MLS EDUCATIONAL RESEARCH
http://mlsjournals.com/Educational-Research-Journal
ISSN: 2603-5820

How to cite this article:

Suárez-Manzano, S., Ruiz-Ariza, A., Lopez-Serrano, S., Martínez López, E.J. (2017). Acute effect of physical exercise on the impulsivity and state of anxiety, in 6-12 years school children with attention deficit and hyperactivity disorder: Systematic review. *MLS-Educational Research*, *1* (1), 39-52. DOI: 10.29314/mlser.v1i1.21

ACUTE EFFECT OF PHYSICAL EXERCISE ON THE IMPULSIVITY AND STATE OF ANXIETY, IN 6-12 YEARS SCHOOLCHILDREN WITH ATTENTION DEFICIT AND HYPERACTIVITY DISORDER: SYSTEMATIC REVIEW

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Abstract. Introduction: The objective of this review was to analyze the effect of physical exercise on behavior in schoolchildren (6-12 years old) with attention deficit hyperactivity disorder (ADHD). **Method:** For this, a bibliographic search was made in three databases (initial search n = 92: PubMed n = 22, SportDiscus n = 63, Web of Science n = 7), from January 2000 to June 2017. **Results:** A total of three longitudinal studies with intervention met the inclusion criteria, assessed as high quality. All studies employed running for at least 25-30 minutes at moderate to vigorous intensity controlling heart rate and technique by specialists. All showed that exercise at the beginning of the class improves behavior in children diagnosed ADHD, in addition to other key variables for academic performance, such as attention and memory. **Discussion:** We can conclude that active displacement or previous intentional activation through a moderate to vigorous intensity run before the beginning of the school day improves the behavior of the students, a better classroom environment is achieved and conflicts are avoided. Further research is needed to clarify the potential key role of exercise intensity and duration, as well as the duration of these benefits.
Keywords: Physical Exercise, behaviour, school, review.

EFECTO AGUDO DEL EJERCICIO FÍSICO SOBRE LA IMPULSIVIDAD Y ESTADO DE ANSIEDAD, EN ESCOLARES DE 6-12 AÑOS CON TRASTORNO POR DÉFICIT DE ATENCIÓN E HIPERACTIVIDAD: REVISIÓN SISTEMÁTICA

Resumen. **Introducción**: El objetivo de esta revisión fue analizar el efecto de la práctica de la ejercicio físico sobre el comportamiento en escolares (6 - 12 años) con trastorno por déficit de atención e hiperactividad (TDAH). **Método:** Se hizo una búsqueda bibliográfica en tres bases de datos (búsqueda inicial n = 92: PubMed n = 22, SportDiscus n = 63, Web of Science n = 7), desde enero de 2000 hasta junio de 2017. **Resultados**: Un total de tres estudios longitudinales con intervención cumplieron los criterios de inclusión, evaluados como de alta calidad. Todos los estudios emplearon carrera durante al menos 25-30 minutos, a intensidad de moderada a vigorosa controlando la frecuencia cardiaca y técnica de ejecución por especialistas. Todos mostraron que el ejercicio al comienzo de clase mejora el comportamiento en niños diagnosticados TDAH, además de otras variables claves para el rendimiento académico, como son la atención y la memoria. **Discusión**: Una activación intencionada previa al comienzo de la jornada escolar, mediante carrera a intensidad moderada a vigorosa, mejora el comportamiento de los alumnos, se logra un mejor ambiente en el aula y se evitan conflictos. Se necesitan más investigaciones para aclarar el posible papel clave de la intensidad y duración del ejercicio, así como la duración de estos beneficios.
Palabras clave: Ejercicio Físico, comportamiento, colegio, revisión.

Introduction

Currently, it is common to find students with difficulties at the classroom. Among the most common ones, there are the Attention Deficit Hyperactivity Disorder (ADHD), a neurdevelopment disorder characterized by a persistent pattern of not paying attention and/or hyperactivity-impulsiveness that interferes in the development of the social, academic/working capacities (DSM5, 2013). Approximately, 5% of children and teenagers are diagnosed, with no differences between ages (Polanczyk, Salum, Sugaya, Caye & Rohde, 2015) ADHD is associated with deficiencies in the executive functions: working memory, mental organization and planning, behavior attention and control (Diamond, 2013) and it is as well associated with psychiatric conditions like the defiant opposition/negative and a low mood or anxiety (Van der Oord, Prins, Oosterlaan & Emmelkamp, 2008). At preschool, between three and six, the disruptive behaviors like tantrums, the search for attention, the non-compliance and the hyperactivity can be associated with the classmates' rejection and the low academic performance during the elementary school years (Egger & Angold, 2006). As well, during childhood, the presence of aggressive and antisocial behaviors is linked to future serious behavior problems and delinquency in adult life (Broidy *et al*., 2013).

There are two main treatments for children diagnosed with ADHD, change behavior and drugs administration. In some cases, the drugs administration has side effects or is not effective in behavior variables, so the change behavior treatment is preferred. It consists of therapy with specialized psychologists who show children to control impulsiveness and aggressivity. In this way, since they are capable of controlling their emotions, they can take advantage of their perceptive abilities and to have a better performance in their tasks (Watson, Richels, Michalek & Raymer, 2015) Nevertheless, Chronis *et al*. (2004) observed the benefits from the change behavior treatments are neither effective in all cases, and have disadvantages such as a loss in efectiveness throughout time and important rates for giving up on the treatment. Conversely, it is well-known that at the physiological-structural level, children diagnosed with ADHD show a deficit in neurotransmitters and dopamine in the frontal lobe (Sharma & Couture, 2014), which is the reason for most of them to be taking

drugs when they are six, a treatment based on stimulants like methylphenidate and amphetamines that act by raising the dopamine levels in the brain, which in turn improves the executive functions (Hodgkins, Shaw, Coghill & Hechtman, 2012).

Kim *et al*. (2011) observed in rats that exercising in a race 30 minutes/day fir 5 days/week x 28 days, same as with methylphenidate improved hyperactivity induced by the ADHD as so they did with the memory impairment while learning via the improvement of the dopamine synthesis and the expression of the neurotrophic factor tht is derived from the brain evidence that exercising elevates the dopamine and norepinephrine levels in the brain. In humans, Wing *et al*. (2003) observed that exercising frees dopamine in the prefrontal cortex and the basal ganglia. Furthermore, results from transversal and longitudinal studies with intervention through aerobic trainings show they have antidepressant and anxiolityc effects, and protects against the stress' harmful effects (Slamon, 2001).

However, and to the knowledge of this paper's authors, there has not been yet an analysis of the studies evaluating doing exercise by taking part in a race, prior to the school day and its effects on children's behavior (6-12 years old) who are diagnosed with ADHD by clinical specialists. Most of the papers focus on knowing the effect of exercising on the cognitive performance (Cornelius, Fedewa, & Ahn, 2017; Grassmann, Alves, Santos-Galduroz, & Galduroz, 2014).

Hence, the question we are raising in this review is the following: Organizing a race prior to the school day could improve the behavior of ADHD children at school? This review article is focused on children, for the first credible diagnosis of ADHD can be done from age six, a stage at which school conflicts and dependency are associated with bad academic results and behavior problems in future years (Hamre & Pianta, 2001).

Method

The methodology used for this study was the systematic review. At first, the search engines and the selection criteria were determined. Subsequently, every one of the authors conducted an own search. The obtained results were discussed, duplicated articles that were not in accordance with the search limits for their heading or abstract were dismissed. Finally, according to the selection criteria, the articles were selected by consensus and the summary table that includes the main aspects of each article was written.

Search limits

The search was made in three data bases (PubMed, SportDiscus and Web of Science). The search dates were: Januay 2000-July 2017. The journals had to have peer review and had to be indexed in ISI, with journals which included articles written in English. The search terms were:

- Race, running, walking, treadmill, cardiovascular exercise, active displacement.
- Attention-deficit hyperactivity disorder, ADHD, attention deficit disorder, ADD.
- Children, childhood, school-age youth, student.
- Behaviour, behavior, mood, conflicts.

Table 1 shows the search strategies that were followed for each of the data bases, as well as the filters used and the articles obtained in every search.

Table 1
Search strategy in the data bases

Databases	Search strategy	Limits	Results
PubMed	Search ((((("physical activity" OR "exercise" OR "Race" OR "running" OR "walking" OR "treadmill" OR "cardiovascular exercise" OR "active displacement")) AND ("Attention-deficit hyperactivity disorder" OR "ADHD" OR "attention deficit disorder" OR "ADD")) AND ("Children" OR "childhood" OR "school-age youth" OR "student")) AND ("Behaviour" OR "behavior" OR "mood" OR "conflicts") Filters: Clinical Trial; Full text; Publication date from 2000/01/01 to 2017/06/31; Humans	Publication from 2000/01/01 until 2017/06/31 -Humans, children: 6-12 years old - English language	22 filtered articles
SportDiscus (EBSCO)	("physical fitness" OR "physical activity" OR "physical education" OR "fitness" OR "exercise", "physical exercise" OR "acute exercise" OR "chronic exercise" OR "healthy exercise" OR "aerobic exercise" OR "resistance exercise" OR "anaerobic exercise") AND ("attention deficit hyperactivity disorder" OR "ADHD") AND ("attention deficit hyperactivity disorder" OR "ADHD" OR "attention deficit disorder") AND ("children" OR "childhood" OR "school-age youth" OR "adolescent" OR "teenagers" OR "student" OR "school" OR "high school")	Publication from 2000/01/01 until 2017/06/31 - Humans, children: 6-12 years old - English language	63 filtered articles
Web of Science	Title: (("physical fitness" OR "physical activity" OR "physical education" OR "fitness" OR "exercise", "physical exercise" OR "acute exercise" OR "chronic exercise" OR "healthy exercise" OR "aerobic exercise" OR "resistance exercise" OR "anaerobic exercise")) *AND* Title: (("attention deficit hyperactivity disorder" OR "ADHD" OR "attention deficit disorder")) *AND* Title: (("children" OR "childhood" OR "school-age youth" OR "adolescent" OR "teenagers" OR "student" OR "school" OR "high school"))	Publication from 2000/01/01 until 2017/06/31 - Humans, children: 6-12 years old -English language	7 filtered articles

Selection Criteria

The selected studies to be included in this article were contrasted following these criteria:

- Complete report published in a journal with peer review.
- The population of study was children diagnosed with ADHD (6-12 years old).
- The study included written in English.
- The study used an interventional study prior to the school day.
- Behavior variables were measured with valid and credible tools.
- There are no exclusion criteria due to ethnicity.

Quality level's evidence

All the articles included in this study rely on a high quality (see Table 2). They meet the selection criteria established in accordance with other standardized evaluation lists (Ruiz-Ariza, Grao-Cruces, de Loureiro & Martínez-López, 2017) and also with out inclusion criteria. The list included six items about design, population, internvention, measures and result reports. Each item was classified as 0 (non-compliance or was unclear), 1 (moderately informed) or "2" (completely informed). For all the studies, the total score was calculated by counting the number of positive items (total score between 0 and 12). Three evidence levels were established. The studies were tagged as counting with a Low Quality (LQ) if their score wasunder five. A total score between five and eight was defined as Average Quality (AQ) and between nine and twelve was classified as High Quality (HQ). All the articles included in this systematic review rely on a high quality (see Table 2).

Table 2
List of included studies with the quality scores

Authors	A	B	C	D	E	F	Total score	Quality level
Tantillo et al. (2002)	2	2	2	2	2	2	12	HQ
Chang et al. (2012)	2	2	2	2	2	2	12	HQ
Hung et al. (2016)	2	2	2	2	2	2	12	HQ

Note: High Quality (HQ)= 9-12 A. Study completely published in a journal with peer review. B. The population of study was schooled children (6-12 years old) diagnosed with ADHD. C. The results regarding the variable attention were clearly described. D. The intervention was made via a race/march prior to the school day. E. Measurement of behavior variables with valid and credible tools. F. There are no excluding criteria in respect of ethnicity and students who showed any other type of learning or neurocognitive problems were not included.

Results

The chart flow corresponding to the results of the review process is shown in Figure 1. In the main search, 92 articles were obtained. 24 were dismissed for being duplicated, so 92 were left. In the following step, 65 articles were ruled out, basing on the information provided by the heading or the abstract, for non-compliance with the inclusion criteria or for not being able to find the full text. So, three studies were reviewed with the selection cirteria, performing an in-depth read of the full texts that met the selection criteria (Chang, Liu, Yu & Lee, 2012; Hung, Huang, Tsai, Chang & Hung 2016; Tantillo, Kesick, Hynd & Dishman, 2002).

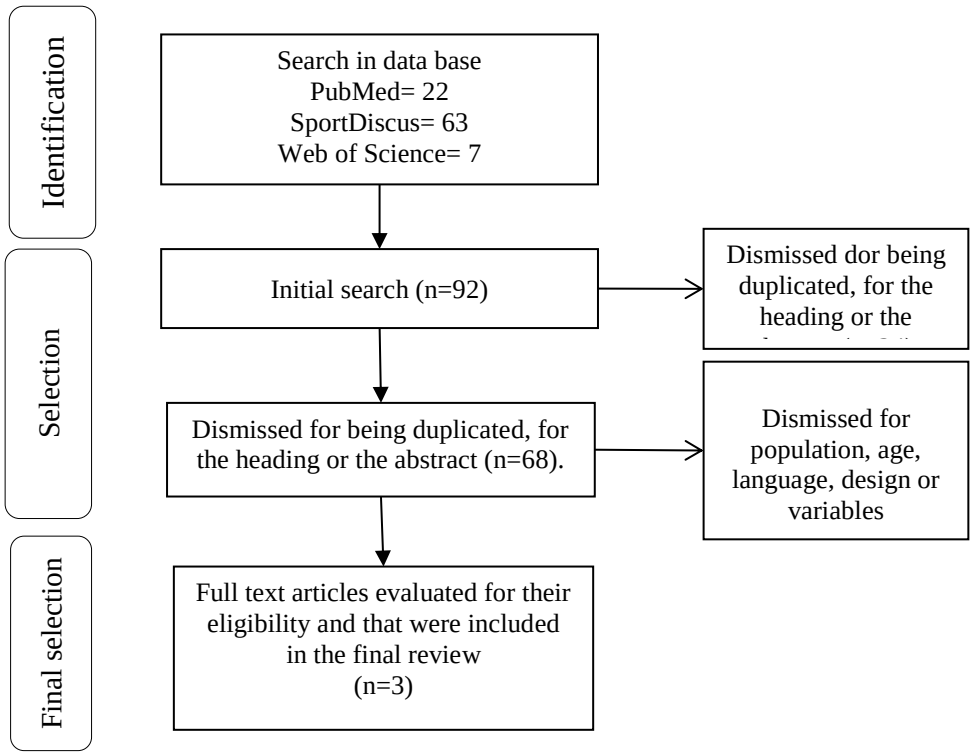

Figure 1. Articles' selection process

In this review paper, three articles were included, all of them with an interventional design, and with the participants being assigned to different groups or conditions randomly. All evaluate the effect of an intervention in a race, with moderate-high intensity, controlled by heart rate, on a treadmill, and also controlled by an specialist in sports and exercise science. The different behavior variables were evaluated before and after the intervention. Children who participated in the different studies were diagnosed with by specialized clinical psychologists using the DSM-III-R (Tantillo *et al*., 2002) or DSM-IV (Chang et al., 2012; Hung *et al*., 2016).

This review includes data from 117 participants, from which 25 were girls (29,25%) and 92 were boys (70,75%), so the sample size of the different studies were between 34 (Hung *et al*., 2016) and 43 Tantillo et al., 2002) participants. The studies were perfoemed in wto countries: two in China (Chang *et al*., 2012; Hung *et al*., 2016) and one in Georgia (Tantillo *et al*., 2002).

Table 3
Three articles from the past 17 years that evaluate the effect of the race at a moderate-high intensity on the behavior of children diagnosed with ADHD

Author and year	Study design/Diagnostic Intervention	Sample Age/ Country	Groups	Measurements/ Measurement time	Results

Tantillo et al. (2002)	Intervention/ DSM-III-R diagnostic 1 day before the school day	43 boys (22 girls) 8-12/ Georgia	2 groups: GE-TDAH (N = 18): 5-25 min race on a treadmill (65-75% VO2máx) CG-no ADHD (n=25) no exercise	STAI-C/ Pre-post	EG improved the behavior, reduced the state anxiety and the trait anxiety in comparison with the CG. CG experimented no change in behavior.
Chang et al. (2012)	Intervention/ DSM-IV Diagnostic/ 1 day before the school day	40 boys (3 girls) 8.-13/ China	2 groups: EG: 30 min race on a treadmill(50-70% MHR) CG: no exercise	Observation by the teacher Stroop and WCST/ Pre-post	EG diminished in impulsive behaviors and cognitive flexibility in comparison with the CG. CG experimented no change in behavior.
Hung et al. (2016)	Intervention/ DSM-IV Diagnostic/ 1 day before the school day	34 boys/ 8-12/ China	2 conditions: EG: 30 min race on a treadmill (50–70% MHR) CG: no exercise	Chinese version of the ADHD test Chinese version of the CBCL test Pre-post	EG improved behavior and symptoms characteristic to the ADHD in comparison with the CG. CG experimented no change in behavior.

Note: CBCL = Child Behavior Checklis.DSM = Diagnostic and Statistical Manual of Mental Disorders. MHR=Maximum Heart Rate. CG = Control Group EG = Experimental Group IOWA = STAI-C = State-Trait Anxiety Inventory for Children. ADHD = Attention Deficit Hyperactivity Disorder. VO_2máx = Maximal oxygen consumption. WCST = Wisconsin Card Sorting Test.

Behavior evaluation

Showing opposition/negative, defiant behaviors, low moods and high anxiety levels are typical in children aged between 6 and 12 diagnosed with hyperactivity/attention disorder (Van der Oord, Prins, Oosterlaan & Emmelkamp, 2008). The selected studies evaluated the students' behavior through using the tests STAL-C, observation by the teacher during the school day, and during the Stroop and Wsct tests, the Chinese version of the ADHD test and the Chinese version of the CBCL test; data was obtained regarding sociability, opposition, defiant behavior, anxiety level and risk of suffering from depression.

Effect of the moderate-high intensity race on the behavior

A total of three studies analyzed the immediate effect of a race with a moderate-high intensity on the behavior (Chang *et al*., 2012; Hung *et al*., 2016; Tantillo *et al*., 2002). All of them only did one intervention in one session, evaluating the short term effect of exercising prior to the school day. All the studies carried our the measurements within 24 to 48 hours after having suspended the administration of the drugs to treat the ADHD symptoms.

The study of Tantillo *et al*. (2002) was one of the first to measure the effects of exercising on the cognition of children diagnosed with ADHD, which is why it is a reference in the area of cognition in children with learning difficulties. This study followed a design based on a control and an experimental group, the students from the control group remained seated and expectant, without making any movement and talking to each other, meanwhile, the students from the experimental group took part in a race, at a submaximal intensity, on a treadmill, in such a way that they completed the first 5 minutes at a low intensity,

approximately 40% and after that, the treadmill's speed was incremented, as well as the race's speed did, until reaching a maximal oxygen consumption between the 65-75% of the VO_2 max. In the students of the experimental group, the state anxiety and the trait anxiety diminished in comparison with the control group, the improvements were most notable in girls than in boys. Chang *et al*. (2012) differentiated between the control group from the experimental group, the control group watched a documentary while seated, at the same time, the experimental group took part in a race at a moderate-high intensity on a treadmill. The intensity was controlled by using a heart rate monitor, the speed was regulated to keep the intensity at a 50-70% of the maximal heart rate, calculated with the Karvonen, Kenthla and Mustala formula (1957). In the experimental group, the impulsiveness levels were reduced during the tests, such improvements were not found in the control group. Hung et al. (2016) carried out a study that was very much similar to the one of Chan et al. (2012), the design was different in the fact that instead of working with two groups, they did an offset, in such a way that the original group was randomly divided into two subgroups. One group was assigned as the control, and watched a video for 30 minutes, and the other was then the experimental, and were those who took part in a race on a treadmill for 30 minutes, at a 50-70% intensity of the maximal heart rate, monitored by a pulse meter; a week after, the participants shifted their conditions. This time, the measurements were took on the same schedule and school conditions, but in a laboratory at which the possible polluting variables, such as the noise and the temperature, could be controlled,. The students improved the ADHD symptoms and the associated behavior after exercising, there were no changes in the video intervention.

These results are similar to those obtained by Flohr, Saunders, Evans & Raggi (2004), when exercising in the stationary bicycle for 25 minutes before starting the school day, at a moderate intensity, 40-50 VO_2 max, the participants (90 boys, aged 7-11) improved their behaviors during the lessons and the tests, also improving in their test results that assessed their skills in algebra and reading comprehension.

Discussion and conclusions

These systematic review has analyzed the studies from the past 17 years that evaluate the effect of the race at a moderate-high intensity on the behavior of children (6-12 years old) diagnosed with ADHD. The search was limited to three data bases and to studies published between January 2000 and June 2017. A total of three articles met the selection criteria, all used a longitudinal design with an intervention on a treadmill prior to the school day, for at least 20-30 minutes and with a high quality as a result and being published in some of the most famous journals in the world. The intensity of the exercise was monitored by the heart rate and controlled by specialists in exercise and sports science. The results have shown that the race boosts an improvement in behavior, diminishes the impulsiveness and the anxiety (Chang *et al*., 2012; Hung *et al*., 2016; Tantillo *et al*., 2002). In addition to that, it had a positive effect on the executive functions and the academic performance. None of the studies proved a negative association.

The lack of specific studies with children diagnosed with ADHD has made it difficult to establish direct comparisons. Working with populations experiencing some learning difficulties makes the task harder, even more if the intention is to intervene in the school environment, for there are other students who must continue with their lessons as long as the study is being done. The inclusion of exercising to start the day means having available and moving all the materials to the center, a no easy task for which multiple permission requests are needed before the intervention. Therefore, the results have been occasionally discussed

basing on the evidences found in interventions in which another type of similar intervention is made or in which teenagers also participate, as well as studies in which population with no learning difficulties is involved (Craig *et al.*, 2016).

There are various mechanisms to explain the effect produced by the physical exercise on the behavior. In children, there is a correlation between the catecholamines release and the exercise. Both in children diagnosed with ADHD and in children with no learning difficulties, when they exercise, the excess in catecholamines is eliminated, reaching a lower anxiey and stress level (Wigal *et al*., 2003). Likewise, exercising activates the release of epinephrine and norepinephrine, increasing the neurotransmitters' concentration in the brain space, being them the responsibles for controlling the executive functions and the body's correct functioning. As well, such enhance the physical condition, which is positively linked to the cognitive performance (Ardoy *et al*., 2014) as it is so to the academic performance regarding algebra and language (Carral, Pérez & Espiño, 2016). Exercising has a relaxing effect, diminishes the cortisol levels, which in turn reduces the anxiety and stress levels (Hillier *et al*., 2011). Exercising could be considered as the best natural drug equivalent to anti-depressants, anxiolytic, and also protects against the negative consequences that stress entails (Salmon, 2001). Young people with ADHD frequently have trobule sleeping (Owens, 2005). Quality sleep in young people with ADHD (9-12 years old) has a positive association with variables such as quality of life, the ability to stay focused and the hemoglobin levels (Yehuda, Rabinovitz-Shenkar & Carasso, 2011). In addition to that, since they are capable of controlling their emotions, they can take advantage of their perceptive abilities and to have a better performance in their tasks (Watson *et al*., 2015).

In this study, differences were found regarding gender in one of the included articles (Tantillo et al., 2002), for the girls experienced a greater improvement than boys. This could be due to the dose-response effect (Martínez-Gómez *et al*., 2011). That is to say, girls are usually more sedentary than boys (Verloigne *et al*., 2012), which is why there is a higher impact in girls before the same physical exercise stimulus.

Weaknesses and strengths

This review presents many weaknesses that have to be recognized. Weaknesses such as the little number of included articles, in spite of that their homogeneity was optimized through a rigorous selection process based on selection and exclusion criteria. Most of the researches analyze a small but homogeneous number of individuals, which may be due to the fact that the ADHD's prevalence is approximately 5% of children and youth (Polanczyk *et al*., 2015). Most of the participants in the study are boys (70.75%) and not girls (29.25%), and this may be due to a greatest prevalence in boys than in girls (Wittchen *et al*., 2011). This paper includes researches that were carried out in just two different countries.

Even so, this systematic review relies on great strengths, on the one hand all the studies that have been selected include boys and girls who have been diagnosed by specialists, and the analysis has been done via reliable, standardized and credible diagnosis tests, dismissing any other kind of learning disorders or difficulties. Likewise, all the articles clearly describe the dependent variable (behavior) and the independent variable (race intervention, duration and precise intensity) specifying the exact moment and procedure that was followed during the data collection, even when in the previous 24-48 hours to the measurements, the administration of the drugs to treat the ADHD symptoms had been suspended. This paper includes studies published within a 17 years period of time, in English language journals, with peer review, being all the included articles of a high quality. Lastly, this review only included

longitudinal studies with an intervention that was carried out prior to the school day of the students with ADHD and the interventions were controlled by specialists in science and exercise sciences.

Conclusions and practical applications

This review selected a total of three intervention articles, that analyzed the immediate effect of taking part in a race at a moderate-high intensity, being the intensity controlled by using a heart rate monitor. All the interventions lasted fr around 25-30 minutes. In the three cases, the intervention prior to the school day showed an improvement in behavior, a less impulsive attitude and lower anxiety and stress levels in children aged between 6 and 12 years old diagnosed with ADHD by clinical psychologists. The totality of the studies that were analyzed have proved that aerobic exercise has a beneficial effect, if made at a moderate-high intensity in order to work the cardiorespiratory endurance, on the behavior of students with ADHD, apart from other benefits at an academic and cognitive level.

Recent studies say that youth's physical activity level is really low. And point at the time spent in front of a screen, the family friend environments as the main causes for the youth to have a sedentary or inactive lifestyle (Vidal-Conti, 2016). We have observed that the benefits are extended depending on the intervention time; physical activity improves not only the behavior, but also the control of emotions, the socialization, the physical condition, the fine and gross motor skills, the executive functions, the school grades, and of course the health status, when exercise is duly structured, lasts for 25-30 minutes and is done at a moderate-high intensity. Plenty of physical activities can be done which are easily adaptable to the skills, motivation and availability of resources. Catching the attention by making use of the new technologies, active video games, active games based on gamification or Smartphone apps. From the World Health Organization (WHO) it is recommended that children and youth between 5 and 17 years old dedicate at least 60 minutes every day to physical activities done at a moderate-high intensity. Such activities comprise games, sports, movements, recreational activities, physical education or scheduled exercises within the family, school or the community activities' context. With the aim of enhancing the cardiorespiratory and muscle functions as well as the bone health, for reducing the risk of non-communicable diseases, great benefits that are added to the ones that have been already shown regarding the behavior.

Future research lines

Nevertheless, further researches are needed to justify the effect's duration, as well as the possible benefits for the children with ADHD doing this type of systematic controlled interventions at the beginning of the school day. The use of well-structured physical activities, combined with tasks that demand from a cognitive work and their combination with psychological treatments to modify the behavior should be promoted during childhood in the educational and family environment. Specially, its is recommended to clarify the influence of confounding variables. If we perform a quick search in the same data bases but focused on children who have not been diagnosed with learning difficulties of any kind, we find a great variety of studies that make use of various variables such as the mother's education, the physical condition indicators, the body mass index, the body fat percentage, or the inclusion of the breastfeeding time. Such aspects, together with the differentiated effect of different stimulus, duration, intensity and frequency could help create a complete program that is adjusted to every child's individual needs.

References

American Psychiatric Association (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. American Psychiatric Pub.

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

Broidy, L. M., Nagin, D. S., Tremblay, R. E., Bates, J. E., Brame, B., Dodge, K. A., & Lynam, D. R. (2003). Developmental Trajectories of Childhood Disruptive Behaviors and Adolescent Delinquency: A Six-Site, Cross-National Study. *Developmental Psychology, 39*(2), 222-245. doi: 10.1037/0012-1649.39.2.222

Carral, J. M. C., Pérez, C. A., & Espiño, M. J. S. (2016). Relación entre la condición física y rendimiento académico en matemáticas y lenguaje en estudiantes españoles de educación secundaria: Un estudio longitudinal. *Cultura, Ciencia y Deporte, 11*(31), 7-16. doi: 10.12800/ccd.v11i31.638

Chang, Y. K., Liu, S., Yu, H. H., y Lee, Y. H. (2012). Effect of acute exercise on executive function in children with attention deficit hyperactivity disorder. *Archives Clinical Neuropsychol, 27*(2), 225–237. doi: 10.1093/arclin/acr094

Chronis, A. M., Fabiano, G. A., Gnagy, E. M., Onyango, A. N., Pelham, W. E., Lopez-Williams, A., … Seymour, K. E. (2004). An evaluation of the summer treatment program for children with attention-deficit/hyperactivity disorder using a treatment withdrawal design. *Behavior Therapy, 35*(3), 561–585. doi: 10.1016/S0005-7894(04)80032-7

Cornelius, C., Fedewa, A. L., & Ahn, S. (2017). The Effect of Physical Activity on Children With ADHD: A Quantitative Review of the Literature. *Journal of Applied School Psychology, 33*(2), 136-170. doi: 10.1080/15377903.2016.1265622

Craig, F., Margari, F., Legrottaglie, A. R., Palumbi, R., de Giambattista, C., y Margari, L. (2016). A review of executive function deficits in autism spectrum disorder and attention-deficit/hyperactivity disorder. *Neuropsychiatric Disease and Treatment, 12*, 1191–1202. doi: 10.2147/ NDT.S104620

Diamond, A. (2013). Executive functions. *Annual review of psychology, 64*, 135-168. doi:10.1146/ annurev-psych-113011-143750

Egger, H. L., & Angold, A. (2006). Common emotional and behavioral disorders in preschool children: presentation, nosology, and epidemiology. *Journal of Child Psychology and Psychiatry, 47*(3-4), 313-337. doi: 10.1111/j.1469-7610.2006.01618.x

Flohr, J. A., Saunders, M. J., Evans, S. W., & Raggi, V. (2004). Effects of physical activity on academic performance and behavior in children with ADHD. *Medicine & Science in Sports & Exercise, 36*(5), S145-S146.

Grassmann, V., Alves, M. V., Santos-Galduróz, R. F., & Galduróz, J. C. F. (2014). Possible cognitive benefits of acute physical exercise in children with ADHD a systematic review. *Journal of attention disorders, 1*(5), 367-371. doi: 10.1177/ 1087054714526041

Hamre, B. K., & Pianta, R. C. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child development, 72*(2), 625-638. doi: 10.1111/1467-8624.00301

Hodgkins, P., Shaw, M., Coghill, D., & Hechtman, L. (2012). Amfetamine and methylphenidate medications for attention-deficit/hyperactivity disorder: complementary treatment options. *European child & adolescent psychiatry, 21*(9), 477–492. doi: 10.1007/s00787-012-0286-5

Hung, C. L., Huang, C. J., Tsai, Y. J., Chang, Y. K., & Hung, T. M. (2016). Neuroelectric and behavioral effects of acute exercise on task switching in children with attention-deficit/hyperactivity disorder. Frontiers in psychology, 7, 1589. doi: 10.3389/fpsyg.2016.01589

Karvonen, M. J., Kentala, E., & Mustala, O. (1957). The effects of training on heart rate: A longitudinal study. *Annales Medicinae Experimentalis Et Biologiae Fenniae, 35*(3), 307–315.

Kim, H., Heo, H. I., Kim, D. H., Ko, I. G., Lee, S. S., Kim, S. E., & Shin, M. S. (2011). Treadmill exercise and methylphenidate ameliorate symptoms of attention deficit/hyperactivity disorder through enhancing dopamine synthesis and brain-derived neurotrophic factor expression in spontaneous hypertensive rats. *Neuroscience letters, 504*(1), 35-39. doi: 10.1016/j.neulet.2011.08.052

Martínez-Gómez, D., Ruiz, J. R., Gómez-Martínez, S., Chillón, P., Rey-López, J. P., Díaz, L. E., Marcos, A. (2011). Active commuting to school and cognitive performance in adolescents: the AVENA study. *Archives of pediatrics & adolescent medicine, 165*(4), 300–305. doi: 10.1001/archpediatrics.2010.244

Organización Mundial de la Salud. OMS. (2010). *Recomendaciones mundiales sobre actividad física para la salud*. Ginebra, Suiza.

Owens, J. A. (2005). The ADHD and sleep conundrum: A review. *Journal of developmental and behavioral pediatrics, 26*(4), 312-322. doi: 10.1097/00004703-200508000-00011

Polanczyk, G. V, Salum, G. A., Sugaya, L. S., Caye, A., & Rohde, L. A. (2015). Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *Journal of Child Psychology and Psychiatry, 56*(3), 345–365. doi:10.1111/ jcpp.12381

Ruiz-Ariza, A., Grao-Cruces, A., de Loureiro, N. E. M., & Martínez-López, E. J. (2017). Influence of physical fitness on cognitive and academic performance in adolescents: A systematic review from 2005–2015. *International Review of Sport and Exercise Psychology, 10*(1), 108–133. doi: 10.1016/j.gaceta.2015.06.002

Salmon, P. (2001). Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. *Clinical psychology review, 21*(1), 33-61. doi: 10.1016/S0272-7358(99)00032-X

Sharma, A., & Couture, J. (2014). A review of the pathophysiology, etiology, and treatment of attention-deficit hyperactivity disorder (ADHD). *Annals of Pharmacotherapy, 48*(2), 209–225. doi: 10.1177/1060028013510699

Tantillo, M., Kesick, C. M., Hynd, G. W., & Dishman, R. K. (2002). The effects of exercise on children with attention-deficit hyperactivity disorder. *Medicine & Science in Sports & Exercise, 34*(2), 203-212. doi: http://dx.doi.org/10.1097/00005768-200202000-00004

Van der Oord, S., Prins, P. J. M., Oosterlaan, J., & Emmelkamp, P. M. G. (2008). Efficacy of methylphenidate, psychosocial treatments and their combination in school-aged children with ADHD: a meta-analysis. *Clinical psychology review, 28*(5), 783–800. doi:10.1016/j. cpr.2007.10.007

Verloigne, M., Van Lippevelde, W., Maes, L., Yildirim, M., Chinapaw, M., Manios, Y., Brug, J. (2012). Levels of physical activity and sedentary time among 10-to 12-year-old boys and girls across 5 European countries using accelerometers: an observational study within the ENERGY-project. *International Journal of Behavioral Nutrition and Physical Activity, 9(*1), 1-8. doi:10.1186/1479-5868-9-34

Watson, S. M. R., Richels, C., Michalek, A. P., & Raymer, A. (2015). Psychosocial Treatments for ADHD A Systematic Appraisal of the Evidence. *Journal of Attention Disorders, 19*(1), 3–10. doi:10.1177/1087054712447857

Vidal-Conti, J. (2016). Identificación de predictores de actividad física en escolares según el modelo socio-ecológico mediante un análisis multifactorial. *Cultura, Ciencia y Deporte, 11*(31), 51-59. doi: 10.12800/ccd.v11i31.642

Wigal, S. B., Nemet, D., Swanson, J. M., Regino, R., Trampush, J., Ziegler, M. G., & Cooper, D. M. (2003). Catecholamine response to exercise in children with attention deficit hyperactivity disorder. *Pediatric research, 53*(5), 756-761. doi: 10.1203/01.PDR.0000061750.71168.23

Wittchen, H.-U., Jacobi, F., Rehm, J., Gustavsson, A., Svensson, M., Jönsson, B., Faravelli, C. (2011). The size and burden of mental disorders and other disorders of the brain in Europe 2010. *European Neuropsychopharmacology, 21*(9), 655–679. doi:10.1016/j.euroneuro. 2011.07.018

Yehuda, S., Rabinovitz-Shenkar, S., & Carasso, R. L. (2011). Effects of essential fatty acids in iron deficient and sleep-disturbed attention deficit hyperactivity disorder (ADHD) children. *European Journal of Clinical Nutrition, 65*(10), 1167-1170. doi: 10.1038/ejcn.2011.80

Receipt date: 9/24/2017
Review date: 9/27/2017
Acceptance date: 11/4/2017