areas in Lampung, Indonesia, and has not covered many
sample criteria. So that researchers are interested in researching this in the research area
in Lampung, Indonesia. It is hoped that this research can provide education and open
people's mindsets so that they can balance academic achievement and physical exercise
or childhood's physical activity.

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 dur-
ing 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, dia-
etes and some cancers. It also helps prevent hypertension, maintains a healthy weight
and can improve mental health. (Janssen & LeBlanc, 2010; Organização Mundial de
Saúde, 2022).

Commented [3PP7]: In order for the article to be more
worthy of publication, please make a pattern with five para-
graphs in the introduction:
1. Background of the problem, deepening of the problem,
2. The gap between the idealized and the existing facts,
3. Supported by the latest theory and research relevant to the
problem,
4. Have new research value (or benefit) which is innovation,
5. Ends with the research objectives

Commented [3PP8]: For theoretical study
1. In this section it is not necessary to explain the fundamen-
tal theories of child development, this section is filled with
research results that support your research variables.
2. Only research articles are needed that
are related to your
research variables
3. The order of the theory is expected to follow your key-
word arrangement, you have not entered the basic tiered
training variable
4. References Mostly refer to the latest published interna-
tional journals
5. All statements must have source citations
WHO recommends:

For childhood 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, high chair, 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, childhood aged 1-2 years should spend at least 180 minutes in a variety of physical activities 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 (eg, stroller/pram, high chair, or strapped on a caregiver’s back) or sitting for long periods of time. For childhood aged 1 year, sedentary screen time (such as watching TV or videos, 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, childhood 3–4 years of age 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 (eg, stroller/pram) or sitting for long periods of time. 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 childhood under 5 years of age. Childhood 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.

Regular physical activity, such as walking, cycling, wheeling, playing sports or active recreation, has significant health benefits. Some physical activity is better than doing nothing. By being more active throughout the day in relatively simple ways, people can easily reach the recommended level of activity. Physical inactivity is one of the main risk factors for death from non-communicable diseases. People who are less active have a 20% to 30% increased risk of death compared to people who are moderately active. Regular physical activity can improve muscle and cardiorespiratory fitness; improve bone health and function; reduce the risk of hypertension, coronary heart disease, stroke, diabetes, various types of cancer (including breast cancer and colon cancer), and depression; reduce the risk of falls as well as hip or spine fractures; and help maintain a healthy weight. In childhood and adolescents, physical activity improves physical fitness (cardiorespiratory and muscle fitness), cardiometabolic health (blood pressure, dyslipidemia, glucose, and insulin resistance), bone health cognitive outcomes (academic work and executive function), mental health (reduces depressive symptoms), and reduced adipose tissue(organização mundial de saúde, 2022).
The relationship of physical activity to improving cognition and academic achievement in childhood 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 childhood. Thus it can be concluded that there is a significant positive relationship between physical activity and cognitive function in childhood. A number of 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 for executive function, suggesting that exercise has the potential to induce altered vascularization, nerve growth, and synaptic transmission, thereby modifying thinking, decision-making, and behavior in areas of the brain related to executive function. In addition, physical activity can also help mental health by improving musculoskeletal/muscle bone function to help relieve or reduce depression, anxiety and stress. The mechanism of the relationship between physical activity, cognition, and mental health can be explained by the conceptual model hypothesis, namely the mechanism of neurobiological, psychosocial, and/or behavioral linkages and can be influenced by frequency, intensity, time, type and type of physical activity (Deer et al., 2020; Gomez-Pinilla & Hillman, 2013; Hildebrandt, 2018; Reikerås et al., 2017).

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. And inconsistent results were observed across several subjects, including mathematics and reading, Mathematical Logic. The relationship between physical activity and mathematics is of more interest. Indeed, mathematics has an irreplaceable position as a fundamental and important scientific discipline. In China, mathematics has become a compulsory subject in grades 1-12, and is a compulsory subject to take college entrance exams and entrance exams for Senior High School/Senior High School. It strongly supports scientific disciplines, Engineering and further learning practices. This explains why researchers pay more attention to mathematics when exploring the relationship between physical activity and academic achievement. Although most studies have reported that physical activity has a positive effect on mathematics. (Beck et al., 2016; Fischer et al., 2020; Flores et al., 2023; Macdonald et al., 2020; Reikerås et al., 2017).
3 METHOD

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

Conceptual definition Mathematical logical intelligence is the ability of childhood related to sensitivity in seeking and finding patterns that are used to perform arithmetic calculations and think abstractly as well as think logically and think scientifically. With indicators of calculating by rote quickly, enjoy computer mathematical logic, always ask questions, enjoy playing chess and other strategy games, explain problems logically, do trials and experiments. The operational definition is a score obtained from the results of childhood's observations about counting outside their heads quickly, always asking questions, enjoying strategy games, explaining problems logically, doing trials and experimenting. Observations were made using an observation scale, which was developed by researchers according to the relevant theory.

4 RESULTS AND DISCUSSION

4.1 Results

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 childhood. Prior to the observation, the researcher conducted a debriefing for 2 observers to study the observation sheet together.

4.1.1 Quantitative Result

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

<table>
<thead>
<tr>
<th>Initial Assessment</th>
<th>Observation Aspect</th>
<th>Final Assessment Cycle 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>Childhood can make groups according to the number of personnel determined by the teacher.</td>
<td>70%</td>
</tr>
<tr>
<td>20%</td>
<td>Childhood can count the movements made</td>
<td>68%</td>
</tr>
<tr>
<td>20%</td>
<td>Childhood have the initiative to ask about something they don't understand</td>
<td>57%</td>
</tr>
<tr>
<td>26%</td>
<td>The child expresses the experience of the movements carried out</td>
<td>47%</td>
</tr>
<tr>
<td>30%</td>
<td>Childhood have a playing strategy to win</td>
<td>50%</td>
</tr>
</tbody>
</table>

Commented [3PP11]: In the abstract it should be like this sentence.

Commented [3PP12]: the description of this method is still incomplete and not in accordance with the systematic writing of methods in scientific work. Please revise in this order:
1. Write down the research method in detail/complete
2. Make sure that if the research is repeated by other people, the results are similar (reproducible)
3. Methods that are familiar and common, don’t need to be written down in detail, just refer to the book.
4. Usually written in past tense.
Observing the flow of the opponent's game 50%

Childhood understand the consequences of a movement made 50%

Childhood can distinguish between right and wrong moves according to the rules of the game 45%

The child tries the function and the weight or lightness of the tools being played 70%

Childhood can solve simple problems that occur in the game 58%

Average 57%

From the table above it shows that childhood's mathematical logical intelligence has increased in value to 57 from 28, out of 10 abilities in mathematical logical 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 childhood's mathematical logical intelligence.

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

<table>
<thead>
<tr>
<th>Initial Assessment Cycle 1</th>
<th>Observation Aspect</th>
<th>Final Assessment Cycle 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>44%</td>
<td>Recognizing the limits of strengths and weaknesses in playing</td>
<td>72%</td>
</tr>
<tr>
<td>45%</td>
<td>Can make your own choices in play</td>
<td>78%</td>
</tr>
<tr>
<td>70%</td>
<td>Can accept the superiority of his friends in playing</td>
<td>85%</td>
</tr>
<tr>
<td>72%</td>
<td>Patiently waiting for their turn to play</td>
<td>82%</td>
</tr>
<tr>
<td>78%</td>
<td>Prepare and organize play equipment</td>
<td>81%</td>
</tr>
<tr>
<td>55%</td>
<td>Independent in activities</td>
<td>77%</td>
</tr>
<tr>
<td>57%</td>
<td>Understand the consequences if you break the rules or make a mistake</td>
<td>77%</td>
</tr>
</tbody>
</table>

Commented [3PP13]: In order for this manuscript to be worthy of publication, please revise it following these directions:
1. The results should summarize the findings or findings rather than simply presenting the research data in detail.
2. Do not describe the figures (tables/graphs) in detail, but rather present findings or trends.
3. Just write down the processed data in the article (in the form of tables or graphs/pictures but not both for the same data).
4. Can statistical data and differences be presented.
From the table above, it shows that childhood's mathematical logical intelligence has increased in value to 78 from 59, out of 10 abilities in mathematical logical 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 childhood's mathematical logical intelligence.

### 4.1.2 Qualitative Results

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

Following are the results of qualitative data:

Learning physical motor activity can improve mathematical logic intelligence. Physical motor activity learning emphasizes play, which is the child's world. By playing, childhood 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, 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 motor physical activity felt by childhood, teachers and parents include childhood knowing many things, increase childhood's experience and vocabulary, childhood become brave and responsible, active, creative, smart, disciplined and independent, as well as teachers' insights can increase, enrich, and integrate conventional learning with physical motor activity loads including making games that are appropriate to the development of childhood'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, how to play, so that they can be applied starting from planning, 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 media used, learning physical motor activity has its peculiarities because it requires a variety of methods and interesting media to stimulate optimal mathematical logical intelligence in childhood. 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 mathematical logic intelligence are: Frequently asking questions, fast counting outside the head, Enjoying strategy games, likes to compile categories, likes to experiment and process high-order (logical) thinking to solve problems.
easily understands causal relationships. Based on the results of the quantitative research, it was found that mathematical logic 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 childhood's mathematical logic intelligence in DKI Jakarta Kindergarten.

This is supported by previous research on cognitive enhancement after being given physical activity treatment, such as in the following studies: Basically, childhood and adolescents who are physically active tend to be physically active throughout adulthood. Recent research also shows that physical activity can improve childhood's cognitive function and academic achievement in school. Therefore, it is important to ensure that childhood 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 childhood, including executive function (e.g., working memory and cognitive flexibility) and brain health. However, this study primarily targets older childhood 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 is a statistically significant relationship between the learning outcomes of physical education and students' mathematics learning outcomes, this shows that when students have sufficient health and appropriate physical exercise, students can participate in the learning process. Practicing to develop the ability to think logically, think critically, and solve the most problems 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, 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 childhood to participate in learning activities. Childhood diligently participate in all activities, even learning physical motor activities with various playing strategies, childhood seem happy and enthusiastic in learning. This is shown by the impressions from the childhood at the time of parting that they wanted researchers to continue teaching them, the attitude of teachers who were open-minded, willing to learn, 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 childhood, support in the form of motivation for teachers, changing schedules from the usual, and providing the necessary infrastructure (hall), providing special time for learning physical activity motor. What stands out is the cooperative attitude of the school principal in the form of a positive re-
response to the results of the research and following up by holding motor-physical activity learning for other class teachers.

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, because learning messages can be conveyed to childhood concretely, so they are more receptive to learning. This is in accordance with their current thinking stage, namely the concrete operational stage.

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). As a result, the teacher sometimes rushes in teaching, application of learning through physical-motor activity, a larger room is needed, so that childhood are free to move and plan activities can be carried out optimally, making game designs and applying them in daily activity plans that are so complicated. The strength of this research is to find a model of 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 effective and positive impact on learning. While the limitations of the research are that the research is conducted in a limited scope, namely to a number of childhood in one class at one Kindergarten. So research is needed in a broader scope to see the significance of the results on different research subjects and kindergartens. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results. Limitations of research, the last research is only applying games that develop one intelligence due to time and place limitations of research. That is, besides having an impact on the cognitive level, it also has an impact on effective and also has a positive impact on learning. While the limitations of the research are that the research is conducted in a limited scope, namely to a number of childhood in one class at one Kindergarten. So research is needed in a broader scope to see the significance of the results on different research subjects and kindergartens. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results. Limitations of research, the last research is only applying games that develop one intelligence due to time and place limitations of research. That is, besides having an impact on the cognitive level, it also has an impact on effective and also has a positive impact on learning. While the limitations of the research are that the research is conducted in a limited scope, namely to a number of childhood in one class at one Kindergarten. So research is needed in a broader scope to see the significance of the results on different research subjects and kindergartens. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results. Limitations of research, the last
research is only applying games that develop one intelligence due to time and place limitations of research. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results. Limitations of research, the last research is only applying games that develop one intelligence due to time and place limitations of research. In addition, further research is needed in the form of experimental research to see the effectiveness of the research results. Limitations of research, the last research is only applying games that develop one intelligence due to time and place limitations of research.

5 CONCLUSION

The results of the study show that the mathematical logical intelligence of Kindergarten-aged childhood can be increased through physical education learning given by the teacher using playing strategies. The results of the initial assessment showed that the average value of the child’s logical-mathematical 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. Supporting factors for childhood’s cooperation to participate in learning activities, cooperative collaborators, support from the kindergarten, and interesting media. While the inhibiting factors of research such as limited time, a lot of media needs, and the need for a large study room. Kindergarten teachers are expected to be able to apply motor-physical activity learning with play strategies in increasing the various potentials possessed by childhood. Future research is expected to examine more in this study, namely intelligence with many subjects and places.

6 ACKNOWLEDGMENTS

I am grateful to all of those with whom I have had the pleasure to work during this and other related projects.

7 REFERENCES


Krisiyanto. (2020). PTK (classroom action research) model Kemmis and Mc Taggrat (pp. 12–15).


EFFECT OF PHYSICAL ACTIVITY ON CHILDHOOD LOGICAL MATHEMATICS INTELLIGENCE

ABSTRACT: Research between the relationship 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 that increasing logical mathematics intelligence in DKI Jakarta childhood. The results of the initial assessment 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 Kinderganten. Future research is expected to examine more childhood intelligence with many respondense.

keywords: early childhood; physical activity; logical-mathematics intelligence

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 have been shown to be 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 cognitive 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, with the aim of producing intentional behavior in a flexible and efficient manner. 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 physical growth, motor development, and cognitive development of children are interrelated. Many cognitive skills, such as visual spatial skills and memory skills contribute to the learning of 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

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, 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, high chair, 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 (eg, stroller/pram, high chair, or strapped on a caregiver’s back) or sitting for long periods of time. For children aged 1 year, sedentary screen time (such as watching TV or videos, 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 (eg, stroller/pram) or sitting for long periods of time. 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. People who are less active have a 20% to 30% increased risk of death compared to people who are moderately active. 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 skin fat and internal organs (Organização Mundial de Saúde, 2022).
**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. A number of 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 number of 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 and important 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, in fact it is highly beneficial for academic work, especially in mathematical logic. (Andriyani et al., 2020; Aubert et al., 2021; Gao et al., 2018)
3. METHOD

This research uses action research method, by combining qualitative and quantitative research (mix method). Action research aims to improve the learning system in order 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). Conceptual definition 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, and experimenting.

2.1 Results

a. Results

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. Prior to the observation, the researcher conducted a debriefing for 2 observers to study the observation sheet together.

i. Quantitative Result

Table 1. Initial Assessment and Final Assessment of Cycle 1 Intelligence Mathematics Logic

<table>
<thead>
<tr>
<th>Observation Aspect</th>
<th>Initial Assessment</th>
<th>Final Assessment Cycle 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>28%</td>
<td>57%</td>
</tr>
</tbody>
</table>

From the table above it 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 2. Initial Assessment of Cycle 1 and Final Assessment of Cycle 2 of Logical Mathematics Intelligence

<table>
<thead>
<tr>
<th>Observation Aspect</th>
<th>Initial Assessment Cycle 1</th>
<th>Final Assessment Cycle 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>59%</td>
<td>78%</td>
</tr>
</tbody>
</table>

From the table above, it 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.

2.1.1 Qualitative Results

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, 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, 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, how to play, so that they can be applied starting from planning, 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 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.

2.2 Discussion

Qualitative improvements in mathematical logic 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, easily understands 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. Basically, 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, 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 from the researcher. They wanted researchers to continue teaching them, the attitude of teachers who were open-minded, willing to learn, 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 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 in 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 of 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, namely a number of 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, namely a number of 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, namely a number of 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, a number of children in one class at one kindergarten and the research only applies games that develop one intelligence due to time and research space limitations. 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, a number of children in one class at one kindergarten and the research only applies games that develop one intelligence due to time and research space limitations. 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.

3 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, because learning messages can be conveyed to children concretely, so they are more receptive to learning. This is in accordance with 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 re-
search is needed in the form of experimental research to see the effectiveness of the research results.

4 ACKNOWLEDGMENTS

I would like to thank the kindergartens in the Jakarta area and the co-authors of this article who have contributed to helping the research process to the end.

5 REFERENCES


Krisiyanto. (2020). PTK (classroom action research) model Kemmis and Mc Taggrat (pp. 12–15).


