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Effects of Sub-Acute Aerobic Exercise on Cognitive Function Among Primary School Pupils Between 7 to 10 Years in Kano State

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ABSTRACT
This study was conducted to examined the effects of sub-acute aerobic exercise on cognitive function among primary school pupils between 7 to 10 years in Kano State, Nigeria. The study adopted a quasi-experimental design. The population of the study include the entire pupils of the school that are between the age of 7-10 years. Purposive sampling technique was use. Sample size f the study was 20 males and 17 females that are aged between 7-10 years. 1 research question and hypothesis were answered and tested using Mean, SD and t-test at α 0.05 level of significance. Data were collected using stop watch, Stroop Test Tools, Verbal Auditory Learning Test Tools (VALT), paper and pen. Data were analysed using mean (X) and Standard Deviation (SD). t-test was used in answering the research hypothesis at α 0.05. findings of the study revealed that Cognitive function was assessed using Strop Test and Verbal Auditory Learning test. After four week of sub-acute aerobic exercise, executive function and working memory have improved. Also, regarding to Verbal Auditory Learning Test there was no significant difference in male and female before and after the treatment ($p=0.40$), the mean test score of males (3.04 ± 1.22) is less than of female (3.86 ± 1.12). After exercise the mean test score of females (4.58 ± 1.09) is greater than that of male (3.48 ± 1.21). However, male score higher in Stoop Test before and after exercise while female score higher in Verbal Auditory Learning Test. Base on the findings of the study, the researcher recommended that sporting facilities should be provide in all schools to enable exercise.

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INTRODUCTION

Exercise is a physical activity that is planned, structured, and repetitive for the purpose of conditioning the body. Exercise consists of cardiovascular conditioning, strength and resistance training, and flexibility. In recent years, there has been a shift in the lifestyles of various age-groups, including children, especially in their late childhood. Unlike children a few decades ago, children today are leading increasingly sedentary lifestyles that involve time spent on computers and watching television (TV). This lifestyle leads them to neglect the physical activity that has been typical to this developmental period (Graf *et al.,* 2003). In times when children are less active, the significance of studies on the positive impact of sport on physical health, mental health, and cognitive functioning, is critical (Cox *et al.,* 2003); Being physically inactive has an independent risk factor for cardiovascular disease as well as other health-related illnesses (Collert *et al.,* 1996). The decrease in physical activity in our everyday life is related to many chronic diseases and risk factors such as type 2 diabetes mellitus and obesity even in children, but growing evidence indicates that an increase in physical activity may enhance cognitive functions at least in older adults (Janssen *et al.,* 2010). However, more research is

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needed on looking at the associations of physical activity with cognition and academic performance in children.

Cognitive function, also called cognitive skills, cognitive abilities or cognitive capacities, are brain-based skills which are needed in acquisition of knowledge, manipulation of information and reasoning. They have more to do with the mechanisms of how people learn, remember, solve problems and pay attention, rather than with actual knowledge. Cognitive skills or functions encompass the domains of perception, attention, memory, learning, decision making, and language abilities. Cognitive functioning refers to a person's ability to process thoughts. It is defined as "the ability of an individual to perform the various mental activities most closely associated with learning and problem-solving. Examples include the verbal, spatial, psychomotor, and processing-speed ability (Kiely *et al.,* 2014).

STATEMENT OF THE PROBLEM

Physical fitness and exercise may be related to general improvements in cognitive function, but do not provide any understanding of the underlying mechanisms by which aerobic fitness may affect brain and cognition in children So far, few studies have investigated the cognitive component of information processing speed and fitness level of active and sedentary children. Playing video games, watching television and using mobile phones among children are the major factors that cause lack of exercise in children. Examining this potential relationship is important, as responding quickly is essential to performing some basic activities such as crossing a street, driving a car of simply avoiding eminent danger. Thus, faster reaction results from the way the individual processes information and subsequently initiates the required action (Sibley *et al.,* 1997).

Physical activity is associated with improved cognition (Etnier *et al.,* 2008). and certain measures of academic skills in children (Trudeau, et al 2003) In addition to regular physical training, single bouts of physical exercise are associated with enhanced neuro-electrical processes in the cortex and with improved cognitive control (Tomporowski *et al.,* 2003) in adults and in children. Single exercise bouts may also contribute to neural protection and synaptic plasticity due to increased levels of the brain-derived neurotrophic factor (BDNF). A close observation of pupils' performance seems to indicate lack of inadequate physical exercise that could increase their cognitive function such as reasoning, memory, perception and decision making which lead the students toward competitive learning and good performance. These problems and concerns necessitate this research to investigate the effect of sub-acute aerobic exercise on cognitive function among primary school pupils between 7 to 10 years in Kano State.

Aim and Objectives of the Study

The aim of the study is to determine the effects of sub-acute aerobic exercise on cognitive function among primary school pupils of 7 to 10 years in Kano State with the following objectives:

1. To determine the function of exercise before and after a session.
2. To compare sex variation of cognitive function test among children.

LITERATURE REVIEW

Physical exercise in an important activity that boost the health of both the young and the old person. physical activity, specifically aerobic activity, can be helpful in improving brain health over time especially cognitive function. Cognitive function is a variety of functions such as perception, attention, memory, learning, and executive function. Cognitive development is best described as the construction of thought processes, including remembering, problem solving, and decision-making, from childhood through adolescence to adulthood (Ando *et al.*, 2018). Cognition is a term that describes higher brain functions such as decision-making, calculating, problem solving, producing and using language, and memory.

Recently, researchers have begun extending studies examining the effect of exercise on brain structures to human participants. The

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hippocampus is located in the medial temporal lobe of the brain and is involved in the consolidation of information from short-term memory to long-term memory. In rat studies, exercise enhances learning and improves retention, which is accompanied by increased cell proliferation and survival in the hippocampus (Van Prang *et al.,* 2005).

The basic development of motor, cognitive, and social skills, which are crucial in further development, is already taking place in early and mid-childhood (Frey *et al.,* 2007). As such, studies that concern children in late childhood, whose executive functions are largely developed, are of special importance. The most intensive development of all components of executive functions, especially cognitive flexibility, happens at school age, usually between 7 and 12 years of age. Cognitive flexibility requires simultaneous inhibition of a dominant reaction, along with the remembering and activation of a new one, i.e.: -

1. The efficient functioning of working memory, responsible for temporary storage of information to be processed, which contributes to the formation of complex cognitive functions, such as speech and operations on symbols; working memory assists in memorizing instructions and stages of plans of actions, as well as comparing alternatives; and
2. The efficient functioning of inhibition control, i.e., the ability to refrain from impulsive behavior, keep one's attention focused, and pursue goals despite distractions, which also conditions stability and selectiveness of attention (Brzezi'nska *et al.,* 2012).

The greatest development of frontal and temporal lobe gyri tends to occur before the age of 12 years (Geidd *et al.,* 1999). The brain matures and develops very rapidly at this time, which in turn makes it particularly prone to environmental influences (both positive and negative). Recent research indicates that the increase of cognitive abilities of children and adolescents co-occurs with a decrease of grey matter density, which is caused by the loss of some synapses and the simultaneous strengthening of others (Rostowski *et al.,* 2012).

Grey matter density peaks, and then decreases, approximately half way through the 11th year of age in girls (still in late-childhood), and approximately the 14th year of age in boys (already in adolescence) (Rostowski *et al.* 2012,). At the same time, white matter content in the brain increases, which is associated with cell myelination processes and increasing the efficiency of impulse conduction. This intense development and brain maturation also translates to limbic system functioning, which, in this period, is particularly sensitive to information from the environment (Rostowski *et al.,* 2012). It is worth noting that this is a period in which brain plasticity increases, which on one hand can help in seeking solutions to new challenges, but on the other, it is responsible for helplessness because it may underlie the sensitivity to all kinds of stress and toxic substances in the environment (Dahl *et al.,* 2004).

Physical activity refers to any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level. In the Guidelines, physical activity generally refers to the subset of physical activity that enhances health (US Department of Health and Human Service, 2018). Accordingly, there are various types of excursive base on duration. These include: Acute exercise is defined here as a single bout of exercise. Research has shown that a single bout of exercise. can immediately improve learning and memory. Aerobic exercise is considered a "priming" effect that may be responsible for promoting neuroplasticity (Statton *et al.,* 2015).

Also, Moderate intensity defined as 70%-80% of maximum heart rate has been known to improve memory. Engaging in sports has a positive influence on all systems: the motor, cardiovascular, respiratory, hormonal, immunologic, and nervous systems. Thus, it stimulates the maturation of the motor areas in the brain, which in turn influences the motoric development and increases the speed of the

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conductance of nervous impulses (Makarowski *et al.,* 2009). Physical activity also stimulates the increase of neuro-hormonal secretion (substances produced by hypothalamic neurons and transported by blood or cerebrospinal fluid), having a significant impact on the excitability of neurons forming synapses (Hollmann *et al.,* 2000).

Chronic exercise is defined as repeated bouts exercise over the course of time. There is plenty of research that supports the idea that over time physical activity and regular exercise can help support cognitive growth (Bhattacharyya *et al.,* 2017). Khan and Hillman's research from 2014 found that children that were considered more-fit compared with those that were unfit had improved retention especially when the task became more challenging. This may suggest that chronic physical activity has something to do with enhanced learning. In order for a child to be considered fit it can be assumed that they have some sort of physical activity in their lives.

Masoudi, Seghatoleslami, and Saghebjoo (2016) conducted research on effects of aerobic exercise over time can have any effect on cognitive development in children with learning disorders. Considering 45 female children at the age of 8 and separated into a control group and experimental groups. Both groups were equal and consisted of girls that had learning disorders. The experimental group was given 8 weeks of aerobic exercise. The results of the study showed the experimental group had "significant influence" on cognitive performance when compared to the control group. This study shows the influence and potential that chronic physical activity may have on cognitive development (Masoudi *et al.,* 2016)

Executive functions allow one to engage in a situation through planning a given action, as well as to inhibit or postpone a given reaction (Jodzio *et al.,* 2008). Their efficient operation is associated with neuronal activity in the frontal lobes, especially in the dorsolateral prefrontal cortex, anterior cingulate cortex, parietal cortex, and subcortical structures, such as the thalamus, caudate nucleus, putamen, and cerebellum (Houghton *et al.,* 1996).

METHODS AND MATERIALS

This research is a pretest and posttest quasi experimental design. The population of the study include the entire primary school pupils in Kano State that are between the age of 7-10 years. Convenient sampling technique was use in selecting 37 male and female from Bayero University Staff Model School. This is due to the availability of facilities and play ground in the school. Materials used for data collection include: Stroop Testing Tools which is used in test tools to assess executive function

Verbal Auditory Learning Test is used to assess episodic memory. (Potter and Keeling, 2005). During Verbal Auditory Learning Test, an auditory recording of 15 words (e.g. car, pen, water, school etc.) was played. Immediately after the presentation, participants will be asked to write down as many of the words they could remember or repeat the possible words he could remember in any order in one minute.

The exercise was conducted tree or under shed. It was simple bout exercise including: Back turn, arm circle, jumping jack, running in place, ski Hops. The subjects were undergoing exercise for 30 minute. 2 minutes for back turn and resting for 1 minute, 2 minutes for arm circle and resting for 1 minute, 2 minutes for jumping jack and 1 minutes for resting, 2minutes for running in place and 1 minute for resting and lastly 2 minutes for Ski Hops and 1 minutes for resting. This process was repeated after 10 minutes. This is a total of 30 minutes' exercise with 10 minutes resting time interval. This exercise was performed three times in a week for four weeks. Pre-test and post-test were conducted to the subject as data collection.

The test before the exercise is called pre-test and the test after the exercise is called post-test. Each participant was asked for his name, gender, age, and in which language he wants to conduct the test. After pre-test the participants were ready for the exercise. It was 30 minutes' simple bout exercise under shed. They were arranged in four rows along five lines and males at the front while females were at the back. The time keeper was aside watching time while the experimenter and the participants were doing the

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exercise. The researcher was instructing the participants standing at the front facing them. The most common version of Stroop test which is Color and Word Test (SCWT) which was originally proposed by Stroop in 1935.

Age, Gender, Version of SCWT (Short, Long, Paper or Computerized) was determined using Scoring method proposed by (Golden *et al.,* 1978). In this method, the number of items correctly named in 45sec in each condition is calculated (i.e. W, C, CW). Then the predicted CW score (PCW) is calculated using formula.

PCW = 45 / (45 * W) + (45 * C)

Equivalent to PCW = (W * C) / (W + C)

Then, the PCW value is subtracted from the actual number of items correctly named in the incongruent condition (CW) (i.e. IG = CW – PCW). This procedure allows to obtain an interference score (IG) based on the performance in both W and C condition. Thus, a negative IG value represent a pathological ability to inhibit interference, while low scores mean greater difficulty in inhibiting interference.

The participants were asked to listen carefully and then the experimenter will play recording of 15 unrelated word in the language that participant will understand. Immediately after the presentation, participants will be asked to write down as many of the words they could remember or repeat the possible words he could remember in any order in one minute. The average between all five trials was calculated for each participant. It was calculated as VALT = (1st trial + 2nd trail + 3rd trail = 4th trail + 5th trail) / 5. Data were analysed using mean and paired sample t-test at α 0.05 level of significance.

RESULTS

Findings of the study is presented in Figure 1 that the Comparison of cognitive function of participants before and after the exercise

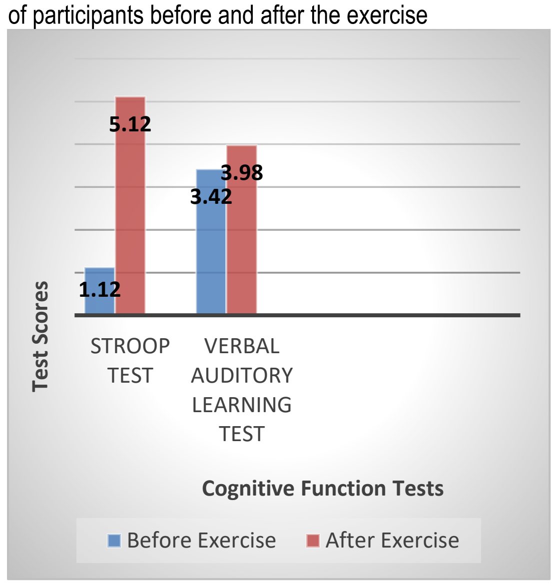

Figure 1: Comparison of cognitive function of participants before and after the exercise

Table 3: Comparison of cognitive function test of male and female participant.

Parameter	Male	Female	Pvalue
Stroop Before	1.29 ± 2.84	0.93 ± 3.53	0.733
Stroop after	5.56 ±3.88	4.59 ± 3.50	0.43
VALT before	3.04 ± 1.22	3.86 ± 1.12	0.40
VALT after	3.48±1.21	4.58 ± 1.09	0.07

Mean ± SD, n=37 and P < 0.05 is significant

DISCUSSION of findings

The present study examined the effect of sub-acute aerobic exercise on cognitive function. Stroop Test was used to assess executive function while Verbal Auditory Learning Test was to assess working memory. The total number of 37 primary school pupils was recruited for the study. The gender distribution of the children in the study population is (54.1%) males which are the majority, and (45.9%) females which are minority. The mean age (± SD) was 8.51 ±

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1.42 years. From the result, the test score significantly increases after exercise, the p-value is < 0.05. The mean ± SD test score before exercise was (1.12 ± 3.14) which is less than the mean ± SD test score after exercise (5.12 ± 3.40). This shows that a single bout of exercise for at least 30 minutes improve cognitive function specifically executive function and working memory. The majority of the previous researches conducted on children shows a significant increase in cognition specifically executive function.

The Stroop Test, in particular the Stroop Color-Word condition, is a measure of selective attention as well as cognitive inhibition or inhibition of a dominant response in favor of completing a required unusual task (Miyake *et al.,* 2000) determined that the Stroop Test is an appropriate neuropsychological task. Therefore, the results suggested that acute exercise particularly benefitted inhibition-related executive function in children. The general relationship observed for acute exercise and Stroop Color-Word has been supported by previous studies that focused on healthy adults (Sibley *et al.,* 2006). Sibley and colleagues (2006) found that the acute bout of exercise improved Stroop Color-Word in college-aged adults and suggested that it was beneficial in interference involved in maintaining goal-oriented processes. It was also found that children who engaged in physical activity demonstrated better executive functions in terms of inhibition (Hillman *et al.,* 2015) and better planning abilities than children who did not engage in any physical activity (Smith *et al.,* 2018). Engaging in sports has a positive influence on all systems: the motor, cardiovascular, respiratory, hormonal, immunologic, and nervous systems.

Thus, it stimulates the maturation of the motor areas in the brain, which in turn influences the motoric development and increases the speed of the conductance of nervous impulses (Makarowski *et al.,* 2009). Physical activity also stimulates the increase of neuro-hormonal secretion (substances produced by hypothalamic neurons and transported by blood or cerebrospinal fluid), having a significant impact on the excitability of neurons forming synapses (Hollmann *et al.,* 2000).

The result also, shows there is a significant increase in Verbal Auditory Learning Test after acute aerobic exercise, the p-value is < 0.05. The mean ± SD test score before exercise is (3.42 ± 1.12) which is less than the mean ± SD test score after exercise (3.98 ± 1.27). Stroth *et al,.* (2010) found a decrease in reaction times in the two-back test, which requires constantly updating the working memory. This indicates that as humans, we direct our focus to certain stimuli and ignore other stimuli and this process plays an important role in consciously selecting to pay attention to other things and inhibiting other stimuli from perception. In relation to exercise, highly fit individuals are better able to use executive control processes to modulate their responses in a selective attention task (Guiney & Machado 2013).

Examining the troop Test scores before exercise in male and female there was no significant difference, p=0.733. The mean test score of females before exercise is (0.93 ± 3.53) which is less than that in male (1.12 ± 2.28), although there was no significant difference, p-value is > 0.05. Stroop Test after exercise also showed that the male mean test score is greater than that of female despite there was no significant difference, p=0.43 (p-value is > 0.05). Regarding to Verbal Auditory Learning Test there was no significant difference in male and female before exercise, (p=0.40), the mean test score of males (3.04 ± 1.22) is less than of female (3.86 ± 1.12).

After exercise the mean test score of females (4.58 ± 1.09) is greater than that of male (3.48 ± 1.21). However, male score higher in Stoop Test before and after exercise while female score higher in Verbal Auditory Learning Test. This indicates that exercise enhance executive function in male and working memory in female. Gender differences between boys and girls have been reported with regards to the volumes of structures, such as the hippocampus or subcortical structures of white matter (e.g., corpus callosum), which are bigger in girls (Rostowski *et al* 2012). Functional activity studies show higher activity in the dorsolateral areas of the prefrontal

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cortex than among adults (Borkowska *et al* 2011). Pre-adolescence is associated with changes in brain structures and functioning in terms of executive functions, as well as rational memory (Johansson *et al* 2004, Khan *et al* 2014)

CONCLUSION

The study concludes that Test there was no significant difference in male and female before exercise, after four week of sub-acute aerobic exercise, executive function and working memory have improved. Male participants have higher executive function while female participants have higher working memory. It was recommended that enabling environment should be made available in each school to improve the cognitive development of children.

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