The Relationship between Non-Verbal Intelligence and the Level of Physical Fitness among Primary School Age Children from 7 to 11 years old

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Abstract

The aim of this study was to evaluate the relationship between the non-verbal intelligence (IQ) and the level of physical fitness among primary school age children from 7-11 years old. Participants were primary school aged-children (n = 237; 112 boys and 125 girls ranging in age from 7 to 11 years old (n= 148 from 7 to 9 years old; n= 79 from 10 to 11 years old). The data were collected by using the German motor test and the Non-Verbal Intelligence. The results showed a better physical and mental (i.e., IQ) performance for children aged between 10-11 years old. The mental performance according to month's age showed typical age development comparing to the range of real age for tested children. The correlation was found between the mental test degree and the mental age with the majorities of the physical fitness items. The children how have better physical fitness levels performed better in the mental test. The level of IQ was correlated with coordinative ability (BB and JS) with r=0.13 and 0.16 respectively. These results demonstrated the important of developing the physical fitness levels during childhood at the school and the impact of this development on the level of mental performance and academic achievement in particular.

Keywords: Mental Ability, Physical Ability, Child Development

Introduction

Currently, the world health organization proposes that higher levels of physical activity in school-aged children are associated with important short- and long-term health benefits in physical, emotional, social, and cognitive domains across the life span (WHO, 2017). Therefore, increased physical activity may provide motor and cognitive benefits across childhood and adolescence (Riethmuller, 2009 & Fisher, 2011). In addition, having a better understanding of physical activity's potential in improving physical and cognition abilities among children is vital and efficient for any intervention strategy.

Non-verbal behaviour is defined as a communication without the use of spoken words. It's include the use of facial expressions, body movements, posture or gestures, vocal qualities, the use of time, space, and even smell. Under non-verbal communication, some other patterns were used. For example, emotive, team work, supportive, imaginative, purposive, and balanced communication using speech, body, and pictures all have been effective in students' learning and academic success (Bambaeeroo and Shokrpour, 2017). A significant number of children enter primary education with reduced levels of proficiency in oral language (Chaney, 1994; Locke, et al 2002; Whitehurst, 1997); some of these children will have difficulties that endure into adolescence and adulthood (Beitchman, et al., 1996; Botting, et al., 2001).

The importance of language and communication for later academic achievement and health and well-being is now well-established. Oral language development is central to a child's ability to access the curriculum and develop literacy skills (Bowman, et al., 2000; Muter et al., 2004). Language ability at ages three and four predicts later reading comprehension through secondary school (NICHD, 2005; Verhoven et al., 2011), and later language ability builds directly on earlier competencies in oral language. Children whose oral language is compromised through disadvantage or specific language learning difficulties are, therefore, at risk of literacy difficulties and academic failure (Bishop & Snowling, 2004; Conti-Ramsden, 2008; Dockrell, et al., 2011; Snow et al., 1998).

The use of IQ scores has become relatively common place within the research practices of speech-language pathology. From a clinical standpoint, speech-language pathologists in the public schools are often encouraged to consider IQ when making decisions regarding treatment eligibility (Casby, 1992; Whitmire, 2000). One distinction across IQ measures that appears particularly relevant to the field of speech language pathology is whether the measure of interest is considered verbal or nonverbal in nature. Nonverbal intelligence tests were designed to measure general cognition without the confound of language ability.

Actually, the development in sport education might be misleading and it was already suggested by a number of recent cross- sectional studies showing improved cognitive function with enhanced physical fitness (Hillman et al., 2009; Pontifex et al., 2011; Voss et al., 2011; Chaddock et al., 2012). In the sport research field, previous studies have examined the positive effects of physical activity on intelligence and brain development using various intelligence measurements such as MRI (Magnetic Resonance Imaging), memory test, concentration test, and cognition test (Colcombe et al., 2006; Zervas et al., 1991; Budde et al., 2008; Kwok et al., 2011).

Currently, children are sedentary for significant portion of the day (Narelle et al., 2013). Since childhood is regarded as an important period of motor and cognitive development, understanding the effects of physical fitness on cognitive and mental development among children has major public health implications.

Aim of Research

This study is aiming to evaluate the relationship between the non-verbal intelligence (IQ) and the level of physical fitness among primary school age children from 7-11 years old.

Methods

2.1 Participants and setting

Participants were primary school aged-children (n = 237; 112 boys and 125 girls ranging in age from 7 to 11 years old (n= 148 from 7 to 9 years old; n= 79 from 10 to 11 years old). The data were collected in 2015 in three public primary schools in the city of Mansoura in Egypt.

The measurement of physical fitness tests, body height, body weight, and body mass index (BMI) were carefully supervised inside the school gym (Abdelkarim et al, 2017a & 2017b). The measurement of mental test was administrated inside the classroom under the supervision of the original school teachers. A well-test environment was considered during the test implementation.

2.2 Test description

The German motor test DMT (Bös, 2009) is targeted for the children ages of 6-18. This test is used to assess physical fitness, including endurance, strength, speed, coordination, flexibility and indicate general motor performance ability (MPA) (Lämmle et al., 2010).

The non- language mental test for mental ability (Terman et al., 1967) is prepared by Dr. Attia Mhany Dep. of Health Psychology at Ain Shams University, Egypt in (1980). This test aims to measure the intelligence of children for the purposes of educational and vocational guidance for ages (5-15) years. This test is based on the definition of intelligence as the ability to abstract thinking measured by the understanding of relations between symbols such as antithesis, similarity, part to all, all to part, and relational relationships. The test consists of (60) questions, in each question there are five different pictures. The examiner has to put a mark under the picture that is different from the rest of the other pictures in each question. This test has been prepared for the testing of time-scales in which the IQ ratio can be calculated. The author found a good test-retest reliability coefficients for the motor and mental tests (r_{min}=0.68 to r_{max}=0.94 and r_{min}=0.56 to r_{max}=0.74, respectively).

2.3 Statistical analyses

All statistical tests were processed using SPSS Software (Version 23). Values were expressed as mean ± SD. Normality was confirmed using the Shapiro-Wilks W-Test. The sample was divided in 2 gender groups (boys and girls) and 32 age groups (7-9 years and 10-

11 years). The effect of gender and age group were analyzed using an independent t-test. The correlations between anthropometric, motor, and mental data were assessed by Pearson product-moment correlation. Significance was set as $p < 0.05$.

Results

Regarding the gender effect, statistical analysis (Table1) showed no significant difference between girls and boys in the anthropometric parameters ($p>0.05$). However, for the mental test (Table 1) and fitness tests (Table 2) a significant difference was found for months age ($p<0.05$), and the majority of physical fitness items with $p<0.01$ for JS and $p<0.001$ for 20 m sprint, JS, PU, Sit UP, LJ and 6min run test. These results indicated a better performance for boys than girls.

Results in (table 3) show a significant correlations were found between the majority of the physical fitness items and the age with $p<0.001$ for the sprint, JS, PU, Sit UP and LJ tests (i.e., $r=-0.52$, $r=0.40$, $r=0.23$, $r=0.32$, and $r=0.44$ respectively) and $p<0.05$ for the 6 min run tests (i.e., $r=0.16$). Concerning the relationship between the physical fitness items and the anthropometric data, Height was correlated with the majority of parameters (sprint, JS, PU, SU, LJ) with $p<0.001$, while Weight and BMI were correlated only to some of these parameters with $p<0.01$ for Weight and $p<0.05$ for BMI.

With regard to the mental performance; the age was significantly correlated with the month age ($p<0.001$, $r=0.83$) and the IQ ($p<0.001$, $r=-0.24$); Height was significantly correlated with the test degree ($p<0.01$, $r=0.20$), the mental age ($p<0.001$, $r=0.23$) and the months age ($p<0.001$, $r=0.56$); Weight was correlated with Mental age ($p<0.05$, $r=0.41$) and Months age ($p<0.001$, $r=0.41$); and BMI was only correlated with months age with $p<0.001$ and $r=0.22$.

Regarding the relationship between the physical and mental performance (Table 4), Pearson correlation found that the test degree and the mental age were correlated with the majorities of the physical fitness items (i.e., Sprint, BB, JS, PU, LJ and 6min run test) with (i) $p<0.05$ for correlation between mental test degree and Sprint ($r=-0.15$), BB ($r=0.16$) and PU ($r=0.14$) and correlation between mental age and PU ($r=0.16$) (ii) $p<0.01$ for correlation between mental test degree and LJ ($r=0.2$) and 6min run test ($r=0.17$) and correlation between mental age and Sprint ($r=-0.17$), BB ($r=0.16$), 6min run test ($r=0.17$) and (iii) $p<0.001$ for correlation between Test Degree and JS ($r=0.28$) and for correlation between mental age and JS ($r=0.31$) and LJ ($r=0.22$). However IQ was only correlated with BB and JS with $r=0.13$ and 0.16 respectively.

Table 1: Effect of gender and age on the anthropometric parameters and the mental abilities for children

	Anthropometric parameters (n=237)			Mental performance (n=237)			
	Height	**Weight**	**BMI**	**Test Degree**	**Mental age**	**Months Age**	**IQ**
Boys (n=112)	1,36 ±0,09	35,39 ±9,98	18,78 ±3,46	27,36 ±7,50	128,15 ±36,70	109,75 ±12,35*	119,20 ±36,37
Girls (n=125)	1,38 ±0,10	35,95 ±11,33	18,64 ±3,55	28,00 ±5,96	130,41 ±30,66	110,82 ±16,12	119,60±28,03
7-9 Years (n=148)	1,33 ±0,08$^{\$\$\$}$	31,65 ±6,57$^{\$\$\$}$	17,81 ±2,76$^{\$\$\$}$	27,96 ±7,24	129,76 ±36,29	102,95 ±12,1$^{\$\$\$}$	125,68 ±33,86$^{\$\$\$}$
10-11 Years (n=79)	1,43 ±0,11	42,42 ±12,71	20,21 ±4,06	29,26 ±5,79	134,65 ±28,74	122,68 ±8,68	136,73 ±25,18

* represent significant difference between gender with p<0.05; $^{\$\$\$}$ represent significant difference between age groups with p<0.001. Values are represented as mean ± SD

Table 2: Effect of gender and age on the motor abilities for children

	MotorAbilities (n=237)							
	Sprint	**BB**	**JS**	**Flexibility**	**PU**	**Sit UP**	**LJ**	**6min**
Boys (n=112)	4,75 ±0,51***	23,21 ±10,49	25,35 ±7,28**	-5,22±5,81	11,95 ±3,95***	16,79 ±6,54***	112,16 ±23,47***	886,44 ±186,8***
Girls (n=125)	5,10±0,56	24,62 ±9,88	22,87 ±5,55	-5,27±5,98	9,97 ±3,55	12,94 ±6,27	100,69 ±20,39	790,40 ±156,8
7-9 Years (n=148)	5,12 ±0,47$^{\$\$\$}$	23,98 ±10,21	22,55 ±5,79$^{\$\$\$}$	-5,71±5,9	10,34 ±3,71$^{\$\$}$	13,33 ±5,99$^{\$\$\$}$	99,86 ±18,97$^{\$\$\$}$	816.65 ± 164,6 $^{\$}$
10-11 Years (n=79)	4,61 ±0,57	23,91 ±10,19	26,53 ±6,96	-4,48±6,30	11,83 ±3,97	17,13 ±7,07	116,49 ±24,36	867.61 ± 194,9

** represent significant difference between gender with p<0.01; *** represent significant difference between gender with p<0.01; $^{\$}$represent significant difference between age groups with p<0.05; $^{\$\$}$represent significant difference between age groups with p<0.01; $^{\$\$\$}$represent significant difference between age groups with p<0.001. Values are represented as mean ± SD

Table 3: Associations of motor and mental abilities with the age and the anthropometric children's parameters

	Age (n=237)		**Height (n=237)**		**Weight (n=237)**		**BMI (n=237)**	
	p	**r**	**P**	**R**	**P**	**R**	**P**	**R**
Motor Abilities								
Sprint	p<0,001	r = -0.52	p<0,001	r = -0.44	p<0,001	r = -0.31	p<0,05	r = -0.13
BB	p>0,05	----------	p>0,05	---------	p>0,05	--------	p<0,01	r = -0.19
JS	p<0,001	r = 0.40	p<0,001	r = 0.40	p<0,001	r = 0.31	p<0,05	r = 0.16
Flexibility	p>0,05	----------	P>0,05	---------	p>0,05	--------	p>0,05	--------
PU	p<0,001	r = 0.23	p<0,001	r = 0.25	p<0,001	r = 0.21	p>0,05	--------
Sit Up	p<0,001	r = 0.32	p<0,001	r = 0.26	p>0,05	--------	p>0,05	--------
LJ	p<0,001	r = 0.44	p<0,001	r = 0.41	p<0,01	r = 0.19	p>0,05	--------
6 min	p<0,05	r = 0.16	P>0,05	---------	p>0,05	--------	p<0,05	r = 0.14
Mental Abilities								
Test Degree	p>0,05	----------	p<0,01	r = 0.20	P>0,05	---------	P>0,05	---------
Mental Age	p>0,05	----------	p<0,001	r = 0.23	p<0,05	r = 0.14	P>0,05	---------
Months Age	p<0,001	r = 0.83	p<0,001	r = 0.56	p<0,001	r = 0.41	p<0,001	r = 0.22
IQ	p<0,001	r = -0.24	P>0,05	---------	P>0,05	---------	P>0,05	---------

The tested abilities were (Sprint in "s", LJ in "cm", 6min in "m" and BB, JS, PU, Sit UP in "pts") for motor abilities and (Test Degree, Mental Age, Months Age and IQ in "pts") for cognitive abilities.

Table 4: Associations between motor and mental abilities

Mental Abilities	**Test Degree (n=237)**		**Mental Age (n=237)**		**Months Age (n=237)**		**IQ (n=237)**	
	p	**R**	**P**	**R**	**P**	**R**	**P**	**R**
Motor Abilities								
Sprint	p<0,05	r= -0.15	p<0, 01	r= -0.17	p<0, 001	r= -0.39	p>0,05	---------
BB	p<0,05	r= 0.16	p<0, 01	r= 0.16	p>0,05	---------	p<0,05	r= 0.13
JS	p<0,001	r= 0.28	p<0, 001	r= 0.31	p<0, 001	r= 0.30	p<0,05	r= 0.16
Flexibility	p>0,05	---------	p>0,05	---------	p>0,05	---------	p>0,05	---------
PU	p<0,05	r= 0.14	p<0, 05	r= 0.16	p<0, 05	r= 0.16	p>0,05	---------
Sit Up	p>0,05	---------	p>0,05	---------	p<0, 01	r= 0.21	p>0,05	---------
LJ	p<0,01	r= 0.20	p<0,001	r= 0.22	p<0, 001	r= 0.40	p>0,05	---------
6 min	p<0, 01	r= 0.17	p<0,01	r= 0.17	p>0,05	---------	p>0,05	---------

The tested abilities were (Sprint in "s", LJ in "cm", 6min in "m" and BB, JS, PU, Sit UP in "pts") for motor abilities and (Test Degree, Mental Age, Months Age and IQ in "pts") for cognitive abilities.

Discussion:

The primary aim of this study was to evaluate the relationship between the non-verbal intelligence (IQ) and the level of physical fitness among primary school age children from 7-11 years old. In this context, the overall results demonstrated a clearly correlation between physical and mental performances. The children how have better physical fitness levels performed better in the mental test. The level of IQ was only correlated with coordinative ability (BB and JS) which is information-oriented ability (Lämmle et al., 2010).

These results confirm the fact that physical fitness is an important predictor of physical and psychological health in children (Ortega et al., 2008; Parfitt et al., 2009). Recent studies demonstrate that children who display high levels of health-related fitness (HRF) (e.g. cardiorespiratory fitness, muscular fitness, and body composition), have a decreased risk of developing cardiovascular disease and other chronic illnesses (McMurray and Anderson, 2010), and are more likely to perform better academically at school (Grissom, 2005; Van Dusen et al., 2011).

Regarding the age and gender factors, the overall performance was better for boys than girls in the level of physical fitness. These results explain that boys are favor for energetic abilities (speed, strength, and endurance) based on stronger muscles performance comparing to girls in the test items such like 20 m sprint, JS, PU, Sit UP, LJ and 6min run. On the other hand, the overall performance in mental test was better for girls than boys with no significant differences. However, for age factor the results indicate better physical and mental (i.e., IQ) performance for children aged between 10-11 years old. The mental performance according to month's age showed typical age development comparing to the real age of the tested children.

These results demonstrated that children need an improvement for their cognitive functions which will reflect positively on their academic achievement. This improvement requires the use of modern teaching methodology such like active learning. In addition, we can recommend the important of developing the physical fitness levels during school sport and the impact of this development on the level of mental performance and academic achievement in particular. This explanation meet some other founding demonstrated the positive of fitness training during childhood period. It helps also for social inclusion by developing their communication skills.

For example, Corder et al., (1966) found that complex fitness training during a 20-day program increased children's intelligence test scores (i.e., Wechsler Intelligence Scale for Children) by analyzing 24 children aged 12–16 years old. Zervas et al., (1991) concluded that aerobic exercise significantly increased cognition among 26 children aged 11–14 years old. Ji-ying's study (2000) indicated that the Intelligence Quotient (IQ) score increased following a six-month gymnastics training program among 186 children aged 4–7 years old. Budde, et al. (2008) found that complex physical training programs increased concentration by stimulating brain function among 99 children aged 13–16 years old.

Previous studies have demonstrated an association between physical activity, aerobic fitness, and anterior prefrontal brain function involved in goal maintenance across the lifespan

(Voss et al., 2010, 2011; Kamijo et al., 2011). In children, a cross-sectional fMRI study by Voss et al. (2011) demonstrated that higher fit children showed less activation in a network of brain regions including the anterior prefrontal cortex, coupled with better flanker task performance, relative to lower fit children. An ERP study by Kamijo et al. (2011) also demonstrated that children involved in a physical activity intervention showed larger amplitudes over the frontal scalp regions in the contingent negative variation (CNV), an ERP component known to play a role in cognitive preparation and task maintenance, as well as better working memory performance.

By improving the working memory the academic achievement will be also improved. Some previous studies observed significant changes in language and academic achievement after 8-month treatment (Bernett et al., 2008), one found improvements in cognitive functions test after 10 weeks (Fisher et al., 2011), and two showed increased learning and working memory following a 4-week intervention (Mavilidi et al., 2015, 2017). Three studies involved task-relevant physical activities (Bernett et al., 2008; Mavilidi et al., 2017) while one used aerobically intense physical education (2 hours/week × 10 weeks) (Mavilidi et al., 2015).

Conclusion

The relationship between the physical and mental performance among children has been statistically found with favor correlation between the level of intelligence (IQ) and the information oriented abilities (coordination ability). This correlation is not affected by age or gender factors during primary school age. The developing of the physical fitness levels during childhood could has a positive impact on the level of mental performance and the academic achievement in particular.

Recommendation

The present study suggests that studies with large scales samples are needed to clarify the relationship between improving the physical fitness and the development of the brain and cognition function during childhood. In addition, a longitudinal studies are also needed to evaluate the developmental changes on the level of physical and mental functions across childhood with focusing on the effect of the school system and the PE curriculum in particular. Moreover, we should raise the awareness of the mental benefits of being active and encourage participation in a multicomponent physical activity program such as physical education, classroom activity breaks, and active transport to school.

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