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RESEARCH ARTICLE

RELATIONSHIP BETWEEN PHYSICAL CONDITION AND ACADEMIC ACHIEVEMENT IN ADOLESCENCE: A SYSTEMATIC REVIEW

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ABSTRACT

Objective: to research scientific evidence on the association between physical fitness components and academic performance in adolescents. **Method:** survey of studies published between July 2016 and August 10, 2019, available in electronic databases (*PsychInfo; Psychology and Behavioral Science; ERIC; Sport Discus; CINHAL and PubMed),* which related the concepts of physical condition and academic performance in adolescents. Of the 54 studies chosen, fifteen were reviewed. **Results:** It was found that most of the studies consulted follow a cross-sectional study methodology. The independent extraction of articles was carried out by two authors, using pre-defined data fields. **Conclusions:** from the fifteen studies, seven report a positive association between the components of physical fitness and academic performance and seven do not find a statistically significant relationship between physical fitness and academic performance. One study is not clear on this approach.

INTRODUCTION

The physical condition in society is a current topic and has received special attention from international organizations (eg, WHO, 2010; WHO 2017; OECD, 2017). There is also an awareness of the benefits for the brain as a result from practicing systematic physical activity, particularly at a structural level, such as changes in synaptic plasticity; neurotrophic aspects; increased blood flow and tissue oxidative capacity, which implies improvements in the cognitive functions of attention/concentration, memory and perception (Sardinha, Santos, Silva, Grentved, Andersen, & Ecklund, 2016; Soga, Kamijo& Masaki, 2017; Wassermaan *et al*., 2019). For the purpose of this research, one of the terms to be explored: physical condition or physical fitness, it can be understood as a set of skills or capabilities to perform physical activity (American college of Sports Medicine, 2016). The search for the term "*physical condition*" may appear in this systematic review associated with the parameters: physical condition; physical activity; strength; flexibility; body mass index; fat mass index; cardiorespiratory condition and also associated with the terms *physical activity* and *fitness.* The concept of academic performance, "*academicachievement*", which is also one of the concepts to be researched, according to the *Centers for Disease Control and Promotion* (2010), can be used to describe different factors that can influence student success at school. These factors are of three levels:

- Cognitive s*kills* (eg, memory; attention/concentration);
- Academic behaviours (eg, conduct, doing homework; committing oneself);
- Academic achievement (eg, results, tests, levels, grades). And it is precisely these parameters that this research focuses on. It can also appear associated with the terms academic performance ("*academic performance*") or academic results ("*academic results*"). The objective of this study is to analyse the theoretical perspectives resulting from the associations between physical condition and academic performance in a school context, during adolescence.

Santana *et al*. (2016), carried out a systematic review of the literature, where they found the existence of a strong positive association between cardiorespiratory function and academic achievement in young adolescent students, with the relationship between muscular strength and flexibility and academic achievement remaining inconclusive. The authors also argued that this evidence could inform educational strategies at state level, particularly with regard to optimizing Physical Education, with a view on promoting students' overall academic performance. Despite the relevance and relevance of the results found, a period of three years has passed since the publication of this systematic review. Hence the need for an update, in order to provide greater robustness to our research project and contribute to the consolidation of evidence in this area. That being said, the main objective of this systematic review of the literature was to update the survey of studies that analyse the relationship between physical condition and academic performance, regarding the age range of students who are part of our sample (the period between 11/12 years old and 17/18 years old); and subsequent production of a review.

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These concepts may be relevant to inform about educational strategies at state level, which is why an update of the systematic literature review was carried out by Santana, Azevedo, Cattuzzo, Hill, Andrade and Prado (2016).

METHODS

This literature review took place according to the following steps: 1 – decision on the concepts to be evaluated "*physical condition" and "academic performance*"; 2 – choice of *keywords*; 3 – selection of databases; 4 – definition of inclusion and exclusion criteria; and 5 – selection and evaluation of studies. The writing of this systematic literature review followed the PRISMA criteria (*Preferred Reporting items for Systematic Reviews and Meta- Analysis criteria*, Moher *et al*., 2015).

Study eligibility criteria: Only cross-sectional, longitudinal, and experimental studies were considered in this literature review. The inclusion criteria were the following: a) Studies with samples of children and adolescent students, aged between 11/12 and 17/18 years old; b) Studies whose samples only include young people attending education levels corresponding to the 3rd cycle, secondary education or complementary courses; c) Studies whose samples do not include students with motor, physical, cognitive "handicaps" or other health conditions; d) Studies published in English, in peer-reviewed scientific journals.

Search strategy: The strategy consisted in combination with resource to theBolean operators, from keywords: "physical condition", "physical fitness", "physical activity", "physical endurance", "cardiorespiratory fitness", "physical conditioning", "cardiorespiratory endurance"; "cardiorespiratorycondition; "muscle strength"; "flexibility"; "muscular endurance," "academic achievement", "academic performance", "academic results", "school performance", "educational status" and "attendance school". The example of a search strategy for the PUBMED/MEDLINE database is found in Appendix 5. The search was conducted electronically in the following databases: PsycInfo (accessed through EBSCO); Psychology and Behavioral Sciences (accessed through EBSCO); ERIC; SportDiscus; PubMed and CINHAL. The strategy was adapted when necessary for other databases.

Selection of primary studies: Initially, titles and abstracts of potentially relevant articles were selected. After this phase, a copy of the full text was acquired for all references that met the eligibility criteria, which were subsequently analysed by two collaborators. If they did not agree, a third reviewer would be called upon to decide. The reference lists of the full texts were also consulted, in order to identify any possible additional references to include.

Data extraction: The following data was extracted from all included articles: (a) year of publication, (b) study design, (c) country, (d) sample size, (e) age, (f) year of education, (g) variables, (h) main results, (i) notes. A data extraction form was created for this purpose (appendix 3). It should be noted that in the present analysis, the studies were first analysed descriptively and subsequently analysed according to their nature.

Assessment of the quality of articles: Regarding the evaluation of the quality of the chosen articles, we used the *checklist evaluation* by Downs and Black (1998), modified, appendix 4. Thus, the evaluation of three articles was carried out independently by different reviewers (three). The inter-observer fidelity process was carried out for the thirteen items included in the *checklist*. A percentage greater than 85% was obtained, regarding the degree of agreement, which provides good inter-observer fidelity of the respective instrument (Bellack, Kliebard, Hyman, & Smith, 1966). After assessing fidelity, the full texts chosen were evaluated.

RESULTS

Search results: A total of 3,610 articles identified in the ERIC database; PubMed; PsycINFO; Sportdiscus; Behavioral& Sciences and CINHAL, 87 titles were excluded because they were duplicates. The titles were read, and 1,409 titles were selected (2,114 titles were excluded), then selection was carried out at the abstract level, excluding 1,322 of these. Two independent reviewers were asked to read, evaluate, and select the 64 articles that reached the full text stage. Based on the eligibility criteria, 15 articles were included in this systematic review. This process is represented in the flowchart in figure 1.

Characteristics of the included studies: From a total of fifteen studies chosen, eleven had a cross-sectional design; three were longitudinal studies and one used the experimental method.

Participants: Sample sizes ranged from 52 participants (Raine *et al*., 2018), to 18,746 participants (Olivares *et al*., 2018), aged between 11/12 and 18 years old. Boys and girls were always part of the samples.

Quality of studies: Regarding the quality of the studies and according to the adapted *checklist*, based on Down & Black (1998), one article was rated Excellent; nine articles were rated Very Good; four articles were rated Good, and one article was rated Fair.

Summary of results

Areas to consider:

- The concept of *health, related* to *physical conditionfitness* and academic achievement *"academic achievement or academic performance");*
- Concentration of the evaluation criteria referenced to the evaluation in "qualitative factor - Number of positive items (yes)" (appendix 4);
- Emphasis on *Fitness*/physical behaviour and academic achievement;
- Use of computerized means regarding data collection, which is also carried out systematically.

In the current literature review, it was observed the existence of studies that point to a close relationship between physical condition, namely cardiorespiratory capacity and academic performance (eg, Castro & Oliveira, 2019; Pertrusa, Sanz-Frias, Salinero, Pérez - Gonsález& Garcia-Pastor, 2018; Raine, Biggan, Baym, Saliba, Cohen & Hilman, 2018); other investigations did not find statistically significant relationships between cardiorespiratory capacity (aerobic fitness) and academic performance (eg, Bestard, Cantallops& Vidal-Conti, 2016; Olivares &Gárcia-Rubio, 2016; Tornbeyns *et al*., 2016).

Table 1 - Description of the characteristics of studies referring to the relationship between physical condition and academic achievement in adolescents

Source and Quality of Study	Study Design	Characteristics of Participants (country, age, gender, n)	Instruments / Measurements – Physical condition	Instruments / Measures – Academic Achievement	Main Results
Tornbeyns *et al*. (2018) (11*/13**)	Belgium N = 44 of both genders (21 boys and 23 girls). Control group (13 boys and 10 girls). Intervention group (8 boys and 13 girls) Mean age – 14.3 and SD = 0.86	Experimental Study (Randomized Group)	Weight; Height; BMI; IMG; SHOVEL. Comes and goes Bicycle tables	Dutch and Mathematics Standardized Test	Aerobic fitness was significantly better in the experimental group compared to the control group. There were no significant effects on academic performance.
Esteban-Cornejo *et al*. (2017) (9*/13**)	Spain N = 1780 (boys – 917 and girls – 863).	Cross-sectional study	Weight; Height; BMI Physical activity levels (moderate and vigorous) – accelerometer	Mathematics and Language (Spanish) and Average of both subjects.	Physical activity in Physical Ed and recess were not associated with academic performance. There were no statistically significant differences in academic performance between quartiles of physical activity in Physical Education and physical activity at recess.
Cosgrove *et al*. (2018) (8*/13**)	U.S N = 397	Cross-sectional study	Fitnessgram Weight; Height; BMI; Comes and goes;	Academic performance – Averages (English; Mathematics; Science; Social Studies); Scale with percentiles Grit (short grit scale) Other information – age; sex and ethnicity.	BMI and (back-and-forth) are not associated with academic performance
Castro & Oliveira (2019) (6*/13**)	Brazil N = 326 (both genders). Aged between 15 and 18 years old	Cross-sectional study	Weight; Height; BMI; Medium strength; Flexibility; Sunny stadiometer ; Filizolaelectronic scale ; Run the mile (1609 m); AHPERD Battery	Languages and Codes, Natural Sciences and Human Sciences, through records. Satisfactory level - average equal to or greater than 6.	Low cardiorespiratory level is associated with worse academic performance. Academic performance below average (12% for boys and 8.8% for girls).
Bertrand- Valls *et al*. (2018) (10*/13**)	Spain N= 269 (140 boys and 129 girls)	Cross-sectional study	Weight; Height; BMI; Comes and goes; Back and forth (20 m);	History and Geography Average; Sciences; Mathematics; Spanish; Catalan; English and Physics Ed. Educational competencies of science associates to assess verbal and numerical skills.	The influence of cardiorespiratory capacity on academic performance is mediated by weight status in adolescence.
Martinez-López *et al*. (2019) (9*/13**)	Spain N= 2272 (1155 boys and 1175 boys). Ages between 12.5 and 14.5 years old	Cross-sectional study	Weight; Height; BMI; Back and forth (20 m – VO2 max .); Strength; Speed/agility; Manual grip;	Academic performance: Mathematics and Language – Spanish + Physical Education (from 0 to 10).	High level of cardiorespiratory fitness associated with better averages in mathematics and languages, regardless of age; Socioeconomic Status and (SES) and BMI. Strategies that aim to increase moderate and vigorous physical activity are associated with improved academic performance.

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Bastard *et al*. (2016) *10/13**	Spain N = 79 (46 boys and 33 girls)	Cross-sectional study	Weight; Height; BMI; Strength; VO2 max .	Classifications of academic achievement: 0 – 4.9 poor; 5 – 6.9 medium; 7 – 8.9 above average; 8.9 – 10 excellent	No significant relationship was found between VO2 max . and academic achievement .
Olivares *et al*. (2016) (9*/13*)	Chile N= 18,746 (9628 boys and 9118 girls)	Cross-sectional study	Weight; Height; WHR by weight/height ratio); BMI using the bio impedance process ; Superior strength; Medium strength; Extension jump; Cardiorespiratory capacity. (Fitnessgram)	Languages, Science and Mathematics (Z score). Other variables: age, sex and socioeconomic status	Fat is negatively associated with academic performance when BMI and BP are calculated independently. Fitness and strength are associated with academic performance. Cardiorespiratory fitness was not associated with academic performance if fat and other components of physical fitness are included in the model. Waist circumference and strength are more related to academic performance than BMI and cardiorespiratory capacity.
Source and Quality of Study	Study Design	Characteristics of Participants (country, age, gender, n)	Instruments / Measurements – Physical condition	Instruments / Measures – Academic Achievement	Main Results
Andersen *et al*. (2017) (11*/13**)	Denmark N= 1084 (554 boys and 530 girls)	Longitudinal study	Cycle ergometer (VO 2 Max .)	Write, read and speak oral Danish and English. Science and Mathematics – oral and written . Other variables: Ethnicity; socioeconomic status ; general health.	Physical fitness had a positive effect on the start of post-compulsory education. A substantial part of this achievement was mediated by academic performance.
Gu *et al*. (2019) (9*/13**)	U.S N= 330 (154 boys and 176 girls) Ages between 11 and 13 years old.	Cross-sectional study	Fitnessgram (2013); Motor literacy (soccer, volleyball, Frisby); Accelerometer (motor performance);	Academic behaviors; Academic achievement.	AFM and AFV and general motor competence are significantly associated with academic performance (executive function, school attendance and reading scores ($p<0.01$), but not significantly associated with Mathematics scores . Boys have higher levels of ACR and muscular adjustment than girls. No significant differences were found for motor competence, AFM and AFV and BMI in this sample. Boys are better in executive function.

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Source and Quality of Study	Study Design	Characteristics of Participants (country, age, gender, n)	Instruments / Measurements – Physical condition	Instruments / Measures – Academic Achievement	Main Results
Iri *et al*. (2018) (10*/13**)	Türkiye N = 1207 (663 boys and 544 girls)	Cross-sectional study	Sit-and-reach (flexibility); Hand grip strength; Strength test (lower limbs); Back strength tests; Physical Activity Scale;	General academic averages; Perception of academic competence; Academic perception of success.	Positive relationship between academic success and perception of academic competence in both sexes, In physical strength, boys are superior to girls and in academic success, girls are superior to boys.
Kyan *et al*. (2018) (11*/13**)	Japan N= 567 (303 boys and 264 girls) aged 12/13 years .	Longitudinal study	Weight; Height; BMI; Back and forth (20 m); 50 m run (speed); Depth jump (lower limb strength); Manual grip; Throwing a handball.	Subject average: Mathematics; Sciences; Social Studies and English. (beginning, middle and end)	No significant association between physical ability and students' average score was observed. SES does not have a negative influence on the PA/academic achievement effect. The possibility was detected that an increase in PA leads to good academic performance in high school students. More research is needed to determine the effect of sex moderation.
Source and Quality of Study	Study Design	Characteristics of Participants (country, age, gender, n)	Instruments / Measurements – Physical condition	Instruments / Measures – Academic Achievement	Main Results
Pertrusa *et al*. (2018) (11*/13**)	Spain N = 1348 (53,32% boys) Mean age 15.65 and SD = 0.97	Cross-sectional study	Fitnessgram (Welk & Meredith, 2008); Physical Activity Level Questionnaire (APACQ)	Questionnaire based on the number of subscriptions suspended in the last evaluation.	Significant differences were found between students who suspended one or more subscriptions and those who did not suspend any, in cardiorespiratory capacity (p = 0.018). Students with better academic performance have better levels of cardiovascular capacity.
Martins *et al*. (2016) (11*/13**)	Portugal N = 391 (189 boys and 202 girls). Ages between 14 and 18 years old.	Cross-sectional study	Weight; Height; BMI and Physical Activity – (distance from home to school). Accelerometer	Academic performance (Portuguese Language; Mathematics and Physical Education) values in the 3rd cycle from (1 - very poor to 5 – excellent and in secondary education from 1 – very poor to 20 – excellent) – Z score	No significant relationships were found between unidirectional or bilateral walking and total physical activity, BMI and academic performance.
Raine *et al*. (2018) (10*/13**)	United State N = 52 (25 girls and 27 boys)	Longitudinal study	Weight; Height; BMI; (Treadmill) Aerobic fitness – progressive cardiovascular resistance tests.	Illinois Academic Achievement Tests – Standards Achievements Test in Reading and Mathematics	Changes in aerobic fitness between 6th and 8th grade were positively related to changes in academic performance, reading and mathematics.

* Actual assessment *score* - referring to the assessment process obtained based on a scale adapted from Down and Black (1998).
** Maximum evaluation *score* – *maximum score* possible to obtain if all items on the scale are answered positively. (Appendix 4)

Table 2 - Study characteristics (design, country of origin of samples and quality of articles)

Study design	Frequency
Cross-sectional studies	11
Longitudinal studies	3
Randomized experimental study	1
Countries of provenance of samples	
U.S.A.	3
Portugal	1
Japan	1
Spain	5
Turkey	1
Denmark	1
Chile	1
Brazil	1
Belgium	1
Incidence of studies on the gender variable	
Just boys	0
Just girls	0
Boys and girls	15
Assessment of the quality of articles	
Great	1
Very good	8
Good	5
Reasonable	1
Insufficient	0

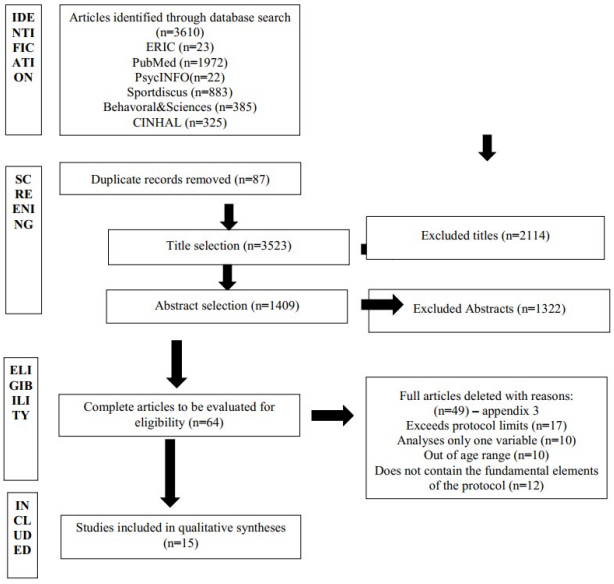

Figure 1. Flowchart of the systematic literature review research and article selection process

There are also studies that, due to the instruments used, consider physical condition (physical fitness), focusing not only on cardiorespiratory condition, but also on physical activity or even Physical Education. In this case, there are studies that point to significant relationships between physical activity and academic achievement (eg, Iri, Ibis, & Aktug, 2017). And there are also studies that do not find statistically significant relationships between physical activity and academic performance (eg, Cosgrove, Chen, & Castelli, 2018; Esteban-Cornejo *et al*., 2017). Other studies suggest that more research is needed (eg, Kyan, Takakura & Miyagi, 2018). Many studies selected a cardiorespiratory capacity test (twelve studies), with most studies using the so-called back-and-forth test (nine studies), and one study opted for the mile test in order to assess cardiorespiratory capacity, and two of the studies used the treadmill and the cycle ergometer. Twelve of the studies (80%) used anthropometric measurements: weight, height, and BMI.

Three of the studies used accelerometers to check whether motor activity was moderate or vigorous. Regarding physical quality, strength, nine studies evaluated this physical quality, in five studies it was evaluated independently and in four studies it was evaluated in the context of the *Fitnessgram protocol.* Regarding the assessment of academic achievement, there are a variety of methods, which makes comparative analysis difficult. Therefore, there are two studies in which native language and mathematics averages are used; two studies in which the assessment was carried out based on Mathematics subjects; Mother Tongue and Physical Education, and in one of these studies the *Z score was used*; five of the studies were based on the average of several subjects in the *curriculum*, two studies took into account the average of some subjects and standardized tests and four studies diversified their methods, for example: academic behaviours; number of subscriptions suspended in the last year of evaluation; general averages and perception of academic competence.

DISCUSSION

Based on this systematic review of the literature, there is evidence of an association between cardiorespiratory condition and academic performance, in some studies, which is in line with recent reviews by Santana *et al*. (2016) and another more recent study by Marques, Santos, Hilman and Sardinha (2018), who also observed the trend of association between the variables physical condition and academic performance. Many of the studies have small samples, which can reveal difficulties in recruiting participants. On the other hand, diversified methods, without being able to ensure consistency in results and conclusions, are evident difficulties and may be due to several factors: 1 – different variables; 2 - samples different in size and characteristics (age, gender, ethnicity); 3 - different instruments; 4 – diversified methods. Regarding the assessment of the quality of the chosen articles, the assessment was adapted based on a *checklist* by Downs and Black (1998), appendix 4. Thus, the assessment of three articles took place independently, by different reviewers (three), and the inter-observer fidelity process was carried out for the thirteen items included in the *checklist*. A percentage higher than 85% was obtained, which provides good inter-observer fidelity of the respective instrument. In this analysis, it became clear the need to carry out more research, with more robust methodologies, for example, randomized experimental designs of a longitudinal nature.

Another difficulty that must be overcome is maintaining consistency in methods, particularly regarding the instruments used and data collection protocols. Specifically, we began by characterizing the studies observed in relation to sample size. The sample of the study by Olivares and Gárcia-Rubio (2016) is highlighted, which had a total of 18,746 participants. Considerable in terms of size are the samples from the studies by Andersen *et al*. (2017), a study with an experimental design and which had a total of 1,084 participants. The cross-sectional studies by Esteban-Cornejo *et al*. (2017), with 1,348 participants; Iri *et al*. (2018), with 2,018 participants; Martinez-López *et al*. (2019), with 1,780 participants and Petrusa *et al*. (2018), with 1,348 participants. However, the biggest difficulties begin with the way in which the variables *physical condition andacademic achievement* were assessed. The protocols are diverse, as are the tests selected. In the relation between physical condition (cardiorespiratory capacity) and academic performance, justification for this positive and significant relation can be found in processes of a

psychophysiological nature, such as changes in brain structures, synaptic density, cerebral vascularization and associated neurotrophic factors, to neurogenesis factors (Erickson, Leckie, & Weinstein, 2014; Firth *et al*., 2018; Giorgio, Kuvacic, Milic , &Palud , 2017; Soga *et al*., 2017). So, it can be said that the type of results and even conclusions has a lot to do with the instruments used, the design of the studies and also the way in which the sample was obtained. In the case of the present study, studies were found that indicated evidence that cardiorespiratory capacity positively influences academic performance: Bertrand- Valls, Adelantado-Renau, Castro- Piñero, Sánchez -López, and Moliner-Urdiales, 2018; Castro and Oliveira, 2019; Iri *et al*. 2018; Mártinez-López *et al*. 2019; Olivares and Gárcia -Rubio, 2016; Pertrusa *et al*. 2018; Raine *et al*. 2018. On the contrary, there are also studies in which there is no evidence that physical condition favours academic performance: Bestard *et al*. (2016); Crosgrove *et al*. (2018); Esteban–Cornejo *et al*. (2017); Martins, Sallis, Marques, Diniz and Costa (2016); Tornbeyns *et al*. (2018). And there are still studies in which there is no declared position for or against the relation between the effects of physical condition on academic performance: Kyan *et al*. (2018), points to the possibility of physical activity being associated with academic performance but considers that more studies are needed. In turn, Gu, Zhang, Chu, Zhang and Tomas (2019), found moderate and vigorous physical activity associated with academic performance, but only in some areas, (specifically it was the case of reading, but not mathematics) and in case of the study by Andersen *et al*. (2017), considered the effect of physical activity, only at the beginning of Post-compulsory Education. Considering the results obtained in this review and corroborating Santana *et al*. (2017), it is necessary to continue research focused on this theme, privileging other methodologies, and investing in schools with more and better Physical Education and School Sports, providing access to Universities and Research Centres, in order to be able to carry out more research.

CONCLUSION

From the fifteen studies in which the relation between physical fitness and academic performance was analysed, only seven clearly associate physical fitness with academic performance and seven do not find a statistically significant relation between these variables. It is therefore a systematic process, with constant readjustments, which has undergone constant adaptations regarding the respective implementation and evaluation process, and which involves anthropometric measurements and cardiorespiratory function. The need to carry out more research with studies using this type of variables was very clear.

REFERENCES

American College of Sports Medicine. (2016). Guidelines for Exercise Testing and Prescription (Tenth Edition). Philadelphia: Wolters Kluwer. http://lccn.gov/2016042823

*Andersen, M.P., Starkof, L., Sessa, M., Mortensen, R.N., Vardinghus -Nielsen, H. and Torp-Pedersen, C. (2017). The indirect and direct pathways between physical fitness and academic achievement on commencement in post-compulsory education in a historical cohort of Danish school youth. *BMC Public Health17:699*doi: 10.1186/s12889-017-4712-y.

Bellack, A. A., Kliebard , H., Hyman, R., & Smith, F, (1966). The language of the classroom. New York: Teachers College Press.

* Bestard V., Cantallops J. & Vidal-Conti J. (2016). The Relationship Between Physical Fitness And Academic Performance In Adolescents From The Balearic Islands. *Journal of PhysicsEducation & Health*. *6, (9),* 19-25.

*Beltran-Valls, M.R., Adelantado- Renau , M., Castro- Piñero , J., Sánchez-López, M. &Moliner-Urdiales , D. (2018). Cardiorespiratory fitness and academic performance association is mediated by weight status in adolescents: DADOS study. *European Journal of Pediatrics.177*: 1037–1043 doi:10.1007/s00431-018-3159-1

*Castro, FJS & Oliveira, ACC (2017). Association between health-related physical fitness and academic performance in adolescents. *Brazilian magazine ofHuman Kinanthropometry* ,441 – 449. doi: http://dx.doi.org/105007/1980-0037216/1814/44

*Cosgrove, JM, Chen, YT & Castelli, DM (2018). Physical Fitness, Grit, School Attendance, and Academic Performance among Adolescents. *Bio Med Research International*. *2018, Article ID 9081258, 1-7*. doi: 10.1155/2018/9801/9801258

Centers for Disease Control and Prevention (2010). The association between school based physical activity, including physical education, and academic performance. Atlanta, GA: US Department of Health and Human Services.

Downs, S. H., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality of both randomized and non-randomized studies of health care intervention. *Journal Epidemiology Community Health*, *52*: 377–384.

Erickson, VI, Leckie, RI & Weintein, AM (2014). Physical activity, fitness, and gray matter. *NeurobiologyofAging*. *35*, S20 – S28. doi: 10.1016/j.neurobiolaging.2014.03.034

*Esteban-Cornejo, I., Martinez-Gomez, D., Garcia-Cervantes, L., Ortega, FB, Delgado- Alfonso , A., Castro- Piñero , J., & Veiga, OL (2017). Objectively Measured Physical Activity During Physical Education and School Recess and Their Associations With Academic Performance in Youth: The UP & DOWN Study. *Journal of PhysicsActivity And Health, 14,* 275 – 282. doi : 10.1123/jpah.1016-0192

Firth, R., Stubbs, B., Vancamffort, D., Schuch , F., Lagapoulos , J.& Ward, P. B. (2018). Effect of aerobic exercise on hippocampus. Volume in humans: A systematic review and meta-analysis. *Neuroimaging. 166, (1),* 230 -238. doi: 10.1016/j.neuroimage.11.007

Giorgio, A., Kuvacic, O., Milic, M., & Paludo, J. (2017). The Brain and Movement: How Physical Activity Affects the Brain. *Journal Sports Science Medicine*. *7, (2)*: 63 – 68. doi: 10.26773/mjssm.180910

*Gu, X., Zhang, T., Chu, T. L., Zhang, X. & Thomas, K. T. (2019) Do Physically Literate Adolescents Have Better Academic Performance? *Perceptual and Motor Skills*. *126 (4),* 585 – 602.

* Iri, R., Ibis, S., Aktug, Z. (2018) The Investigation of the Relationship between Physical Activity and Academic Success. *Journal of Educational and Learning.6, (1),* 122 – 129.

*Kyan, A., Takakura, M., & Miyagi, M. (2018). Does Physical Fitness Affect Academic Achievement among Japanese Adolescents? A Hybrid Approach for Decomposing Within-Person and Between-Person Effects. *International*

*Journal of Environmental Research And Public Health. 15, (*1901), 1 – 13. doi: 10.3390/ijerph15091901

Moher, D.; Shamseer, L; Clarke, M.; Ghersi, D.; Liberati, A.; Petticrew, M.; …& Group, P. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA – P) 2015 Statement. Moher *et al*, Systematic Reviews, 1 – 9.

Marques, A., Santos, DA, Hilman, CH & Sardinha, LB (2018). How does academic achievement report to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6-18 years. Brazil *Journal Sports Medicine, 52*: 1039. doi: 10.1136/bjsports-2016-097361

*Martins, J., Sallis, JF, Marques, A., Diniz, J. & Costa, FC (2016). Potential correlates and outcomes of active commuting to school among adolescents. *Motricity, 12, (4),* 62-72. doi: 10.6063/motricidade.9565

* Martínez -López, E.J., Grao-Cruces, A., Torre-Cruz, M. & Ruiz- Ariza , A. (2019). Associations Between Physical Fitness And Academic Performance in Teenagers. *South African Journal for Research in Sport, Physical Education and Recreation*, *41 (1):* 63 – 75.

OECD (2017). Obesity update. Available at: www.oecd.org/ health/obesity-update.htm Accessed on 24.8.2018

* Olivares, PR &Gárcia -Rubio, J. (2016). Associations between different components of fitness gram and fatness with academic performance in Chile youths. *PeerJournal*.*4*:e 2560 ttp :// doi. Org./10.77717/peerj.2560

Oliveira, T., Pizarro, A., Costa, M., Fernandes, L., Silva, G., Mota, J. & Ribeiro, (2017). Cardiorespiratory fitness, but not physical activity, is associated with academic achievement in children and adolescents. *Annals Of Human Biology. 44, (4)*, 309–315. doi: 10.1080/03014460.2017.1308010

*Pertrusa , G., Sanz-Frias, D., Salinero , JJ., Pérez- Gonsález , B. & Garcia–Pastor, T. (2018). Academic performance and su relationship with levels of physical activity and physical fitness in adolescents. Revista de Psicologia del Deporte / *Journal of Sport Psychology. 27, (1),* 125 – 130.

*Raine, LB, Biggan , JR, Baym , CL, Saliba , BJ, Cohen, NJ & Hillman, CH (2018). Adolescent Changes in Aerobic Fitness Are Related to Changes in Academic Achievement. *PediatricExerciseScience*,*30,* 108-116. doi: 10.1123/pes.2015-0225

Santana, CCA, Azevedo, LB, Cattuzzo , MT, Hill, JO, Andrade, LP & Prado, WI (2016). Physical fitness and academic performance in youth: A systematic review. *Scandinavian Journal Of Medicine & Science In Sports*. 1 – 26. d10.1111/sms.12773

Sardinha, LB, Marques, A., Minderico, C., Palmeira, A., Martins, S., Santos, DA &Ekelund, U. (2016). Longitudinal Relationship between Cardiorespiratory Fitness and Academic Achievement. *Medicine & Science Of Sports & Exercise.* 839 – 844.doi:10.1249/MSS.0000000000000830

Soga, K., kamijo, K., &Masaki, Y. (2017). Aerobic Exercise During Encoding Impairs Hippocampus-Dependent Memory. *Journal of Sport & Exercise Psychology, 39, (4),* 249 – 260. doi : 10.1123/jsep.2016.0254

Swinbum, B.A.; Kraak , VI; Allender, S.; Atkins, V.; Baker, P.; Bogard , J. …& Dietz, W. H. (2019). The Global Syndemic of Obesity, Undernutrition, and Climate Change: *The Lancet Commission Report. www.thelancet.com. Published online January, 27, 2019*. doi: 10.1016/S0140 – 6736 (18) 32822 - 8

* Torbeyns, T., Geus , B., Bailey, S., Decroix , L., Cutsem, J., Pauw , K., &Meeuseu, R. (2018). Bike Desks in the Classroom: Energy Expenditure, Physical Health, Cognitive Performance, Brain Functioning, and Academic Performance. *Journal of PhysicsActivity and Health, 14,* 429 – 439. doi: 10.1123/jpah.2016

Wassenaar, T. M., Whetley, C. M., Beale, N., Salvan, P., Meaney, A. & Johansen-Berg, H. (2019). Effects of a program of vigorous physical activity during secondary school physical education on academic performance, fitness, cognition, mental health and the brain of adolescents (Fit to Study): study protocol for a cluster randomized trial. *Trials. Open Access 20:189*, 1-14. doi: 10.1186/s13063-019-3279-6

WHO (2010). Global Recommendation on Physical Activity for Health. Geneva. Switzerland. To t http://whqlibdoc who.int/publications/2010/9789241599979_eng.pdf . Acce ssed on 12/24/2017

WHO (2017). Tenfold increase in childhood and adolescence in four decades: new study by Imperial College London and WHO. *Saudi Medical. 38(11),* 1162 – 1163. Accessed 17.8.2018

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