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Research article

Physical fitness and cognitive function among school–aged children in selected basic schools in the Ho Municipality of Ghana

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ABSTRACT

Physical fitness is thought to promote cognitive function. Evidence about this is however lacking in the Ghanaian context. This study aimed to investigate the association between physical fitness and cognitive function among basic school children aged 8–13 years. A cross-sectional study involving 591 school children, recruited from 12 randomly selected public and private basic schools was conducted. Physical fitness tests were done using a five-test battery (Fifty metre run, handgrip strength, sit-up, flexibility and standing board jump) following standardized procedures. Cognitive function test using the Raven's Coloured Progressive Matrices (RCPM) were carried out. More girls (55%), children from 8-13 years old (49.1%) and public school children (66.1%) participated in the study. For fitness, boys performed better than girls in sit ups 3.4 ± 2.2 (mean ± SD), p = 0.012, handgrip 4.3 ± 2.0, p = 0.001 and overall fitness 4.3 ± 2.0, p = 0.007. Children in public schools performed significantly better in forward jump (p < 0.001) while those in private schools did better in 50m run (p < 0.001). For cognition, 46.1% of participants had less than 50% of the total score. Cognitive test score varied for forward jump and handgrip alone and not for sit ups, 50m run and overall score. Mean forward jump score was lowest in poor cognition group (4.9 ± 2.3), followed by good (5.3 ± 2.2) and highest among excellent (5.5 ± 2.3, p = 0.044) cognition group. Similar observation was made for handgrip. Cognition score and hand grip strength were positively but weakly correlated. (r = 0.132, p = 0.026). Although handgrip strength (measuring muscular strength) was significantly associated with cognitive function, this study found no significant association between overall physical fitness and cognitive function. These results indicate that only some components of physical fitness may be associated with cognitive function. This study is however correlational and one cannot infer causality.

1. Introduction

Cognitive function of children is a strong correlate of their future economic prospects [1] since optimum cognitive function will translate into better academic performance and outcomes [2]. Lees and Hopkins [3] defined cognition as "a student's ability to learn through perception, reasoning, analysis, and judgment, which is commonly measured in schools through the use of objective tests". Academic achievement however, describes a student's accomplishments on school-related work, tasks or assignment such as standardized tests or grades [3]. Cognitive abilities, which are usually exhibited include the aptitude for problem-solving, reasoning, possession of language and social skills among others, are known to have a strong relationship with intelligence [4]. Cognitive function has been shown to be a determinant of academic performance [5]. Various studies have found relationships between the different components of cognitive function and academic performance. For instance, Lan et al, [6] discovered that, attentional control is vital for all components of academic performance in reading and math skills. In their study, they found that, attentional control uniquely predicted all aspects of achievement (reading: b = .27, t = 2.9, p < .01; calculation: b = .18.t = 2.0, p < .05; counting: b = .36, t = 4.5,p < .01) among Chinese participants and marginally predicted reading (b = .12, t = 1.7, p < .10) and calculation (b = .21, t = 1.7, p < .10) but not counting (b = .20, t = 0.4, ns) among American participants. Castillo-Parra et al. [7] found that executive function plays a vital role in academic success. Another study also concluded that executive functions predict achievement in various

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academic fields [8]. In a Colombian study, Machacón, Herazo and Vidarte [9] evaluated the psychomotor profile and logical-mathematical performance of 389 school children and showed a correlation of 0.12 ($p = 0.01$) between the two measures, with the former representing the perception component of cognitive function. Furthermore, Castillo-Parra et al. [7] found that academic success requires more memory capacity during the early school years hence is important. Another cognitive function component that is shown to be important to academic success is verbal ability [10]. Language predicted academic performance specifically in reading at the end of primary school [11, 12]. The relationship between cognitive skills and academic performance however, wavers as the student progresses through school, resulting in a progressively reducing correlation between intelligence and academic performance [13, 14].

Several factors are known to affect the cognitive function of children [15]. These include socioeconomic factors such as poverty and maternal education. These socioeconomic factors have been found by Santos et al. [15], to be mediated by psychosocial stimulation at school and home, and physical environmental conditions that exist at home and in the neighbourhood. Another important determinant of cognitive function among children is children's early health indicators such as birth weight, linear growth and nutritional status [16, 17].

Apart from the above factors that affect cognition function of children, physical fitness has also been found to have positive effects on cognition function, which subsequently affects academic performance [18, 19, 20]. Physical fitness is defined as the capacity to perform physical activity. Physical fitness and physical activity have been used interchangeably although they are different [21]. While the latter affects the former [22], physical activity specifically refers to any movement produced by muscle contraction. Physical fitness on the other hand, involves a full range of physiological and psychological qualities [23]. Physical fitness comprises various components; cardiorespiratory fitness (CRF), muscular strength and endurance, body composition and flexibility as well as motor abilities such as speed, agility, power and balance [21, 24]. Physical fitness is an important health indicator [25]. Poor physical activity and fitness levels are associated with preventable diseases such as obesity, heart disease, and diabetes [26] and this warrants interventions to increase physical fitness especially, in children.

There is emerging evidence that suggests an association between physical fitness and academic performance [24, 27, 28]. The association between physical fitness and academic performance has been attributed to the positive effects of physical fitness on cognitive function and performance in attention tasks, or by its effects on sleep quality, stress and depression [18, 19, 20]. More specifically, the CRF component of physical fitness has been linked with better cognitive functions among both young and old people [29, 30]. Suggestions regarding the mechanism underpinning CRF and cognition, include: increased cerebral perfusion, improved levels of neurotransmitters and other growth factors that promote neurogenesis and synaptic plasticity [31]. Other components of physical fitness may also affect neuronal functions. For instance, exercises that require specific mental processing have been suggested to greatly activate total cognitive growth compared to aerobic exercises alone [32, 33].

Previous findings on the association between physical fitness or its components and cognitive function have been inconsistent [34]. While most studies [35, 36, 37] reported positive correlations between motor function and cognitive ability indices (e.g. Academic achievement) among adolescents and children, others [38] reported no such associations. Essential causes of weakness in most of the previous studies which contribute to their inconsistency in assessing cognitive capacity and lack of finding power is due to the non-inclusion of major confounders such as age and sex [34, 35]. In addition, most of these studies used different physical fitness components thereby making it difficult to make specific comparisons.

Özdirenç et al. [39] reported high levels of inactivity and sedentary lifestyle of many young children and Nyawornota et al. [40], found that 70% of Ghanaian children do not engage in enough physical activity. Several reasons have been suggested to account for this trend. Technological advancements have provided children with more opportunities to engage in sedentary behaviours such as playing video games, watching TV and surfing the Internet [41]. In addition to this, there have been reports of parents having concerns about the safety of their children playing outside, resulting in a further limitation of children's physical activity levels [42]. As a result, it is projected that children with inadequate physical activity levels could have suboptimal cognitive development as compared to their counterparts that meet the physical activity levels that are recommended by the WHO. Notwithstanding the documented effects of physical fitness on cognition status, majority of studies that analysed cognitive function of children in Ghana considered the nutritional and socioeconomic factors [43, 44, 45]. Although these are also strong correlates, understanding the role of physical fitness will create another caveat that could be explored to improve the cognitive function of school age children since there is currently inadequate literature and evidence on the subject matter in Ghana. Such information is vital for policy formulation, intervention design and implementation among children.

Considering the suggested effects of physical fitness on cognition functions of children, as well as the lack of evidence regarding the Ghanaian context, this study aimed at examining the associations between physical fitness and the cognitive ability of school age children within the Ho municipality. This paper seeks to provide new evidence regarding association between the two, which can potentially help in shaping new interventions to promote academic and cognitive performance of children.

2. Materials and methods

2.1. Study design and participants

This study employed a cross-sectional study design. Sample consisted of a total of 591 school children of ages from 8 to 13 years, living and attending government owned or private basic schools. Participants were recruited from twelve (12) randomly selected schools in the Ho municipality. The study was approved by the Committee on Human Research Publications and Ethics of the Kwame Nkrumah University of Science and Technology (CHRPE/KNUST) with Ref. number CHRPE/AP/239/18. Permission was sought and given by the schools' authorities and the Regional and District Offices of the Ghana Education Service. Informed consent for children participation was obtained from their parents or guardians via written letters. Procedures to be undertaken were communicated to parents at a Parents Teachers Association meeting prior to data collection.

2.2. Sample size and sampling procedure

Using the Cochran formula for sample size determination, sample size of 527 pupils were arrived at using a response rate of 50% and an estimated population of 20000 children with a 95% confidence interval and a margin of error of 5%. A total of 12 basic schools of either public or private ownership were randomly sampled from a list of all schools in the Ho Municipality. From each of the 12 sampled schools, 50 school children within the ages in of 8–13 years were recruited conveniently to participate in the study. Based on the availability of the recruited child in the school on the day of enrolment, and the fact that some schools had less than the 50 children within age 8–13 years, the final sample size came up to 591 which was used for the study. Only apparently healthy-looking school age children who voluntarily accepted to participate, were included in the study. Children with any physical disability or above 13 and below 8 years old were excluded from the study.

2.3. Data collection

Socio-demographic data such as age, gender, household size and socioeconomic status of parents or guardians as well as physical activity performance history were collected using a questionnaire developed based on the Food and Agriculture Organization (FAO) Guidelines for assessing nutrition-related nutrition Knowledge, Attitude and Practice (KAP) [76]. Physical fitness was measured based on Ramírez-Vélez et al. [46]. Cognition tests were performed on children using Raven's Coloured Progressive Matrices (RCPM) [47]. Pretesting of all instruments and procedures was done in another school, not part of the selected ones, a day prior to main data collection.

2.4. Assessment of physical fitness

The following physical fitness elements were measured: flexibility element (flexibility and sit-ups), musculoskeletal element (forward jump and hand grip strength), and the motor element (50m run). Except the 50m run, all the other assessments were conducted in twofold. Explanations and demonstrations were given prior to the beginning of the measurements and thereafter as required.

Using a dynamometer, hand grip was measured. For this assessment, the children first hold the dynamometer in their left hands and squeeze it when they were instructed to do so. The activity repeated using right hand too. Following each test, the measurement was recorded in kg and the instrument reset to zero for the next test.

In measuring forward jump, the children stood at the start-line and were directed to jump forward as far as they could, taking off with both feet. The distance between the point at which the jump started to the heel of the foot that is closer to the jump start point using the jump-end point as reference, was recorded to the nearest 1 cm. The activity was repeated once and a second measurement was taken after which an average of the two readings is struck.

To measure sit ups, the participants laid on a mat placed on a flat floor, placing both hands under the head and bending both knees. The participants ankles were held by the enumerator. The ipsilateral knee of the participants needs to be touched by their elbows. The participants resumed their initial position after each upward movement. The number of sit ups performed in 30 s is the score.

Flexibility was determined using the forward flexion of the trunk test which was scored as the most distant point touched on a ruler with the fingertip through bending the body at the waist. Both thumbs needed to touch each other with straightened knees. Trials were conducted twice and values recorded to a precision of 0.5 m following which an average of determined and used for the analyses.

The 50-metre run required participants to sprint and complete a 50-meter distance as fast as they can. Using stopwatches, completion time for each participant was determined and recorded to a precision of 0.1s.

Crude values from all tests were converted to standard scores using physical fitness performance standards for Japanese school-aged children.

The Japanese standard contain eight physical fitness tests, with scores ranging from one to ten, for each physical fitness test; one being the lowest and ten, the highest score. Following the transformations, a total fitness score was obtained by adding all the standard scores. Each child's fitness level was then determined as poor, average, very good, or excellent, depending on age and gender. Instead of eight activities, only five (hand grip strength, forward jump, flexibility, sit up and fifty-metre run) were performed in this study by the participants. Therefore, overall fitness score, calculated from the score for each child was based on five instead of eight measures. This modification in the number of tests was done because, some of the tests measured the same component of physical fitness. Due to large sample size used in this study, it was deemed appropriate to reduce the number of tests by applying the most relevant test to manage resources. The scores were included in the analyses as continuous variables such that the higher the score, the more fit a participant child. Additionally, percentiles were generated for the total standard scores, since applying Japanese-based classifications created in the template was impossible. Children with scores above the 75th percentile, between 75th and 60th, between 59th and 40th and those below 40th were classified as excellent, very good, average and poor, respectively.

2.5. Assessment of cognitive function

The cognition of the participants was accessed using Raven's Coloured Progressive Matrices (RCPM). Prior to the administration of the cognitive test, the test procedure was explained to the participants and the test carried out in a quite environment. Contained in the test booklets were three sets of twelve problems (36 colored questions), which measure abstract reasoning by analogy and fluid intelligence by problem-solving. This test has been applied widely as a culturally fair assessment of intelligence [47]. The tests are made up of progressively geometrical patterns and designs with a missing piece. The questions increase in difficulty as one progresses. In this study, an overall performance out of the 36 questions was used. The scores were therefore either continuous variables or percentiles with each question having six to eight options to select from and fill the missing piece. Trained research assistants conducted the cognitive tests. Each participant was provided with a booklet containing the test and answer sheets to select the correct answer for each question.

2.6. Statistical analysis

Normality test was performed on the data variables using the Shapiro-Wilk test. The percentage score of the mean score was determined and used to categorize performance on the cognition function test. Participants were classified as Poor, Good or Excellent when they achieved percentage cognition scores of less than 50, 50–69 or greater than or equal to 70, respectively. Descriptive statistics were performed on socio-demographic and cognitive function test categories data. Chi-squared tests were used to compare categorical data on physical fitness with respect to gender and age groups of the participants. Mann -Whitney and Kruskal-Wallis tests were used to compare mean physical fitness test scores by age group, school type and gender. The mean physical fitness test scores and cognition test categories were compared using the Kruskal-Wallis tests. To determine the association between cognitive function test scores and physical fitness test scores, partial correlations were performed using total raw scores of cognition function test and physical fitness test components, adjusting for age and gender. significance level was two-tailed with a p-value less than .05. Continuous data are reported as mean value ±standard deviation (SD) while categorical data are presented as percentages. All data were analyzed using Statistical Package for Social Sciences version 22 (SPSS IBM Inc).

3. Results

Table 1 presents socio-demographic characteristics of the study participants. There were more female school children (55.0%) than males (45.0%) in this study with majority (49.1%) of the children, being within age group of 11–13 years. The study had more participants from public schools (66.2%) than private schools (33.8%) (Table 1). A total of 585 participants completed the cognitive function test of which 46.0%, 29.0% and 25.0% performed poor, good and excellent respectively (Table 1).

Table 2 shows results of Shapiro-Wilk test of normality on selected variables. All tested variables did not meet the criteria for normality.

Table 3 presents mean comparison of socio-demographic, school classification and physical fitness level. Apart from forward jump and fifty metre sprint score, male and females differed significantly in all fitness components. On average, males performed better in sit ups ($p = 0.012$) and handgrip ($p = 0.001$ Table 3). More female participants performed poorly (43.7%) and excellently (3.1%) than males (Table 4) in handgrip activities. Comparing mean total fitness scores indicates male participants (20.7 ± 6.6) were significantly (p value = 0.007) more fit than their females (19.6 ± 6.8) (Table 3). Children in public schools performed significantly better in forward jump ($p < 0.001$) while those in private schools did better in 50m run ($p < 0.001$).

Out of all the other fitness components, only handgrip (p value = 0.001) was significantly different among the age groups, with the 10 years performing better than the other age groups (Table 3). Less 10 years old performed both poorly (25.1%) and excellently (1.6%) in handgrip activities compared with the other age groups (Table 4). Participants in public schools performed better in forward jump (5.6 ± 2.4) compared to their counterparts in private schools (4.5 ± 1.9) (p value <0.001). Conversely, private school (8.8 ± 2.6) participants performed better than their peers from the public schools (7.7 ± 3.2) (p value <0.001) in fifty metre activity. Schoolchildren aged 10 years (25.1%) had overall better fitness level than those aged 8–9 years (17.4%) and 11–13 years (24.2%) (p value = 0.004). Gender differences were not found for total fitness scores (p value = 0.066) (Table 4). All physical fitness components (Mean sit ups (p value <0.001), forward jump (p value <0.001), fifty metre run (p value <0.001), total handgrip (p value <0.001) tested, as well as total fitness were significantly different among all the various schools involved in the study. Bonferroni multiple comparison shows significant mean differences between age groups and schools of participants (p value <0.05) (Table 3). Flexibility component of physical assessment was omitted in this analysis because all the participants obtained the same score after conversion hence, there was no variability in this variable. Presented in Table 5 is the mean comparison between physical fitness and cognition test percent. Forward jump (p value = 0.044) and handgrip scores (p value = 0.0005) varied significantly across the cognitive function test performance categories. Participants who performed excellent (greater than or equal to 70%) on the cognitive function test performed significantly better (4.3 ± 1.9 versus 3.8 ± 1.9) in the handgrip activities than those who performed poor (less than 40%) on the cognitive function test. Similarly, children with good (50–69%) performance on the cognitive function test, performed better (4.3 ± 2.0) in the handgrip activities than children who performed poor (less than 40%) (Table 5).

Table 6 presents association between physical fitness and total raw cognition test. All but handgrip strength score (p value = 0.0026), showed no significant association between any physical fitness tests and cognition function test (p value = 0.438) (Table 6).

Table 7 presents a multinomial regression to predict cognition function using various predictor variables. The odds of having poor cognition compared with excellent cognition is lower for a child who performs poor in the 50 m run compared to a child who performs excellent in the 50m run given all other predictor variables are held constant. All other analyses showed no significant association.

Table 1. Sociodemographic characteristics and cognitive test outcomes of study participants.

Sociodemographic	Frequency (n)	Percentage (%)
Gender, n = 591		
Male	266	45.0
Female	325	55.0
Age (Years), n = 591		
8–9 years	114	19.3
10 years	187	31.6
11–13 years	290	49.1
School Type, n = 591		
Public school	391	66.2
Private school	200	33.8
Physical fitness level		
Mean handgrip	4.1 ± 1.9‡	
Mean sit-up	3.2 ± 2.1‡	
Mean forward jump	5.2 ± 2.3‡	
Mean 50 m run	8.1 ± 3.0‡	
Mean all fitness score	20.1 ± 6.7‡	
Percentage cognition test n = 585		
Mean Cognition test score	18.9 ± 8.2‡	
Less than 50% (Poor)	269	46.0
50–69% (Good)	170	29.0
70–100% (Excellent)	146	25.0

‡ Mean ± SD (standard deviation are also reported).

4. Discussions

This study aimed to investigate the association between physical fitness and cognitive function of school children in both public and private primary schools in the Ho Municipality in the Volta Region of Ghana. The results showed that handgrip strength but not total physical fitness had a significant association with cognitive function among the studied population. This is an indication that, certain physical fitness components may be associated with cognitive function.

This current study observed no association between overall physical fitness score and cognitive test score although there were correlations with specific components. This could be indicative that some components of physical fitness may be more predictive of cognition function than others. Handgrip and standing board jump are both measures of musculoskeletal strength and hence is suggesting that, children with stronger muscle strength may have better cognitive abilities. Handgrip strength has been recently regarded as an early marker of nutritional status especially among youth and adults [48, 49, 50, 51]. In their study among Malaysian adolescents (age: 15 years), Ng Ak et al [52] reported a positive correlation between handgrip strength and dietary (Energy, carbohydrate and fat) intakes. It could therefore be hypothesised that, participants with stronger grips and higher cognitive ability may be better nourished. Our findings are indirectly supported by evidence from older people that also showed a positive correlation between muscle strength and nervous system processing such that, reduced muscle strength will cause delayed nervous processing, reflecting in cognitive function [53].

Our findings are at odds with some studies that linked cardiorespiratory fitness (CRF) to better cognitive functions and academic achievement [54, 55]. Although these studies function focused on the cardiopulmonary component, existing evidence suggests that other physical fitness components may affect brain function positively and in different ways [56, 57, 58]. Some theorists suggested that exercises that require specific mental processing (e.g. MF components such as agility)

Table 2. Shapiro-Wilk test of normality for selected variables.

Variable	Statistic	P value
Age	0.912	<0.0001
Sit up score	0.887	<0.0001
Forward jump score	0.959	<0.0001
Fifty metre score	0.663	<0.0001
Average handgrip score	0.951	<0.0001
All fitness score	0.968	<0.0001
Total cognitive Assessment	0.982	<0.0001

Table 3. Mean comparison of socio-demographic, school classification and physical fitness level.

Variables	Physical fitness level, Mean ± SD (SEM)									
	Sit ups	p value	Forward jump	p value	Fifty meters	p value	Handgrip	p value	All fitness	p value
Gender										
Male	3.4 ± 2.2 (0.1)	**0.012**[ǂ]	5.2 ± 2.5 (0.2)	0.502[ǂ]	8.2 ± 2.9 (0.2)	0.220[ǂ]	4.3 ± 2.0 (0.1)	**0.001**[ǂ]	20.7 ± 6.6 (0.4)	**0.007**
Female	3.0 ± 2.1 (0.1)		5.2 ± 2.2 (0.1)		8.0 ± 3.1 (0.2)		3.9 ± 1.9 (0.1)		19.6 ± 6.8 (0.4)	
Age (Years)										
8–9	3.6 ± 2.3 (0.2)	0.220[¥]	5.1 ± 2.1 (0.2)	0.229[¥]	8.2 ± 2.9 (0.3)	0.760[¥]	3.8 ± 1.6 (0.1)[a]	**0.001**[¥]	20.3 ± 6.3 (0.6)	0.423[¥]
10	3.2 ± 2.2 (0.2)		5.4 ± 2.1 (0.2)		8.0 ± 3.1 (0.2)		4.5 ± 1.7 (0.1)[a,b]		20.8 ± 6.7 (0.5)	
11–13	3.1 ± 2.0 (0.1)		5.1 ± 2.5 (0.2)		8.1 ± 3.0 (0.2)		3.9 ± 2.2 (0.1)[b]		19.6 ± 6.9 (0.4)	
School Type										
Public school	3.2 ± 2.1 (0.1)	0.244[ǂ]	5.6 ± 2.4 (0.1)	**<0.001**[ǂ]	7.7 ± 3.2 (0.2)	**<0.001**[ǂ]	4.1 ± 1.9 (0.1)	0.860[ǂ]	20.0 ± 7.0 (0.4)	0.796[ǂ]
Private school	3.4 ± 2.1 (0.1)		4.5 ± 1.9 (0.1)		8.8 ± 2.6 (0.2)		4.1 ± 2.0 (0.1)		20.2 ± 6.1 (0.4)	

Data are presented as mean ± standard deviation (standard error mean), and p value is significant at $p < 0.05$. [¥]Kruskal Wallis test and [ǂ]Mann Whitney test, Bonferroni multiple comparison showed significant mean differences between cognition test percent with same alphabets.

Table 4. Physical fitness and cognition test performance among school age children.

Physical fitness level	Total	Gender		p value	Age groups (years)			p value
		Boys	Girls		8–9	10	11–13	
		(264)	(327)		(114)	(187)	(290)	
Sit-up score				0.094				
Poor	338 (57.2)	138 (52.3)	200 (61.2)		59 (51.8)	109 (58.3)	170 (58.6)	0.135
Average	156 (26.4)	78 (29.5)	78 (23.9)		32 (28.1)	45 (24.1)	79 (27.2)	
Good	76 (12.9)	35 (13.3)	41 (12.5)		14 (12.3)	27 (14.4)	35 (12.1)	
Excellent	21 (3.6)	13 (4.9)	8 (2.4)		9 (7.9)	6 (3.2)	6 (2.1)	
Forward jump score								
Poor	145 (24.5)	69 (26.1)	76 (23.2)	0.052	21 (18.4)	34 (18.2)	90 (31.0)	**<0.001**
Average	166 (28.1)	64 (24.2)	102 (31.2)		47 (41.2)	54 (28.9)	65 (22.4)	
Good	184 (31.1)	78 (29.5)	106 (32.4)		29 (25.4)	70 (37.4)	85 (29.3)	
Excellent	96 (16.2)	53 (20.1)	43 (13.1)		17 (18.5)	29 (15.5)	50 (17.2)	
Fifty meters score								
Poor	73 (12.4)	29 (11.0)	44 (13.5)	0.674	11 (9.6)	24 (12.8)	38 (13.1)	0.810
Average	50 (8.5)	23 (8.7)	27 (8.3)		11 (9.6)	16 (8.6)	23 (7.9)	
Good	47 (8.0)	24 (9.1)	23 (7.0)		12 (10.5)	16 (8.6)	19 (6.6)	
Excellent	421 (71.2)	188 (71.2)	233 (71.3)		80 (70.2)	131 (70.1)	210 (72.4)	
Hand grip score								
Poor	222 (37.6)	79 (29.9)	143 (43.7)	**0.006**	50 (43.9)	47 (25.1)	125 (43.1)	**<0.001**
Average	221 (37.4)	109 (41.3)	112 (34.3)		47 (41.2)	85 (45.5)	89 (30.7)	
Good	130 (22.0)	68 (25.8)	62 (19.0)		15 (13.2)	52 (27.8)	63 (21.7)	
Excellent	18 (3.0)	8 (3.0)	10 (3.1)		2 (1.8)	3 (1.6)	13 (4.5)	
All fitness score								
Poor	583 (98.6)	261 (98.9)	322 (98.5)	0.664	113 (99.1)	182 (97.3)	288 (99.3)	0.362
Average	7 (1.2)	3 (1.1)	4 (1.2)		1 (0.9)	4 (2.1)	2 (0.7)	
Good	1 (0.2)	0 (0.0)	1 (0.3)		0 (0.0)	1 (0.5)	0 (0.0)	
Mean cognition score								
Cognition test percent		19.2 ± 8.1 (0.5)	18.7 ± 8.2 (0.5)	0.606[†]	18.5 ± 7.8 (0.8)	18.7 ± 7.8 (0.6)	19.3 ± 8.3 (0.5)	0.535[ǂ]
Poor		119 (45.4)	150 (46.4)	0.778	53 (46.9)	85 (46.2)	131 (45.5)	0.669
Good		74 (28.2)	96 (29.7)		36 (31.9)	56 (30.4)	78 (27.1)	
Excellent		69 (26.3)	77 (23.8)		24 (21.2)	43 (23.4)	79 (27.4)	

Data are presented as frequency (percentage), and Mean ± SD (SEM), [†]Mann Whitney and [ǂ] Kruskal-Wallis tests reported, Some cells were less than 5, Chi-square p values, Bold values are significant at $p < 0.05$. Percentiles used for fitness score categories, Poor- < 40th, Average - 40-59th, Good- 60-74.9th, Excellent- 75th percentiles and above, Cognition scores were converted to standard scores between one and ten for age and gender for physical fitness standards for Japanese children.

might be more effective triggers of global cognitive development than aerobic exercises alone [30, 33]. Likewise, there are other components of fitness such as skill related fitness, which may be stronger predictors of cognition than aerobic fitness [59]. Hence, Ruiz-Ariza et al. [57], resolved that not only cardiopulmonary fitness, but also motor coordination, speed agility and perceptual-motor skill are associated with cognitive function in adolescents. In the current study, differences in muscular strength across levels of cognition function might be attributed to changes in excitability of spinal motoneuron which induces synaptogenesis within the spinal cord, suggested by Adkins et al [60].

This study revealed that majority of the participating children (46.7%) performed poorly on the RCPM test score, scoring below fifty

Table 5. Mean comparison between physical fitness and cognition test performance.

Physical fitness	Cognition test percent Mean ± SD (SEM)			p value
	Poor (less than 50)	Good (50–69)	Excellent (≥70)	
Sit ups	3.1 ± 2.2 (0.1)	3.3 ± 2.1 (0.2)	3.3 ± 2.1 (0.2)	0.508
Forward jump	4.9 ± 2.3 (0.1)	5.3 ± 2.2 (0.2)	5.5 ± 2.3 (0.2)	**0.044**
Fifty meters	8.3 ± 2.8 (0.2)	8.1 ± 3.0 (0.2)	7.7 ± 3.4 (0.3)	0.314
Handgrip	3.8 ± 1.9 (0.1)[a,b]	4.3 ± 2.0 (0.2)[a]	4.3 ± 1.9 (0.2)[b]	**0.005**
All fitness	19.8 ± 6.9 (0.4)	20.6 ± 6.1 (0.5)	20.2 ± 6.8 (0.6)	0.402

Data are presented as mean ± standard deviation (standard error mean), and p value is significant at $p < 0.05$. Bonferroni multiple comparison showed significant mean differences between cognition test percent with same alphabets (handgrip: a: p value = 0.019, b: p value = 0.027). The flexibility test was not included as all the participants scored low for it.

Table 6. Correlation between physical fitness scores and cognition test scores.

Variable	Handgrip	Sit ups	Forward Jump	Fifty meters run	All fitness
Cognition scores	0.1 32 (**0.026**)	0.071 (0.231)	0.081 (0.174)	-0.065 (0.271)	0.046 (0.438)

Adjusted for age and gender, Data is presented as correlation coefficient, r (p value), P value is significant at $p < 0.05$. The flexibility test was not included as all the participants scored low for it.

Table 7. Multinomial regression predicting cognitive test performance.

Variable	Poor cognition			Good Cognition		
	AOR	(95%CI)	P value	AOR	(95%CI)	P value
Age group (years)						
8–9	0.7	(0.5–1.2)	0.276	0.7	(0.4–1.2)	0.225
10	0.9	(0.5–1.8)	0.841	1.0	(0.5–1.9)	0.935
11–13	Reference					
Gender						
Boys	1.0	(0.6–1.5)	0.921	0.9	(0.6–1.4)	0.662
Girls	Reference					
Sit-ups						
Poor	0.4	(0.1–1.7)	0.196	0.4	(0.1–2.1)	0.285
Average	0.4	(0.1–1.6)	0.178	0.4	(0.1–1.9)	0.238
Good	0.3	(0.1–1.3)	0.102	0.4	(0.1–2.3)	0.333
Excellent	Reference					
Forward jump						
Poor	1.5	(0.7–3.1)	0.281	0.9	(0.4–2.1)	0.883
Average	1.6	(0.8–3.0)	0.212	1.6	(0.8–3.1)	0.218
Good	1.5		0.207	1.0	(0.5–1.9)	0.933
Excellent	Reference					
50 m run						
Poor	0.5	(0.3–0.9)	**0.017**	0.6	(0.3–1.1)	0.111
Average	0.8	(0.4–1.9)	0.671	1.4	(0.6–3.0)	0.445
Good	1.7	(0.7–4.1)	0.269	2.0	(0.8–5.2)	0.144
Excellent	Reference					
Handgrip						
Poor	1.5	(0.3–6.9)	0.568	0.4	(0.1–1.7)	0.23
Average	0.8	(0.2–3.7)	0.835	0.3	(0.1–1.3)	0.106
Good	0.8	(0.2–3.8)	0.824	0.3	(0.1–1.4)	0.127
Excellent	Reference					
All fitness score						
Poor	0	0	0.998	1.1	(0.1–15.7)	0.935
Average	0	0	0.998	0.1	(0.1–1.1)	0.979
Good	Reference					

Adjusted for school type. Reference category: Excellent cognition test score, AOR- Adjusted odds ratio P value is significant at $p < 0.05$.

(50%) percent. This contradicts previous finding by Annan et al. [61], who found close to a third (63.8%) of school children in the Kumasi Metropolis scoring above average percent (50%) of the RCPM test score. It is however still unclear whether this sample is at odds with general population, as there is no populational data on cognitive ability to compare the results of the current study with. This therefore is an indication that, interventions are needed to help improve the cognitive function of children and thus, possible proxies to achieving this such as being physically fit, needs to be explored to better understand their effects so that maximum benefits may be attained from them.

On account of physical fitness, majority (98.6%) of participant children performed poorly with only 0.2% performing good and none performing excellent. This is surprising as majority (90.7%) of the participants reported engaging in physical activity. Possible explanations might be as follows. Primarily, that the other determinants of physical fitness are much stronger than physical activity in determining physical fitness, and secondarily, that there was bias in the reporting of engagement in physical activity by the children. Whatever the reasons maybe, the data indicate that the total physical fitness levels of the participants are alarming and hence interventions must be put in place at both the schools and homes to improve the physical fitness of these children. This should be done with urgency especially at these younger ages before the children enter adulthood. The deleterious effects of low fitness levels on adult health would thus be prevented.

The current study addressed limitations of previous studies [43, 44] by investigating effects of age and sex on the link between cognition and physical fitness. The current study found that boys were generally more physically fit than their female counterparts. This finding is in line with many other studies [62, 63, 64, 65, 66]. Variances in haematological markers and ventricular chamber sizes have been debated to justify the differences in fitness levels among the sexes [66, 67]. Annan *et al.* [68], (2020), however found the contrast of these results when their study conducted among 438 pupils (boys = 213; girls = 225) attending government-owned primary schools in Kumasi found girls to be fitter than boys. Authors argued that females in their research reportedly engaged in more physical activity compared to males, which might have led to their higher results in physical fitness tests. It should however be noted that, the performance on individual fitness tests components, varies across the sexes [69, 70, 71, 72]. More specifically, Santos et al. [73] reported that 10- to 12-year-old boys performed better than girls of the same age in muscle endurance (i.e., curl-ups, push-ups endurance) and (i.e., 20-m shuttle run), while girls outperformed boys in flexibility (i.e., modified back-saver sit-and-reach) than boys. Furthermore, Roriz De Oliveira et al. [70] found that 6 to 10-year-old boys attained better results in muscular power (i.e., SLJ-test), speed (i.e., 50-yard dash), agility (i.e., 4 × 10-m shuttle run), isometric voluntary muscle strength (i.e., HGS-test), and endurance (i.e., 1-mile run/walk) while girls performed better in the flexibility test (i.e., sit-and-reach). Reasons have been given to these differences. Martin & Malina [74] attributed the better performance in agility of boys compared to girls to their (boys) higher absolute and relative (i.e., in relation to body mass and fat-free mass) anaerobic power values achieved through the 30-s Wingate Anaerobic Test. Better flexibility in girls might be explained by a greater percentage of body fat and a lower percentage of muscle mass because of increased circulating levels of oestrogens or lower circulating levels of androgens in girls compared to boys, resulting in lower tissue density in girls [75]. In this current study, males performed better in sit ups and handgrip than girls. This occurrence can be attributed to a higher percentage of muscle in the males than females, hence, a better muscular strength.

5. Conclusions

Although handgrip strength (measuring muscular strength) was significantly associated with cognitive function, this study found no significant association between overall physical fitness and cognitive function among primary school children aged 8–13 years in the Ho Municipality. This is an indication that only some components of physical fitness may be associated with cognitive function. Majority of the children performed poorly both in cognition function test and in the physical fitness tests. Boys were generally fitter than girls. Reported engagement in physical activity was high among the study subjects. Further studies are required to understand better the association between cognition and physical fitness and among school-aged children.

6. Limitations

The physical fitness tests and standards for scoring were based on those of Japanese children. We recognise the lack of standards for Ghanaian children and the fact that there has been no validation of the tests in Ghanaian children. Moreover, the overall fitness score from the Japanese standards is determined from 8 fitness tests, while our study involved 5 tests, as we did not have the resources to include the other 3 tests. However, our overall score generated from 5 tests were used as continuous variables so that higher score signified better performance. Also, the categories for fitness were also determined from percentiles of the performance of our sample. The Japanese standards allowed us to determine scores for the children which we have used as continuous variables and percentile to compare the children in our study. We have not compared our children with Japanese children, neither have we made any assertions as to whether our children are fitter or less than the Japanese children. An observation from our data that could also be a possible limitation to the study is the high proportion of physically unfit children realised from the data and based on our cut-offs in this study. This occurrence could possibly be the reason why we did not find association between cognition and physical fitness in this study considering our hypothesis that, physical fitness has an effect on cognition.

Declarations

Author contribution statement

P. C. A. Amenya: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

R. A. Annan: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

C. Apprey: Performed the experiments; Wrote the paper.

D. E. Kpewou: Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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