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The Development of Physical Education Programs to Enhance the Executive Functions of Primary School Students

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Abstract

Problem Statement: To develop students' potential to become the main force of a country's future development, it is important to encourage their growth in every aspect: physical, mental, social, emotional, and intellectual. The purposes of this study were the development of a physical education program to enhance executive function in primary school students and to study the efficiency of physical education programs to enhance the executive function of primary school students.

Approach: The subjects of this study were 30 students aged 7-9 years, who were selected using a multi-stage random sampling method. The research instruments consisted of a structured interview form (physical education program), a computer-based cognitive ability test using the Trail Making test, the Eriksen flanker task, and an assessment form for the executive function behavior of primary school students. The physical education program was applied to the experimental group for 8 weeks, with 3 sessions per week at 60 minutes each. They were tested before the trial, after, and after a follow-up period of four weeks. One-way repeated measures analysis of variance and paired sample t-tests were used to compare executive function at pre-test, post-trial, and the follow-up periods, resulting in 95% confidence interval.

Results: The results found that physical education programs have an Index of Item Objective Congruence of .92 and the executive function of the experimental group after the trial and the follow-up period were better compared to before the trial—statistically significant at .05. However, there was no difference on comparing the post-trial with the follow-up period.

Conclusions: The physical education program encourages movement in every part of the body and stimulates executive function of primary school students when performed regularly.

Keywords— physical education program; physiological development; executive function; primary school students

I. INTRODUCTION

To develop students' potential to become the main force of a country's future development, it is important to encourage their growth in every aspect: physical, mental, social, emotional, and intellectual. Developing their growth would help children to be successful in both education and work in the future. Such success is not solely dependent on knowledge ability, but also on other skills such as thinking, problem solving,

decision making, reasoning, restraint, creativity, morality and ethics, and the readiness of physical ability.

Executive Functions (EFs) are a set of the brain's higher-level cognitive processes that give the individual the ability to plan, manage, and complete the tasks processed by the frontal lobe of the brain. Executive functions also allow the different parts of the brain to coordinate properly. While the brain's frontal lobe plays the most important role and function, it is the command center for processing experiences from the raw stimulus-response data that people receive through the various senses in the brain for analysis; it leads to thought processes, inhibition, cognitive flexibility, emotional control, working memory, attention and organization. Students with good executive functions have improved thinking, learning, planning, work ethic, and problem solving. In addition, students with good executive function are more practical, are able to achieve their goals, and are be able to live happily within society (Chutabhakdikul et al., 2017; Ellioti, 2003; Haenjohn, 2017; Morrin, 2014; Pahirun et al., 2018). Therefore, the development of executive functions is necessary to encourage students in primary school so that they can develop holistically and become functional members of society. To enhancing executive function in terms of management and quality is to organize learning activities that focus on students' engagement in participatory activities, allowing students to learn both during and outside school. These activities focus on ideas and planning, leading to new experiences that stimulate students to develop the learning and thinking skills necessary to achieve their desired goals. This development is natural and appropriate during these ages (Office of the Thai Health Promotion Foundation, 2017).

Physical education is a curriculum that encourages students to participate in physical activities, exercise, sports, and recreation. It helps students develop themselves in all dimensions based on their potential, strengthen morality, ethics, discipline, good attitude and be able to live happily with others in society. Furthermore, doing physical education activities regularly, continuously, and sufficiently will stimulate the nerve cells that control movement (motor control), sensory neurons, and motor neurons, as well as the ability of the brain to memorize information from repeated practice until learning is accurate (motor learning). Motor control and motor learning in conjunction become a skill (motor skill) that makes movements automatically (Srisupornkun, 2020; Supaviboon & Krabuanrat, 2021). This means that physical education can increase the performance of the brain as well, which is consistent with the study of Ishihara et al. (2017) that examined the effect of game-based exercise using age-appropriate tennis lessons on executive function of students aged 6-12. Ishihara et al. found that playing and practicing tennis had a significant increase in executive function than watching TV, while game-based tennis teaching had a greater increase in executive function than only tennis skill training. Additionally, O'Malley's (2011) study found that aerobic exercise encourages the development of executive functions and the success of overweight boarding school students, who were aged 7-11. This development of executive functions is important for behavioral adjustment and cognitive development according to Davis et al. (2011), who studied how exercise increases executive function, success, and brain alertness in sedentary overweight students. Their results showed that exercises have a positive effect on executive function and mathematics learning. Preliminary evidence that suggests an increase in the dorsal cerebral cortex response and the posterior cerebral response caused by exercise was also observed. These studies' results were corroborated by the related literature review of Best (2010) on studies about the effects of physical activity on students' executive

functions The reviewed literature showed that prolonged, sudden, and sustainable exercise could clearly encourage students' EF more than students who did not exercise, which furthers the idea that a relationship between exercise and executive function supports the development of brain mechanisms. All of these aforementioned studies have covered the development of the mind, body movement, and nervous system signals. In the case of intelligence and psychology, Phutthakoet et al. (2018) studied the effect of playing in the BBL playground on physical performance and motor intelligence among primary school students. Their results showed that after using the BBL playground program, physical fitness and kinesthetic intelligence of students were better than before ($p < .05$). Kuksai and Opasanon (2017) corroborated these findings by showing in their study that the practice of Tai Chi meditation improved planning and problem solving skills, which they suggest can also be used to enhance concentration and executive function in management. Thus, it can be seen that physical activities such as exercise and sports focus on students' movements of every part of the body continuously, which is significant enough to affect their EF. A person who exercises regularly will develop good executive functions and will have systematic thought processes, a precise memory, and the ability to control emotions in various situations. Systematic planning and problem solving are skills that are essential to work successfully (Morin, 2014; Office of the Higher Education Commission, 2016).

Despite the established positive relationship between physical activity and executive function development, there is no current research data on the development of physical education programs to improve the executive function of primary school students. Primary school is the most important period in human learning and students should be encouraged properly to develop in an appropriate manner for their age to prepare them for the future. The researcher therefore realized the importance of physical education programs to encourage the development of the executive functions of primary school students.

II. MATERIAL & METHODS

The basic research methods included analysis and synthesis (study of the conditions, problems and needs using literature review and in-depth interview), and the development of a physical education program to enhance the executive functions of primary school students. Data analysis in this study was carried out using quantitative analysis and statistical analysis to confirm the efficiency of the physical education program.

Participants

The participants consisted of 30 primary school students studying in grades 1-3 under the Office of Basic Education, Udonthani Province, Thailand. This group consists of 13 males and 17 females, with an average age of 8.10 years ± 0.75 years, height of 119.62 ± 4.37 centimeters, and weight of 23.50 ± 2.73 kilograms. The students were selected by a multi-stage random sampling method. Only primary school students who have no neurological, movement, communication, vision, or hearing problems and can participate in physical education activities were allowed to participate. Participation in the study was voluntary; students must volunteer and obtain permission from their parents to participate in this physical education activity. This inclusion criteria means that primary school students with a doctor's refusal to exercise, or having severe problems such as diseases related to stroke, heart disease, diabetes, lung disease, or other psychiatric disorders were not included. Student participation in this research was approved by the Thailand National Sports University Ethics Committee (TNSU 168/2020).

Research Procedure and Method

The research process is divided into three phases. Phase one studied the principles, theories, and condition of executive function in primary school students. Principles, theories, and content related to physical education programs, physical activities, exercise, executive function, development, potential, and limitations of primary school students from related literature, Using the information gathered from this review, a structured interview form to ascertain the condition of the executive functions of primary school students was created. This structured interview form was used to perform in-depth interviews with stakeholders of primary school students. There were 30 participants in this stakeholder interview, consisting of 10 parents, 5 advisor teachers, 6 primary school teachers, 5 physical education teachers, 1 psychologist, and 3 sports scientists. The results from in-depth interviews in conjunction with the gathered information from the related literature review were used formulate an appropriate physical education program (PEP) to enhance the executive functions of primary school students. In Phase two, the quality of the formulated PEP was examined and improved. The Index of Item Objective Congruence (IOC) of the PEP was checked with the assistance of five individuals with expertise in physical education and sports. Suggestions and corrections from these five experts were incorporated into the program, and the improved PEP was tested on groups with similar characteristics as the experimental group.

Phase three involved the testing of the students, the implementation of the PEP, and the post-program evaluation. Before the PEP implementation, the executive functions of the experimental group were evaluated by testing their cognitive ability using two kinds of cognitive performance tests and one assessment form. First, two types of Trail making test (TMT) were performed: Type A, where the test takers must use the mouse to click on the numbers they want to find in order from 1 to 25, and Type B, where the test takers must use the mouse to click on the numbers (1-13) alternating with English letters (A-L) in the correct order (1->A->2->B->C....,L->13). The time taken to complete these TMTs were used in the analysis. Second, two types of Eriksen flanker test (EFT) were carried out: congruent trails, where the target is the centered arrow in the same direction as the other our arrows (< < < < < or > > > > >), and incongruent trails, where the target is the centered arrow in the same direction opposite the remaining four arrows (< < > < < or > > < > >). Students used the Z and / keys as their response; arrow pointing to the left meant pressing Z, and arrow pointing to the right meant pressing /. The test result applied in the analysis was the average response time for a correct response, measured in milliseconds (Colcombe et al., 2004; Delis et al., 2001; Pontifex & Hillman, 2007; Swanson, 2005; Yongtawee et al.,).The assessment form was used to evaluate the executive function behavior of primary school students. This form used five-level rating scale (0, 1, 2, 3, 4)to make quantitative observations. The total scores obtained from observations in each aspect were used in the analysis.

The conducted PEP included twelve activities: ball slide activity, hoop jumping and throwing activity, zigzag ball dribble activity, alternating zigzag ball pick-up activity, hoop throwing activity, 9-square activity, two-hand ball dribble activity, colored cone sprinting activity, colored hoop running activity, ball throwing activity, coin toss on the line activity, and a juggling ball activity. Each activity involved a warm up, a demonstration, the activity itself, and a cool down. The PEP was carried out three times a week at 60 minutes each session (Monday, Wednesday, Friday) over the course of eight weeks, a total of 24 times. The TMT and FKT cognitive performance evaluations as well as the assessment forms were carried out again

after each individual trial and during the follow-up period of four weeks after the eight-week PEP was over.

Research Instruments

The instrument used in the trial was a physical education program developed by the researcher to enhance executive function of primary school students. This program passed the content validation examination by five experts of physical education and sports. It was found that the Index of item Objective Congruence (IOC) was between 0.5 – 1.00. The recommendations received were taken to improve and the improved program was tried out on another group similar to the sample group.

The instruments used for data collection were: 1) a structured interview form that was assessed for the quality of the instruments through content validation by the same five experts in the field(with an Index of Item Objective Congruence (IOC) of between 0.5 – 1.00), 2) a computer-based cognitive ability test using the Trail Making Test (TMT) and the Eriksen Flanker Task (EFT) 3) the assessment form on executive function behavior of primary school students, which was a five-level rating scale (0, 1, 2, 3, 4) that was assessed for quality by five experts checking its content validity. It was found that the Index of item Objective Congruence (IOC) had a result between 0.5 – 1.00. The reliability was found by applying it on a group similar to the experimental group and the entire evaluation form was checked using Cronbach's alpha coefficient, which showed a result of 0.86.

Data Collection and Analysis

Data analysis in this study was conducted as follows:

1. Qualitative analysis was performed on the data from the in-depth interviews
2. Descriptive statistics used were mean and standard deviations for expression characteristic of simple.
3. Shapiro-Wilk tests were used to check the distribution of the variables pre-trial, post-trial, and during the follow-up period.
4. One-way repeated measures ANOVA was used to analyze the difference in mean scores of executive function obtained from the assessment form pre-trial, post-trial, and during the follow-up period.
5. The Bonferroni method was used to formulate a pair-wise comparison of the executive function mean scores pre-trial, post-trial, and during the follow-up period.
6. Paired sample t-tests were used to analyze the difference in executive function mean scores pre-trial and post-trial.

A p-value alpha level of less than .05 ($p < .05$) was used in determining statistical significance for all statistical analyses performed.

III. RESULTS

It was found that the PEP had a consistency index of 0.92, which indicates that it could be appropriately used as a physical education program for primary school students. On the other hand, the Trail making test (TMT) and the Eriksen flanker task found that the following, which are all summarized in Table 1:

1. For TMT Type A, the difference between the pre-trial and the follow-up period mean scores had statistical significance at .05, while the post-trial and follow-up period mean scores had no difference. The pre-trial mean score was higher than the post-trial and the follow-up period scores.
2. Similarly for TMT Type B, the difference between the pre-trial and the follow-up period mean scores had statistical significance at .05, while the post-trial and follow-up period mean scores had no difference. The pre-trial mean score was

higher than the post-trial and the follow-up period scores.

3. In the congruent trails EFT, the difference between the pre-trial and the follow-up period mean scores had statistical significance at .05, while after the post-trial and the follow-up period mean scores had no difference. The pre-trial mean score was higher than the post-trial and the follow-up period scores.
4. In the incongruent trails EFT, the difference between the pre-trial and the follow-up period mean scores had statistical significance at .05, while the post-trial and follow-up period mean scores had no difference. The pre-trial mean score was higher than the post-trial and the follow-up period scores.

Table 1. Mean, standard deviation and the results of One-way repeated measures ANOVA of variance analysis

Variables	Mean (±S.D.) (n=30)	*p*
Trail making test A (second)		.000
Before the trial	89.40 (±0.54)	
After the trial	76.86 ±0.54) *	
Follow-up period of 4 weeks after the trial	76.75 (±0.51) *	
Trail making test B (second)		.000
Before the trial	117.65 (±5.00)	
After the trial	104.93 (±3.24) *	
Follow-up period of 4 weeks after the trial	105.02 (±3.26) *	
Congruent trails (milliseconds)		.000
Before the trial	826.33 (±11.31)	
After the trial	768.93 (±10.74) *	
Follow-up period of 4 weeks after the trial	768.77 (±11.80) *	
Incongruent trails (milliseconds)		.000
Before the trial	899.33 (±15.43)	
After the trial	839.43 (±17.63) *	
Follow-up period of 4 weeks after the trial	838.33 (±18.83) *	

* Significant difference when comparing with before the trail at $p < .05$

After conducting analysis on the assessment form results pre-trial and post-trial, it was found that the mean scores in all areas of executive function post-trial were significantly different compared to pre-trial and had statistical significance at .05. This data is summarized in Table 2.

Table 2. Mean, standard deviation and the comparison results of the differences in EF of the experimental group

Variables	Mean (±S.D.) (n=30)	*p*
1. Attention		
Before the trail	1.47 (± .23)	.000
After the trail	2.98 (± .14)*	
2. Working memory		
Before the trail	1.52 (± .22)	.000
After the trail	2.91 (± .26)*	
3. Cognitive flexibility		
Before the trail	1.52 (± .18)	.000
After the trail	2.89 (± .21)*	
4. Planning/Organizing		
Before the trail	1.59 (± .15)	.000
After the trail	2.93 (± .23)*	
5. Emotional control		
Before the trail	1.52 (± .10)	.000
After the trail	2.84 (± .25)*	

* Significant difference when comparing between before and after the trial at $p < .05$

IV. DISCUSSIONS

During the validation of the PEP, it was found that the Index of Consistency *(*IOC*)* was 0.92, which showed that the PEP developed by the researcher had considerable quality and can be used as a physical education program to enhance the executive functions of primary school students outside of this study as it is a program that focuses on the development of motor skills in all parts of the body, both stationary and dynamic. The continuous and sufficient movement of the body will result in strong physical fitness in all aspects. When the body is healthy, it affects the brain's ability to respond effectively to external information. In addition, voluntary participation in physical education programs encourages students to obtain practical knowledge and experience. As a result, the brain can learn effectively. This is consistent with the study of Lambrick et al. *(*2016*)* conducted on children aged 8-10 years, which found that intellectual abilities were significantly increased one minute after the start of an moderate-intensity treadmill exercise with statistical significance. This effect was maintained for 30 minutes after the exercise was finished, which means that the effects of sudden, continuous and discontinuous exercise can increase executive function in children and lasts up to 30 minutes after stopping exercise. Therefore, in primary school, physical activities should be encouraged during school breaks. A study by Ardoy et al. *(*2013*)* studied the effects of physical activities on the cognitive abilities and the educational performance of 67 adolescents for four months. The control group practiced normal physical education activities twice a week. An experimental group practiced moderate-intensity physical education activities four times a week, while a second experimental group practiced physical education activities of the highest intensity four times a week. The results showed that the second experimental group gained a statistically significant increase in cognitive abilities and learning efficiency compared to the control group and the first experimental group. Short-term and long-term effects of sudden exercise on executive function was studied by Huug et al. *(*2014*)*. Their results showed that the positive effect of sudden exercise results in an increase in test scores, which had a response effect on executive functions after a suddenly stopping exercise. The above-mentioned study results are all consistent with the statistical outcome of this study's results.

Additionally, sudden exercise led to longer initiations associated with an improved

inhibitory response at 30 minutes and 60 minutes of stopping exercise. From the study one can conclude that the benefits of sudden exercise on planning, planning types, and response time were evaluated on the relation between sudden exercise and executive function. Moreover, de Greeff et al. (2017) collected the studies on the effects of exercise on cognitive abilities, concentration and academic performance in early adolescence published in 2000-2017; the number of 31 subjects which collected data on the following topics: cognitive abilities (mechanism of inhibition, working memory, flexibility of brain function, and planning), concentration, and learning efficiency (mathematics, spelling and reading). These exercises can be divided into short-term exercises, long-term exercises, aerobic exercises, and exercises to improve brain efficacy and duration of exercise. de Greeff et al. (2017) concluded that short-term exercise has a positive effect on concentration while long-term exercise has a positive effect to increase brain efficacy and learning efficiency.

After participating in a physical education program to enhance executive function of primary school students, it was found that the executive function of primary school students improved in all tests when comparing pre-trial scores with post-trial and follow-up period scores, as there was a statistically significant difference at .05. While the results of the comparison of executive function post-trial with the follow-up period had no difference because participating in physical education program gave students the opportunity to do activities with other people, use knowledge, abilities and various skills during the implementation of each activity to achieve the goals, the researcher believes that the continuous and sufficient participation in physical activities will stimulate the function of the brainadequately to maintain this effect. As a result, brain function of students can improve in terms of attention, cognitive flexibility, emotional control, working memory, and planning/organizing. After completing the physical education program that the researcher organized, the executive function in the brain of the sample group in each area still remained. It also helped participants to be happy, have fun, enjoy, and relieve themselves from stress. This is consistent with a study by Byun et al. (2014) which studied the positive effects of moderately intense exercise on executive function through prefrontal cortex arousal. The results showed that moderately intense exercise increased ability of brain function, which was positively correlated with levels of alertness and led to the stimulation of cortex according to the stimulus along lateral and anterior regions of the frontal lobes of the brain. This study indicates that moderately intense exercise affects executive function by increasing brain activation. This is also consistent with Cooper et al. (2016), who studied sprinting exercise and cognitive abilities in adolescents. The results showed that the time of response of the basic test was significantly faster after 45 minutes of sprinting exercise and the time of response at complex level faster immediately after exercise while the accuracy remains the same. The effect of sprinting exercises on cognitive abilities of adolescents was done using a brain test. Intellectual abilities can be enhanced by exercise, which can be obviously seen in the response time of the body. It can be concluded that high-intensity running during the day can enhance the ability of perception and understanding in adolescents. In addition, Mandolesi et al. (2018) studied the effects of exercise on brain function and well-being. It found that exercise causes structural and functional changes in the brain and affects the brain's ability to remember, concentrate, inhibit processes and maintain well-being. Chen et al. (2014) conducted a study on the effects of sudden aerobic exercise on executive function pre-adolescent children, and the results showed that sudden exercise enhanced in all three areas of executive function in children at both levels. While better performance was found in fifth grade students in inhibition and working memory, there was no difference compared to third grade students. From the conclusion of the study, it was indicated that sudden exercise affects in all three areas of executive function

among pre-adolescent children. Alves et al. (2012) studied the immediate effects of exercise on executive function: a comparison between aerobic exercise and strength exercise. The results showed that the immediate effect of aerobic exercise and strength exercise can increase executive function. Phuengphon et al. (2019) studied about the development of combination exercise program of Thai hermit exercise and yoga for increasing of executive function in early adults; it was found that the combination exercise program of Thai hermit exercise and yoga can increase the management function of executive function in the brain

V. CONCLUSIONS

Physical education programs encourage movement in all parts of the body to stimulate the brain's functions, such as controlling movement (motor control) and the ability of the brain to remember information from repeated practice until it learns how to move accurately and automatically (motor learning). Regular and adequate moderate physical activities, can help stimulate executive function in attention, cognitive flexibility, working memory, and organization. This leads to physical and intellectual development which enhances the quality of life of individuals and improves society as a whole.

Suggestions for further research: 1) other physical education programs should also be developed to similarly enhance the executive functions of preschool students, and 2) physical education programs that promote the development of skills in other areas such as thinking, decision making, recognition, and creativity should be explored.

REFERENCES

1. Alves, C. R. R., Gualano, B., Takao, P. P., Avakian, P., Fernandes, R. M., Morine, D., & Takito, M. Y. (2012). Effects of acute physical exercise on executive functions: a comparison between aerobic and strength exercise. *Journal of Sport and Exercise Psychology*, *34*(4), 539-549.
2. Ardoy, D. N., Fernández-Rodríguez, J. M., Jiménez-Pavón, D., Castillo, R., Ruiz, J. R., & Ortega, F. B. (2014). A physical education trial improves adolescents' cognitive performance and academic achievement: the EDUFIT study. *Scandinavian Journal of Medicine & Science in Sports*, *24*(1), e52-e61.
3. Best, J. R. (2010). Effects of physical activity on children's executive function: contributions of experimental research on aerobic exercise. *Developmental Review*, *30*(4), 331-351.
4. Byun, K., Hyodo, K., Suwabe, K., Ochi, G., Sakairi, Y., Kato, M., Dan, I., & Soya, H. (2014). Positive effect of acute mild exercise on executive function via arousal-related prefrontal activations: an fNIRS study. *Neuroimage*, *98*, 336-345.
5. Chen, A. G., Yan, J., Yin, H. C., Pan, C. Y., & Chang, Y. K. (2014). Effects of acute aerobic exercise on multiple aspects of executive function in preadolescent children. *Psychology of Sport and Exercise*, *15*(6), 627-636.
6. Chutabhakdikul, N. ,Thanasetkorn, P., & Lertawasdatrakul, O. (2016). *Tool development and evaluation criteria for assessment of executive function in early childhood* (1st ed.).Bangkok: Institute of Molecular Biosciences. Mahidol University.
7. Colcombe, S. J., Kramer, A. F., Erickson, K. I., Scalf, P., McAuley, E., Cohen, N. J., Webb, A., Jerome, G. J., Marquez, D. X., & Elavsky, S. (2004). Cardiovascular fitness, cortical plasticity, and aging. *Proceedings of the National Academy of Sciences*, *101*(9), 3316-3321.
8. Cooper, S. B., Bandelow, S., Nute, M. L., Dring, K. J., Stannard, R. L., Morris, J. G., & Nevill, M. E. (2016). Sprint-based exercise and cognitive function in dolescents. *Preventive Medicine Reports*, *4*, 155-161.
9. Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., Allison, J. D., & Naglieri, J. A. (2011). Exercise improves

executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial. *Health Psychology*, *30*(1), 91.

10. Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan executive function system (D-KEFS)*. San Antonio, TX: Psychological Corporation.
11. de Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2018). Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of Science and Medicine in Sport*, *21*(5), 501-507.
12. Elliott, R. (2003). Executive functions and their disorders. *British Medical Bulletin*, (65), 49-59.
13. Haenjohn, J. (2017). A development of executive functions of the brain of adolescent by integrative learning modules. *Journal of Education Burapha University*, *28*(2), 130-144.
14. Hung, T. M., Tsai, C. L., Chen, F. T., Wang, C. C., & Chang, Y. K. (2013). The immediate and sustained effects of acute exercise on planning aspect of executive function. *Psychology of Sport and Exercise*, *14*(5), 728-736.
15. Ishihara, T., Sugasawa, S., Matsuda, Y., & Mizuno, M. (2017). The beneficial effects of game-based exercise using age-appropriate tennis lessons on the executive functions of 6–12-year-old children. *Neuroscience Letters*, *642*, 97-101.
16. Kuksai, P., & Opasanon, N. (2017). Effect of Tai Chi mindfulness training on planning problem solving. *Naresurn Research Conference 13: Research and Innovation on Economy and Society*, 1191-1198.
17. Lambrick, D., Stoner, L., Grigg, R., & Faulkner, J. (2016). Effects of continuous and intermittent exercise on executive function in children aged 8–10 years. *Psychophysiology*, *53*(9), 1335-1342.
18. Mandolesi, L., Polverino, A., Montuori, S., Foti, F., Ferraioli, G., Sorrentino, P., & Sorrentino, G. (2018). Effects of physical exercise on cognitive functioning and wellbeing: biological and psychological benefits. *Frontiers in Psychology*, *9*, 509.
19. Morin, A. (2014). *Understanding executive functioning issues.* USA: UNDERSTOOD.
20. Office of the Health Promotion Foundation (Thai Health Promotion Foundation) .(2017). *Parents' guideline to develop executive functions from fertilize-3 years*.(1st ed.). Bangkok: Akson Sumphan Printing (1987) Co., Ltd.
21. Office of the Higher Education Commission . (2016). *Executive function strategies for college students with disabilities* .(2nd ed). Bangkok : Office of the Higher Education Commission.
22. O'Malley, G. (2011). Aerobic exercise enhances executive function and academic achievement in sedentary, overweight children aged 7-11 years. *Journal of Physiotherapy*, *57*(4), 255-255.
23. Pahirun, P., Haenjohn, J., & Sirithadakunlaphat, S. (2018) .The effect of brain mind and learning training program on executive function of the brain of primary school students. *Ratchaphruek Journal*, *16*(3), 64-71.
24. Phuengphol, N. ,Kaewkaen, P., & Suksawang, P. (2019). The development of mixed rusie dutton and yoga exercise program for enhancing executive function of brain in early adult. *KKU Research Journal (Graduate Studies)*, *19*(4), 159-171.
25. Phutthakoet, S., Kasiyaphat, A., & Nakornkhet, K. (2018). The effects of brain mind and learning training program on executive functions of the brain of primary school student. *Journal of Graduate Research*, *9*(2), 151-162.
26. Pontifex, M. B., & Hillman, C. H. (2007). Neuroelectric and behavioral indices of interference control during acute cycling. *Clinical Neurophysiology*, *118*(3), 570-580.

27. Sisurakonrkun, K. (2020) . *Improving mobility: from principles to practices* (1st ed.) . Phitsanulok: Naresuan University Press.
28. Supaviboon, M., & Krabuanrat, C. (2018). *Teaching guide on physical activities for children with intellectual disability (Parent Version)* (1st ed.). Bangkok: Office of the Health Promotion Foundation (Thai Health Promotion Foundation).
29. Swanson, J. (2005). The Delis-Kaplan executive function system: a review. *Canadian Journal of School Psychology*, *20*(1-2), 117-128.
30. Yongtawee, A. ,Pitaksathienkul, C. , Noikhammueang, T., & Sukdee, N. (2020). *Sport intelligence: The role of cognitive performance on sporting success in Thai youth athlete* . (1st ed.). Bangkok: Full fill management Co., Ltd.