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## The Recommended Aerobic Gymnastics Has Better Effects on Improving Cognitive and Motoric Ability in Children

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### Abstract

#### Background

Cognitive and motoric ability has important role in children's development, whereas exercise has benefit effects on those abilities. Knowledge materials mostly have dominant role in primary school curriculum. Physical exercise lesson is only complementary lesson without a target to improve children's cognitive ability. We conducted a study to give evidence that 3x/week structured exercise program has better effect compared to 1 x/week exercise on cognitive and motoric skill ability in children.

#### Materials and methods

Children aged 6-8 years old were divided into treatment (n=34) and control group (n=33). Treatment group were performing fun aerobic gymnastics guided by trained instructor, 45 minutes each, 3 times a week for 8 weeks with intensity target. Control group were also performing the same gymnastic activity for only once a week with no target. Cognitive and motoric ability were assessed before and after intervention.

#### 6 Results

A recommended regular exercise has better effect on executive function, reaction speed, coordination, flexibility and agility, compared to control. There were no differences on memory and balance ability. Both groups have shown better result for all indicators after exercise. Exercise in both groups has positive effect on cognitive and motoric ability, but a recommended 3 x/week regular exercise has better effects compared to 1 x/week exercise.

#### Conclusions

School program should give more portions for exercise activity in their curriculum.

**Keywords:** Gymnastics exercise, cognitive ability, motoric ability

### Background

Physical exercise is the stimulation of learning that has a positive effect on cognitive function.<sup>1</sup> There is a positive correlation between the level of physical activity with the ability of perception, intelligence quotient (IQ), memory, verbal skills, math skills, as well as the skills and academic skills in young children.<sup>2</sup> Physical exercise conducted since the younger will develop brain elasticity, increase the durability of the brain, increase cognitive capacity in childhood, and it will continue throughout life.<sup>3,4</sup>

The structure of the brain is formed in the embryonic phase, but the development of a complex network of neurons will be developed after birth and relies on the experience and lessons learned.<sup>2</sup> The continuous experience and learning will stimulate the brain through a long-term potentiating mechanisms (LTP). LTP will stimulate the synthesis of specific proteins and new synapses associated with the experience. The more experience or knowledge is built, there will be more synaptic connectivity.<sup>6</sup>

Research in animal model has shown that aerobic exercise improves the cognitive function through three mechanisms. First, exercise stimulates neurogenesis by neuron proliferation or neuroplasticity. Second, increase neuron survival, and last improve vascular function and angiogenesis.<sup>7-9</sup>

Although exercise is believed could enhance cognitive abilities, but strong scientific evidence is still inadequate. Experimental research <sup>4</sup> on the effect of exercise on cognitive was only widely applied in experimental animals. Scientific evidence in humans mostly in the form of observational and cross-sectional studies and showed a weak positive relationship.<sup>10</sup> In addition, the type of aerobic exercise that observed is <sup>3</sup> in the form simple movements such as running on a treadmill, riding a stationary bike, a brisk walk or exercise resistant, with the result that a small benefit to building cognitive, especially executive functions.<sup>11</sup> Therefore, further study is needed on the type of physical exercise that actually improve cognitive especially executive function.

Children spend more time in school. Schools have an important role to optimize the their potency of growth and development. Schools must provide adequate opportunity to the children to do the structured physical activity properly. However, many schools put physical activity only as supplementary material. The structured physical activity lesson is provided only a limited time between theoretical subjects. The Institute of Health has to promote that schools should offer more opportunities for children to be physically active along the school day. Once a week physical acitivity lesson is not enough, so that, we conducted a study to give evidence that 3 x/week aerobic gymnastic exercises program has better effect compared to 1 x/week exercise on memory, executive function, and motoric ability among children.

## Methods

The exercises experimental with control was carried out on children aged 5.5 to 7.5 of the first years in a primary school Palembang, Indonesia. The school only has two classes with 90 students, only 67 consist of 34 students in the treatment group and 33 subjects in

control group were join the study. A cluster randomization of the class was conducted to find which class will be included in the treatment or the control group. All the students were selected based on their class.

Aerobic gymnastics exercise was performed on both groups. Treatment group was performed aerobic exercise 24 times for 8 weeks, consists of 3 sessions per week. Each exercise sessions was guided by a licensed trainer, conducted for 40-45 minutes with 3 stages of 5 minutes warming up, 30 minutes core exercise, and 5-10 minutes cooling down. At the core exercise, subjects perform various gymnastics imaginative and fun movement, such as combination of fun animal movements, worship motion exercises, and work-day activities movements. When undergoing exercise, subjects were targeted to reach exercise intensity approximately 125-150 times of pulse rate per minute. For the control group, subjects perform the same exercises for 1 time a week or total of 8 times in 8 weeks. They were guided by local school teacher without a target exercise. The memory, executive function and motoric skills among both groups were examined before and after intervention. Memory and executive function were assessed by licensed psychologist, and motoric skills were assessed by licensed trainer.

Memory ability was assessed by digit span working memory test. Digit-span working memory test consist of digit forward and digit backward (reverse). Students were presented with a series of numbers, and they must immediately repeat them back. Score was measure by psychologist based on the longest digit of a students can remember.<sup>12</sup>

Executive function abilities was assessed by coding-A processing speed index (CPSI) as part of Wechsler Intelligence Scale for Children.<sup>13</sup> The instrument is <sup>10</sup> assesses ability to focus attention and scan quickly, and the ability to discriminate and order visual information. Students have to write an appropriate symbol in a box based on the clues. Ability of students were assessed based on proportion of appropriate symbols and time to finished the task. Students also perform Goodenough-Harris Draw A Person test (GHDPT). They have to draw a person based on their original creation, and a psychologist measure the result based on mental age equivalent scores which written in the manual.<sup>14,15</sup>

For motoric abilities, the study was assessed reaction speed, balance, <sup>11</sup> agility, and coordination. Reaction speed were assessed by ruler method. Students have to catch the handy ruler a soon as possible after released by observer with no command. Balance was assessed by one leg standing time test and students has to stand by one leg as long as possible.<sup>15</sup> Agility were assessed by 10-m agility shuttle test, students run fast between two

lines 10m-apart twice, to pick up two small blocks. Coordination was assessed by alternate hand wall toss test. Students stands behind the line 2 meters facing to the wall. Students throw the ball against the wall by one hand and catch it with another hand, than the ball thrown back against the wall and to be caught by initial hand. The number of successful catches in 30 seconds was calculated.<sup>17</sup> All of data were analyzed by Microsoft® Office Excel 2007 and Statistical Package for the Social Sciences(SPSS) version 13.0 software. Differences between treatment and control were analyzed with independent-t and Mann-Whitney test. Study protocols was reviewed and approved by the Unit for Bioethics and Humanities at the University of Sriwijaya.

**Results**

At the beginning of the study, both groups have the same level for all cognitive indicators. At the end of the study, all of cognitive indicators have improved in both treatment and control group. However, treatment group has the better level of coding-A processing speed index and Goodenough-Harris draw a person test index compare to control, while there were no differences on digit-span working memory test (Figure 1-3).

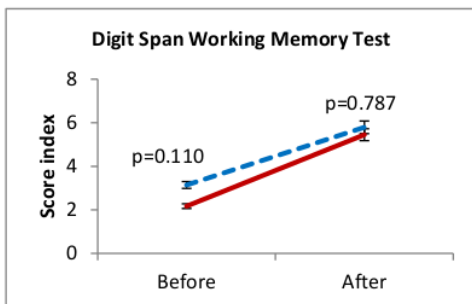


Fig.1. Digit span working memory test

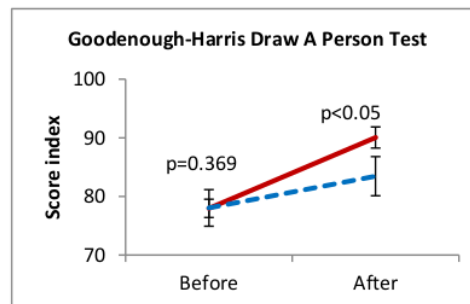


Fig. 2. Goodenough-Harris draw a person Test

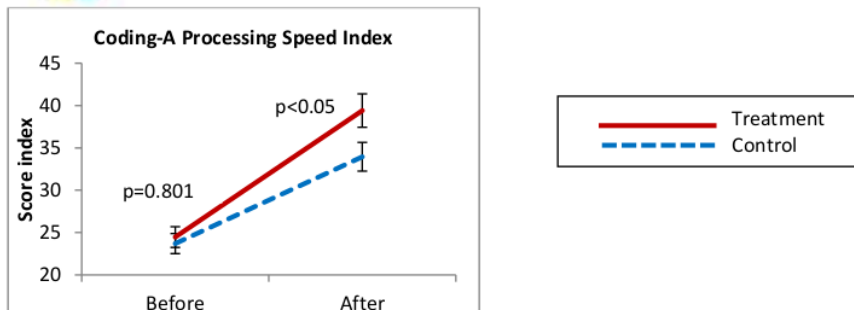


Figure 3. Coding-A Processing Speed Index

The motoric skills have same pattern with cognitive abilities, that there were no differences of all motoric skills at the beginning of the study and all of indicators have improved at the end of the study in both treatment and control groups. At the end of the study, the treatment group has better abilities on reaction speed, flexibility, agility and coordination, while there were no difference on balance (Figure 4-8).

In anticipation of bias, authors examined the patterns of physical activity, and extra lessons that were undertaken by students. All of students in both groups has similar pattern of physical activity. They spent around one hour a day for light physical activities such as soccer, traditional games, and cycling at their neighborhood. Rest of their time were spent for watching television, play video games, studying and sleeping. They also have similar way to go to school. Most of them (95.5%) were going to school by walking and 3 students used bicycle, because radius of the school only under one kilometers from their houses. All students of the two groups did not follow regular exercise led by a trainer/instructor outside of research program. In addition, all of them were not follow extra lessons outside of school hours.

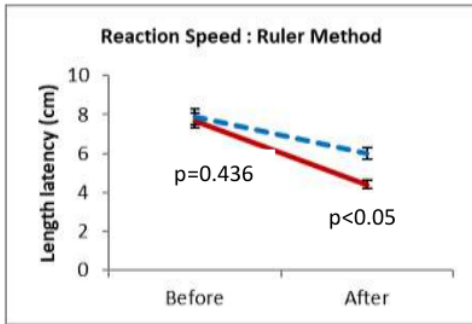


Fig. 4. Reaction speed

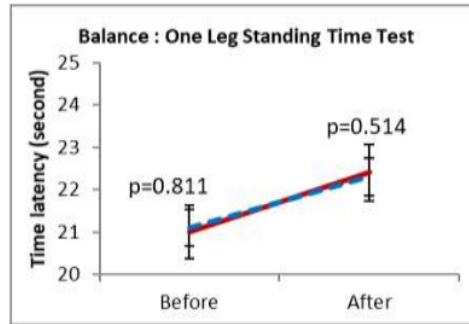


Fig. 5. Balance

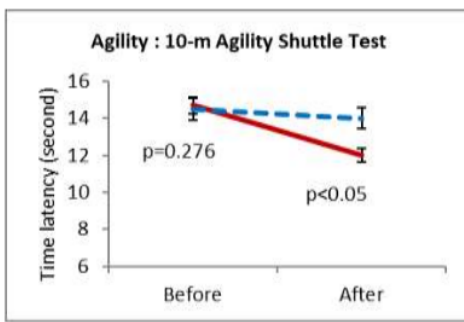


Fig. 6. Agility

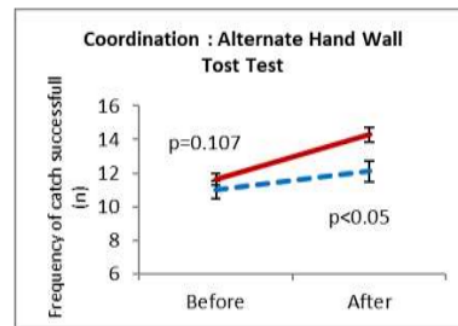


Fig. 7. Coordination

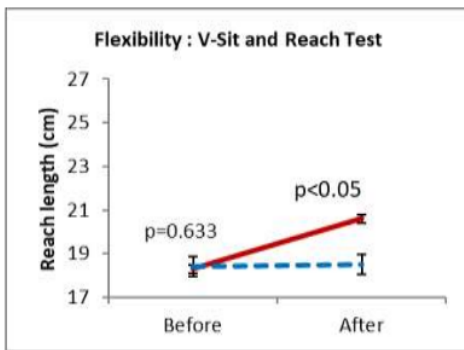
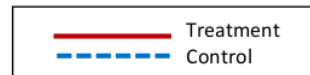


Fig. 8. Flexibility



### Discussion

The study has proved the increase of cognitive abilities after exercise program. Memory capability was increase in both groups, while the treatment group showed better improvement for executive function than control. Chaddock *et al.*, had proved that among 9-10 years old children, there was no differences of non-relational memory capabilities between

higher aerobic capacity and lower aerobic capacity, but the higher aerobic capacity had better score on complex relational memory. Other studies also proved that aerobic exercise can improve executive function of children.<sup>17-19</sup> A cross sectional study using brain imaging have shown that children with higher prefrontal cortex activity have better abilities of executive function.<sup>19</sup>

Both of acute and chronic exercise may improve cognitive function. Acute exercise improve children's attention, processing speed, and executive control. Chronic exercise training could improve children's executive functions and problem solving.<sup>20</sup> Even single sessions of physical activity have been associated with better scores on concentration, and better memory abilities. Children participating in physical activity are better able to stay focused and remain on task in the classroom.<sup>21</sup>

Regularly gymnastic exercise group has better capabilities of flexibility, agility, reaction speed and coordination compared to control. Previous research also shown similar result that some motoric abilities have increase after regular exercise.<sup>8</sup> Children who spend the most time in moderate to vigorous physical activity tend to have the highest motoric skill.<sup>12</sup> This may be because physically active children spend more time learning and improving new motor skills. Motor skills do not always improve naturally, it is important to introduce children to new movements and create opportunities for them to practice.<sup>22</sup>

We found that balance ability in treatment group has no better effects than control. In a previous study,<sup>5</sup> children were trained daily for 15 min over 7 month at the preschool for agility, balance, endurance and jump performance. The trained children has better abilities in agility, endurance and jumper performance, while balance performance did not relevantly improve.<sup>23</sup> The balance is influenced by visual, vestibular and proprioceptive. Balance exercises may need to be trained through special training patterns.

Exercise improve activity of prefrontal cortex and efficiency of recruitment from others region likes parietal in controlling movements. Prefrontal is the largest area exposed by continuous physical activity. It will stimulate body coordination and lowering motor error, and accelerate cognitive and motoric development.<sup>24</sup> Human has largest area of frontal region, and prefrontal is the most develop area. Prefrontal has important role in human specific characteristics, likes self awareness, complex planning capabilities, and problem solving abilities.<sup>25</sup>

In this study, the treatment group had a similar memory capabilities relative to the control. Gymnastics provide learning and improvement of motor skills that are dominated by



pre-central region. Precentral has a bigger role in executive functions, while the ability to build a memory is dominated by sensory centers, which is abundant in the hippocampus and parietal region.<sup>26</sup>

Although three times a week structured exercises had a better effect, this study still proved that once a week unstructured gymnastics, was still able to improve cognitive and motor function. Gymnastics has several advantages, gymnastics requires a complex movement, and requiring the coordination of the entire limb movement. Gymnastics with music and guided instructors, requires coordination between vision, hearing and gestures. Fun movement in gymnastics will stimulate the brain to be healthy. Gymnastics is also often carried out in groups so that participants can socialize with each other. Executive function will improve, if we are happy, safe, comfortable, and physically fit, and feel socially supported.

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Gymnastics in this study is an aerobic physical activity. Aerobic activity will move the components around the body. Gymnastics movements are more complex than running or walking. In this study, gymnastics imitating cute animal movements, movements of people work and worship movements. These movements evoke a child's imagination to build the components of intellectual. The motion including stimulation of experience, and will increase the formation of specific proteins, increase in nerve synapses, increased synaptic connectivity in the form of communication between the nerve signals that are more complex.<sup>27</sup> Gymnastics also set up communication between the hemispheres. Gymnastic movements enable collaboration between right brain and left brain without competition. This collaboration, is difficult to achieve with drugs or surgery. The more often the child to practice, more and more parts of the brain to collaborate without pressing other brain areas. This collaboration brings an element of emotional and cognitive achieve balanced level, as well as allowing the brain to give the same attention to both elements.<sup>28</sup> Children who often play a structured games in the form of a group, were able to adapt better than children who practice alone and in the form of isolated exercise such as a treadmill or stationary bike.<sup>29</sup>

Research on the relationship between physical exercise and cognitive showed a similar result, that physical exercise improves cognitive function. However, the type of physical exercise should be a concern for cognitive function. Some studies showed that aerobic activity with simple movements and resistant exercises did not provide substantial benefits for cognitive function. Exercises with complex movements such as martial arts and yoga showed better benefits for cognitive function. Those exercises stimulate the brain to work harder, because it requires bimanual and eye-hand coordination.<sup>11</sup>

Exercise will have benefits if performed in a regular program with appropriate dose. Voluntary exercise without target could be ineffective.[30] In this study children performed the exercise in the early part of the morning for 40-45 minutes each. <sup>1</sup> One study suggested that the greatest cognitive benefits from physical education resulted when physical education classes were scheduled during the early or middle part of the day. Physical Activity Guidelines for Americans suggest the duration of physical activity is 60 minutes for a day.<sup>21</sup>

### Conclusion

A regular aerobic exercise program could improve a child's cognitive and motoric abilities. Therefore, routine stimulation of aerobic exercise should be added as an addition of learning stimulation in school curriculum. Educational institutions may need to review the curriculum, so that regular physical activities programmed become one of intra-curriculum activities. The exercise should follow the recommended program such as 3-4 times a week regularly, with 30-45 minutes duration and reach the recommended aerobic intensity.

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