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The Impact of A 12-Week Exercise Intervention on The Cognitive Functioning of Young People in Ghana

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Abstract

Objective Research findings have indicated a link between exercise and cognitive performance of school children. The influence of exercise on executive functioning however, is not conclusive. This study examined the impact of a 3-month exercise intervention on the executive functioning, a form of cognitive functioning, in African youth

Methods: *An experimental design was used, including 120 adolescents in junior high school (48 males, 72 females) aged 13 to 18 years (mean age = 14.83 years) in Ghana. Exercise levels and cognitive functioning of the participants were assessed at baseline and also at the end of the intervention. Exercise levels were measured using the Physical Activity Questionnaire for Older Adolescents (PAQ-A) and pedometer; cognitive functioning was assessed with the Raven's Progressive Matrices test. The participants in the experimental group participated in aerobic exercise, twice a week for 3 months and also met the exercise recommendations of 10,000 steps per day.*

Results: *Post-test results indicated that participants in the experimental group scored higher on cognitive functioning than the control group [45.00 (9.38) vs. 32.62 (9.54)] and the observed difference was significant [F (1, 56) =63.39, p<0.001].*

Conclusions: *The study found that higher levels of moderate to vigorous exercise improved the cognitive functioning of the students.*

Introduction

Physical activity improves physiological processes such as the body's blood flow to the brain [1,2]. It has been found that adequate levels of exercise could benefit young people experiencing difficulties in cognitive functioning [3,5,6]. Cognitive functioning is performance of the brain. Three components of cognitive functioning have been identified: executive functioning, cognitive skills and academic achievement [7,8,9]. Executive functioning is a complex construct which involves reasoning, logical analysis, and abstract thinking [10,11]. Academic achievement is performance on tasks learned and cognitive skills are mental capabilities such as attention and concentration [9].

An association has been found between exercise and cognitive skills - attention and concentration [12,13]. The association between exercise and executive functioning of the brain however, is inconclusive [14]. Possibly, this is because previous studies have used tools with many subscales to assess executive functioning.

Academic performance of young people in Africa

Academic performance of school children is one of the major concerns of parents in Africa. In Ghana for example, parents and teachers use physical punishment to address low academic performance in young people. As a result, young people experiencing learning difficulties show emotional and behavioural problems which require psychological intervention [15]. Also, a number of schools in Ghana do not implement the school physical education programme which provides opportunities for students to increase their physical activities. It has been recommended therefore, that studies be conducted to assess the impact of decreased physical exercise on the

wellbeing of African youth [16]. However, a significant factor that could influence young people's cognitive functioning is nutritional practice [17,18].

The Present study

This experimental study was therefore designed to examine the impact of a 3-month physical exercise on cognitive functioning among adolescents in Ghana. In order to improve on the methods of previous studies, the current study defined executive functioning simply as 'reasoning' and used a single tool to assess the construct. A possible confounding variable of nutrition was controlled by including participants with higher scores on the nutritional practice scale. The study also examined the impact of exercise intervention on students' physical activity levels. The following predictions were made: H1: There will be a significant increase in physical activity levels among students in the experimental group compared with those in the control group. H2: There will be a significant improvement in cognitive functioning among students who participate in the exercise intervention compared to those in the control group. As nutrition was controlled in the study, it was expected that the impact of the exercise intervention on cognitive functioning will not be mediated by the students' nutrition.

Methods

Design

This study was a repeated measures experimental design to examine the impact of an exercise intervention on the cognitive functioning of African adolescents in junior high school.

Setting of the Study

The study was conducted in 2 private junior high schools in Accra, the capital city of Ghana: God's Home Academy and Mt. Olivet Methodist Academy. The selected schools were private schools attended by students from high socioeconomic background and similar in terms of their ranking in academic performance. The school chosen to be the experimental school had PE as part of their curriculum but it was not conducted. The school where the control group participants were selected did not have PE in their curriculum.

Sampling of participants

The total number of junior high school students in each school was around 500. A sample size calculation indicated that a sample of 60 participants per group was appropriate to detect a large effect size (d=0.8) for exercise and cognitive functioning, based on a statistical power of 0.8 with a probability level of 0.05. The junior high schools in Ghana comprised three academic levels of JHS one, two and three. In each school, the various classes were put into strata, and simple random sampling was used to recruit 60 participants from each stratum. One hundred and eighty (180) participants were recruited from each school. The recruited participants were given an informed consent package to be completed by themselves and their parents and to be returned to the school within one week.

Sample Size

The recruited students who consented to participate in the study were screened for health problems and fitness to do physical exercise. Sixty (60) students were finally selected from the experimental school to participate in the exercise programme. Similarly, 60 students were selected from the school assigned the control condition. Participants included 48 males and 72 females; age range of 13 to 18 years old.

Patient and Public Involvement

The school heads and physical education teachers approved the physical exercises to be participated by the students. The assessment tools were also approved by the Ethical Review Committee at Progressive Life Centre, Ghana.

Assessment Areas and Tools

Four kinds of assessment were conducted: Assessment of healthiness for moderate to vigorous exercise including anthropometric characteristics; assessment of existing exercise levels and nutrition; and assessment of cognitive functioning (Assessment schedule of the study, Table

Table 1: Assessment Schedule of the Study

Time Point	Activity	Measures
1	*Screening of fitness for physical exercise*	*Health Screening Questionnaire, Weighing Scale, Frisancho (2008)Comprehensive References*
2	*Baseline Assessment*	*NL-800 pedometer, PAQ-A,Standard Progressive Matrices*
	Assessment of a Confounding factor	*Food Frequency Questionnaire*
3	*Physical activity intervention (12 weeks)*	*Moderate to vigorous aerobic physical activities including running,skipping, football, etc., for 2 sessions a week.*

4	*Post-intervention Assessment*	*NL-800 pedometer, PAQ-A, Standard Progressive Matrices*

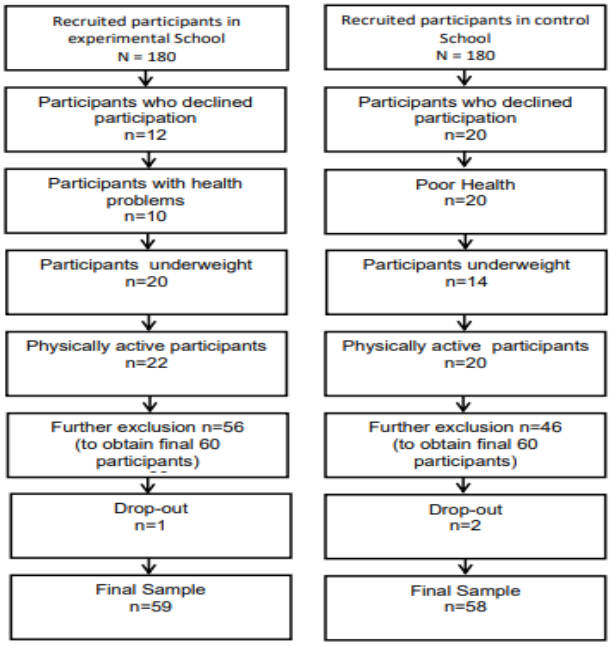
*p<0.001

Assessment of healthiness for Physical Exercise

Among the students who consented to participate in the study, the health screening tool [19] was administered in order to choose students who were healthy to perform moderate to vigorous physical exercise. The health screening tool is a questionnaire with a list of major health problems including cardiovascular disease, asthma, injuries, etc. Parents read through the list and tick the health problems which are applicable to their children [19]. Participants who experienced any of the indicated health conditions were not included in the exercise intervention study [19].

Additional screening was done using anthropometric measures [20]. A Seca weighing scale was used to measure the weight of the recruited participants in the two schools. The participants were measured in light clothing and bare-footed. Weight was measured in kilograms. Using the norms of weight-for-age [21], participants who were underweight were not included in the study. Further screening was done using the stadiometer to assess participants' height. Participants were measured bare-footed and height was recorded in centimetres. Using the norms of height-for-age [21], participants with height ≤5th percentile were classified as stunted. Participants who were stunted without nutrition problems were included in the study (Recruitment of participants and the screening process, Figure 1).

Fig 1: Chart illustrating the recruitment of participants and the screening process for the exercise intervention study in two separate schools.



Assessment of Exercise Participation

The Physical Activity Questionnaire for older Adolescents (PAQ-A), developed by Kowalski, Crocker, and Donen [22], was used to assess participants' exercise levels. Respondents read the items of the scale and rate how often they do physical exercises using a 5-point scale. It is scored by adding up the values ticked and then dividing by the number of items. The PAQ-A has good validity and reliability [22].

New lifestyle (NL)-800 Pedometer

The NL-800 electronic pedometer was used to objectively assess the participants' exercise levels [23]. It is put on a waist belt or waistband to measure steps when walking or running. Accumulating 10,000 steps a day provides significant health benefits [24]. The NL-800 pedometer models have higher validity and reliability than other pedometers [24].

The Exercise Log

This was used to record the time the pedometer was worn and the time it was taken off. It is a single sheet which consists of specified days in the week, as well as a column for time and the kind of physical exercises performed.

Assessment of Cognitive Functioning

The Standard Progressive Matrices

The Standard Progressive Matrices (SPM), for abstract thinking [25, 26] was used to assess participants' executive functioning. The test is a booklet with 60 problems divided into Sets A, B, C, D and E. On every page in the book, a figure with a missing part is presented. Respondents have to understand the meaningless figures and select the appropriate missing part to complete the figure. The test has been standardised in Africa [26] and has a good reliability ranging from 0.83 to 0.88. The score on the matrices is the total number of problems the person solves correctly [26].

ASSESSMENT OF NUTRITION

The Food Frequency Questionnaire

The participants' nutrition was assessed using a Food Frequency Questionnaire (FFQ) developed by Rockett et al. [27]. The FFQ measures the intake of food items in a week. Respondents indicate how often they eat the food items in a week. The FFQ correlates with the 24-hour dietary recall (r = 0.21 to 0.58) [27]. In scoring the FFQ, the scores ticked for the food items are added up. A higher score on the FFQ

indicates a good food intake. Only participants with higher score on the FFQ were selected to participate in the study.

Procedure

The study procedure consisted of three stages (Figure 2):

1.The Screening processes

2.The study assessment (data collection)

3.The 3-month exercise intervention

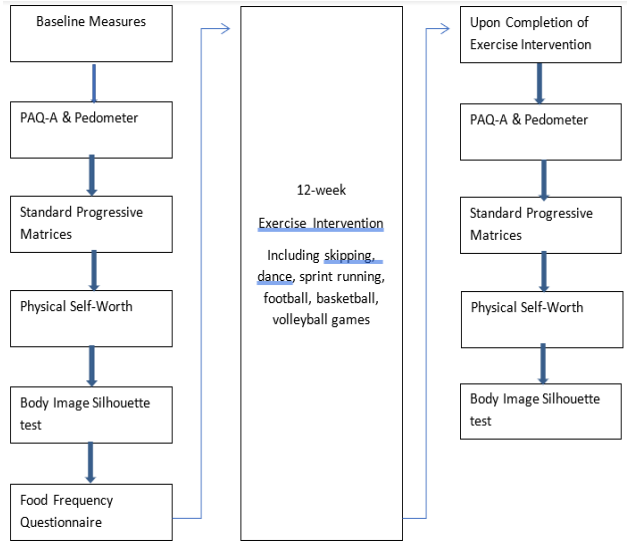
1. Study Screening Process

Participants in both the experimental and control groups were screened for health conditions, weight status and their participation in physical exercise. Participants who had health problems as indicated on the health screening questionnaire were excluded from the study. Both experimental and control group participants who were underweight [21] were also excluded from the study. The participants' baseline physical exercise levels were assessed using the PAQ-A and the pedometer. Those who scored highly on physical exercise were also excluded from the study. This is because the main purpose of the intervention was to increase physical exercises among participants who did not meet the recommended level of physical exercise. Then, using a simple random sampling method, additional number of participants was excluded to get the final 60 participants for the experimental and control group in the study (Recruitment of participants and the screening process, Figure 1).

2. Study Assessment (Data Collection)

The experimental study was conducted in God's Home Academy. During the first week of the data collection, participants in both the experimental and control groups were assessed. The baseline assessments included exercise participation, executive functioning, and nutritional practice. The participants of both the experimental and control groups were guided to wear pedometers for one week in order to confirm reported physical exercise levels (via the PAQ-A). After the baseline assessment, a moderate to vigorous physical exercise programme was organised for the participants in the experimental school only. Participants in the school assigned the control condition however, did not participate in the exercise programme.

After the physical exercise intervention, participants in both the experimental and control groups were assessed again on participation in physical exercise and cognitive functioning in order to find out the outcome of the exercise intervention on participants' physical exercise levels and cognitive functioning (The data collection procedure, Figure 2).



3. The 12-week physical exercise intervention

A moderate to vigorous physical exercise programme was planned for participants in the experimental group only. Participants in the experimental school engaged in after-school physical exercises of two times a week for 12 continuous weeks. The programme included skipping, jumping, running, dancing and football. These participants were also instructed to engage in physical exercise in their free time. The participants in the control group did not do any physical exercise.

Statistical Analyses

First, frequency and descriptive analyses were conducted to obtain descriptive information about participants in the experimental and control group. In order to provide descriptive statistics for categorical and continuous variables, frequency and descriptive analyses were conducted respectively. All differences among categorical variables were analysed using Chi-square tests, and differences among continuous variables were analysed using independent t-tests. (Characteristics of the sample at baseline, Table 2). Second, the one-way repeated measures ANOVA was performed to investigate the impact of the exercise intervention on the students' physical exercise levels (Table 3). Third, the one-way repeated measures ANOVA was performed to determine the impact of the exercise intervention on executive functioning (Table 4). Finally, the one-way repeated measures ANCOVA was performed to assess whether nutritional practice moderated the relationship between the exercise intervention and executive functioning (Table 5).

Results

Sample Characteristics

A total of 120 students who met the study's inclusion criteria participated in the study. These students were recruited from a private school in the city of Accra, Ghana. At baseline, the mean age of the participants was 14.83 (*SD* = 1.32) years, which ranged from 13 to 18 years. Of the entire 40.0% (*N* =48) sample 60.0% (*N*=72) were females. With regards to stature, 18.3% of the participants were stunted. Regarding the weight of the participants, the average BMI (24.19 kg/m2) was within the normal range. However, nearly half of these participants were overweight (30.0%) or obese (11.7%). There were no significant differences between participants in the experimental and control groups at baseline (p>0.05) (Table 2). Most of the participants (97%) were present for the post-testing.

Table 2. Characteristics of the sample at baseline

Table 2:Characteristics of the sample at baseline

Variable	Overall (*N*= 120) *M (SD)*	InterventionSchool (*n*= 60) *M (SD)*	Control School (*n*= 60) *M (SD)*	*p*
Age	*14.83 (1.32)*	*14.73 (1.20)*	*14.93 (1.43)*	***0.56***
Height (cm)	*155.08 (7.06)*	*155.63 (7.58)*	*154.23 (6.51)*	***0.36***
Weight (kg)	*57.70 (9.04)*	*57.87 (8.29)*	*57.53 (9.87)*	***0.88***
BMI	*24.19 (3.14)*	*23.91 (3.16)*	*24.47 (3.15)*	***0.50***
	F (%)	***F (%)***	***F (%)***	
Gender				
Males	*48 (40.0%)*	*26 (43.3%)*	*22 (36.6%)*	***0.44***
Females	*72 (60.0%)*	*34 (56.6%)*	*38 (63.3%)*	***0.44***
Grade				
JHS 1	*44 (36.7%)*	*22 (36.6%)*	*20 (36.0%)*	***0.95***
JHS 2	*48 (41.7%)*	*24 (40.0%)*	*28 (40.0%)*	***0.95***
JHS 3	*28 (26.7%)*	*14 (23.3%)*	*12 (23.3%)*	***0.95***
Height Classification				
Normal (≥ 5.0 percentile)	*110 (81.7%)*	*54 (90.0%)*	*56 (93.3%)*	***0.74***
Stunted (< 5.0 percentile)	*10 (18.3%)*	*6 (10.0%)*	*4 (6.6%)*	***0.74***
Weight Classification				
Normal (<25kg/m^2)	*62 (58.3%)*	*28 (66.67%)*	*34 (56.6%)*	***0.34***
Overweight (>25kg/m^2 ≤30kg/m^2)	*46 (30.0%)*	*26 (26.67%)*	*21 (35.0%)*	***0.34***
Obese (>30kg/m^2)	***12 (11.7%)***	***6 (6.67%)***	***5 (8.3%)***	***0.34***

p<0.001

The Impact of the exercise intervention on physical activity and exercise levels

This study firstly examined whether the exercise intervention had an influence on the participants' physical activity levels. From Table 3, the participants in the experimental and control group had similarly lower levels of physical exercise participation at baseline [1.40 (0.43); 1.42 (0.49), respectively]. At post intervention, however the experimental group scored higher on self-reported physical exercise (PAQ-A) than the control group [4.65 (0.48); 1.56 (0.58)]. The repeated measures ANOVA showed that the observed difference in exercise participation scores from baseline to post intervention was significant [F (1, 58) = 406.39, p< 0>

In addition, participants in the experimental group obtained significantly higher scores on the pedometer at post-testing than participants in the control group [F (1, 58) = 328.41, p< 0>

Table 4*:* One-way repeated measures ANOVA results for cognitive functioning

Group	Baseline*M* (*SD*)	Post Intervention*M* (*SD*)	*F*	*p*
Experimental	*33.83 (9.54)*	*45.00 (9.38)*	*63.39*	*0.000**
Control	*34.03 (9.38)*	*32.62 (9.58)*		

Assessing a possible moderator of the impact of the exercise intervention on participants' cognitive functioning.

From the health literature, nutrition is likely to be a confounder of the relationship between exercise and cognitive functioning [8, 17]. This study-controlled nutrition by including participants with higher scores on the nutritional practice scale. Results in Table 5 shows that the impact of exercise intervention on cognitive functioning did not show any interaction with nutritional practice [F (1, 58) = 0.56, p> 0.05]. The findings indicated that when nutrition was controlled, the exercise intervention had a significant positive impact on cognitive functioning [F (1,58) = 61.09, p<0>

Table 5: One-way repeated measures ANCOVA results for exercise intervention, nutritional practice and cognitive functioning

Variable		Experimental Group	Control Group		
	Time point	***M (SD)***	***M (SD)***	***F***	***p***
Physical Activity	*1*	*33.83 (9.54)*	*34.03 (9.48)*	*61.09*	***0.000****
	2	*45.00 (9.38)*	*32.62 (9.58)*		
Nutritional Practice				**0.56**	**0.45**

ANCOVA: covariate nutritional practice in the model. *p<0>

Summary of the study findings

The exercise intervention had a significant impact on physical exercise participation levels.

The exercise intervention had a significant positive impact on cognitive functioning.

Participants' nutrition was not significantly associated with performance on the cognitive functioning test.

Discussion

The present study found that participants who participated in the physical exercise intervention increased their physical activity levels. This finding indicates that if the schools in Ghana properly implement the Physical Education programmes, students can meet the recommended physical activity levels. Also, it was found that moderate to vigorous physical exercise had a significant positive impact on cognitive functioning of young people. This finding is consistent with studies conducted among Western young people, which indicated that physical activity is associated with attention and concentration [28, 29, 30, 31].Research indicates that mental health is involved in learning [32]. Therefore, there is the possibility that students who participated in the structured exercise experienced improvement in mental health which in turn enhanced their cognitive functioning compared to the students in the control group who did not take part in the exercise.

This finding contributes to the physical activity literature by assisting to make the association between exercise and executive functioning clearer. This is because there have been inconsistent findings on the association between physical activity and executive functioning [33, 34].

Strengths and Limitations of the study

The reason for the present finding seems to be that the present study utilised an experimental design to minimise some of the extraneous factors which are associated with non-experimental studies.

Also, this study assessed executive functioning simply as reasoning capabilities and therefore used a simple tool to assess executive functioning.

On the contrary, when utilising the results of the present study, it should be considered that the schools from which participants were recruited were not randomly selected to the experimental and control conditions. A specific school was used as the experimental school as a result of the schools' receptiveness to the exercise intervention.

Conclusion

The main purpose of this study was to strengthen current literature showing the associations between physical exercise and cognitive functioning using an intervention study. It was found that participation in moderate to vigorous physical activity has a significant impact on executive functioning, an aspect of cognitive functioning. The findings imply that conduction of physical exercise in schools would help students to learn better. Ghanaian parents are advised to make children walk to school if the distance is not too long and the environment is safe.

School physical exercises should be conducted consistently for students.

Declarations

Ethical Considerations and consent to participate

Ethical approval for the study was given by Progressive Life Centre, a human services organisation. Permission letters were also sent to the school heads in order to conduct the study in the schools. Moreover, informed consent was obtained from the parents and the students before data collection. To ensure confidentiality, codes were assigned to participants and these codes were used to identify participant's responses to the questionnaires.

Consent for publication

The schools have consented for the data to be published.

Data Sharing

Data of the study are available upon request

Competing Interests

No competing interests.

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