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EFFECTS OF PHYSICAL EXERCISE ON SUSTAINED ATTENTION IN SCHOOLCHILDREN AGED 8 TO 12 YEARS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER IN THE MUNICIPALITY OF MONTERÍA, CÓRDOBA.

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Abstract

This study evaluates the impact of a physical exercise program on improving sustained attention in children aged 8 to 12 years with Attention Deficit Hyperactivity Disorder (ADHD) in the municipality of Montería, Córdoba. The research was developed through a pre-experimental design, in which 12 schoolchildren diagnosed with ADHD participated. A 4-week physical exercise program was applied, with 3 weekly sessions of 1 hour, focused on activities that combine strength, endurance, speed and coordination, adapted to the needs of the participants. The evaluation of the impact of the program was carried out using the d2 test, which allowed measuring various dimensions of care, including total answers, correct answers, omissions, commission errors, and the total effectiveness of the test. The results showed significant improvements in children's sustained attention, with an increase in correct answers (from 93.58 to 126.91) and a reduction in commission errors (from 5.83 to 2.83). In addition, an increase in reaction times and a greater ability to concentrate were observed, which was confirmed by the statistical analyses performed (ANOVA-MR, $p = 0.001$ and $\omega^2 = 0.161$). The study concludes that the inclusion of planned physical exercise can be an effective tool in the management of ADHD symptoms, offering a complementary alternative to traditional pharmacological treatments. In addition, the importance of a psychoeducational and multidisciplinary approach, involving teachers, parents and health professionals, to enhance the benefits of exercise in the child and adolescent population with ADHD is highlighted. This work provides relevant evidence for the integration of physical activity programs in the school context, promoting an improvement in the quality of life and cognitive development of children affected by this disorder.

Keywords: ADHD, Physical Exercise, Sustained Attention, Psychoeducational Intervention, Schoolchildren.

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most prevalent neurodevelopmental disorders in early childhood (Thapar A & Cooper M, 2007). The global prevalence of ADHD is estimated to be between 5.29% and 7.2%, and has shown a significant increase in recent years (Lancet, 2020).

Characteristic symptoms of ADHD include inattention, hyperactivity, and impulsivity, as detailed in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, 2014). Children and adolescents with ADHD often have difficulties in processing information and a limited ability to concentrate in the school environment, which can negatively impact their academic performance (Ann Pharmacother, 2014). In addition, they often face challenges in motor coordination, emotional regulation, and have a low tolerance for frustration, which makes it difficult for them to perform both academic activities and social interactions, compared to their peers without ADHD (Anastopoulos A & Smith T, 2011). This situation can lead them to feel excluded among their peers, which in turn contributes to low self-esteem and poor social adaptability (Hodgens J & Cole J, 2000).

Treatments for ADHD often include medication, psychological therapy, and behavioral therapy. However, recent research has indicated that physical exercise can be an effective intervention to mitigate ADHD symptoms. Studies have shown that both acute exercise (Yu C & Hsieh S, 2020) and regular physical activity can activate physiological and psychological mechanisms that not only improve physical and mental health, but also optimize cognitive functions such as memory and executive function. Given the nature of ADHD symptoms, such as impulsivity and hyperactivity, combining exercise with conventional treatments can amplify the benefits.

Importantly, many physical interventions for children with ADHD focus on clinical rehabilitation exercises designed to improve motor coordination, cognitive function, and interpersonal skills, as well as address emotional disorders (Hoza B & Martin C, 2017). Structured physical exercises are especially valuable for the development of executive function, emotional regulation, spatial memory, learning, and interpersonal relationships, as well as promoting structural and functional neuroplasticity in the brain (Muller & Duderstadt, 2020).

However, the current literature presents a lack of research on the immediate and long-term benefits of exercise interventions, as well as on the neurophysiological and neuropsychological effects associated with different exercise models and intensities. In addition, although it has been observed that 50% of children with ADHD tend to improve their attention over time, symptoms of impulsivity can persist into adulthood. Therefore, the aim of this research is to evaluate the effects of physical exercise on sustained attention in schoolchildren with attention deficit hyperactivity disorder.

1.1 Problem statement

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that begins in the childhood of those who suffer from it. It is characterized by causing alterations in patterns of inattention and hyperactivity/impulsivity. Inattention manifests itself behaviorally when the child shows no or little attention to the explanations that are presented to him or when he abandons the activities he is doing, especially those that are prolonged. On the other hand, hyperactivity manifests itself through constant movements most of the time (as if the child were moving for the simple fact of doing so). Finally, impulsivity manifests itself when the individual performs actions hastily and without having a logical reason to do so, for example; act before receiving a complete indication (Diagnostic and Statistical Manual of Mental Disorders [DMS-5], 2014).

Additionally, the DSM-5 (2014) stipulates criteria for diagnosing an individual with ADHD. These criteria assess persistent patterns of inattention, hyperactivity/impulsivity separately. For each case, individuals must comply with at least 6 symptoms of the 9 described where

they must last for at least 6 months. Similarly, symptoms must be present in more than one environment either at school, at home, in the park or at work and must manifest before the age of 12. In the case of children, their home and school are normally taken into account because they are the places where the individual interacts the most, for this reason the observation of parents and teachers is of vital importance for the diagnosis.

To understand the heterogeneity of ADHD symptomatology, science has tried to determine its etiology for many years, however, there is still no concrete cause of it. However, in recent decades it has been found that this disorder is highly inherited. This fact is largely due to the fact that multiple studies on monozygotic and dizygotic twins have yielded results of an approximate 70 to 85% heritability (Faraone & Larsson, 2019; Larsson et al., 2014; Grimm et al., 2018; Wood & Neale, 2010).

Likewise, a study of adopted children with ADHD found that 18% of the biological parents of adopted children suffered from the disorder (Sprich et al, 2000). On the other hand, some research has focused on investigating DNA through genome-wide association studies (GWAS), finding that the possible cause of ADHD is due to a series of genetic risk variants in the genome or rare copy number variants (CNVs, among them, the dopamine receptors DR4 and DR5, as well as PARK2, the gene 2 of the Parkinson's protein (Mabres et al., 2013; Demontis et al, 2019; Faraone et al, 2021; Jarick et al., 2012; Williams et al., 2010). However, more studies are needed to solidify these findings.

Another important component is the environmental one, which reveals a high incidence of ADHD. Various studies have shown that factors such as high blood lead concentration, the use of artificial dyes, and mothers' exposure during pregnancy to pesticides, tobacco, or second-hand cigarette smoke are related to attention deficit hyperactivity disorder (Faraone et al, 2021). On the other hand, other research reveals that medication intake, obesity during pregnancy, early or underweight births of children also have a high relationship with ADHD (Rivera, 2013; Tapar et al., 2013). In this sense, there are many environmental factors that affect this disorder. Therefore, a child who is exposed to any of these environmental factors (in the prenatal or postnatal stage) and also has the genetic characteristics already mentioned, increases his or her probability of suffering from the disorder.

Probably, the multiple genetic, environmental and social factors that affect the development of attention deficit hyperactivity/impulsivity disorder are responsible for this being one of the most common pediatric disorders worldwide. According to Polanczyk et al. (2014). In addition, Polanczyk et al. in 2007 estimated a prevalence of 5.9 and 7.1%.

At the international level, some studies report important data, e.g. In Spain, epidemiological studies conducted by Catalan et al., 2012, estimated a combined global prevalence of 6.8% (95% CI), an equivalent of 361580 of children and adolescents in the Spanish community. On the other hand, a recent study conducted in China showed that the combined global prevalence in Mainland China, Hong Kong, and Taiwan is 6.3% (Liu et al., 2018), a value very similar to that estimated in a meta-analysis conducted by Wang et al. in 2012, which was 6.29% prevalence. Likewise, there are results from France, with a prevalence ranging from 3.5% to 5.6% in children aged 6 to 12 years (Lecendreux et al., 2010). While in the United States between 2015 and 2016, the prevalence of diagnosed ADHD increased from 6.1% to 10.2% according to Xu, et al., 2018, a slightly higher figure compared to the others.

In Colombia, the prevalence of attention deficit hyperactivity disorder has been estimated in some cities, and the results found in some of them have been alarming. An example of this is a study carried out by Cornejo and collaborators in 2005, which was carried out in the city of Sabaneta, south of Medellín. The study was applied to individuals from 4 to 17 years of

age and used the DSM-IV survey. The estimate obtained was 20.4% prevalence and 15.86%. Likewise, a study in Manizales applied the DSM-IV survey to children between the ages of 4 and 17 years, showed that about 17.1% suffered from ADHD disorder (Pineda et al., 2001). On the other hand, in the city of Bogotá, a lower prevalence was estimated. From a sample of 1010 children over 4 years of age, 584 children were found to suffer from ADHD, an equivalent to 5.7% prevalence (Vélez et al., 2008). In general terms, Bará et al., 2003 establish that about 16% of the Colombian school population suffers from attention deficit hyperactivity disorder in all possible forms, where only 7.4% receive a well-structured psychiatric diagnosis, and of this percentage, only 6.6% receive treatment.

There is still a lack of cities in Colombia that have a population registry of children and young people who suffer from ADHD, as is the case of Montería. A city in which no public records were found where the reality of this problem is described and therefore the knowledge that is available is scarce, however, due to observations in psychiatric centers and different schools in the city, it is known that there is a significant population of children and young people who suffer from ADHD in its different modalities and that, In some cases, they use medications to control or inhibit symptoms.

As a result of the high prevalence, attention deficit hyperactivity disorder has become a major social problem, as it is estimated to be the cause of most school dropouts in young people. Similarly, it is attributed that it is responsible for increasing addictive drug use disorder, not only because of the impulsive tendency that stimulates consumption, but also because of the low self-esteem of individuals that forces them to seek out inappropriate reference groups and, this, in turn, causes incarceration problems.

In this order of ideas, young people with ADHD also find it very difficult to make social relationships, especially with children of the same age, they tend to injure or hit themselves often, since they suffer accidents easily and of any kind. They have a low tolerance for frustration or have it more frequently than expected in children of the same age and sociocultural level. In addition to that, it is attributed a high comorbidity with other psychiatric disorders such as; conduct disorder, depression disorder, anxiety disorder, the aforementioned substance use disorder, and antisocial personality disorder (Pellicer et al., 2020; DMS-5, 2014).

Taking into account this problem, different areas of science have made considerable efforts to find an effective treatment that controls, decreases or suppresses the symptoms of attention deficit hyperactivity disorder/impulsivity. To date, there are 3 most commonly used methods to treat ADHD: pharmacological, non-pharmacological and multimodal.

These treatments, especially pharmacological ones, although effective in their measure, in some cases do not have good tolerability, which causes side effects on the part of those who use them. Studies have found that the most common side effects in ADHD patients who consume stimulant or non-stimulant drugs are: decreased appetite, constant headache, difficulty sleeping, higher pulse/heart rate, daydreaming, obsessive thinking, gastrointestinal problems, headaches or dizziness, fatigue, constant sweating, and urinary discomfort (Tchang et al., 2020; Storebo, et al., 2015). In some cases, these adverse events are short- to medium-term and can be controlled with dose regulation or medication change, although in some cases the side effects are so severe that it is decided to discontinue the medication and switch to non-pharmacological treatment (Elliott et al., 2020). Faced with this problem, the following problem question arises.

What are the effects of physical exercise on attention in schoolchildren with attention deficit hyperactivity disorder aged 7-12 years in the municipality of Montería, Córdoba?

2. Objectives

2.1 General objective

To determine the effects of physical exercise on sustained attention in school children between 8 and 12 years of age diagnosed with attention deficit hyperactivity disorder in the municipality of Montería, Córdoba.

2.2 Specific objectives

- To determine the levels of attention of the participants of the present pre- and post-intervention study
- To determine the direct scores of correct answers, reaction time and commission errors in the experimental group before and after the intervention
- To evaluate the effects of physical exercise on attention and impulsivity hyperactivity levels in the pre- and post-intervention intervention group of the program.

3. Methodology

3.1 Study design

The study developed is a quantitative approach of a pre-experimental type, where a physical exercise program was applied to a study group with ADHD, prior to which the evaluation of the variables before and after the intervention was carried out. There was no control group (Hernández et al, 2014). The group was given 3 sessions of physical exercise for 4 weeks, giving a total of 12 intervention sessions. The sessions lasted 1 hour, in which exercises based on games and sports were implemented with moderate and high intensities 6 to 10 according to scale; which, in turn, were evaluated with the scale for the measurement of children's perceived effort (EPInfant). Physical exercise variables were taken into account, such as: training volume, frequency, sets, repetitions or work time, rest and intensity. Before the intervention, the participants signed an informed assent and consent, in addition to that, they were given a physical fitness test (1000-meter test) with the aim of determining their functional status.

3.2 Study site

The study will be carried out in the municipality of Montería, department of Córdoba, Colombia, with a sample of 10 children diagnosed with ADHD in educational institutions.

3.3 Population and sample

The population in this study consisted of school children diagnosed with attention deficit hyperactivity disorder belonging to different public and private educational institutions in the municipality of Montería, Córdoba, aged between 8 and 1 years. To estimate the sample parameter, estimates of statistical power a priori and the size of the effect were used, this to determine how many individuals are required to constitute the sample and to perform a more robust hypothesis test. Thus, with the G*Power v.3.1.92 program (Heinrich-Heine-Universität Düsseldorf, Germany) the sample under consideration was calculated with the following criteria: i) two-tailed two-dependent mean (paired t) comparison test; ii) error α =

0.05; effect size = 0.5; statistical power of (probability error 1-β) = 0.85. Thus, a sample of 12 children was determined who were randomly assigned to the groups of this project.

3.4 Techniques and instruments (d2)

The intervention developed in this work was carried out taking into account validated instruments such as the d2 test, which is a paper and pencil test (although there is also a computerized test) that can be performed individually or in groups. The structure of the sheet with which the test is carried out is made up of 14 linear lines along the sheet, one below the other and each line has 47 characters or stimuli. The stimuli are the letter "d" and "p" accompanied by 1 or 2 lines that are located above, to the sides or below the letters. To carry it out, those evaluated have to cross out only the letter "d" that contains 2 lines, for this they have a time of 20 seconds for each line. At the end of the test, the professional in charge must calculate the scores corresponding to: total answers (TR), total correct answers (TA), omissions (TO), commissions (TC), total effectiveness of the test (TOT), concentration index (CON), line with the highest and least number of items attempted, and the variation index (VAR).

3.5 Physical exercise program

This physical exercise work plan is based on the organizational structure of a macrocycle; however, it was not developed in all its dimension or structure because it belonged to a macro-project. In this sense, only a mesocycle of training with physical exercise is taken based on the components of strength, resistance, speed and coordination at intensities that were moderate to high.

This mesocycle comprises 4 microcycles with 3 weekly intervention sessions, for a total of 12 sessions with physical exercise of 1h per session. The microcycles worked on are called: adaptation, developer and stabilizer and were worked respecting the basic principles of sports training such as the principle of overload, principle of progression, principle of individuality, among others. In addition, the characteristics of children with attention deficit hyperactivity disorders were taken into account. The following structure is described below.

3.6 EPInfant Scale (Scale of Perception of Children's Effort)

The perceived effort scale is an instrument that seeks to evaluate, by means of a numerical scale, the level of effort that an individual makes when performing physical exercise. Initially, this scale was designed by Borg in the mid-sixties and is made up of numerical values that are located vertically and in ascending order from the number 6 to 20 (Castellanos & Pulido, 2009).

However, despite the relationship that exists between the heart rate that an individual reaches when performing physical exercise and the numerical value that they choose on the scale according to the effort they perceive, this scale is validated for the adult population, that is, it does not have a validation in the child population and much less in the pediatric population. For this reason, Rodríguez et al. (2015) constructed and evaluated a scale of perceived effort for the child population called EPInfan (scale for measuring the perceived effort of children) in a population under 18 years of age. To construct this scale, Rodríguez et al. conducted a systematic literature review (RSL) on other effort perception scales and took into account the opinion of 4 experts in the areas of health and education, who were given information on the perception of effort, an image of the HPALY (pediatric visual analog scale) and 3 questions from the previous scale (YALY). After the analysis of the experts, they suggested that the

EPInfant scale should contain illustrations and number in its structure, in the same way it should contain verbal descriptors and graphic illustrations and finally, it was suggested that the design should be constituted by columns with exponential growth (Rodríguez et al., 2015).

The result of the construction of the Scale for the Measurement of Childhood Perceived Exertion (EPInfant) is shown in Figure 1:

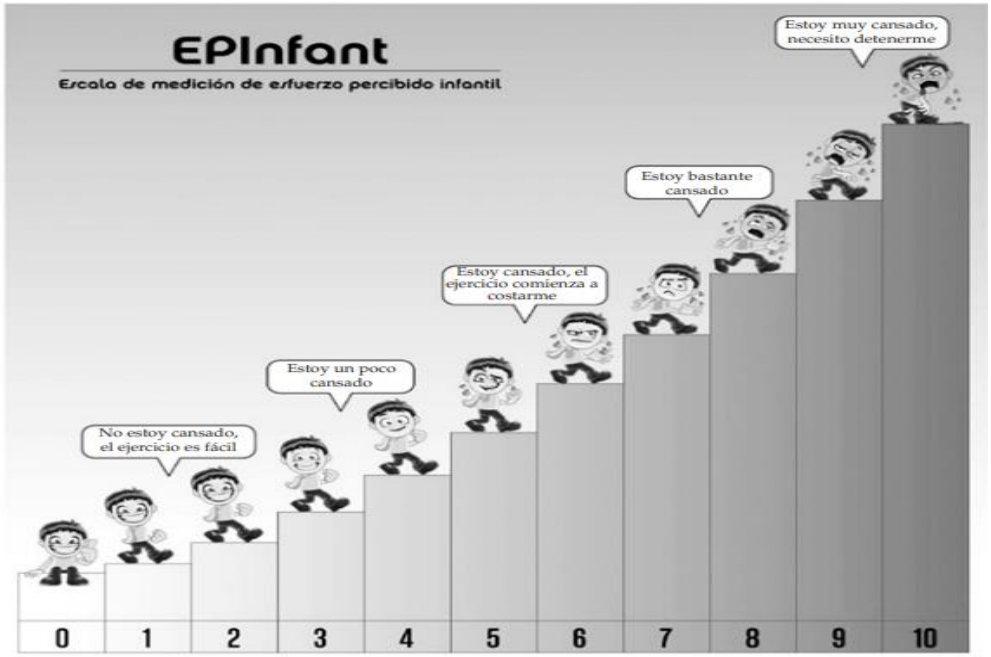


Figure N° 1: taken from Rodríguez et al., 2015

3.7 Inclusion criteria

Children of both sexes between 7 and 12 years of age were included, with a diagnosis of ADHD confirmed by specialists in accordance with the DSM-5 criteria; children with the various subtypes of ADHD (i.e., inattentive, hyperactivity/impulsivity, combined) regardless of whether or not they receive pharmacological treatment for ADHD; and finally, children who have the informed consent to participate in this study signed by their parents and with the informed consent signed by the child.

3.8 Exclusion Criteria

Children with autism spectrum and other serious affective disorders, children with a personal history of brain injury or neurological disorders, children who are currently receiving treatment with sedatives or other mood-altering medications, other than the stimulants normally prescribed for ADHD, children with a physical injury that makes it difficult to perform physical exercise, and children who do not have prior informed consent signed by the parents.

4. Results

For the statistical analysis process of the data, it was determined if the distribution of the measures of the variables of the d2 test complies with the assumptions of normality, for this the SHAPIRO-WINKS test was used. Thus, if the assumption of normality is met, the value

of P-value of Shapiro-Wilk must be greater than 0.05 (p>0.05); in this sense, if the value of P is less than 0.05 (p<0.05) it means that it does not follow a normal distribution.

DESCRIPTIVE STATISTICS														
	TR	**TRpost**	**TA**	**TApost**	**Or**	**Opost**	**C**	**Cpost**	**TOT**	**TOTpost**	**WITH**	**CONpost**	**VAR**	**VARpost**
Mean	291.00	323.08	93.58	126.91	28.66	9.91	5.83	2.83	256.50	310.33	87.75	124.08	19.00	15.91
Std. Deviation	68.30	82.60	40.85	35.90	27.08	11.86	6.47	5.25	76.35	86.25	43.16	38.74	8.13	4.60
Shapiro-Wilk	0.97	0.97	0.97	0.94	0.83	0.78	0.83	0.55	0.93	0.95	0.95	0.94	0.86	0.91
P-value of Shapiro-Wilk	0.95	0.95	0.92	0.57	0.02	0.00	0.02	<.001	0.43	0.75	0.74	0.55	0.05	0.27

Table 1. DESCRIPTIVE STATISTICS

As can be seen in the table, the measures of TR (p=0.95), TRpost (p=0.95), TA (p=0.92), TApost (p=0.57), TOT (P=0.43), TOTpost (p=0.75), CON (p=0.74), CONpost (p=0.55), VAR (p=0.05) and VARpost (P=0.27) complied with the assumption of normality, while the measures of O (p=0.02), Opost (p=0.00), C (p=0.001) and Cpost (p=0.43) do not comply with the normality data, therefore, parametric tests cannot be applied with the latter measurements, since they are susceptible to interpretation.
Subsequently, the ANOVA-MR parametric test (Analysis of variance of repeated measures in related samples) was applied, since 2 measurements were made from a sample that was related. This test led us to formulate 2 hypotheses for the related sample:

1. Null hypothesis: means that there are no significant differences between the measures of care before and after the intervention.
2. Alternative hypothesis: means that there are significant differences between the measures of care before and after the intervention.

For the analysis of the ANOVA-MR, a significance level of <0.05 must be established, where the decision criteria establish that:

- If p is greater than 0.05 (p>0.05), the null hypothesis is accepted and the alternate hypothesis is rejected.
- If p is less than 0.05 (p<0.05), the alternative hypothesis is accepted and the null hypothesis is rejected

Likewise, the effect size (ω^2) was calculated, in order to determine if it obtained a small effect, a medium effect or a large effect. To do this, the following scale was taken into account.

- If the ω^2 value is between 0.01 and 0.06: The effect size is small
- If the ω^2 value is between 0.06 and 0.014: The effect size is medium
- If the value of ω^2 is greater than 0.014: The effect size is large.

Next, the analysis was carried out with 12 cases where the measures related to care were taken into account, which is the total response, BP, which is the total number of correct answers; that is, the number of correct relevant elements, OR which is the omissions; that is, the number of relevant elements marked but not marked, C which are the commissions; that is, the number of irrelevant marked items marked, TOT which is the total effectiveness of the test; that is, TR- (O+ C), as well as CON which is the concentration index or TA-C, TR+ which is the line with the highest number of elements attempted, TR- which is the line with the lowest number of concentrated elements and finally VAR which is the variation or difference index (TR+) - (TR¬-). See table.

Variables	**ANOVA – MR** **N = 12**		
	F	***p***	**ω^2**
TR	12.269	0.005	0.040
TA	38.938	0.001	0.155
Or	7.439	0.020	0.148
C	2.070	0.178	0.032
TOT	59.962	0.001	0.097
WITH	43.147	0.001	0.161
VAR	1.146	0.307	0.007

The results found in each of the measures evaluated in the population intervened in the pre-test and post-test referring to d2 are described below, in this sense the measures that showed a significant effect after the intervention can be seen in the table above.

The first measure corresponds to the TR, which refers to the total response of the children in the test. This showed a significant effect with a small effect size (F= 12.26; p= 0.005; ω^2= 0.040) after the intervention. This means that the group obtained a statistically significant improvement in this measure, therefore TR accepts the alternative hypothesis and rejects the null hypothesis.

The second measure corresponds to TA, which refers to the total number of correct stimuli in the test. This showed a significant measurement effect with a large effect size (F=38.938; p= 0.001; ω^2=0.155) after the intervention. This means that the group obtained a statistically significant improvement in this measure, therefore TA accepts the alternative hypothesis and rejects the null hypothesis.
The third measure corresponds to O, refers to the total number of errors due to omissions in the test. Although it showed a significant effect with a large effect size (F=7.439; p= 0.020; ω^2=0.148) after the intervention, it does not meet the assumptions of normality, for this reason these data are susceptible to interpretation.
The fourth measure corresponds to C, which refers to the total number of commission errors in the test. The statistical values show that this measure did not reach the level of significance and the effect size was small (F=2.070; p= 0.178; ω^2=0.032) after the intervention. In addition to that, this measure does not comply with the assumptions of normality either, for this reason these data are susceptible to interpretation.

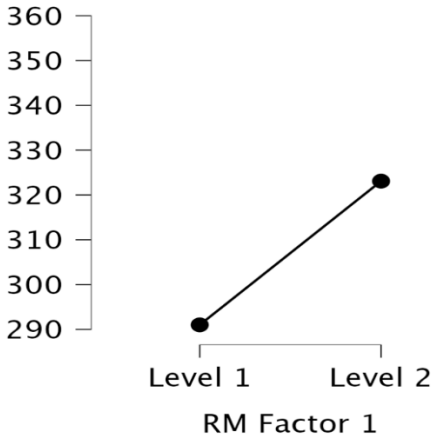
The fifth measure corresponds to TOT, which refers to the total effectiveness of the test. This showed a significant measurement effect with a median effect size (F=59.962; p= 0.001; ω^2= 0.097) after the intervention. This means that the group obtained a statistically significant improvement in this measure, therefore TOT accepts the alternative hypothesis and rejects the null hypothesis.
The sixth measure corresponds to CON, referring to the concentration index or the index of sustained attention of the participants. This showed a significant measurement effect with a large effect size (F=43.147; p= 0.001; ω^2= 0.161) after the intervention. This means that the group showed statistically significant improvements in this measure, therefore CON meets the alternative hypothesis.
Finally, the seventh measure corresponds to VAR, which refers to the index of variation or difference of the test. The statistical values show that this measure did not reach the level of significance and the effect size was small (F= 1.146; p= 0.307; ω^2=0.007) after the intervention. This means, it did not show significant improvements to this extent, for this reason VAR accepts the null hypothesis and rejects the alternative.

4.1 Results TR: Repeated Measures ANOVA-MR

Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω^2**
RM Factor 1	6176.0	1	6176.0	**12.269**	**0.005**	**0.040**
Residuals	5537.4	11	503.4			

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	120835.4	11	10985.0		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	291.0	68.3	19.7	0.23
Level 2	12	323.0	82.6	23.8	0.25

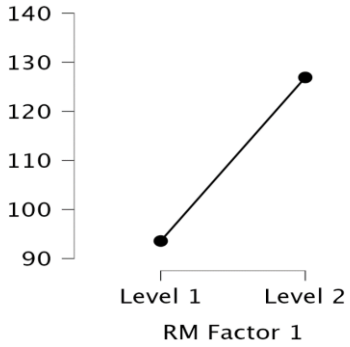


4.2 Results TA: Repeated Measures ANOVA

Within Subjects Effects						
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω²**
RM Factor 1	6666.6	1	6666.6	**38.9**	**<.001**	**0.15**
Residuals	1883.3	11	171.2			
Note. Type III Sum of Squares						

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	30652.500	11	2786.591		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	93.5	40.8	11.7	0.43
Level 2	12	126.9	35.9	10.3	0.28

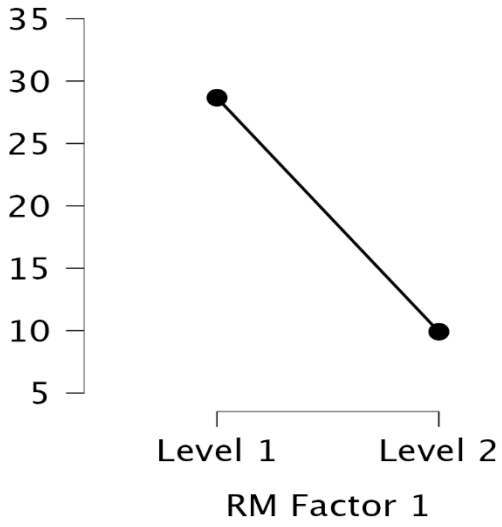


4.3 Results O: Repeated Measures ANOVA-MR

Within Subjects Effects						
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω²**
RM Factor 1	2109.3	1	2109.3	**7.43**	**0.02**	**0.14**
Residuals	3119.1	11	283.5			
Note. Type III Sum of Squares						

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	6498.4	11	590.7		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	28.6	27.0	7.8	0.945
Level 2	12	9.9	11.8	3.4	1.197

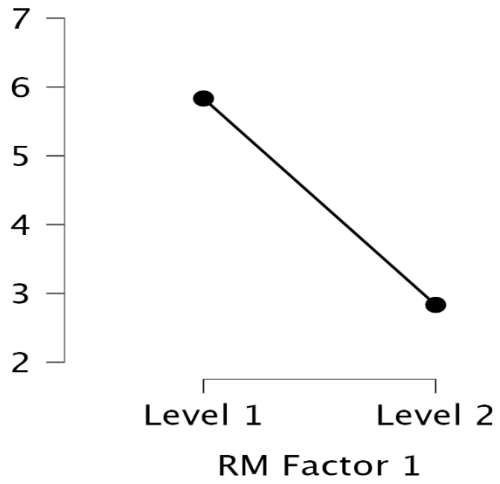


4.4 Results C: Repeated Measures ANOVA-MR

Within Subjects Effects						
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω²**
RM Factor 1	54.000	1	54.000	**2.070**	**0.178**	**0.032**
Residuals	287.000	11	26.091			
Note. Type III Sum of Squares						

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	478.333	11	43.485		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	5.833	6.478	1.870	1.111
Level 2	12	2.833	5.254	1.517	1.854

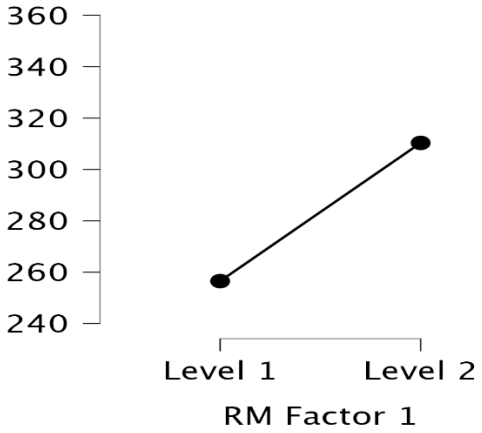


4.5 Results TOT: Repeated Measures ANOVA-MR

Within Subjects Effects						
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω²**
RM Factor 1	17388.1	1	17388.1	**59.9**	**<.001**	**0.097**
Residuals	3189.8	11	289.9			
Note. Type III Sum of Squares						

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	142781.8	11	12980.1		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	256.5	76.3	22.0	0.29
Level 2	12	310.3	86.2	24.9	0.27

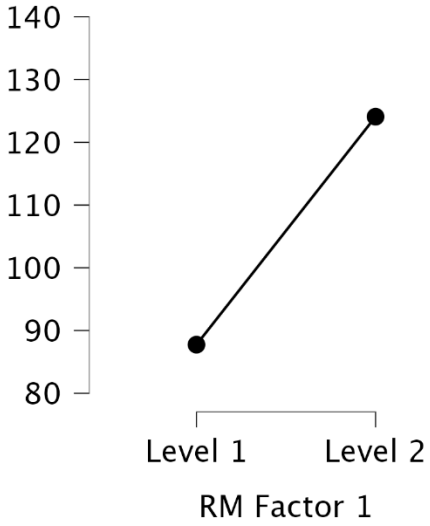


4.6 Results CON: Repeated Measures ANOVA-MR

Within Subjects Effects						
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω²**
RM Factor 1	7920.6	1	7920.6	**43.147**	**<.001**	**0.161**
Residuals	2019.3	11	183.5			
Note. Type III Sum of Squares						

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	34981.8	11	3180.1		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	87.7	43.1	12.4	0.49
Level 2	12	124.0	38.7	11.1	0.31

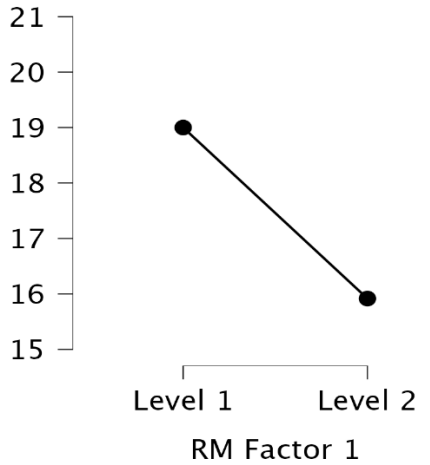


4.7 8.7. Results VAR: Repeated Measures ANOVA-MR

Within Subjects Effects						
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**	**ω²**
RM Factor 1	57.042	1	57.042	**1.146**	**0.307**	**0.007**
Residuals	547.458	11	49.769			
Note. Type III Sum of Squares						

Between Subjects Effects					
Cases	**Sum of Squares**	**Mexico City**	**Mean Square**	**F**	**p**
Residuals	413.4	11	37.5		
Note. Type III Sum of Squares					

Descriptives					
RM Factor 1	**N**	**Mean**	**SD**	**HERSELF**	**Coefficient of Variation**
Level 1	12	19.0	8.1	2.3	0.42
Level 2	12	15.9	4.6	1.3	0.28



Discussion

According to the results obtained in the present research, it can be stated that the intervention through a physical exercise program with the development structure of a macrocycle that addresses the components related to physical fitness (strength, speed, endurance and flexibility), diversified games and pre-sports games during a training mesocycle of 4 microcycles, with 3 training sessions per week for 1 hour, applied to a group of children aged 8 to 12 years, produces positive effects related to total answers (TR), total correct answers (TA), omission (O), commission (C), total effectiveness of the test (TOT), concentration index (CON) and variance index (VAR).

In this way, very significant results have been found with research carried out by Muñoz et al., (2019) where a comparative analysis is made with a population of students from 5 to 15 years old, who were intervened in the physical education class through pre-sports activities for 6 weeks. The results of this study showed that quality of attention and sustained attention had significant effects with a moderate-to-large sample size. These results are similar to that of our research, where response time, total responses, test effectiveness, concentration or sustained attention, and variance also showed significant results with moderate to large sample size, in addition, improvements in the health, social interaction, and physical fitness of the intervened group are also reflected. as evidenced in a meta-analysis by Christiansen et al. (2019).

Similarly, the meta-analyses carried out by Sun et al. (2022); Manzano et al. (2018) show the multiple benefits that physical exercise generates on cognitive processes and executive functions, a construct of which the processes of attention and its different manifestations are part.

Finally, the results obtained above denote the importance of promoting and developing psychoeducational programs (physical exercise programs) in the educational and social field, as an ethical and moral spring that the new professional in the area of physical education, recreation and sports must assume.

5. Conclusions

The research carried out within the framework of the project "Effects of physical exercise on sustained attention in schoolchildren aged 8 to 12 years with attention deficit hyperactivity disorder (ADHD) in the municipality of Montería, Córdoba", has made it possible to identify significant improvements in various attention indicators after the implementation of the intervention program based on physical exercise.

First, a considerable increase was observed in the measure of correct answers, going from an average of 93.58 in the pre-intervention diagnosis to 126.91 in the post-intervention, which shows a significant advance in the precise response capacity of the participants. This suggests that the exercise program favored a more efficient development of sustained attention, improving accuracy in the identification of relevant stimuli.

Likewise, the results reflected a significant improvement in reaction times, which increased from 256.50 to 310.33. This change suggests an optimization of cognitive processing capacity and speed of response to visual stimuli, which is crucial for school adaptation and participation in activities that require focus and concentration.

In the area of commission errors, the intervention showed a significant reduction from 5.83 to 2.83, indicating a lower number of impulsive or incorrect responses by the participants. This denotes an improvement in inhibitory control and the ability to avoid impulsive errors,

which is a central aspect in the management of ADHD, where impulsivity is a predominant symptom.

The analysis of sustained attention levels also showed relevant progress, with an increase from 87.75 in the pre-intervention phase to 124.08 in the post-intervention phase. This finding reinforces the hypothesis that physical exercise has a positive impact on children's ability to sustain attention for prolonged periods, thereby contributing to greater stability and performance in school settings.

In addition, the statistical analyses performed, such as the ANOVA-MR, showed highly significant results ($p = 0.001$ and $\omega^2 = 0.161$), which confirms that the changes observed in the different measures of attention were not the product of chance, but reflect a true influence of the physical exercise program on the improvement of attention indicators in children with ADHD.

Finally, the intervention program included neuromotor stimulation strategies, social interaction and inclusion activities, which had the collaboration of teachers, parents and coaches. This multidisciplinary approach made it possible to consolidate the work in a comprehensive way, not only as a physical intervention, but as a psychoeducational treatment that positively impacted the quality of life of the participating children. This suggests the need to incorporate similar programs into educational and public health policies, as a viable and effective alternative for the treatment of ADHD in childhood, contributing to reducing dependence on pharmacological treatments and favoring the integral development of children. but also as a key component in the formation of healthy habits that benefit children's cognitive and emotional development. Therefore, the promotion of physical exercise programs in the school context is recommended as part of a comprehensive approach to attention to diversity in education.

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