MLS - SPORT RESEARCH

https://www.mlsjournals.com/Sport-Research

ISSN: 2792-7156

How to cite this article:

Sánchez Boyano, J. M. & Berrios Aguayo, B. (2022). Association between cardiorespiratory resistance and intellectual maturity in primary school children: educational implications. *MLS Sport Research, 2*(1), 58-71 . doi: 10.54716/mlssr.v2i1.1349

ASSOCIATION BETWEEN CARDIORESPIRATORY RESISTANCE AND INTELLECTUAL MATURITY IN PRIMARY SCHOOL CHILDREN: EDUCATIONAL IMPLICATIONS

Juan Miguel Sánchez Boyano
Colegio San Vicente de Paul (España)
juanmiguel@colegiosanvicente.org · https://orcid.org/0000-0002-0820-1478
Beatriz Berrios Aguayo
Universidad de Jaén (España)
bberrios@ujaen.es · https://orcid.org/0000-0002-3791-2906

Abstract. Objective. This study analysed the relation between 10-12-year-old student´s cardiorespiratory resistance and their intellectual maturity as indicator to improve the academic performance. Method. Data were collected from primary education schools in Spain. A total of 150 children in 5th and 6th grades (age = 10.72 ± 1.25 years of age) participated. The Leger test measured cardiorespiratory fitness, the Goodenough-Harris Drawing test assessed intellectual maturity and the school grades the academic performance. Results. Significant differences were found between the genders; boys showed greater cardiorespiratory endurance. However, there were no significant genders differences in mental age. Children with better aerobic endurance physical scores scored better on the Goodenough-Harris Drawing test. In turn, intellectual maturity turned out to be a solid indicator of academic performance. Conclusions. There is a relationship between intellectual maturity and cardiorespiratory endurance in children in the third cycle of primary education, which is relevant to health and academic performance.

Key words: Cognitive development, academic performance, educational achievement physical conditioning, health education, primary education

ASOCIACIÓN ENTRE RESISTENCIA CARDIORRESPIRATORIA Y MADUREZ INTELECTUAL EN NIÑOS DE ESCUELA PRIMARIA: IMPLICACIONES EDUCATIVAS

Resumen. Objetivo. Este estudio analizó la relación entre la resistencia cardiorrespiratoria de estudiantes de 10 a 12 años y su madurez intelectual como indicador para mejorar el rendimiento académico. Método. Los datos se recogieron de centros de Educación Primaria de España. Participaron un total de 150 niños de 5° y 6° grado (edad = 10,72 ± 1,25 años). La prueba de Leger midió la aptitud cardiorrespiratoria, la prueba de dibujo de Goodenough-Harris evaluó la madurez intelectual y las calificaciones escolares el rendimiento académico. Resultados. Se encontraron diferencias significativas entre los géneros; los chicos mostraron mayor resistencia cardiorrespiratoria. Sin embargo, no hubo diferencias significativas de género en la edad mental. Los niños con mejores puntuaciones físicas de resistencia aeróbica obtuvieron mejores resultados en la prueba de dibujo de Goodenough-Harris. A su vez, la madurez intelectual resultó ser un indicador sólido del rendimiento académico. Conclusiones. Existe una relación entre la madurez intelectual y la resistencia cardiorrespiratoria en niños del tercer ciclo de Educación Primaria, lo cual es relevante para la salud y el rendimiento académico.

Palabras clave: Desarrollo cognitivo, rendimiento académico, logro educativo, acondicionamiento físico, educación para la salud, educación primaria.

Introduction

Several investigations have investigated the importance of physical activity in children's health (Boreham & Riddoch, 2001; Janssen et al., 2010). There are numerous biomarkers that determine people's health from a very young age, being physical condition one of them (Ortega, Ruiz, Castillo & Sjöström, 2008). In turn, it is possible to find a connection between body growth, physical condition (Ortega et al., 2011) and cognition (Heinonen et al., 2008). Similarly, there is a close association between motor and cognitive development, which takes place in the cerebellum and prefrontal cortex.

Children who are in good physical shape have greater cortical activation which in turn is reflected in better cognitive performance (Tomporowski, Davis, Miller & Naglieri, 2008). Haapala et al. (2015) and Aberg et al. (2009) showed that motor skills and cardiorespiratory resistance play an important role in cognitive development during childhood and young adulthood. Therefore, increasing physical fitness levels is beneficial for cognition during preadolescent development (Latorre Román, García Pinillos, Pantoja Vallejo, & Berrios Aguayo, 2017; Berrios Aguayo, Pantoja Vallejo, Latorre Román, 2019).

The analysis of children's drawings can be an important indicator of some cognitive aspects such as intellectual maturity (Pérez Testor & Pérez Testor, 2000; Loxton, Mostert, & Moffatt, 2006; Soto, Mendoza y Ramírez, 2009) or even as intelligence indicator (Mamani Ortiz, Choque Ontiveros, & Rojas Salazar, 2014). Furthermore, studying the progression of the drawings that children make over a period of time can show the level of intellectual development (Thomas & Jolley, 1998). In several investigations, children's drawings have been used to analyse cognitive and motor skills (Hasab Allah, El Adawy, Moustafa & Ali, 2012; Imuta et al., 2013; Latorre-Román, Mora-López & García-Pinillos, 2016; Soto et al., 2009). Although the association between physical fitness and cognitive functions has been investigated in various studies (Ellemberg & St-Louis-Deschênes, 2010; Gallotta et al., 2015; Janssen et al., 2014), the relationship between physical condition, mainly cardiorespiratory resistance, and intellectual maturity is unclear.

The chronological age and its relationship with the academic performance has been widely studied (Ardoy et al., 2014; Abel et al., 2016; Vergel-Ortega, Martínez-Lozano, Zafra-Tristancho, & Zafra-Tristancho, 2016). Nevertheless, the association between intellectual maturity and school performance has not got the enough attention, being it really relevant for educational implication.

Taking into account the above information, we propose the following hypothesis: children with greater cardiorespiratory resistance have an older mental age as well as a better academic performance. Therefore, the purpose of this study is to analyse the relationship between mental age and cardiorespiratory resistance in children 10-12 years old which knowledge could be useful to improve the academic performance.

Method

Participants

A total of 150 children 10-12 years old (age = 10.72 ± 1.25 years of age) participated. Demographic characteristics revealed that 81 children were male and 69 were female, and they were selected from two primary schools in southern Spain, one public and one private. Every students of those courses participated in this study except a total of five students with intellectual or physical disabilities such as a wheelchair user or an autistic person. The parents were given an explicit verbal description of the nature and purpose of the research to be carried out and consequently their informed consent was obtained. The study was conducted in compliance with the standards of the Declaration of Helsinki (2013). The study was approved by the Bioethics Committee of the University of Jaen.

Materials and testing

Anthropometric variables

Height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany) and weight with a weighing scale (Seca 899, Hamburg, Germany). Body mass index (BMI) was calculated by dividing weight (in kilograms) by height^2 (in metres).

Physical variables

Cardiorespiratory endurance was assessed using the Leger test (Leger, Mercier, Gadouryl and Lambert, 1988). In this test, the students start walking and finish running, moving from one point to another located 20 metres away and making a change in direction to the rhythm indicated by a sound signal that is accelerated progressively. The test is stopped when the participant cannot maintain the race pace, registering the last period of the test in which the individual was.

The maximum oxygen consumption (VO_2 max.) was calculated taking into account the speed that the participant reached using the following equation: VO_2 max. = (31,025) + (3,238 * X) - (3,248 * A) + (0,1536 * A * X), X = speed, A = age (Leger et al., 1988). It is another appropriate indicator of cardiorespiratory endurance (Kabiri, Mitchell, Brewer, & Ortiz, 2017).

The reliability and validity of Leger test for determining the VO2 max in children has been widely demonstrated (Liu, Plowman, & Looney, 1992; Ruiz et al., 2009).

Intellectual maturity

For the evaluation of intellectual maturity, the Goodenough-Harris Drawing Test (GHDT), developed by Goodenough (1926) and revised by Harris (1963), was used. The GHDT test indicates the cognitive ability of the student, which in turn is represented in the intellectual maturity of the child or the metal age (MA) and a final score interpreted as intellectual quotient (IQ) (Table 1).

Table 1

Conversion of crude score GHDT to MA

Ages		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
Months	**0**	-	4	8	12	16	20	24	28	32	36	40	44	48	**Scores**
	3	-	5	9	13	17	21	25	29	33	37	41	45	49	
	6	2	6	10	14	18	22	26	30	34	38	42	46	50	
	9	3	7	11	15	19	23	27	31	35	39	43	47	-	

Note: Source: Harris (1963)

The present study used the most recent edition in which the child is asked to make two drawings, one of a man and one of a woman of a whole body (Soto, Mendoza, & Ramírez, 2009). The evaluation focuses on the details and the proportion of the general body of the figure drawn from a man (73 details) and a woman (71 details). We used the average crude score of the two drawings which was the total details performed. The GHDT test was designed to evaluate both children and adolescents up to 15 years of age.

The GHDT test has several editions, all validated. The GHDT showed good reliability and validity compared to other tests of intelligence in children aged 3 to 15 (Abell, Horkheimer, & Nguyen, 1998; Plbrukarn & Theeramanoparp, 2003). The GHDT had not yet been examined from a modern test theory perspective in full. However, Campbell & Bond (2017) revealed that the GHDT and mainly the children's human figure drawings are proper according to Rasch analysis and deem to be generally psychometrically sound.

In addition, a Cohen's Kappa coefficient was calculated to determine the effect of chance. According to Sim & Wright (2005) the concordance between the measurements of two researchers in the GHDT is proper given that the Kappa value is 0.621 (Table 2) being between 0.6 and 0.8 (good concordance).

Table 2
Cohen´s Kappa coefficient

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	,621	,063	27,049	,000
N of Valid Cases		60			

Academic performance

The school grades were required of the teachers to measure the academic performance of the students. The required school grades were: Spanish Language, Maths, Natural Sciences, Social Sciences, Physical Education, Arts, Music and English Language. The school grades were presented in a range of 0-10. Finally, the average was calculated that was the score used for the statistical calculations. School grades as a reliable measure to determine academic performance, have been supported by authors such as Lambating & Allen (2002) and Allen (2005) who determine that school grades justify the student's learning objectives.

Procedure

Once the appropriate permits were obtained from the schools and the informed consent from the parents, the different tests were administered. Two separate sessions were conducted by a trained researcher. The GHDT was evaluated during the first test session, in the school classroom and in the presence of the teacher. The examiner gave the children two sheets, one to draw the man and another to draw the woman. The students were previously instructed to draw with as much detail as possible but through free draw. In the second session, the anthropometric measures (weight and height) were carried out followed by the Leger test. Before the execution of this test, a demonstration of how they should execute it was made. The children performed a typical warm-up consisting of 5 minutes of smooth running and 5 minutes of general exercises (i.e., jumping, raising the legs, side and front races, arm rotations, etc.). Each child was evaluated individually. Both physical and cognitive tests were evaluated by a previously trained researcher. Children were encouraged to achieve the highest possible performance by motivating them with a small reward such as extra credit for those classes if they participated in the study. Finally, school grades were required of the teachers to measure the academic performance.

Statistical Analysis

Data were analysed using the program SPSS (version 21, SPSS Inc., Chicago, Ill.) for Windows. The significance level was set at $p<0.05$ and $p<0.01$. The data are shown as descriptive statistics including mean, standard deviation (SD) and percentages. Tests for normal distribution and homogeneity (Kolmogorov-Smirnov & Levene's, respectively) were conducted on all data before analysis. Analysis of variance (ANOVA) was conducted for the genders comparison. Additionally, effect sizes for group differences were expressed as Cohen's *d* (Cohen, 1988); effect sizes of less than 0.4 represented a small difference, whereas effect sizes of 0.41–0.7 and greater than 0.7 represented moderate and large differences, respectively (Thomas, Silverman, & Nelson, 2015). Pearson correlation was carried out among intellectual maturity, BMI, academic performance and cardiorespiratory resistance. In addition, a scatter plot was developed between cardiorespiratory endurance and intellectual maturity with genders adjust. In the end, regression analyses were developed between intellectual maturity and academic performance.

Results

Table 3 shows the results of age, anthropometric characteristics, cardiorespiratory endurance, intellectual maturity and academic performance with gender adjust. Boys showed greater cardiorespiratory resistance than girls, but no significant differences were found in the other variables.

Table 3
Age, anthropometric characteristics, cardiorespiratory endurance, intellectual maturity, academic performance in relation to gender

	Girls Mean (SD)	Boys Mean (SD)	F	p-value	Cohen's *d*
Age (years)	10.72 (0.74)	10.67 (0.72)	0.232	0.631	0.0684
Weight (Kg)	38.74 (7.33)	41.46 (10.96)	3.06	0.082	0.2917
Height (m)	1.45 (0.80)	1.46 (0.80)	0.364	0.547	0.0125
BMI (kg/m^2)	18,17 (3,06)	19.07 (3.83)	2.45	0.120	0.2596
Leger test (number of periods)	3.13 (1.44)	3.98 (1.65)	11.113	0.001	0.5902
$V0_2$ (ml/kg/min)	43.89 (3.69)	45.95 (4.13)	10.11	0.002	0.5260
Average crude score GHDT (0-73)	35.03 (8.32)	32.64 (9.78)	2.40	0.123	0.2632
Average school grades	7.69 (1,76)	7.45 (1.85)	1.195	0,432	0,1349

Note: SD (Standard deviation); BMI (Body mass index); V02 Oxygen consumption); GDHT (Goodenough-Harris Drawing Test)

In Table 4, the intellectual maturity of the students is positively associated with cardiorespiratory resistance, specifically with VO_2max ($r = 0.415$, $p < 0.01$). In addition, BMI and intellectual maturity show a negative association (r = -0.313, p < 0.01). Regarding academic performance, it is also positively associated with the Leger test (r = 268, p < 0.01) and intellectual maturity (r = 799, p < 0.01).

Table 4

Pearson correlation between intellectual maturity, BMI, the Léger test, VO_2max and academic performance

	Intellectual maturity	BMI	Leger test	VO_2max	Academic performance
Intellectual maturity	1.000	-0.313**	0.410**	0.415**	0.799**
BMI		1.000	-0.436**	-0.422**	-0.120
Léger test			1.000	0.983**	0.268**
VO_2max.				1.000	0,067
Academic performance					1.000

Note: BMI (Body Mass Index); V02max (maximum oxygen consumption); GDHT (Goodenough-Harris Drawing Test). ** p <0.05

Figure 1 shows the scatter plot between intellectual maturity and VO2max according to gender. As the cardiorespiratory endurance of the students increases, their intellectual maturity increases.

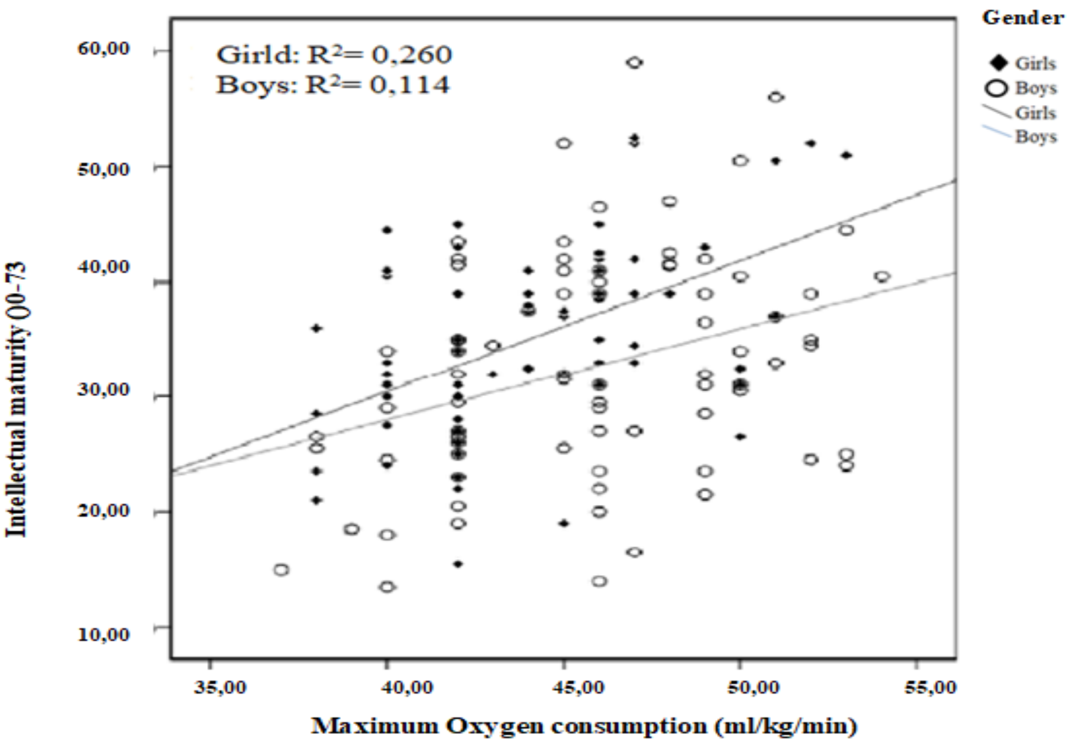

Figure 1. Dispersion figure between intellectual maturity and VO2max adjusted by gender

The intellectual maturity is a good indicator of academic performance in children of school age. For this, the linear regression model (Table 5) shows that intellectual maturity is positive predictor of academic performance (R^2=0.638, p<0.05).

Table 5
Multiple linear regressions between intellectual maturity and academic performance

	B	T	p-value	95% cofidence interval	
				Higher limit	Lower limit
Academic performance	2,861	16.139	0.000	0.125	0.160
Intellectual maturity	0,142	9.301	0.000	2.253	3.468
R^2			0.638		

Figure 2 shows the drawings of a woman and a man made by an 11-year old girl in 6th grade of primary education with high scores on the GHDT and high average school grades. Those scores agree with an appropriate VO2max according to the references of Hamlin et al. (2014). On the other hand, the drawing of another girl from the same school year with low GHDT score and low average school grades is also associated with an inappropriate VO2max.

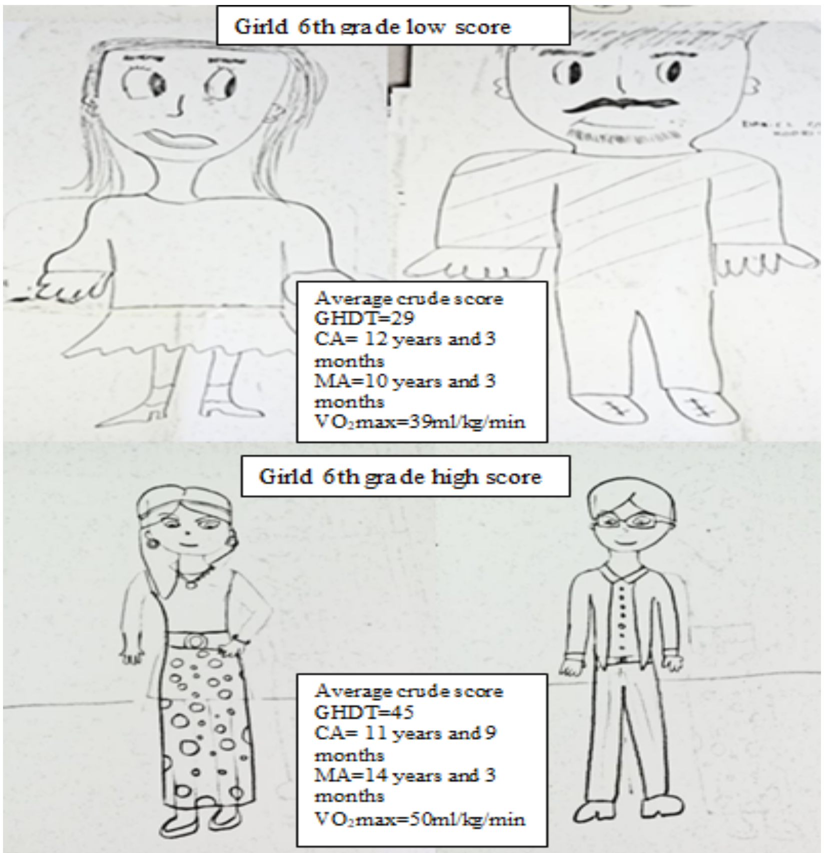

Figure 2. Drawings of girls in 6th grade of Primary Education

Note: Chronological age (CA); Mental age (MA); maximum oxygen consumption (VO2max)

Discussion

The purpose of this study was to analyse the relationship between intellectual maturity and cardiorespiratory resistance in children 10-12 years old. The main finding shows that children's intellectual maturity is associated with cardiorespiratory resistance. In addition, intellectual maturity is a predictor of academic performance.

In a similar study, Latorre et al. (2016) found significant associations between GHDT and physical fitness in preschool children; thus, from an early age, physical-motor performance and intellectual maturity are linked, being the physical fitness a good tool to determine it.

In turn, several authors have found an association between cognitive and motor development in children aged 5 to 12 years (Chaddock, Pontifex, Hillman & Kramer, 2011; Niederer et al., 2011). However, this relationship may be direct or may be affected by other factors, such as the influence of parents. Wassenberg et al. (2005) showed the parallel development of cognitive and motor-specific performance in children during normal or late development; some specific brain structures, such as the basal ganglia or frontal cortex and the transmission of dopamine, develop in parallel with some cognitive aspects. Niederer et al. (2011) found that increased cardiorespiratory fitness, motor skills and dynamic balance correspond with a better memory of spatial work and attention in school-age children. Additionally, Krombholz (2006, 2013) found positive correlations between the measures of physical growth and physical performance and between motor performance and cognitive performance, physical fitness, body coordination and manual dexterity in children, which improved with age.

On the other hand, BMI was negatively correlated with the GHDT and the cardiorespiratory fitness test. According to a study about nutritional status and intelligence quotient (IQ), a better nutritional status was associated with a higher IQ (Suvarna & Itagi, 2009). Likewise, Li et al. (2008) found that an increase in body weight is related to a reduction in the general mental ability in children. Gunstad et al. (2008) noted that high BMI is not associated with cognitive function in healthy children and adolescents. Likewise, Latorre et al. (2016) did not find a relationship between BMI and GHDT in preschool children. Therefore, the results are controversial and require more research to clarify the association between weight status and cognition in children.

According to Janssen et al. (2010), there are a myriad of not only physical but also cognitive benefits when children perform physical activity; therefore, policies that facilitate the realisation of physical activity for this population are needed. Chaddock et al. (2011) carried out a systematic review in which the importance of physical activity and cardiorespiratory capacity to maximise brain health and cognitive function during development was shown.

The pre-pubertal period offers many opportunities to stimulate cognitive function. However, the relationship between participation in PA and cognitive performance has been a subject of discussion between advocates and sceptics of physical activity, as well as parents concerned about decreases in study and homework time. Additionally, opportunities to be physically active at school are limited because of pressure to perform well academically (Mahar et al., 2006; O'Dwyer et al. 2013). However, participation in physical activity is not associated with less time dedicated to study (Jonatan R Ruiz et al., 2010). An additional curricular emphasis on PE may result in significant gains in cognitive performance. In this regard, the literature suggests that academic achievement, physical fitness and health of children will not be improved by limiting the time allocated to PE and physical activity (Trudeau & Shephard, 2008).

Academic performance and intellectual maturity have been linked according few research (Pérez, 1996; Berrios Aguayo, Latorre Román, & Pantoja Vallejo, 2017). Therefore, this is strength of our research as it demonstrates a little but relevant academic studied issue. If from an improvement of the cardiorespiratory resistance of the students their mental age is increased, this in turn would be making benefits in terms of academic performance.

A limitation of this study is its cross-sectional design, so caution should be exercised in interpreting the associations observed. More studies are needed to provide adequate evidence of causality through longitudinal records. Regarding the development of health in school, it is necessary to emphasise that there is a large connection between body growth, physical fitness and cognition. Therefore, increasing the amount of time spent in physical education can promote cognitive benefits and improve the health of school-age children.

In conclusion, from an early age cardiorespiratory endurance and mental age seem to be related. This link is a good training tool for cognitive development in children 10-12 years old.

Reference

Abel, K., Heuvelman, H., Wicks, S., Rai, D., Emsley, R., Gardner, R., & Dalman, C. (2016). Gestational age at birth and academic performance: population-based cohort study. *International Journal of Epidemiology*, *46*(1), 324-335. https://doi.org/10.1093/ije/dyw284

Abell, S. C., Horkheimer, R., & Nguyen, S. E. (1998). Intellectual evaluations of adolescents via human figure drawings: An empirical comparison of two methods. *Journal of Clinical Psychology*, *54*(6), 811–815. https://doi.org/10.1002/(SICI)1097-4679(199810)54:6<811::AID-JCLP8>3.0.CO;2-J

Aberg, M. A. I., Pedersen, N. L., Toren, K., Svartengren, M., Backstrand, B., Johnsson, T., Kuhn, H. G. (2009). Cardiovascular fitness is associated with cognition in young adulthood. *Proceedings of the National Academy of Sciences*, *106*(49), 20906–20911. https://doi.org/10.1073/pnas.0905307106

Allen, J. D. (2005). Grades as Valid Measures of Academic Achievement of Classroom Learning. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *78*(5), 218–223. https://doi.org/10.3200/TCHS.78.5.218-223

Ardoy, D. N., Fernández-Rodríguez, J. M., Jiménez-Pavón, D., Castillo, R., Ruiz, J. R., & Ortega, F. B. (2014). A Physical Education trial improves adolescents' cognitive performance and academic achievement: the EDUFIT study. *Scandinavian Journal of Medicine & Science in Sports*, *24*(1), e52–e61. https://doi.org/10.1111/sms.12093

Berrios Aguayo, B., Latorre Román, P. Á., & Pantoja Vallejo, A. (2017). Asociación entre la práctica deportiva familiar y la capacidad cognitiva del alumnado. *Revista Electrónica de Investigación Y Docencia*, 17, 79–92. https://doi.org/10.17561/reid.v0i17.2979

Berrios Aguayo, B. Pantoja Vallejo, A. & Latorre Román, P. Á. (2019). Acute effect of two different physical education classes on memory in children school-age. Cognitive

Development, 50, 98-104. https://doi.org/10.1016/j.cogdev.2019.03.004

Boreham, C., & Riddoch, C. (2001). The physical activity, fitness and health of children. *Journal of Sports Sciences*, *19*(12), 915–929. https://doi.org/10.1080/026404101317108426

Campbell, C., & Bond, T. (2017). Investigating young children's human figure drawings using Rasch analysis. *Educational Psychology*, *37*(7), 888–906. https://doi.org/10.1080/01443410.2017.1287882

Chaddock, L., Pontifex, M. B., Hillman, C. H., & Kramer, A. F. (2011a). A Review of the Relation of Aerobic Fitness and Physical Activity to Brain Structure and Function in Children. *Journal of the International Neuropsychological Society*, *17*(17), 1–11. https://doi.org/10.1017/S1355617711000567

Chaddock, L., Pontifex, M. B., Hillman, C. H., & Kramer, A. F. (2011b). A review of the relation of aerobic fitness and physical activity to brain structure and function in children. *Journal of the International Neuropsychological Society : JINS*, *17*(6), 975–85. https://doi.org/10.1017/S1355617711000567

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. *Statistical Power Analysis for the Behavioral Sciences*. https://doi.org/10.1234/12345678

Ellemberg, D., & St-Louis-Deschênes, M. (2010). The effect of acute physical exercise on cognitive function during development. *Psychology of Sport and Exercise*, *11*(2), 122–126. https://doi.org/10.1016/j.psychsport.2009.09.006

Gallotta, M. C., Emerenziani, G. P., Franciosi, E., Meucci, M., Guidetti, L., & Baldari, C. (2015). Acute physical activity and delayed attention in primary school students. *Scandinavian Journal of Medicine & Science in Sports*, *25*(3), e331-8. https://doi.org/10.1111/sms.12310

Goodenough, F. L. (1926). *Measurement of intelligence by drawings*. New York: Harcourt, Brace & World,.

Gunstad, J., Spitznagel, M. B., Paul, R. H., Cohen, R. A., Kohn, M., Luyster, F. S., … Gordon, E. (2008). Body mass index and neuropsychological function in healthy children and adolescents. *Appetite*, *50*(2–3), 246–51. https://doi.org/10.1016/j.appet.2007.07.008

Haapala, E. A., Poikkeus, A.-M., Tompuri, T., Kukkonen-Harjula, K., Leppänen, P. H. T., Lindi, V., & Lakka, T. A. (2014). Associations of motor and cardiovascular performance with academic skills in children. *Medicine and Science in Sports and Exercise*, *46*(5), 1016–24. https://doi.org/10.1249/MSS.0000000000000186

Hamlin, M. J., Fraser, M., Lizamore, C. A., Draper, N., Shearman, J. P., & Kimber, N. E. (2014). Measurement of cardiorespiratory fitness in children from two commonly used field tests after accounting for body fatness and maturity. *Journal of Human Kinetics*, *40*, 83–92. https://doi.org/10.2478/hukin-2014-0010

Harris, D. (1963). *The Goodenough Harris Drawing Test*. Harcourt Brace Javanovich.

Harris, D. B. (1963). *Children's drawings as measures of intellectual maturity*. Harcourt, Brace & World.

Hasab Allah, M. F., El Adawy, A. R., Moustafa, M. F., & Ali, H. A. (2012). Effect of Mode of Delivery on Children Intelligence Quotient at Pre-School Age in El-Minia City. *Journal of American Science*, *88*(1212), 1188–1198. http://www.jofamericanscience.org

Heinonen, K., Räikkönen, K., Pesonen, A.-K., Kajantie, E., Andersson, S., Eriksson, J. G., Lano, A. (2008). Prenatal and postnatal growth and cognitive abilities at 56 months of age: a longitudinal study of infants born at term. *Pediatrics*, *121*(5), e1325-33. https://doi.org/10.1542/peds.2007-1172

Imuta, K., Scarf, D., Pharo, H., Hayne, H., Barnes, E., Cooke, E., Nezworski, M. (2013). Drawing a Close to the Use of Human Figure Drawings as a Projective Measure of Intelligence. *PLoS ONE*, *8*(3), e58991. https://doi.org/10.1371/journal.pone.0058991

Janssen, I., LeBlanc, A. G., Janssen, I., Twisk, J., Tolfrey, K., Jones, A., Janssen, I. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 40. https://doi.org/10.1186/1479-5868-7-40

Janssen, M., Chinapaw, M. J. M., Rauh, S. P., Toussaint, H. M., van Mechelen, W., & Verhagen, E. A. L. M. (2014). A short physical activity break from cognitive tasks increases selective attention in primary school children aged 10–11. *Mental Health and Physical Activity*, *7*(3), 129–134. https://doi.org/10.1016/j.mhpa.2014.07.001

Kabiri, L. S., Mitchell, K., Brewer, W., & Ortiz, A. (2017). Muscular and Cardiorespiratory Fitness in Homeschool versus Public School Children. *Pediatric Exercise Science*, *29*(3), 371–376. https://doi.org/10.1123/pes.2017-0028

Krombholz, H. (2006). Physical performance in relation to age, sex, birth order, social class, and sports activities of preschool children [1]. *Perceptual and Motor Skills*, *102*(2), 477–484. https://doi.org/10.2466/pms.102.2.477-484

Lambating, J., & Allen, J. D. (2002). How the multiple functions of grades influence their validity and value as measures of academic achievement. In *Annual Meeting of the American Educational Research Association* (p. 32). New Orleand.

Latorre-Román, P. Á., Mora-López, D., & García-Pinillos, F. (2016). Intellectual maturity and physical fitness in preschool children. *Pediatrics International*, *58*(6), 450–455. https://doi.org/10.1111/ped.12898

Latorre Román, P. Á., García Pinillos, F., Pantoja Vallejo, A., & Berrios Aguayo, B. (2017). Creativity and physical fitness in primary school-aged children. *Pediatrics International*, 59(11), 1194-1199. https://doi.org/10.1111/ped.13391

Leger, L. A., Mercier, D., Gadouryl, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences*, *6*, 93–101.

Li, Y., Dai, Q., Jackson, J. C., & Zhang, J. (2008). Overweight is associated with decreased cognitive functioning among school-age children and adolescents. *Obesity (Silver Spring, Md.)*, *16*(8), 1809–15. https://doi.org/10.1038/oby.2008.296

Liu, N. Y.-S., Plowman, S. A., & Looney, M. A. (1992). The Reliability and Validity of the 20-Meter Shuttle Test in American Students 12 to 15 Years Old. *Research Quarterly for Exercise and Sport*, *63*(4), 360–365. https://doi.org/10.1080/02701367.1992.10608757

Loxton, H., Mostert, J., & Moffatt, D. (2006). Creening of intellectual maturity: Exploring south african preschoolers' scores on the goodenough-harris drawing test and teachers' assessment. *Perceptual and Motor Skills*, *103*(6), 515. https://doi.org/10.2466/PMS.103.6.515-525

Mahar, M. T., Murphy, S. K., Rowe, D. A., Golden, J., Shields, A. T., & Raedeke, T. D. (2006). Effects of a classroom-based program on physical activity and on-task behavior. *Medicine and Science in Sports and Exercise*, *38*(12), 2086–94. https://doi.org/10.1249/01.mss.0000235359.16685.a3

Mamani Ortiz, Y., Choque Ontiveros, M. del C., & Rojas Salazar, E. G. (2014). Nutritional status and its relationship with the IQ of children of school age. *Gaceta Médica Boliviana*, *37*(1), 6–10. http://www.scielo.org.bo/scielo.php?pid=S1012-29662014000100002&script=sci_arttext

Niederer, I., Kriemler, S., Gut, J., Hartmann, T., Schindler, C., Barral, J., & Puder, J. J. (2011). Relationship of aerobic fitness and motor skills with memory and attention in preschoolers (Ballabeina): a cross-sectional and longitudinal study. *BMC Pediatrics*, *11*, 34. https://doi.org/10.1186/1471-2431-11-34

O'Dwyer, M. V, Fairclough, S. J., Ridgers, N. D., Knowles, Z. R., Foweather, L., & Stratton, G. (2013). Effect of a school-based active play intervention on sedentary time and physical activity in preschool children. *Health Education Research*, *28*(6), 931–42. https://doi.org/10.1093/her/cyt097

Ortega, F. B., Artero, E. G., Ruiz, J. R., España-Romero, V., Jiménez-Pavón, D., Vicente-Rodriguez, G., … Castillo, M. J. (2011). Physical fitness levels among European adolescents: the HELENA study. *British Journal of Sports Medicine*, *45*(1), 20–29. https://doi.org/10.1136/bjsm.2009.062679

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. *International Journal of Obesity (2005)*, *32*(1), 1–11. https://doi.org/10.1038/sj.ijo.0803774

Pérez, V. M. O. (1996). *Factores determinantes del rendimiento académico en enseñanza media*. Colegio Oficial de Psicólogos de Madrid.

Pérez Testor, S., & Pérez Testor, C. (2000). El impacto de una clase de iniciación a la danza en la estructura del esquema corporal: Proyecto D.E.C. In *Proceedings of the 1st Jornadas de Danza e Investigación*. Murcia: Universidad de Murcia.

Plbrukarn, R., & Theeramanoparp, S. (2003). Human Figure Drawing Test:Validityin Assessing Intelligence in Children Aged 3-10 Years. *Journal of the Medical Association of Thailand*, *86*(S3), 610–617. https://www.ncbi.nlm.nih.gov/pubmed/14700157

Ruiz, J. R., Castro-Pinero, J., Artero, E. G., Ortega, F. B., Sjostrom, M., Suni, J., & Castillo, M. J. (2009). Predictive validity of health-related fitness in youth: a systematic review. *British Journal of Sports Medicine*, *43*(12), 909–923. https://doi.org/10.1136/bjsm.2008.056499

Ruiz, J. R., Ortega, F. B., Castillo, R., Martín-Matillas, M., Kwak, L., Vicente-Rodríguez, G., Moreno, L. a. (2010). Physical activity, fitness, weight status, and cognitive performance in adolescents. *The Journal of Pediatrics*, *157*(6), 917-922-e5. https://doi.org/10.1016/j.jpeds.2010.06.026

Sim, J., & Wright, C. C. (2005). The Kappa Statistic in Reliability Studies: Use, Interpretation, and Sample Size Requirements. *Physical Therapy*, *85*(3), 257–268. https://doi.org/10.1093/ptj/85.3.257

Soto, C. M., Mendoza, L. H., & Ramírez, W. G. (2009). Prueba del dibujo de una persona para estimar la habilidad intelectual para en niños, adolescentes y adultos, DAP-IQ (Reynolds y Hickman, 2004). *Revista Psicopedagogia*, *26*(79), 77–87.

Suvarna, & Itagi, S. K. (2009). Nutritional status and level of intelligence of school children*. *Karnataka Journal of Agricultura Sciences*, *22*(4), 874–876. http://14.139.155.167/test5/index.php/kjas/article/viewFile/1542/1534

Thomas, J., Silverman, S., & Nelson, J. (2015). *Research methods in physical activity, 7E*. (C. Human Kinetics, Ed.). IL.

Thomas, G. V., & Jolley, R. P. (1998). Drawing conclusions: A re-examination of empirical and conceptual bases for psychological evaluation of children from their drawings. *British Journal of Clinical Psychology*, *37*(2), 127–139. https://doi.org/10.1111/j.2044-8260.1998.tb01289.x

Tomporowski, P. D., Davis, C. L., Miller, P. H., & Naglieri, J. A. (2008). Exercise and Children's Intelligence, Cognition, and Academic Achievement. *Educational Psychology Review*, *20*(2), 111–131. https://doi.org/10.1007/s10648-007-9057-0

Trudeau, F., & Shephard, R. J. (2008). Physical education, school physical activity, school sports and academic performance. *International Journal of Behavioral Nutrition and Physical Activity*, *5*(10). https://doi.org/10.1186/1479-5868-5-10

Vergel-Ortega, M., Martínez-Lozano, J. J., Zafra-Tristancho, S. L., & Zafra-Tristancho, S. L. (2016). Factores asociados al rendimiento académico en adultos - Factors associated with academic achievement in adults. *Revista Científica*, *2*(25), 206. https://doi.org/10.14483//udistrital.jour.RC.2016.25.a4

Wassenberg, R., Feron, F. J. M., Kessels, A. G. H., Hendriksen, J. G. M., Kalff, A. C., Kroes, M., Vles, J. S. H. (2005). Relation between cognitive and motor performance in 5- to 6-year-old children: results from a large-scale cross-sectional study. *Child Development*, *76*(5), 1092–103. https://doi.org/10.1111/j.1467-8624.2005.00899.x

Fecha de recepción: 24/05/2022
Fecha de revision: 06/06/2022
Fecha de aceptación: 09/05/2022