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The impact of a 3-month continuous exercise intervention on the cognitive functioning of African youth

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Abstract

Background: Exercise has been identified as vital for the development of young people. The human body is designed for movement and therefore a lack of exercise produces tremendous negative impact. Moderate to vigorous exercise is protective of health. Studies have indicated a link between exercise and the cognitive performance of students. There are consistent findings that continuous exercise improves cognitive skills of attention and concentration. The influence of exercise on executive functioning however is not conclusive. This study examined the impact of a structured exercise on the executive functioning, an aspect of cognitive functioning, in African young people.

Methods: An experimental design was used with 60 adolescents (27 males, 33 females) aged 13 to 18 years (mean=14.83 years) living in Ghana.

Participants' exercise and cognitive functioning were assessed both at baseline and at the end of the intervention. Exercise levels were measured using the Physical Activity Questionnaire for Older Adolescents (PAQ-A) and by pedometer; cognitive functioning was assessed with the Raven's Progressive Matrices test, with additional psychological variables of physical self-worth being measured with a subscale of the Physical Self Perception Profile, and body dissatisfaction using the body image silhouette test. The participants in the experimental group participated in aerobic exercise, twice a week for 3 continuous months.

Results: Results from the study showed that participants in the experimental school scored significantly higher on cognitive functioning compared to the control group [44.48(8.88) vs. 34.17(9.82)] [F (1,56)=24.99, p<0.001].

Conclusion: The study found that higher levels of moderate to vigorous exercise improve the reasoning capacity of students. The findings also indicated that African students do not participate in regular exercises. Increasing the participation of exercises in school can facilitate the development of executive functioning among young people who are still developing their cognitive functioning. Nutritional practice was controlled in the study by ensuring that only participants with higher scores on the Food Frequency Inventory were included. Therefore nutritional practice did not meditate the relationship between the exercise intervention and cognitive functioning.

Keywords: physical activity, exercise, moderate to vigorous physical activities, cognitive functioning, executive functioning, reasoning, cognitive skills, self-esteem, mental health, cognitive development, young people, adolescents, students.

Background

Movement is important for the body because it contributes to good health [1]. Low levels of exercise have reduced physical activity levels of adolescents [2]. Children are more active during their early stages of development, around 8 years. After 11 years however, their participation in structured exercise decline [1]. Many adolescents do not meet exercise guidelines of 60 minutes of moderate to vigorous physical activities (MVPA) a day [2, 3].

Low levels of exercise have been associated with health problems among young people [5, 6]. Findings indicate that adequate levels of exercise could prevent and protect young people from mental health problems [5]. Cognitive functioning is an indicator of well-being among students because students who perform poorly are likely to experience depression and self-esteem problems [7]. Mental health problems are issues which distract the mind and interfere with proper functioning of the brain [8]. Cognitive functioning refers to the performance of the brain. Three components of cognitive functioning have been identified: executive functioning, cognitive skills and academic achievement [9]. Executive functioning is a complex construct which includes logical analysis, abstract and flexible thinking [10, 11]. Academic achievement is performance on tasks taught and cognitive skills are learning behaviours including concentration and attention [9].

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

Students' academic performance is one of the major concerns for parents in Africa. In Ghana for example, parents and teachers put pressure on students to perform using punishment. Students experiencing learning difficulties therefore manifest behavioural problems which require psychological intervention [15]. Moreover, it has been established from research that a healthy diet is associated with cognitive functioning among students [16]. Studies indicate that adolescents, who skip meals, consume fast foods and snacks limit the intake of healthy nutrients, especially vitamins for well-being. The study therefore controlled for nutritional practice by ensuring that students selected for the study had similar nutritional practices. Essential nutrients for cognitive performance are carbohydrates and vitamins. Assessment of food groups with these nutrients can determine a good nutritional practice [16]. In Ghana, learning difficulties among children is a major precipitator of emotional difficulties among parents and students themselves [15]. It has been recommended however, that more studies be conducted to assess the impact of decreased exercise on the wellbeing of African youth [17].

This experimental study is therefore designed to examine the impact of a 3-month structured exercise on executive functioning-an aspect of cognitive functioning and mental health among adolescents in Ghana. Nutritional practice, a possible confounding variable 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 receive the exercise intervention compared to those in the control group. H3: There will be a significant increase in physical self-worth among students in the exercise intervention compared to those in the control group. H4: There will be a significant reduction in body image dissatisfaction among students in the intervention compared to those in the control group. H5: As nutritional practice was controlled in the study, it was expected that the impact of the exercise intervention on cognitive functioning will not be mediated by nutritional practice.

Methods

This study is a repeated measures experimental design to examine the impact of an exercise intervention on the cognitive functioning of African adolescents. In addition, well-being outcomes examined were physical self-worth and body dissatisfaction, which were indicators of self-esteem. The study was conducted in 3 private junior high schools in Accra, the capital city of Ghana: God's Home Academy, Mt. Olivet Methodist Academy and Kings College International. These schools were private schools 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 control school however didn't have PE in their curriculum. The study was also repeated in a single school that didn't have PE in their curriculum. The average number of junior high school students in each school was around 200 students. A sample size calculation indicated that a sample of 30 participants per group was sufficient 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. This calculation supports the practical limitation that was encountered in the schools whereby only 60 students were likely to be available. The large effect size may be an overestimate and it is a limitation. A stratified and simple random sampling method was used to select participants from each of the chosen schools. The junior high schools in Ghana comprised three academic levels of JHS one, two and three. The various classes were put into strata, and simple random sampling was used to recruit 30 participants from each stratum. Therefore, 90 participants were recruited from each school. The recruited participants were given an informed consent package to be signed by themselves and their parents and to be returned to the school within one week. The consent form was such that if the parents did not respond within one week it was assumed that they had agreed for their child to participate in the study.

Assessment Areas and Tools

Four kinds of assessment were conducted: Assessment of eligibility for moderate to vigorous exercise including anthropometric characteristics; assessment of existing exercise levels and

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, Physical Self-worth questionnaire & Silhouette test
	Assessment of a Confounding factor	Food Frequency Questionnaire
3	Physical activity intervention (6 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, Physical Self-worth questionnaire & Silhouette test

Table 1. Assessment Schedule of the Study

nutrition; assessment of cognitive functioning; and assessment of self-esteem (Table 1).

Assessment of Eligibility for Moderate to Vigorous Exercise

A Seca weighing scale was used as a screening tool to measure the weight of participants in both the experimental and control groups. A stadiometer was also used to assess participants' height to the nearest centimetre. The anthropometric measures were taken to identify participants who were underweight and unhealthy to do moderate to vigorous exercise [18]. The participants were measured in light clothing and bare-footed. Weight was recorded to the nearest kilogram. Using the norms of weight-for-age of Frisancho [19], participants with weight ≤5th percentile were classified as underweight. In addition a standardised health screening questionnaire [20] was used to assess participants' health for exercise. The health screening tool is a questionnaire which has a list of major health problems including cardiovascular disease, asthma, injuries, etc. it requires parents to read through the list and tick then health problems which are applicable to their children. Participants who experienced any of the health conditions were screened out of moderate to vigorous physical activity. [20].

A stadiometer was used to measure the height of the participants. Participants were measured bare-footed and height was taken to the nearest centimetre. Using the norms of height-for-age of Frisancho [19], participants with height ≤5th percentile were classified as stunted.

Assessment of Exercise Participation

The Physical Activity Questionnaire for older Adolescents (PAQ-A), developed by Kowalski, Crocker, and Donen [21], was used to asses participation in physical exercises. It is a self –administered recall questionnaire designed to measure physical activity levels among adolescent students aged 13 to 19 years of age. It consists of 8 items which ask about the frequency of doing particular games and also physical activities in a variety of contexts. Respondents read each item and then rate how often they do specific physical exercises. It is scored by adding up the values checked and then dividing by number of items. A score of 1 to 2 indicates a low physical exercise, 3 moderate exercise and 4 to 5 high exercise. The PAQ-A has good validity and reliability. It correlates significantly with scores of the 7-day Physical Activity Recall interview (PAR, r = 0.60), the Activity Rating questionnaire (r= 0.73) as well as with the Caltrac motion sensor (r=0.33) [24]. The PAQ-A was slightly modified to suit the African culture. Only two specific games 'floor-hockey and baseball' were changed to African games-'ampe' and 'tumatu'. This is not likely to affect the validity of the tool. A pilot study using 20 random sample of junior high participants from high socioeconomic group and 20 from low socioeconomic group yielded a reliability of .87 of the PAQ-A tool.

New lifestyle (NL)-800 Pedometer

A pedometer was used to objectively assess ambulatory physical activity levels. It is a battery-operated electronic device that measures steps and distances when walking or running [22]. It was chosen over other objective mechanical measures of physical exercise, such as the accelerometer, because the pedometer measures walking, which is the most popular form of physical activity, and is cheap to use [23]. Brisk walking, is a form of exercise, which has been associated with physical health benefits including a reduced risk for cardiovascular diseases, diabetes and cancer [1]. The NL-800 electronic pedometer models have been used in a wide range of research and has been found to have a high validity and reliability than other pedometers [24]. To use the pedometer, it is usually put on a waist belt or waistband. It has a horizontal, spring-suspended lever that moves up and down with each step the person makes. It only responds to vertical movements of the hip that occur when walking and running. It shows the accumulated steps on a digital screen. It has been indicated that accumulating 10,000 steps a day provides substantial health benefits [24]. When using the pedometer in research, demonstrations are made to show participants how to wear the device. Research shows that the use of pedometer motivates people to do physical activity and exercise. Therefore, in order to control participants' reactivity to the pedometer, it has been suggested that participants be told that it is a body posture device [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 dates in the week, as well as a column for time and exercise performed.

Assessment of Cognitive Functioning

The Standard Progressive Matrices

The Standard Progressive Matrices (SPM), a non-verbal reasoning test [25] was used to assess participants' executive functioning. Executive functioning was assessed with a non-verbal reasoning test because tests with verbal items might be influenced by respondents past learning and are not culture-free. Moreover, tests with many subscales such as the Wechsler Intelligence Scale for Children (WISC) [26] may create difficulties when comparing respondents' performances [27] because of the tendency for some respondents to score higher on some subscales than others. The Progressive matrices test was chosen over other tests to measure non-verbal reasoning because it is a single and culture-free test which assesses reasoning capabilities irrespective of respondent' education or nationality [25]. In the present research, executive functioning was operationally defined in a simpler way of 'reasoning' [25], hence the main reason for choosing the matrices test over other cognitive tests. The Progressive Matrices test is in a form of book which consist of 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. Below each figure are response options of the missing parts. Respondents have to understand the meaningless figures, consider how the patterns are related in each figure, and select the appropriate missing part to complete the figure. The problems appear simpler at beginning and become more difficult. The Progressive Matrices has been standardised among British young people [25] and also Ghanaian young people [28]. The test-retest reliability of the Progressive Matrices ranges from 0.83 to 0.88, which indicates a high reliability. It also correlates significantly with the Mill-Hill Vocabulary test 90.44 to 0.60. [25]. The test is suitable for comparing people regarding their capabilities for immediate observation, clear thinking and understanding. It can be used as an individual or group test. It takes 45 minutes to complete the test. The score on the matrices is the total number of problems the person solved correctly on the test. A higher score indicates high reasoning capability. The total score is converted to percentile score using the norms for the Progressive Matrices.

Assessment of Self-esteem; Physical Self-Worth (PSW)

Participants' physical self-worth was assessed using the subscale from the Physical Self-Perception Profile (PSPP) [29]. The PSPP consists of five subscales, each containing 6 items, which measures the following domains of self-esteem: perceived competence in sports (Sport), perceived bodily attractiveness (Body), perceived physical development (Strength), perceived ability to do exercise (Condition), and overall physical self-worth (PSW). The PSPP has been widely used in exercise research [30]. The PSW subscale was chosen instead of using the entire scale because young people are likely to evaluate their physical self-worth [27]. The Physical Self-worth subscale assesses feelings of self-respect, satisfaction and confidence in the physical domain. It consists of 6 items. Respondents read each item and rate how it describes themselves using response options ranging from 1 "not at all like me" (lowest score) to 5 " very much like me" (highest score). The internal consistency of the PSW is between 0.6 and 0.7. It also has a high test-retest reliability [29]. It takes 5-10 minutes to complete this test. The test is scored by adding up the score circled from each of the 6 items. Items 2, 4 and 6 are reversed when adding up the scores. A higher score on this test indicates a high physical self-worth or related sub-domain. The PSW scale was modified from two-directional to a one-directional response options such as 1) "Not at all like me" to 5) "Very much like me". A pilot study was conducted to ensure that participants understood the instructions on the questionnaire.

The Body Image Silhouette test

The Body Image Silhouette test [31] was used to assess body image. The test was chosen because among adolescents an evaluation of their body image is the most important determinant of their self-esteem and well-being [27]. This test consists of 9 pictures of different human figures, ranging in body size from thin to obese. Respondents look at the pictures and then rate, on a 9-point scale, their current perceived body size and also their ideal body size. Different pictures are designed for boys and girls. The silhouette rating scales are widely used to assess body image and body dissatisfaction in exercise research. The silhouette rating scales have good face validity and also are highly reliable [32]. The scales consist of visual images and therefore require less verbal skills to complete compared to other questionnaires. Test-retest reliability scores range from 0.89 to 0.92 for assessment of current body image and 0.71 to 0.82 for ideal body image among males and females [32]. It takes about 3 minutes to complete this test. When scoring the test, the difference between scores of the current body image and scores of the ideal image is calculated. A high score on the Silhouette test indicates greater body dissatisfaction.

Assessment of Nutritional Practice: The Food Frequency Questionnaire

Nutritional practice was assessed using a Food Frequency Questionnaire (FFQ) developed by Rockett et al. [33]. The FFQ was chosen over other well established measures of nutritional practice such as the 24-hour dietary recall because it assesses dietary intake for a longer period of time. For example, the 24-hour dietary recall measures food intake only for a single day. The FFQ use for this study consisted of 28 food items about the intake of carbohydrates, proteins, vitamins and minerals. Respondents have to indicate, using the response options, how often each food item is eaten in the past week. The FFQ has good validity. Correlation coefficients between the FFQ and the 24-hour dietary recall range from 0.21 to 0.58 [33]. It takes about 15 minutes to complete the questionnaire. In scoring the FFQ, a score of 7 is assigned to the response option which indicates highest consumption of the food item through to 0 which is assigned to the response option "not eaten". The score ticked for each of the food items are summed up in order to provide the total frequency of food consumed daily. A higher score on the FFQ indicates high food intake, whereas a lower score indicates less 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:

1) The Screening process

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 actual activity participation. Participants who had health problems as indicated on the health screening questionnaire were excluded from the study. Both experimental and control group participants were weighed to the nearest kilogram. With reference to the norms of weight-for-age [19], those with weight <5th percentile were classified as underweight and excluded from the exercise intervention study. This is because it is not healthy for underweight participants to do moderate to vigorous physical activity [18]. The participants' baseline physical activity levels were assessed using the PAQ-A and the pedometer. Those who scored highly on physical activity 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. Again, using a simple random sampling method, additional number of participants were excluded to get the final 60 participants for the experimental and control group in the study. Figure 1 shows the screening procedure for the study.

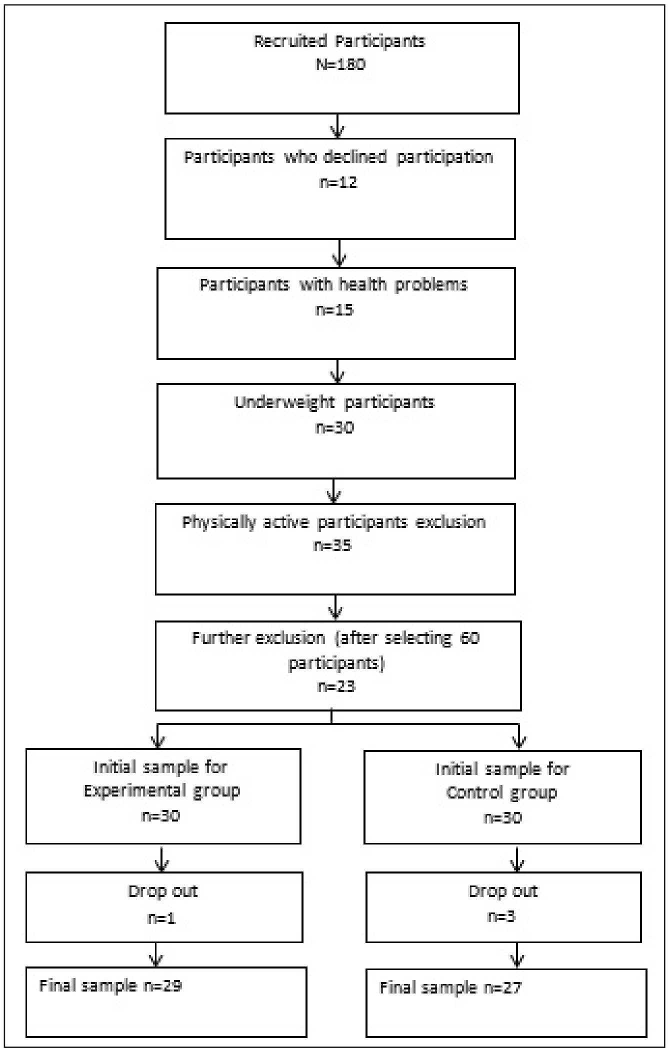

Figure 1. Chart illustrating the recruitment of participants and the screening process for the exercise intervention study in one school (pilot study)

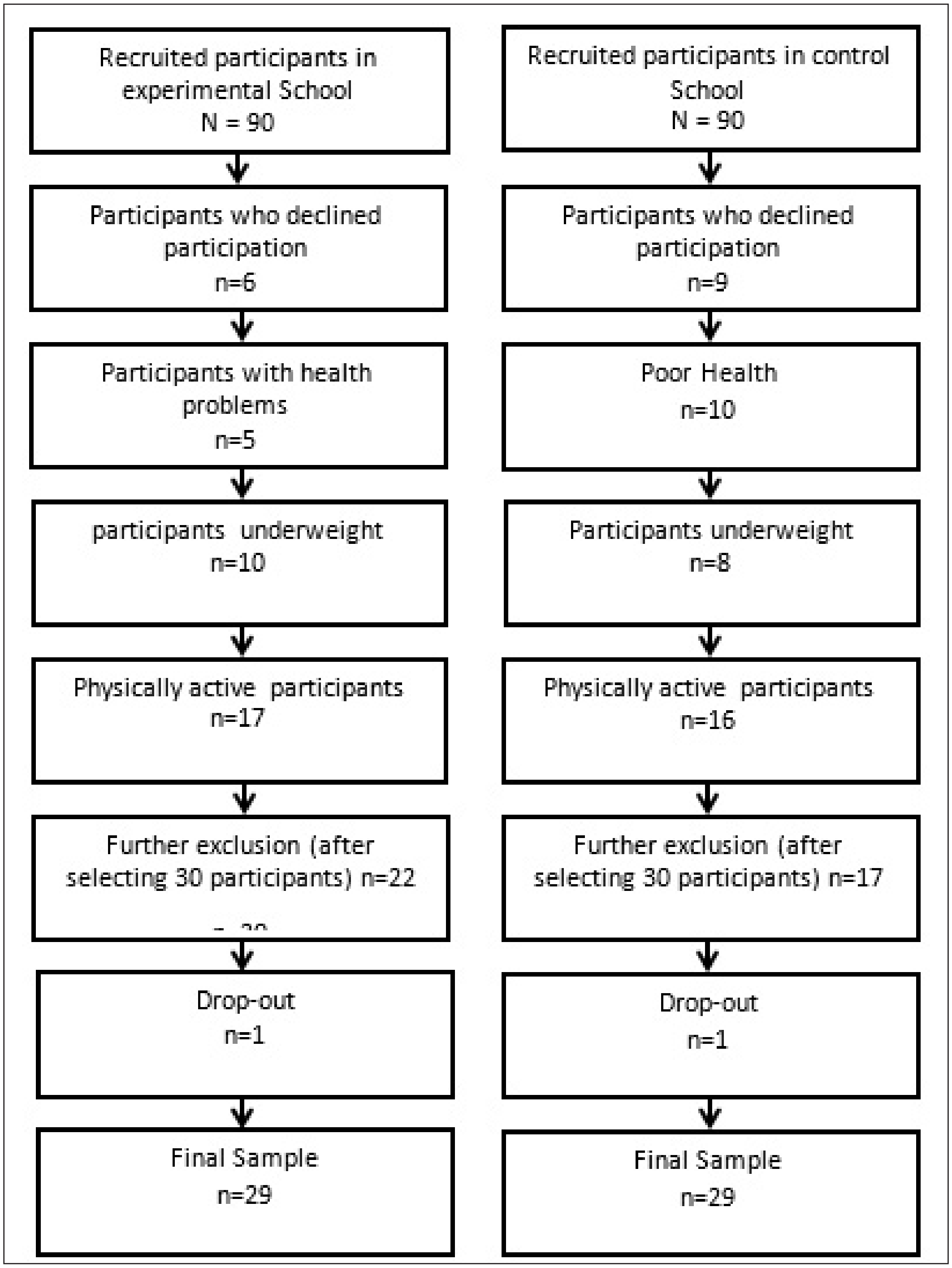

Figure 2. Chart illustrating the recruitment of participants and the screening process for the exercise intervention study in two separate schools.

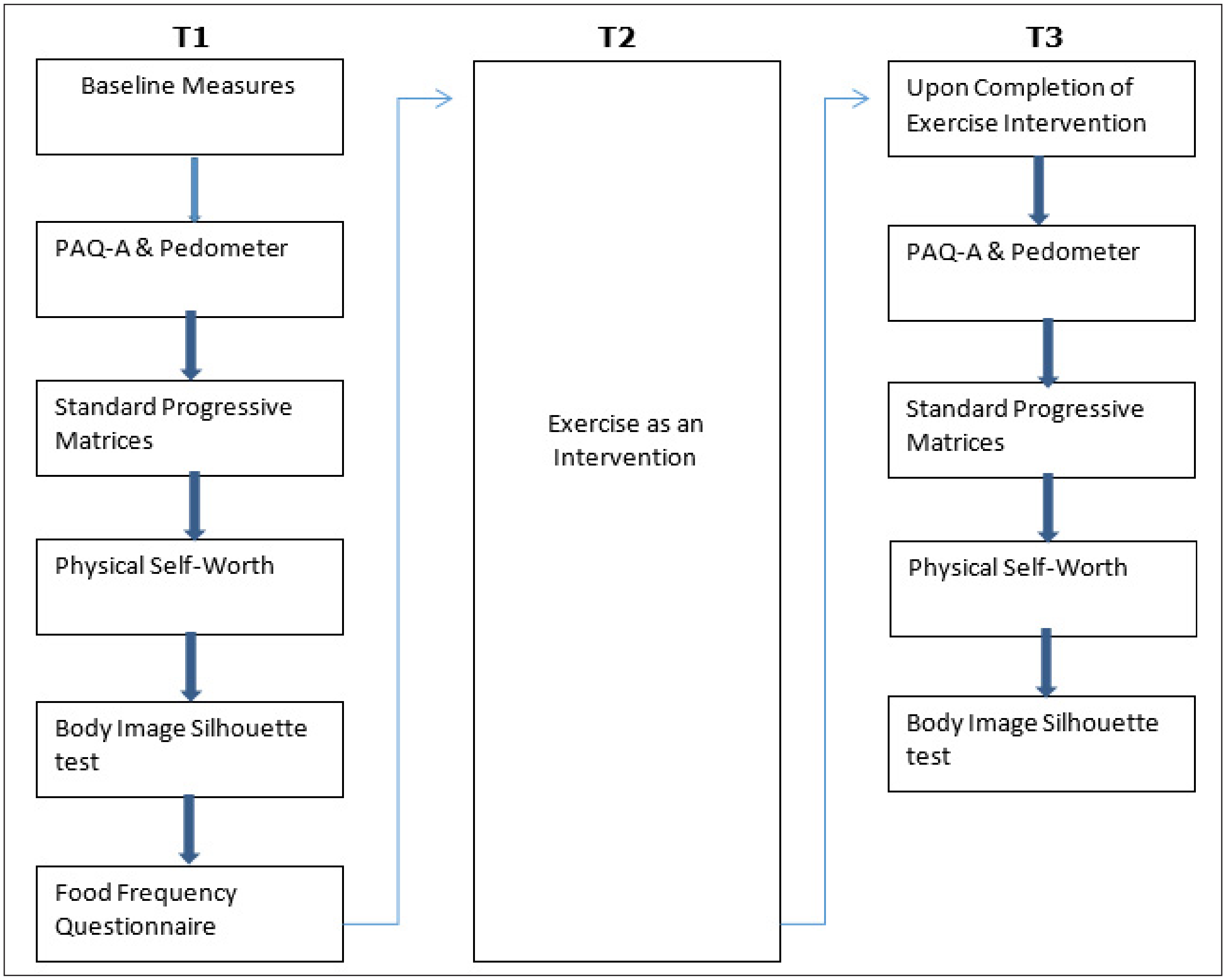

Figure 3. Data Collection Procedure

2. Study Assessment (Data Collection)

This experimental study was to determine the impact of an exercise intervention on participants' physical activity participation levels, executive functioning, physical self-worth and body image. First of all, a pilot study of the experimental study was carried out in one school in order to find out if there was the need for modification of the study procedure. In the single school, where the pilot study was conducted, participants were separated into experimental and control groups. The actual experimental study, however, was conducted in two separate schools. In the procedure, first, baseline assessments were taken on exercise participation, executive functioning, physical self-worth, body image and nutritional practice for both the experimental and control groups during the first week. Secondly, a moderate to vigorous physical exercise programme was planned for the participants in the experimental school only. Participants in the control school did not do any structured exercise.

After the physical exercise intervention, both the experimental and control groups did a post-test on physical exercise participation, cognitive functioning, physical self-worth and body image in order to find out the outcome of the exercise intervention on participants' physical activity levels and well-being.

It is important to note that the baseline and the post-intervention assessment were conducted in the morning in order to avoid the possible influence of tiredness on the cognitive performance test. It has been suggested that cognitive tests should be administered in the morning time when students seem to have a better concentration [34]. During the baseline and post-test assessment, participants were comfortably seated in a classroom. They were given some brief information about the purpose of the study and what they were supposed to do. They were told that the questionnaires they would be completing were not an exam and also assured of confidentiality. After the introductory guidelines, the participants were provided with pens. Then the study questionnaires on physical activity participation, cognitive functioning, and self-esteem were distributed.

The researcher read out the instructions of each questionnaire to the students. Research assistants were also around to assist students who needed help regarding completion of the questionnaires. The data collection lasted about 2 hours. After the students finished responding to the questionnaires, the participants from each school were guided to wear pedometers for one week. The pedometer measurement was done in order to confirm the reported physical exercise levels (via the PAQ-A). Demonstrations were done to show these participants how to wear the pedometer.

3. The 3-month structured exercise intervention

A moderate to vigorous physical exercise programme was planned for the experimental school. Participants in the experimental school engaged in an after-school physical exercise programme of two times a week for 3 continuous months. The programme included skipping, jumping, running, dancing and football. These participants were also given verbal persuasion to engage in physical activity and exercise in their spare time. The participants in the control did not do any structured exercise.

Additional Information Based on the Pilot Study

The experimental study was first conducted in a single school as a pilot study in order to modify the instruments as well as the methods in the actual research if necessary. The actual study, however, was conducted in two separate schools, one school was the experimental school and the other was the control school. Before the pilot study, the time allocated for the completion of the questionnaires was 1 hour 45 minutes. After the pilot study and the comments from the participants, it became necessary to increase the time for the assessment to 2 hours. Moreover, all the questionnaires were completed in English. In order to ensure that participants received similar instructions for the completion of the questionnaires, the instructions for each questionnaire was printed out and read aloud to the participants by the principal researcher only. Research assistants were around to supervise the students and also attend to participants who needed some assistance in completing the questionnaires. In each school, participants were given a 5 minutes break during the questionnaire time.

Process Evaluation of Data Collection

The data collection was successful. The school heads were grateful for the research to be conducted in their schools and the students involved were very cooperative. Two of the schools did not have Physical Education (PE) in their curriculum and one of the schools had PE on their curriculum but did not utilise the time for PE, therefore the physical exercise intervention gave opportunity for the students to do exercise at school. The students enjoyed the exercise activity programme and they wished that it continued as part of their curriculum.

Ethical Considerations

Ethical approval for the study was issued by the Ghana Education Service. Permission letters were 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.

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 variable were analysed using independent t-tests. (Table 2). Second, the one-way repeated measures ANOVA was performed to investigate the impact of the physical exercise intervention on the students' physical activity levels (Table 3). Third, the one-way repeated measures ANOVA was also performed to determine the impact of the physical activity intervention on executive functioning (Table 4) and self-

Variable	Overall (N= 60)	Intervention School (n= 30)	Control School (n= 30)	
	M (SD)	***M (SD)***	***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	27 (45.0%)	12 (40.0%)	15 (50.0%)	0.44
Females	33 (55.0%)	18 (60.0%)	15 (50.0%)	0.44
Grade				
JHS 1	19 (31.7%)	10 (33.3%)	9 (30.0%)	0.95
JHS 2	25 (41.7%)	12 (40.0%)	13 (43.3%)	0.95
JHS 3	16 (26.7%)	8 (26.7%)	8 (26.7%)	0.95
Height Classification				
Normal (≥ 5.0 percentile)	49 (81.7%)	25 (83.3%)	24 (80.0%)	0.74
Stunted (< 5.0 percentile)	11 (18.3%)	5 (16.7%)	6 (20.0%)	0.74
Weight Classification				
Normal (<25kg/m^2)	35 (58.3%)	20 (66.67%)	15 (50.0%)	0.34
Overweight (>25kg/m^2 ≤30kg/m^2)	18 (30.0%)	8 (26.67%)	10 (33.33%)	0.34
Obese (>30kg/m^2)	7 (11.7%)	2 (6.67%)	5 (16.67%)	0.34

Table 2. Characteristics of the sample at baseline

Physical Activity Levels	Time point ***M (SD)***	Experimental Group	Control Group		
		M (SD)	***F***	***p***	
PAQ-A	1	1.40 (0.43)	1.42 (0.49)	417.35	0.000*
	2	4.55 (0.48)	1.55 (0.58)		
Pedometer	1	3187.40 (683.32)	3006.73 (620.50)	372.95	0.000*
	2	12001.67 (1545.68)	3643.07 (493.84)		

*p<0.001

Table 3. One-way repeated measures ANOVA results for levels of physical activity and exercise on the PAQ-A and the pedometer

Group	Baseline *M* (*SD*)	Post Intervention *M* (*SD*)	*F*	*p*
Experimental	34.17 (9.82)	44.48 (8.88)	24.99	0.000*
Control	34.38 (9.48)	35.62 (9.58)		

*p<0.001

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

Self-esteem category *M* (*SD*)	Time point	Experimental Group *M* (*SD*)	Control Group *F*	*p*	
Physical Self-worth	1	15.66 (4.30)	17.86 (4.88)	37.31	0.000*
	2	24.34 (4.06)	17.62 (2.87)		
Body dissatisfaction	1	2.14 (1.13)	2.10 (1.15)	17.61	0.000*
	2	0.62 (0.75)	2.28 (1.13)		

*p<0.001

Table 5. One-way repeated measures ANOVA results for physical self-worth and body dissatisfaction

Variable	Time point	Experimental Group **M (SD)**	Control Group **M (SD)**	**F**	**p**
Physical Activity	1	34.17 (10.51)	34.38 (9.16)	5.43	0.03*
	2	44.48 (8.87)	32.62 (9.58)		
				0.21	0.67
Nutritional Practice					

ANCOVA: adjusted for nutritional practice.
*p<0.05

Table 6. One-way repeated measures ANCOVA results for exercise intervention, nutritional practice and cognitive functioning

Well-being Category Mean (SD)	Time point	Experimental Group Mean (SD)	Control Group *F*	*p*	
Cognitive functioning	1	31.41 (8.69)	33.48 (9.33)	33.89	0.000*
	2	41.34 (9.74)	31.59 (8.93)		
Physical Self-worth	1	16.45 (5.04)	16.74 (5.08)	41.11	0.000*
	2	24.76 (4.18)	16.59 (4.36)		
Body dissatisfaction	1	2.28 (0.88)	2.11 (0.93)	51.19	0.000*
	2	0.62 (0.56)	1.96 (1.16)		

*p<0.001

Table 7. One-way repeated measures ANOVA of exercise and well-being indicators of the pilot study

esteem indicators of physical self-worth and body dissatisfaction (Table 5). Finally, the one-way repeated measures ANCOVA was performed to assess whether nutritional practice moderated the relationship between the exercise intervention and cognitive functioning. (Table 6).

RESULTS

Sample Characteristics

A total of 60 students who met the study's inclusion criteria participated in the study. These students were recruited from two private schools in the city of Accra, Ghana. At baseline, the mean age of the participants was 14.83 (1.32) years, which ranged from 13 to 18 years. Of the entire sample 55.0% 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 ($p>0.05$). Most of the participants (97%) were present for the post-testing.

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. The one-way repeated measures ANOVA was used to examine the difference between baseline physical activity levels and post-intervention physical activity levels of both the experimental and control participants.

From Table 3, the experimental and control group had similar levels of physical activity 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 activity (PAQ-A) than the control group [4.55 (0.48); 1.55 (0.58)]. The repeated measures ANOVA showed that the observed difference in exercise participation scores from baseline to post intervention was significant [$F(1, 56) = 417.35$, $p< 0.001$]. In addition, participants in the experimental group obtained higher scores on the pedometer at post-testing than participants in the control group. Participants who participated in the exercise intervention increased their physical activity participation to 12015.67 steps per day. Again, the observed difference in physical activity participation levels between participants was statistically significant [$F(1, 28) = 372.95$, $p< 0.001$]. The results indicated that the exercise intervention had a significant impact on participants' physical activity participation levels.

The Impact of the 3-month continuous exercise on executive functioning (an aspect of cognitive functioning)

The second objective of this study was to examine the impact of the physical exercise intervention on performance on a standardised cognitive test. In order to avoid the use of complicated tests which is a major methodological flaw of previous studies [13], this study assessed the impact of exercise on cognitive functioning with a simpler standardised culture free-test (progressive matrices) to assess reasoning. Results presented in Table 4 below indicates that the experimental and control group had similar performance on the matrices test at baseline. However, at post-test, the experimental group participants obtained increased scores on the cognitive test compared with those in the control group. Results from the repeated measures ANOVA showed that the increase in the matrices test scores of the experimental group participants was significant [$F(1, 56) = 24.99$, $p< 0.001$]. The findings indicated that the physical exercise intervention had an impact on participants' reasoning capacity, hence supporting the prediction of the study.

In the exercise literature it has been recommended that experimental studies be conducted to strengthen the evidence base of the impact of exercise on mental health variables [39]. It was therefore the objective of this study to examine the causal relationship between exercise intervention and mental well-being in African adolescents (Table 5). From Table 5, the mean scores on self-esteem showed that the experimental and control group were comparable at baseline on physical self-worth. The post intervention means showed that the experimental group scored higher on physical self-worth than the control group. The repeated measures ANOVA showed that the difference observed between the two groups at post intervention was significant [$F(1, 56) = 37.31$, $p< 0.001$]. Therefore the physical exercise had a significant positive impact on physical self-worth, which supported the study prediction.

Regarding results on the body image test, (Table 5), the mean scores at baseline revealed that the experimental and control group had similar scores on body dissatisfaction. However, the mean scores at post intervention showed that participants in the experimental group had a decrease in scores on the body image scale (which indicates less body dissatisfaction) than the control group. The repeated measures analysis of variance showed that the observed difference between the experimental and control group at post intervention was significant [$F(1, 56) = 17.61$, $p< 0.001$]. Physical exercise intervention had a significant impact on the reduction of body dissatisfaction, thus supporting the study prediction.

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

From the health literature, nutritional practice is likely to be a confounder of the relationship between exercise and cognitive functioning (e.g. Black, 2003; Kim et al., 2010). This study controlled nutritional practice by including participants with higher scores on the nutritional practice scale. Results in Table 6 shows that the impact of exercise intervention on cognitive functioning did not show any interaction with nutritional practice. As nutritional practice was controlled, participants' nutritional practice was not significantly associated with performance on the executive functioning test [$F(1, 55) = 0.20$, $p> 0.05$]. The findings indicated that when nutritional practice was controlled for, the exercise intervention had a significant positive impact on cognitive performance.

The Pilot Study Results

The experimental study, which was conducted in two separate schools (from April ending to July ending and one month follow-up to the end of August) was initially conducted in a single school as a pilot study. The findings of the pilot study were similar to results obtained from the actual study conducted in two separate schools.

When assessing the impact of the exercise intervention on the physical activity levels of the participants, the pilot results showed that both the experimental and the control group participants had comparable levels of physical activity at baseline. At post testing however, participants in the experimental group scored significantly higher on the PAQ-A [$F(1, 54) = 590.19$, $p< 0.001$], and also on the pedometer [$F(1, 28) =267.03$, $p< 0.001$]. When assessing the impact of the exercise intervention on cognitive functioning, the experimental group had significantly higher scores on executive functioning than the control [$F(1, 54)= 33.89$, $p< 0.001$]. Moreover, the experimental group participants scored significantly higher on self-esteem than participants in the control group (Table 7).

Summary of Findings

- The exercise intervention had a significant impact on physical activity participation levels.
- The exercise intervention had a significant positive impact on cognitive functioning.
- The exercise intervention had a significant positive impact on aspects of self-esteem.

Discussion

The present study found that moderate to vigorous exercise had a significant positive impact on cognitive functioning and mental health of young people. This finding is consistent with studies conducted among Western young people, which indicated that physical activity is associated with good mental health [35, 36, 37, 38]. In this study, participants who took part in the physical exercise intervention experienced enhancement in cognitive functioning and self-esteem compared to those who did not do exercise. This finding indicates that moderate to vigorous physical exercise improves mental health. Research indicates that self-esteem problems are strongly associated with depression [39, 40]. Therefore, there is the possibility that students who participated in the structured exercise experienced a reduction in depression symptoms which in turn enhanced self-esteem compared to the students in the control group who did not take part in the exercise.

With regards to cognitive functioning, students who participated in the exercise intervention significantly improved their reasoning capabilities compared to those who did not do 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 [13, 14]. This study based on experimental design is supported by some studies from Western cultures which have also found that exercise has a significant positive impact on executive functioning in young people [41, 42, 43]. This finding however, contradicts with previous studies which have found no association between physical activity and executive functioning [44, 45]. 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. This study assessed executive functioning simply as reasoning capabilities and therefore used a simple tool to assess executive functioning.

Moreover, the reason for the present results is possibly due to the fact that prior to the physical exercise intervention, both the experimental and control group students might be experiencing some symptoms of depression which inhibited their cognitive capacities. Research studies indicate that depression affects cognitive performance [7]. Goldney et al. [46] also reported that even subclinical levels of depression have a significant negative impact on productivity. After the exercise intervention, the students who participated in exercise (the experimental group) seem to have experienced reduction in depressive symptoms, which manifested in their improvement in cognitive functioning as well as improvement in their low self-esteem. Probably, the students in the control group, however, continued to manifest depressive symptoms which inhibited their cognitive performance as well as their self-esteem.

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. Moreover, the test utilised to assess executive functioning was a non-verbal cognitive test, which measures spatial skills. Therefore the improvement observed on the executive functioning can only be specified to spatial skills but not verbal skills. In summary, the present findings indicate that participation in exercise is associated with improved reasoning capabilities. This suggests that physical activity and exercise is beneficial for young people who are still developing in executive functioning [27]. More importantly, the present findings seem to support the evidence and make it clearer the association between exercise and executive functioning. This finding is helpful for schools in making decisions about school physical education programs for students. It has been clearly demonstrated that participation in exercise improves cognitive functioning and mental health. The finding however, is mainly generalizable to students from upper class schools in Ghana.

Conclusion

The main purpose of this study was to strengthen current literature showing the associations between physical exercise and well-being using an intervention study. It was found that participation in moderate to vigorous physical activity has an impact on executive functioning, an aspect of cognitive functioning. The findings imply that conduction of 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 and students are encouraged to participate in them as regular exercises can improve cognitive functioning.

Consent

Written informed consent was obtained from parents/guardians of participants and also the participants themselves.

Competing Interests

No competing interests.

Contribution of Authors

First author conducted the assessment and exercise intervention programme in the schools, data analysis and write up of exercise and health aspects of the paper. The second author assisted with data-analysis, proof reading and write-up of the well-being/ mental health aspect of the paper. Both authors approved the final manuscript.

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