Revista Românească pentru Educație Multidimensională
ISSN: 2066-7329 | e-ISSN: 2067-9270
Covered in: Web of Science (WOS); EBSCO; ERIH+; Google Scholar; Index Copernicus; Ideas RePeC; Econpapers; Socionet; CEEOL; Ulrich ProQuest; Cabell, Journalseek; Scipio; Philpapers; SHERPA/RoMEO repositories; KVK; WorldCat; CrossRef; CrossCheck

2022, Volume 14, Issue 4 Sup.1, pages: 330-352 | https://doi.org/10.18662/rrem/14.4Sup1/676
Submitted: May 9th, 2022 | *Accepted for publication:* September 16th, 2022

Exercise and Academic Performance: Implications of Aerobic Capacity and Hand Grip Strength in Middle-School Students

Samuel HONÓRIO[1],
Luis RAMOS[2],
Jorge SANTOS[3],
João SERRANO[4],
João PETRICA[5],
Marco BATISTA[6]

[1] SHERU - Sports, Health and Exercise Research Unit – Polytechnic Institute of Castelo Branco, Portugal; samuelhonorio@ipcb.pt
[2] Polytechnic Institute of Castelo Branco, Portugal; luisramos20082008@hotmail.com
[3] SHERU - Sports, Health and Exercise Research Unit – Polytechnic Institute of Castelo Branco, Portugal; jorgesantos@ipcb.pt
[4] SHERU - Sports, Health and Exercise Research Unit – Polytechnic Institute of Castelo Branco, Portugal; j.serrano@ipcb.pt
[5] SHERU - Sports, Health and Exercise Research Unit – Polytechnic Institute of Castelo Branco, Portugal; j.petrica@ipcb.pt
[6] SHERU - Sports, Health and Exercise Research Unit – Polytechnic Institute of Castelo Branco, Portugal; marco.batista@ipcb.pt

Abstract: The regular practice of physical exercise has a positive role on mental health and a positive contribution to the development of cognitive function, considered beneficial to academic performance. The present study aimed to analyse the impact of physical exercise on students' academic performance. 227 students participated, of which 112 (49.3%) were male and 115 (50.6%) were female, aged between 10 and 13 years old, from 5th and 6th grades in a Portuguese public school. The Susan Harter Self-Concept Scale validated for the Portuguese population was used, and a descriptive and inferential analysis of the data was conducted to analyse the levels of handgrip strength, aerobic capacity and academic performance. Linear regression analysis was used to interpret the predictive variables and we calculated the magnitude of the effect. The results suggest that the practice of physical exercise enhances the levels of aerobic capacity, handgrip strength and academic performance of students. In addition to physical education classes, the individual sports combined with the team sports present very positive values in relation to the variables described.

Keywords: *Physical activity; exercise; aerobic capacity; hand grip strength; academic performance.*

How to cite: Honório, S., Ramos, L., Santos, J., Serrano, J., Petrica, J., & Batista, M. (2022). Exercise and Academic Performance: Implications of Aerobic Capacity and Hand Grip Strength in Middle-School Students. *Revista Românească pentru Educație Multidimensională, 14*(4Sup1), 330-352. https://doi.org/10.18662/rrem/14.4Sup1/676

Introduction

Over the years, there have been several changes in terms of the definition of health. The World Health Organization in 1946 defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (González, 1998, p.6). Health is considered not only as a state of absence of disease (Araújo & Araújo, 2000) but as a state of balance between the various systems. Where the practice of physical exercise can be a positive indicator of health.

Physical activity can be considered "as any body movement produced by skeletal muscles, which causes an expenditure of energy, that is, causes an increase in energy consumption beyond resting levels" (Biddle et al., 2015, p. 9; Leal et al. 2012, p. 186). Physical activity does not essentially imply the practice of sports, since this definition can cover the physical activity we perform when moving around in everyday tasks, in leisure activities and regarding children and young people, the sport activities they practice at school. The concept of voluntary physical activity "can be considered spontaneous physical activity, which is typically involuntary, consisting of small body movements, such as waving a leg when in a sitting position, and also all the muscle contractions associated with different body postures" (Teixeira et al., 2006, p. 2).

In this line of thought, Barata cited by Paulo (2014, p. 7) states that "Physical Activity is everything that involves movement, strength or maintenance of body posture against gravity, resulting in energy consumption, and should, according to Pitanga and Pitanga cited by Paulo, (2014, p.7), being this continuous energy expenditure".

In another perspective, Devís and Velert cited by Paulo (2014, p. 7) state that "human movement should only be considered as Physical Activity if there is intentionality, and therefore all reflex movements should be excluded". The author clarifies Physical Activity as "all intentional bodily movement that is carried out with the skeletal muscles, originating energy consumption and a personal experience, which allows us to interact with beings and the environment that surrounds us." For Caspersen et al. cited by Batista (2011, p. 7) exercise is a subgroup of Physical Activity, defined as "planned, structured and repetitive body movement, performed to promote or maintain one or more components of physical condition". The same idea is mentioned by Thompson, Gordon and Pescatello (2010) in their study stated that physical exercise is defined by planned, organized and repeated

body movements to maintain or improve one or more constituent elements of physical fitness.

Literature Review

Academic performance associated with physical exercise, "it is verified that there can be an increase in the hippocampus, an increase in the volume of the basal ganglia, as well as significant improvements in structures that involve memory, attention and cognitive flexibility (Chaddock-Heyman et al., 2013, p. 1), in the findings of these researches, it Is noted that the peak of cognitive development occurs between the ages of 5 and 15 years, and this is the crucial period for better academic performance."

For Bills cited by Tomporowski & Ellis (1986) the practice of physical exercise in schools, promotes the increase of muscular tension, which constitutes a facilitating element in the accomplishment of several psychological tasks. In their study, subjects submitted to physical exercise show faster acquisition and evolution of nonsense syllables and a greater ability in terms of learning/memorizing associated pairs, greater accuracy in solving simple mathematical problems and greater efficiency in a test perceptive colour naming than subjects who perform the same tasks under normal conditions.

"The hand is a complex system of static and dynamic anatomical structures through which the brain explores and dominates the world" (Rezende et al., 2016, p. 229). "It is at the same time receptive, as it is rich in proprioceptive and exteroceptive receptors that allow Man to better understand the environment he explores; and effector, which allows you to intervene around you with precision and variety of movements using force or subtlety. It is one of the main, if not the main, instrument of human work, it is also an organ that transmits a large number of knowledge to the brain, allowing its storage in memory. It has an immense value, because from birth we perform functions and collect information through it, however, this is only recognized after limitation or loss of function" (Rezende et al., 2016, p. 229).

The wrist and hand are made up of 27 bones, 33 muscles (intrinsic and extrinsic), three peripheral nerves (with sensory and motor functions), a complex vascular system and other structures, namely ligaments, joint capsules and tendon sheaths, all located within of a protective skin layer 1 to 2 millimetres thick (Reis, 2014).

Hand assessment includes the "understanding of the assessment of motor function (muscle strength, pinch strength, grip strength and joint mobility through goniometry), sensory assessment (superficial, deep and

combined), aesthetic assessment (colour and shine), and functional assessment (manual dexterity and gross and fine motor skills)" (Guimarães et al., 2012, p. 7). According to Carmeli, Patish and Coleman (2003, p. 146) "the quality and performance in activities of daily living, work and leisure are largely determined by the functions of the hand and manual dexterity." Muscle strength is currently considered as "an essential factor in the identification, prediction and monitoring of processes, in which there is a need to obtain data about the musculoskeletal condition of the individual, as well as their general condition" (Eichingera et al. 2015, p. 109). Muscular strength is the individual's ability to maintain correct levels of strength and resistance. Its development is stimulated through aerobic, strength and resistance exercises. According to Araújo & Araújo (2015, p. 40), "the muscular strength/power component is very important for autonomy and health-related quality of life".

Because it is understood as a general indicator of muscle strength and power, handgrip strength appears to be a significant marker of mortality or "access" to disease (Eichingera et al., 2015), such as cancer and cardiovascular diseases, both in young and older individuals (Eichingera et al., 2015). In addition, the decline in motor function, associated with a decrease in muscle strength and performance, leads to a reduction in autonomy evidenced in performing exercises of daily living (Brill et al., 2000).

Allied to what has been mentioned so far, it is still relevant to point out other components that influence the ability to use the hands. "Using the hand is highly dependent on cognition, in that it is necessary to assign a precise purpose and/or meaningful objective to using the hand. Therefore, the task to be performed must be coded and translated into intentional actions, and these must be performed in the proper sequence. Another cognitive aspect is motivation, which is closely related to attention and concentration, all of which have an influence on the good performance of motor skills" (Reis, 2014, p. 31). "With regard to the integration of somatosensory information, this is essential for an adjustment of motor commands, regulation of force and the accumulation of strategic memories to grasp and manipulate objects" (Reis, 2014, p. 31). The term somatosensory information processing refers to the way in which the Central Nervous System manages sensory information, including the registration, modulation, integration and organization of sensory input, with about 80% of the CNS involved (Correia, 2015). "The body receives sensory input through movement, pressure, touch, vision, hearing, taste, smell, which is sent to the brain stem through the different sensory systems, mainly

through the cranial nerves. All sensory input must be recorded at the brainstem level" (Correia, 2015, p. 8). "The brain is constantly to analyse which stimuli are important and which should be ignored. Consciously or unconsciously, we make decisions about which stimuli to react to and how much of our attention to direct to that input. This is how we can respond adequately to stimuli and, consequently, to environmental requests" (Correia, 2015, p. 8). It is important to note that "all movement is highly dependent on the way the central nervous system plans and organizes it, with the contractile components of muscles, bones and joints being effectors of the planned movement, which in turn is conditioned by aspects cognitive, somatosensory and perceptual" (Reis, 2014, p. 32).

According to Ozmun and Gallahue cited by Pereira (2015, p. 8), "strength capacity is understood as the maximum amount of tension that a muscle or group of muscles can develop, in turn, the resistance is subordinated to the ability of a muscle (or group of muscles) to perform work repeatedly against resistance. This ability increases functional capacity, reduces the risk of low back pain, decreases localized muscle fatigue and reduces systolic blood pressure during intense physical exertion. Endurance increases work capacity, reduces fatigue, as well as the risk of developing cardiovascular disease".

Aerobic resistance is determined by the integrated functioning of the respiratory, cardiovascular and muscular systems and is evaluated from the measurement of VO2 max (Fernandes et al., 2005). "Aerobic capacity can also be understood as the maximum amount of oxygen, in millimetres, that the child is able to use during physical exercise in one minute per kilogram of body, that is, it refers to the capacity of the cardiovascular and respiratory systems to perform prolonged exercise" (Pereira, 2015, p. 25).

Thus, VO2 max is "the maximum consumption of oxygen that can be achieved during maximal or exhaustive exercise. The higher the value of VO2 max. of an individual, the greater the amount and intensity of aerobic work that the individual can perform (…). The unit of measure for VO2 max. are litters of oxygen per minute [VO2 max.(l/min-1)]" (Montoro et al., 2009, p. 64).

Ana, Pupo, Gheller and Diefenthaeler (2012, p. 434), refer that "aerobic capacity and body composition are important components of physical capacity focused on health. Physical exercise is recognized for acting in the improvement of these components." In addition, the adoption of a sedentary lifestyle "may be strongly associated with a higher incidence of fat body mass, excess weight and reduced cardiovascular capacity, implying health risks" (Ana et al., 2012, p. 434). Aerobic capacity is strongly related to

the level of physical activity (Bertoletti, 2005). Thus, "although cardiorespiratory capacity has a genetic component that explains about 25 to 40% of the variation in its capacity, it is well established that both physical activity and physical exercise are determinants of physical capacity" (Bertoletti, 2005, p. 8). "Aerobic capacity is directly related to cardiovascular health in young people" (Lobelo & Ruiz, 2007, p. 471). Taras cited by Carvalhosa (2012, p. 33) found in his study "an increase in learning, mental health and concentration in the period immediately following physical activity and an association between physical activity and reduced adoption of behaviour's". risk." The same author states that "cardiovascular capacity boosts blood circulation, increasing cerebral blood flow and levels of norepinephrine and endorphins, effects that can reduce stress, improve mood, induce a relaxing effect after exercise and, as a result, improve school performance" (Carvalhosa, 2012, p. 41).

Methodology

Batista (2011) states that students who practice physical exercise regularly obtain better results at school, since the practice provides good blood circulation and greater blood oxygenation, which ensure higher levels of vitality and consequently a better performance at a cognitive level. Symons, Cinelli, James and Groff cited by Ciotto & Fede (2015) mention that an individual who has a good aerobic condition can improve his memory capacity, since physical exercise can strengthen specific areas of the brain and that the entry of oxygen during exercise improves connections between muscles. Physical exercise improves cognitive function and has a positive influence on memory processes in children (Chaddock-Heyman et al., 2011). In this sense, a quantitative, descriptive, analytical and cross-sectional research methodology was followed, in which only a single data collection was conducted. We assume this research methodology because we formulate previous hypotheses, use systematic verification techniques, seek explanations about the effects of physical exercise on academic performance and produce theoretical generalizations with validity and reliability about the data obtained, where the objective is to expand and generalize the model theoretical found, from the study.

Objective

The general objective focuses on evaluating the relationship between the practice of exercise and the academic performance of students,

considering the implications that aerobic capacity and handgrip strength have on their academic performance.

Variables

The dependent variables of our study are aerobic capacity (VO2 max), handgrip strength and academic performance. The independent variables defined were gender, type of modality, age of starting practice, years of practice, sport context and volume of weekly training hours.

Participants

The sample (convenience sample) of this study had a total number of 227 students (N=227) of which 112 (49.3%) are male and 115 (50.6%) are female, aged between 10 and 13 years old with a mean age of 11.78±0.71, attending a public Portuguese middle-school of 5th and 6th grade classes.

Procedures and instruments for data collection

After the approval of the study by the Polytechnic Institute, it was made a request to the School Director for authorization. After this authorization was granted, the purposes of the study and the number of fifth and sixth grade classes attending the school were clarified. In a second phase, after scheduled visits, the researchers went to the school to collect data on the assessment of handgrip strength. Academic performance was collected and evaluated by the arithmetic mean of the grades obtained by the students, in the respective curricular contents.

One Mile Running Test

The *One-mile test* was developed by George, Vehrs, Fellingham & Fisher (1993) and is used as a submaximal exercise test to estimate VO2 max. The purpose of this test is for the student to run a mile (1609 meters) as fast as possible. If the practitioner is not able to cover the entire distance to run, he can do so walking in the shortest possible time. Before the test, the student must perform a 3–5-minute warm-up. Students begin the test with the voice of "Ready, Go." As they cross the finish line, they are informed of the race split time. The *One Mile Run*ning *Test* is recorded in minutes and seconds. A time of 99 minutes and 99 seconds must be recorded whenever the practitioner does not complete the desired distance. To obtain the VO2 max, the following formula is used:

VO2max (ml/Kg/min) = 0.353 x route – 1.121 x age + 45.619
(Welk, Laurson, Eisenmann & Cureton, 2011).

Hand grip strength through dynamometer

Most ergonomic analyses of handgrip strength use hydraulic or electronic dynamometers as a data collection instrument. These equipment's provide reliable and accurate data. The type of test performed to determine handgrip strength using a dynamometer will be the maximum voluntary strength test, which includes the measurement of absolute strength of the handgrip movement (Nicolay & Walker, 2005).

To measure handgrip strength, a bulb dynamometer (Saehan 5008, Korea) was used, with a certain capacity in kilograms (Kg). A first registration will involve registering the student's dominant hand. Subsequently, measurements will be taken in the dominant hand and opposite hand of each subject, in the orthostatic position, keeping the arms extended at the sides of the body. During gripping, it will not be allowed to support the equipment on the body. The one-repetition test requires maximum dynamic grip contraction in a single movement. Students will be instructed to squeeze the hand dynamometer to 100% of its maximum force for 3 seconds, enough time to collect data on the dynamometer. The maximum force will be established by the highest value generated in two attempts.

Academic Performance

For academic data it was provided a systematic recording grid of students' academic performance for the curricular units (n) of Portuguese Language, Mathematics, Civic Education, Accompanied Study, Sciences, English, History and Geography, Drawing and Painting, Music and Physical Education. This variable was obtained according to the grades at the end of the 1st, 2nd and 3rd terms, through the classification's grades of the students, assuming five categories: very insufficient (1), Insufficient (2), Sufficient (3), Good (4), very good (5). For this variable, the calculation formula was [(∑1st / n) + (∑2st / n) + (∑3rd / n)] / 3 terms (decree-law, no. 139/2012).

Statistical procedures

For the introduction and statistical analysis of the data, we used the statistical analysis program (Statistical Package for a Social Sciences (SPSS 21.0) as an auxiliary means). maximums, means, standard deviations, variances.) However, to obtain statistical inferences, we performed the normality test to assess the normal distribution of the data, verified by the Kolmogorov-Smirnov test.

Finally, we used linear regression analysis to interpret the predictive variables and a significance level of 0.05 was used for a confidence interval of at least 95%.

Results

In this section its presented the results obtained through the evaluation instruments used, namely aerobic capacity, handgrip strength and academic performance according to the independent variables, gender, type of sport, sport context, age group, number of weekly training sessions and total years of sport practice.

Table 1 presents the results obtained through the Kolmogorov-Smirnov test, we can observe that the variables whose distribution is normal are, theVO2 max (0.70) and academic performance (0.63), as the statistical significance is greater than 0.05. For the handgrip strength variable (0.05) non-parametric tests will be applied.

Table 1 -Descriptive statistics of VO2 max variables, handgrip strength and academic performance

	Minimum	**Maximum**	**Mean**	**SD**	**Kolmogorov smirnov**
VO2max	35.28	58.06	43.76	4.53	0.70
Hand Grip Strength	7.25	26.25	13.48	3.41	0.05*
Academic Performance	2.60	5.00	3.74	0.61	0.63

**p≤0.05 - Does not respect the assumption of normality
Source: Authors' own conception

Table 2 represents the mean values and standard deviation of the dependent variables of VO2 max, handgrip strength and academic performance, depending on the school year. In the data collected for VO2 max, its observable higher values in 5th grade classes ($\bar{X}$=43.93±4.78) compared to sixth year classes with ($\bar{X}$=43.65±4.40). For handgrip strength, higher mean values are presented in sixth grade classes ($\bar{X}$=13.91±3.54) compared to fifth grade classes ($\bar{X}$=12.80±3.10). The academic performance presented is higher in sixth grade classes with mean values ($\bar{X}$=3.81±0.62) compared to fifth grade classes with means of ($\bar{X}$=3.66±0.59).

Table 2 - Means and Standard Deviation of the variables of VO2 max, handgrip strength and academic performance, depending on the school year.

Variables	Grade				Total		t-student
	5th year		6th year				
	Mean	SD	Mean	SD	Mean	SD	Sig.
VO2 max	43.93	4.78	43.65	4.40	43.76	4.53	0.759
Hand Grip Strength	12.80	3.10	13.91	3.54	13.48	3.41	0.054
Academic Performance	3.66	0.59	3.81	0.62	3.74	0.61	0.233

Source: Authors' own conception

Further is described the results of the same dependent variables in relation to gender. The analysis performed on the VO2 max variable translates into higher mean values in males when compared to females, respectively ($\bar{X}$=44.15±5.09) and ($\bar{X}$=43.34±3.86). Moving on to the handgrip strength variable, male students ($\bar{X}$=13.51±3.50) appear with slightly higher mean values than female students ($\bar{X}$=13.45±3.33). Finally, the academic performance variable appears, where female students have higher mean values ($\bar{X}$=3.94±0.62) than male students ($\bar{X}$=3.57±0.55). In terms of statistically significant differences, we performed the t-student test on the variables that make up the VO2 max, handgrip strength and academic performance, where we verified the homogeneity through the Levene test. In this case, it is concluded that the variances are equal in both groups, since the significance associated with the test is greater than 0.05. Once the homogeneity of variances is assumed, we chose to use the t-test values of Equal variances not assumed. The results indicate that there are differences between the female and the male gender in the variables behavior and academic performance.

Table 3 - Means, standard deviation and significance value of the variables of VO2 max, handgrip strength and academic performance, according to gender.

Variables	Gender				Total		t-student
	Male		Female				
	Mean	SD	Mean	SD	Mean	SD	Sig.
VO2 max	44.15	5.09	43.34	3.86	43.76	4.53	0.374

Hand Grip Strength	13.51	3.50	13.45	3.33	13.48	3.41	0.943
Academic Performance	3.57	0.55	3.94	0.62	3.74	0.61	0.004*

Source: Authors' own conception

It was also analysed the variables under study in terms of the number of weekly physical exercises (up to three hours, between four and six hours and seven or more hours of exercise). In the variables VO2 max, handgrip strength and academic performance is seen a total of mean values, respectively ($\bar{X}$=43.76±4.53), ($\bar{X}$=13.48±3.41) and ($\bar{X}$=3.74±0.61). In handgrip strength and VO2 max, we observed an increasing trend of mean values with the increase in the number of hours per week, however the handgrip strength presents mean values for practice up to three hours of ($\bar{X}$=13.41±3.00), between four and six hours of ($\bar{X}$=13.42±3.63) and seven or more hours of ($\bar{X}$=13.70±3.57). In the VO2 max variable, the observed values of the practice of up to three hours are ($\bar{X}$=43.02±5.42), between four to six hours ($\bar{X}$=43.42±3.97) and seven or more hours we found mean values ($\bar{X}$=45.36±3.94). The mean values of academic performance assuming higher mean values in the practice of four to six hours per week ($\bar{X}$=3.88±0.62), practice of seven or more hours appears with a slightly lower mean value ($\bar{X}$=3.86±0.57) and practice up to three hours with a mean value of ($\bar{X}$=3.49±0.55). The *Scheffe Post-hoc* multicomparison test determined significant differences in the group of up to three hours and between four to six ($p=0.03$).

Table 4 - Means, standard deviation and significance value of the VO2 max variables, handgrip strength and academic performance, according to the weekly physical exercise

Variables	**Weekly physical exercise**						**Total**		**Anova**
	up to 3 hours		**4 to 6 hours**		**7 or more hours**				
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Sig.**
VO2 max	43.02	5.42	43.42	3.97	45.36	3.94	43.76	4.53	0.129
Hand Grip Strength	13.41	3.00	13.42	3.63	13.70	3.57	13.48	3.41	0.944
Academic Performance	3.49	0.55	3.88	0.62	3.86	0.57	3.74	0.61	0.017*

Source: Authors' own conception

After analysing the variables means of VO2max, handgrip strength and academic performance, it was found that these assume a certain trend according to the weekly exercise practice. In the VO2 max variable, the highest mean value appears for students who practice team sports ($\bar{X}$=44.42±5.54), followed by the mean values of students who practice individual sports ($\bar{X}$=44.19±3.92), individual and team sports ($\bar{X}$=43.66±2.85) and the lowest mean value to be recorded in physical education practice ($\bar{X}$=42.50±4.72).

Regarding handgrip strength, in students who practice team sports, a more outstanding mean value ($\bar{X}$=14.11±3.95) is observed in relation to the practice of curricular physical education ($\bar{X}$=13.38±3.14), which appears next, at the mean value of students who practice individual sports ($\bar{X}$=13.28±3.13) and the practice of individual and team sports ($\bar{X}$=12.89±3.78). In the academic performance variable, the only variable where there are significant differences, the highest mean value is in students who practice an individual sports with a team sport ($\bar{X}$=4.25±0.51), followed by an equality in mean terms of students in that the practices focus on individual sports ($\bar{X}$=3.79±0.61) and team sports ($\bar{X}$=3.79±0.58). Lower mean values are present in the practice of curricular physical education ($\bar{X}$=13.38±3.14). The *Scheffe Post-hoc* multicomparison test determined significant differences in the group that practices PE and an individual sport with a team sport (*p=0.01*).

Table 5 - Means, standard deviation and significance value of VO2 max variables, handgrip strength and academic performance, according to the exercise practice on team sports, individual sports and physical education (PE).

Variables	Exercise practice								Total		Anova
	Individual sport		Team sport		Individual and team sport		PE				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Sig.
VO2 max	44.19	3.92	44.42	5.54	43.66	2.85	42.50	4.72	43.76	4.53	0.41
Hand Grip Strength	13.28	3.13	14.11	3.95	12.89	3.78	13.38	3.14	13.48	3.41	0.57
Academic Performance	3.79	0.61	3.79	0.58	4.25	0.51	3.46	0.56	3.74	0.61	0.01*

Source: Authors' own conception

Making an observation of the variables under study, described in table 6, depending on the context of the sport, there is a higher mean value in practitioners of sports with body contact ($\bar{X}$=44.47±4.90) in relation to practitioners of sports without body contact ($\bar{X}$=*44.06±3.85*) in the approach to the VO2 max variable. In the handgrip strength variable, practitioners of sports with body contact have higher mean values ($\bar{X}$=*13.78±4.15*) when placed at the same level as individuals who practice sports without body contact ($\bar{X}$=*13.45±3.42*). Finally, addressing the academic performance variable, students practicing sports without body contact present slightly higher mean values ($\bar{X}$=*3.85±0.65*) compared to practitioners of sports with body contact ($\bar{X}$=*3.82±0.57*).

Table 6 - Means, standard deviation and significance value of the VO2 max variables, handgrip strength and academic performance, depending on the context of the sport.

Variables	Sport context				Total		t-student
	Sports without body contact		Sports with body contact				
	Mean	SD	Mean	SD	Mean	SD	Sig.
VO2 max	44.06	3.85	44.47	4.90	44.22	4.24	0.55
Hand Grip Strength	13.45	3.42	13.78	4.15	13.57	3.67	0.64
Academic Performance	3.85	0.65	3.82	0.57	3.84	0.61	0.75

Source: Authors' own conception

In view of the application of Spearman's non-parametric correlation test, we verified significant levels of correlation in the correlated variables under study. In students who practice physical exercise up to 3 hours per week, it was found that:

• There is a moderate positive and statistically significant correlation between the academic performance and VO2 max;

• There is a negative and statistically non-significant correlation between the academic performance and handgrip strength.

In students who practice physical exercise between 4 and 6 hours per week, it was found that:

• There is a positive and statistically non-significant correlation between academic performance and VO2 max;

• There is a positive and statistically non-significant correlation between academic performance and handgrip strength.

In students who practice 7 or more hours of physical exercise per week, it was found that:

• There is a positive and statistically non-significant correlation between academic performance and the VO2 max;

• There is a positive and statistically non-significant correlation between academic performance and handgrip strength.

Table 7 - R Spearman correlation test of academic performance levels and handgrip strength, VO2 max as a function of the variable of weekly physical exercise.

Exercise practice	**up to 3 hours**	**4 to 6 hours**	**7 or more hours**
Academic performance	-		
VO2 max	0.54**	0.30	0.19
Hand Grip Strength	-0.22	0.17	0.03

*Sig≤0.05 **Sig≤0.01

Source: Authors' own conception

A linear regression test was also conducted to know the variables of VO2 and handgrip strength predict good levels of academic performance represented by the symbol R2. In the field of resistance (VO2 max) it explains 10% (R2=0.104) of academic performance. The Beta value for this variable is equal to 0.322. The force variable (handgrip strength) represents 0.3% (R2=0.003) where the value of Beta=0.059. Finally, the physical exercise indicator, we can see that it explains 5% (R2=0.051) of academic performance, where the beta value is assumed to be positive (Beta=0.226).

Table 8 - Linear regression for the variables of aerobic capacity (VO2 max), strength and exercise indicator as predictors of academic performance for 5th and 6th grade students.

Variables		**Beta**	**T**	**P**	**R2**
Aerobic capacity	VO2 max	0.322	3,152	0.002	0.104
Strength	Hand Grip Strength	0.059	0.554	0.581	0.003
Exercise indicator	Number of weekly exercises	0.226	2,177	0.032	0.051

Source: Authors' own conception

To analyse the magnitude of the effect on the variables under study in middle-school children (5th and 6th grades), depending on the years of practice, two groups were defined (less than or equal to three years of practice and more than three years of practice). The magnitude of effects classification (d Cohen) were as follows: 0-0.2, trivial; 0.21-0.6, small; 0.61-1.2, moderate, 1.21-2.0, large; >2.0, very large (Hopkins et al., 2009).

There was a trivial effect on handgrip strength (0.04), a small effect on VO2 max (0.37) and academic performance had a moderate effect (0.67).

Table 9 - Effect Size on handgrip strength, VO2 max and academic performance as a function of Years of Practice, for fifth and sixth grade students

Variables	years of practice		Cohen's d	Effect Size(r)
	≤ 3 years	> 3 years		
VO2 max	44.20±4.41	42.50±4.72	0.37	0.18
Hand Grip Strength	13.52±3.51	13.38±3.14	0.04	0.02
Academic Performance	3.85±0.60	3.46±0.56	0.67	0.32

Source: Authors' own conception

Lastly, it was carried out a multiple mediation model through bootstrapping techniques where the existence of variables mediating the relationship between total physical exercise and academic performance generates α coefficients, b coefficients, c and c` coefficients. In more detail, these coefficients designate, respectively, the main, secondary, indirect and direct effects between the independent variable of total physical exercise and the variables mediating handgrip strength and VO2 max with influence exerted on the dependent variable academic performance. As for the main effect, the total amount of physical exercise practiced by students has a positive and statistically significant effect on strength,

As for the secondary effect reported by the variables and represented as coefficient b, it tells us that there is effectively a statistically significant positive relationship between the variables total physical exercise and self-concept on academic performance. A positive relationship with statistical significance is also established between the total amount of physical exercise and handgrip strength on academic performance. In turn, total physical exercise and self-esteem have a statistically significant influence on academic performance. Only between total exercise and VO2 max, despite the coefficient value (b) being positive, no statistical significance was observed on academic performance (b=0.13, p=0.09).

Analysing the diagram, we observed that the direct effect of total physical exercise on academic performance presents positive and statistically significant values (c' =0.44**, p<0.01). For the mediating variable Handgrip strength and its relationship with total physical exercise and academic performance, we recorded non-significant positive values with regard to the direct effect (c' =0.01, p=0.64). The indirect effects were calculated, where we found positive and statistically significant c coefficient values (c =0.20*,p<0.02). Continuing the analysis, for the mediating variable VO2 max, we observed that in the direct effect it presents significant positive values (c' =0.04*, p<0.01). As for the indirect effects,

Although there were positive direct and indirect effects on the academic performance variable, the confidence interval of the indirect effects on the academic performance variable was not statistically significant since it included the value 0 in the minimum value range and maximum value in all variable's mediators.

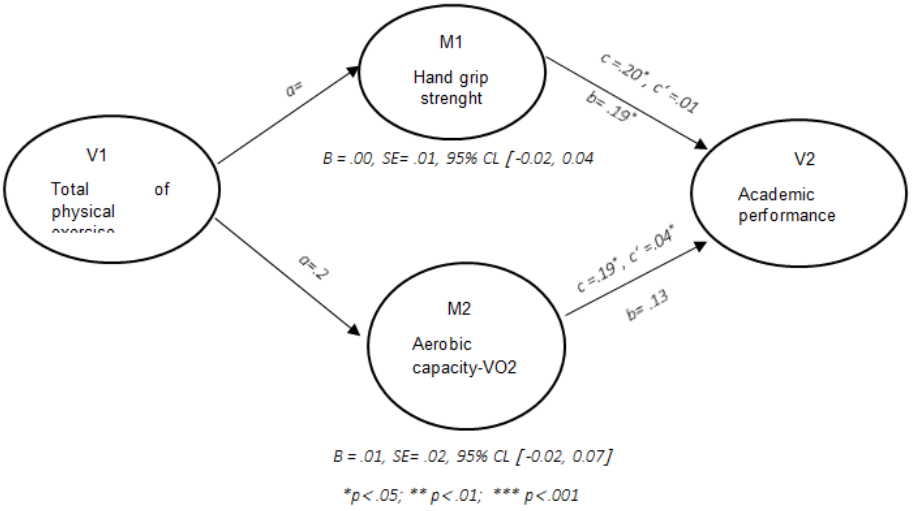

Figure 1 - multiple mediation bootstrapping model.
Source: Authors' own conception

Discussion

In the variable of aerobic capacity (VO2 max) fifth grade students present higher means, although without significant differences, when compared with sixth grade students. In the variables of handgrip strength and academic performance, the mean values are slightly higher, where there are no statistically significant differences, in sixth grade students when

compared with mean values of fifth grade students. These results agree, with the study carried out by Bolognini, Plancherel, Bettschart and Halfon (1998), in their study with 216 Swiss adolescents aged between 12 and 14 years, they obtained results that point to an increase in academic performance.

Regarding gender, there is a presence of significant differences in the variables of academic performance, in favour of the female gender, which is in line with the study carried out by Peixoto (2003). There is also a tendency in favour of boys at the level of strength and endurance, the same situation was revealed in the study by Fernandes and Pereira (2006).

Regarding the influence of hours of weekly practice, we found significant differences in terms of academic performance, that is, as the student practices more hours of physical exercise, there is a tendency on students to obtain better academic results (Ministry of Science, 2012). The vast majority of investigations agree with the results of our study (Oliveira, 2009), positively relating high levels of physical exercise to good academic results, not only with Physical Education but also academic results in general (Oliveira & Moreira, 2009).

Students who practice more hours of physical exercise have a progressively higher aerobic capacity, although no statistically significant differences are observed, and these results are in line with the studies by Batista (2011). From another perspective, the practice of physical exercise favours the oxygenation of neuropsychological structures, where the practice of more hours of physical activity positively influences students' behaviours in a learning context and consequently a better academic performance (Singh et al., 2012). Data on handgrip strength refer to a progressive increase, although not significant differences of students practicing only physical education compared to students practicing 7 or more hours of weekly exercise, where this group presents higher values of strength. These results agree with the study by Faigenbaum, Kraeme, Blimkie, Jeffreys, Micheli, Nitka and Rowland cited by Faigenbaum & Myer (2010) and indicating the potential benefits that strength training can develop in children from 7- 8 years, that is, when properly prescribed and supervised (Faigenbaum & Myer, 2010). In addition to increasing levels of muscle strength and performance of motor skills, lifelong physical activity can facilitate weight control, strengthen bones, and increase a teenager's resistance to sports-related injuries (Faigenbaum & Myer, 2010).

From the observation and analysis of the results, the practice of team sports promotes higher rates in terms of aerobic capacity and strength, although not significant, in relation to the practice of physical education and other sports. Correia, Greten, Machado & Gonçalves (2016), made a

comparison between students who practice extracurricular exercise and those who only practice curricular exercise, found that the aerobic capacity and strength capacity of students are increasing and significant over age as they age, which was not found in our study.

The practice of individual and team sports together revealed significant values compared to students who practiced only physical education. These results were also observed by Zenha, Resende and Gomes (2009) and Batista (2011), stating that the practice of curricular or extracurricular physical exercise on a regular basis does not negatively influence academic performance.

It was observed that the practice of sports without body contact, according to academic performance, present higher mean values, although not statistically significant. The aerobic capacity (VO2 max) and the handgrip strength capacity are favoured by the practice of sports with body contact, which presents non-significant higher values, as verified in Batista (2011). The results of the correlations obtained for practitioners of up to 3 hours per week induce those dimensions such as VO2 max and academic performance revealed significant values.

As for students who practice physical exercise of four to six hours per week, they present a significant VO2 max, although the correlation values are negative in relation to handgrip strength. The results obtained in the verification of academic performance predictors were favourable where we found that at a lower level of prediction the VO2 maximum appears, explaining 10% of academic performance, where R2=0.104. Also, the number of weekly workouts explain respectively 5%. It was analysed the magnitude of the effect on the variables under study where it was defined two groups: less than or equal to three years of practice and more than three years of practice. From the Cohen classification values, the obtained results pointing to a trivial effect on handgrip strength and a small effect on VO2 max. Finally, academic performance had a moderate effect. This effect agrees with studies by Kaufmann (2002), JacAngelo (2003), Lipscomb (2007) and Trudeau and Shepard (2008) who, in their results, show that the practice of regular and continued exercise can help students to improve their academic performance.

Conclusions

Through the results obtained, it appears that physical exercise directly influences the variables of VO2 max, handgrip strength and academic performance. In this case, the practitioners of individual and team sports reported better indices of academic performance. As for the volume

of physical exercise, this presented statistically significant differences in the academic performance variable, where we observed that the group that practiced four to six hours had higher levels of academic performance. Although there were no differences between the group that practiced seven or more hours and the group that practiced fewer hours of physical exercise per week, there appeared to be an evolution in the positive direction in favour of the group that practiced more hours of weekly exercise. These results point to a positive and statistically significant relationship between VO2 max and academic performance in curricular physical education practitioners. As the student practices more hours of exercise, there is a tendency for the results to become lower and without statistical significance.

Regarding handgrip strength, the results obtained report that students who practice less time of weekly exercise have lower values of strength and academic performance, although not significant, compared to those who practice more hours of weekly exercise.

In the VO2 max variable, students who practice extracurricular modalities in addition to curricular physical education have higher mean values than those who practice exclusively physical education. Although not significant, the most outstanding values were those registered in the group of students who practice collective modalities, followed by those who practice individual modalities and later by students who combine both types of modalities during the week. Despite not presenting significant data, students who present superior handgrip strength values are practitioners of collective modalities followed by practitioners of exercise in physical education classes.

In terms of predictor variables, the VO2 max and the number of weekly workouts appear with prediction values lower than 10%. Despite the direct and indirect effects of the variables under study on academic performance, the variables of strength and VO2 max were good predictors of the relationship between physical exercise and academic performance.

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