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Effects of High Intensity Interval Training Using Ifittkids Module on Memory Strength, Attention and Aerobic Capacity

Vadivelan Lohonathan, Siti Hartini Azmi, Norhazira Rahim

Department of Health Sciences, Faculty of Sports Science and Coaching, Sultan Idris Education University (UPSI), Tanjung Malim, 35900, Perak, Malaysia

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Abstract

Executive function, attention, and memory are an important indicator of cognitive health of children. Cardiovascular fitness has a positive relationship with cognitive function performance. IFITTKIDS module is a training programme guided by High Intensity Interval Training (HIIT) used to see the effect on memory strength, attention and aerobic capacity. This HIIT training is able to increase the fitness level optimally in a short period of time. This study was conducted quantitatively using a 'Pre and post control group design'. The study subjects consisted of 64 primary school students aged 11 years who were divided into two groups namely 32 participants in the treatment group and 32 in the control group. The intervention was conducted for 12 weeks with a training frequency of two times a week for 20 minutes per session. The results using ANCOVA test analysis showed that by adjusting the pre-test score as a covariate, the post-test score for memory strength, attention and aerobic capacity of the treatment group was significantly higher with the score from the control group with F (1.61) = 68.15, p <.05, and eta squared = .53, F(1,61) = 54.906, p < .05, eta squared = .47 and F (1.61) = 63,987, p <.05, and eta squared = .51. Substantially, the findings of this study show that HIIT training guided by IFITTKIDS MODULE for 8 weeks is productive in improvising aerobic capacity and memory strength in 11-year-old school children. The results of this study, recommend that this IFITTKIDS MODULE can be used as one of the training programme to increase the level of memory strength, attention and aerobic capacity in children.

Keywords: High Intensity Interval Training (HIIT), Memory Power, Aerobic Capacity, Physical Education

Introduction

As many as 39 % of all children in Malaysia are inactive physically and 424,000 children have health problems in Malaysia (NHMS, 2019). Physical inactivity is the fourth leading risk factor for death globally (Malina, 1996; World Health Organization, 2019). There are 3.9 million

adolescents aged 18 and above with diabetes in Malaysia (NHMS, 2019). A sedentary lifestyle during childhood will not only influences physical health, but cognitive health. That is, accumulating evidence suggests that low involvements in physical activity and aerobic fitness are associated with declines in academic achievement, cognitive abilities, brain structure, and brain function (Mora-Gonzalez et al., 2019; Castelli et al., 2007; Kim, et al., 2010; Hillman et al., 2008; Pontifex et al., 2011; Chaddock et al., 2011).

In recent years HIIT training has become a popular physical activity among athletes and fitness practitioners to improve fitness to an optimal level. Cardiovascular fitness has a positive relationship with cognitive function performance (de Greeff et al., 2018; Raine et al., 2016; Drollette et al., 2015; Buck et al., 2008). Aerobic exercise improves brain cognitive function and nerve performance in the brain (El-Sayes et al., 2018). Frequent involvement of physical activity and fitness are the best methods for improving cognitive function and memory strength in children (Erickson et al., 2015; Khan & Hillman, 2014). Physical fitness is an indicator that can be used to assess memory strength (Canepa et al., 2020). There is sufficiet evidence that physical activity has a positive relationship to cognitive function and academic performance in children (Donnelly et. al., 2016; Mura et al., 2015; Vazou et al., 2016; Esteban-Cornejo et al., 2015; Bass et al., 2013). Aerobic exercise for 20 minute increases memory strength (Kao et al., 2020; Chang et al., 2012; Papp et al., 2014; Scherder et al., 2014). One of the cognitive aspects that has been the concern of researchers is to see the relationship between motor skills and memory strength (Hsieh et al., 2017; Herrmann, et al., 2018). Physical activities based on cardiovascular intervention programmes and motor skills' physical training for 10 weeks systematically improved memory strength of children (Koutsandreou et al., 2016; Lin et al., 2021).

According to Tomporowski et al (2011), brain cognitive functions can be classified into perception, concentration, memory, working memory, brain executive function, concept formation and reasoning, intelligence, and academic achievement. Memory is a systematic process that involves the active storage, maintenance, and manipulation of information retrieved over short intervals (Postle, 2006). Memory strength is the most crucial cognitive aspects in planning and problem solving (Postle, 2016). It's been discovered that there is a productive relationship between increased physical activity with brain cognitive function especially short-term memory strength and concentration among school children (Sujatha et al., 2020; Leahy et al., 2020; Moreau & Chou, 2019; Rassovsky & Alfassi, 2019; Rao, Vhavle & Manjunath 2019). Physical exercise and activities that improvise magnitude of brain is derived neurotrophic factor (BDNF) in the cerebral cortex and hippocampus which have a very high association in enhancing learning performance, concentration and memory strength (Farmer et al., 2004; Berchtold et al., 2010). Regular physical exercise can produce new neurons in the hippocampus that are important in enhancing learning performance and memory strength (Curlik and Shors, 2013; Déry et al., 2013).

Typically, HIIT training can be defined as an exercise which consists of several movements that is alternate between high -intensity exercise in the range of 85 to 95 percent of the maximum pulse rate or maximum oxygen consumption and followed by rest or active rehabilitation activities (Gibala, & McGee, 2008; Little et al., 2011). There are two types of HIIT training, which are resistance HIIT training and aerobic HIIT training. HIIT resistance training is interval training that includes body movements, weight objects, barbells, or

resistance training equipment, while aerobic HIIT training is intermittent training which uses traditional aerobic training (such as walking or cycling) (Kilpatrick, Jung, and Little, 2014). HIIT training designated into various forms and the most effective method of improving cardiorespiratory and metabolic function, thus improving the physical performance of athletes (Buchheit & Laursen, 2013). HIIT training is seen as an enjoyable exercise compared to traditional medium-intensity training which is performed continuously (Bartlett et al., 2011). The problem of time constraints is the common reason given by society for not engaging in sports and fitness activities (Frazão et al., 2016; Thum et al., 2017; Heinrich et al., 2014). High Intensity Interval Training is used as an alternative aerobic exercise that could improve body health and brain function (Cvetković et al., 2018; Moreau & Chou, 2019).

HIIT training could accomplish the improvisation of Peripheral Vascular function which encourages the cardiovascular system to adapt to high aerobic exercise intensity (Cvetković et al., 2018). Manipulation of intensity in aerobic exercise has been shown to have beneficial effects on cognitive and executive function of the brain (Kao et al., 2019; Kao et al., 2018; Crova et al., 2014; Gallotta et al., 2015; Pesce et al., 2013; Pesce et al., 2016; Schmidt et al., 2015; van der Niet et al., 2016; Knaepen et al., 2010; Niet, Smith et al., 2015; Moreau et al., 2017 Davis et al., 2011). HIIT training comes in various forms and is the most implicit method of improving cardiorespiratory and metabolic function. Hence, improving the physical performance of athletes (Buchheit & Laursen, 2013).

Physical Education is a platform where students learn sports, fitness skills and explore new physical activities at the outdoors (Chandler & Stringer, 2020). A 15-minute HIIT activity with adequate rest intervals can improve fitness and health (Chandler, 2020). This HIIT activity is the safest activity that can be carried out by children and is suitable to be carried out at the school level (Chandler, 2020). HIIT training is more constructive in terms of time utilisation because studies show that HIIT training results in greater improvement compared to traditional endurance training which increase aerobic fitness and maximum oxygen consumption despite using shorter training volume and duration (Zapata-Lamana et al. al., 2019; Wisløff et al., 2007; Burgomaster et al., 2008; Milanović, Sporiš, & Weston, 2015). HIIT physical activity interventions in Physical Education among children can optimally improve fitness levels (Dobbins et al., 2013).

Indeed, there is a need to conduct high-intensity interval training (HIIT) physical training over a short period of time to improve fitness performance (Gibala et al., 2006; Lonsdale et al., 2013; Moreau et al., 2017). Children in schools need an effective training programme framework with short training periods to improve fitness (Lonsdale et al., 2013). The purpose of this study was to evaluate the effectiveness of HIIT training based on the IFITTKID Module to boost the performance of memory strength, concentration and aerobic capacity among 11-year-old students.

Materials and Methods

This study was conducted based on quantitative method with Pre and Post control group in which is an 8-week intervention training programme with pre and post tests to determine the outcome of using IFITTKIDS Module on memory strength, concentration and aerobic capacity. Study participants was 64 healthy 11 -year -old male and female students in total. Participants were divided into two groups which are treatment group (n = 32) and control group (n = 32).

Participants of this study involves healthy 11-year-old male and female students. All participants were primary school students from two schools in the Sepang District. All participants were free of health problems and had undergone a screening test of readiness to perform physical activity using the PAR Q questionnaire (Thomas, Reading, & Shephard, 1992) to detect potential risks that may occur during training. The study protocol was described orally and written consent to participate in the study was also obtained from all participants.

Cognitive Tests

Based on previous research in adults, the anticipated cognitive performance effects following maximal exercise resided in areas of memory and attention (Covassin et al., 2007; Lo Bue-Estes et al., 2008; Moore et al., 2012; Abraham, George, & Kunnath 2016; Moreau et al. al., 2017).

Digit Span Test

The 'Digit Span Test' is widely used as neuropsychological test to assess cognitive ability in aspects of short-term memory strength (Youngjohn et al., 1992; Richardson, 2007; Wambach et.al. 2011; Abraham et al., 2016; Moreau et al. al., 2017). There are 2 types of 'Digit Span Test' namely 'Forward Digit Span' and 'Backward Digit Span'. The 'Digit Span Test' using a computer to measure the strength of short-term memory has high values of accuracy and reliability (Woods et al., 2011). Pupils answer each 'Digit Span Test' item within the allocatted time period. Pupils have to type the numbers seen on the computer screen in the correct order using the computer keyboard. Pupils answer 40 'Forward Digit Span Test' questions. The series of numbers range from 1 to 9. These series of numbers are arranged in ascending order from 2-digits (2–5; 6–3; 4–7) to 5-digits (6-9-1-6-3; 3-1- 7-9-5; 3-8-2-9-5) only. Pre and post test scores were recorded upon completion of the 'Digit Span Test' test.

Stroop Word Colour Test

The 'Stroop Word Color Test' is widely used as neuropsychological test to assess cognitive ability in aspects of concentration adapted from past studies (Stroop, 1935; Golden's 1978; Golden et al., 2003; Zimmermann et al., 2015; Scarpina & Tagini, 2017; Sañudo et al., 2020).

Progressive Aerobic Cardiovascular Endurance Run (PACER)

Progressive Aerobic Cardiovascular Endurance Run (PACER) is one of the methods used in FITNESSGRAM to measure aerobic capacity. The PACER test allowed participants to adapt systematically by increasing the repetition capacity of the run according to the physiological appropriateness of the response. The PACER test has high validity in assessing aerobic capacity (Chun et al., 2000; Suminski et al., 2004; Burns et al., 2014). This test involves a method of continuous running between two distances of 20 meters where the 'beep' time will be faster at each level. The subject has to cross the line at a distance of 20 meters and wait until the next beep to continue the run. Subjects had to continue running according to their ability until they could not keep up with the 'beep' sound. When the subject is unable to keep up with the 'beep' for the second time then the test against him is terminated.

IFIITKIDS Module Intervention Program

In this study, the IFITTKIDS Module is used as an alternative training programme in Physical Education classes to improve memory, concentration and aerobic capacity. The training procedure started with a briefing session on the protocol of training programme to the

participants. Treatment group participants went through HIIT training using IFITTKIDS Module for 8 weeks during Physical Education class under the supervision of Physical Education teacher for 30 minutes twice a week (5 minutes warm -up; 5 minutes cool -down; 20 minute exercises guided by IFIITKIDS Module). While the control group subjects went through continuous aerobic exercise under the supervision of Physical Education teacher for 30 minutes twice a week (5 minutes warm -up; 5 minutes cool -down; 20 minute exercises guided by continuous aerobic exercise. This training programme uses the concept of Tabata training on a ratio of 1: 2 between training time and rest time which is 10 seconds of rest and 20 seconds of training. The total duration of training is 20 minutes, 5 minutes of warm up and 5 minutes of cooling down. Pre-test score of memory strength, concentration and aerobic capacity were taken before subjects performed intervention training for both groups. At the end of 8 weeks, the level of memory strength, concentration and aerobic capacity of the treatment and control groups of each participant from both groups were measured again (post-test).

Results

In this study, Statistical Package for the Social Science for Windows (SPSS) version 26.0 computer software was used to analyse the data. Before the data were analysed, a data review process was made to detect errors or data loss by checking the frequency output from the descriptive analysis for each variable measured. In addition, data exploration has also been done to meet the general assumptions of each statistical analysis used. The normality of the data was examined using Shapiro-Wilk and Kolmogorov-smirnov statistics. ANCOVA (Analysis of Covariance) analysis was used to determine the existence of differences in aspects of memory strength and aerobic capacity between the treatment group and the control group by controlling for pre-test scores as covariates. The significance level was set at $p \leq 0.05$.

Findings

Table 1.

Demographics of Study Participants in the Form of Frequency and Percent

Gender

	Frequency	Percent	Std. Deviation
Boys	32	50.0	.50
Girls	32	50.0	
Total	64	100.0	

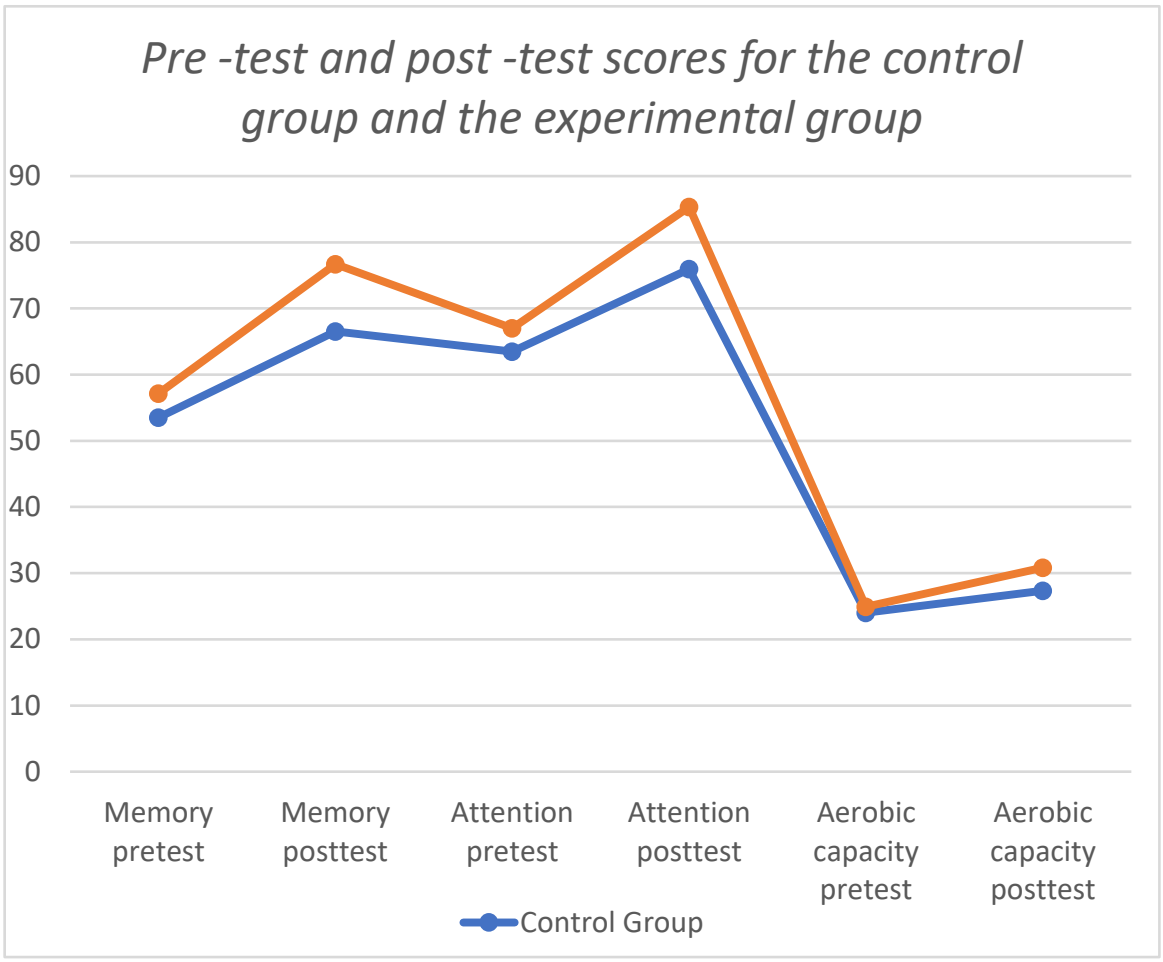
Table 2.

Pre -test and post -test scores for the Control Group and the Experimental Group in the Form of Mean and Standard Deviation

	Pre test		Post test	
Varaiable	Control Mean (SD)	Experimental Mean (SD)	Control Mean (SD)	Experimental Mean (SD)
Memory strength	53.52 (5.57)	57.12 (5.78)	66.53 (5.15)	76.69 (3.72)*
Attention	63.50 (5.51)	67.00 (5.78)	75.94 (4.66)	85.34 (4.56)*
Aerobic capacity (ml·kg·min)	24.02 (1.56)	24.92 (1.33)	27.33 (1.74)	30.81 (1.41)*

Memory strength, attenion, capacity aerobic

* Differences in pretest and posttest scores between control and experimental groups with significant values (*P ≤ 0.05*).



Descriptive statistical results showed that the mean post-memory test values for the treatment group (76.6969 ± 3.72105) surpassed the control group (66.5250 ± 5.14793). For the aspect of concentration, the mean post-test memory value for the treatment group (85.3438 ± 4.55511) surpassed the control group (75.9375 ± 4.65547) and the aerobic capacity score for the treatment group (30.8125 ± 1.41666) surpassed the control group (27.3313 ± 1.74253). One -way ANCOVA analysis was conducted to compare the effectiveness of the IFITTKIDS Module between the intervention group and the control group performing the 'Continuous Aerobic Exercise' exercise. ANCOVA assumptions are carried out first to ensure that it does not violate the assumptions of normality, linearity. homogeneity of variances, homogeneity of regression slopes and reliable measurement of the covariate. After controlling for the pre-test score, then statistical analysis showed that there was a significant difference on the post-test score of memory strength between the treatment group and the control group. F (1.61) = 68.15, p <.05, and squared = .53. For concentration, statistical analysis showed that there was a significant difference on the post-test score of concentration between the intervention group and the control group. F (1.61) = 54.906, p <.05, and squared = .47. Meanwhile, statistical analysis showed that there was a significant difference on the post-aerobic capacity score between the intervention group and the control group. F (1.61) = 63,987, p <.05, and squared = .51. These findings prove that the score of the treatment group

using the IFITTKIDS Module recorded a higher score than the score of the control group in terms of memory strength, concentration and aerobic capacity.

Discussion

This study intended to evaluate the effects of HIIT training guided by the IFITTKID Module for 8 weeks on memory strength, concentration and aerobic capacity. The findings of this study showed that children in the treatment group recorded a good improvement in memory strength, concentration and aerobic capacity. The findings of this study are in line with several previous studies that used the concept of HIIT training in their study. Findings of studies (de Greeff et al., 2018; Raine et al., 2016; Drollette et al., 2015; Buck et al., 2008) prove an increase in high-intensity aerobic physical activity improves brain fitness and executive function. Moreover, HIIT training has the same capability as peak (high level) exercise in maximum oxygen uptake and utilization and is able to achieve max VO2 in a shorter period of time compared to continuous exercise (Baquet et al., 2010). In addition, HIIT training has been shown to be effective in increasing aerobic capacity and memory strength in children (Tottori et al., 2019). Moreover, HIIT training conducted over a longer period of 12 weeks effectively increased oxygen dissipation by 18 percent (Dunn, 2009). While Samuel, Zavdy et.al (2017) reported that high-intensity physical training improves cognitive ability in terms of memory and concentration of children. Smith et al (2015), meanwhile, proved that aerobic exercise can improve the strength of memory and concentration of children among students aged 8 to 12 years.

HIIT training increases aerobic capacity among the obese and overweight children (Yin, Zhou, & Lan, 2020; Cvetković et al., 2018; Delgado-Floody et al., 2019; Delgado-Floody et al., 2018). The findings of Jeon & Ha (2017) study are also in line with this study where high-intensity physical training among the male students improved short-term memory strength and concentration. Not only that, HIIT training improves the performance of brain executive function and adolescent cardiovascular fitness (Kujach et al., 2018). Besides that, Delgado-Floody et al., 2018 proved that 22 weeks of HIIT training in Physical education increases aerobic capacity and reduces body composition in children. The study of Zapata-Lamana et al., 2019 stated that HIIT training can be used as a reliable and time-saving alternative to improve children's cardiovascular fitness while in school.

However, the findings of the study of Alves, Tessaro et. al (2014), are not in line with the findings of the study because there is no positive relationship in the aspect of short-term memory with HIIT intervention training for 7 days for a period of 20 minutes. Furthermore, the study of Costigan et al (2016), is not in line with this study where HIIT training in school for 8 weeks had only a slight improvement on cognitive function among adolescents. These findings may be influenced by the fact that the duration of HIIT training for 8 weeks is not enough to have a productive effect on the cognitive function of brain. Training duration and intensity are important factors in determining the effectiveness of HIIT training on memory strength and aerobic capacity. Other than that, this 4-week HIIT training improved the cardiovascular fitness and memory of the children on the treatment group (Tottori et.al 2019). Based on the study of Lambrick, Westrupp, Kaufmann, Stoner and Faulkner (2016), high-intensity game training for 6 weeks has a positive effect on aerobic capacity in children. Meanwhile et al (2014), reported that high-intensity training for two weeks is sufficient to increase aerobic capacity among adolescents aged between 14 to 16 years. Indeed, high-

intensity aerobic exercise for extended periods of time i.e. from weeks to months improves brain cognitive function (Northey et al., 2017; Landrigan et al., 2020).

Conclusion

The strength of memory and concentration is the important aspect to make sure the academic excellence of students. The findings of this study show that HIIT training programme using IFITTKIDS Module improves memory strength, concentration and aerobic capacity among 11-year-old school children. For future studies researchers can apply HIIT-guided games with a shorter duration in Physical Education to see its effects on aerobic capacity and other cognitive functions such as cognitive flexibility. This IFITTKIDS module can be used as a flexible and time-saving training programme to make children's aerobic fitness and memory strength while in school.

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Corresponding Author

Vadivelan Lohonathan
Department of Health Sciences, Faculty of Sports Science and Coaching,
Sultan Idris Education University (UPSI), 35900 Tanjung Malim, Perak, Malaysia.
Email: vadivelanphd494@gmail.com

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