I benefici dell'esercizio fisico nei bambini con il disturbo da deficit dell'attenzione ed iperattività (ADHD)

The benefits of physical exercise in children with attention deficit hyperactivity disorder (ADHD)

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ABSTRACT
The aim of this study was to analyze the articles about the effects of physical exercise in subjects with ADHD, to locate and study the possible benefits. After establishing the criteria for selection, a total of 23 articles were selected. All items found can be classified into four tables. The first one focuses on oriental disciplines, like: thai chi, yoga and meditation. The second group focuses on physical exercise in water, third one deals with sport and game (even the virtual one). Finally the last line of research includes articles addressing different physical activities. For example authors focus on high intensity exercise like HIIT, other authors prefer to focus on the enviroment like the essential element of the research.

Lo scopo di questo lavoro è stato quello di analizzare gli articoli riguardanti l'esercizio fisico in soggetti con ADHD per individuare e studiare i possibili benefici. Dopo aver stabilito i criteri di selezione, sono stati selezionati 23 studi. Tutti i documenti trovati, sono stati classificati in quattro tabelle. La prima si focalizza nelle discipline orientali quali: thai chi, yoga e meditazione. Il secondo gruppo incentra il proprio lavoro sull'esercizio fisico in acqua; il terzo invece sullo sport e il gioco (anche quello virtuale). Infine l'ultimo raggruppamento include articoli con attività fisiche differenti. Per esempio autori si focalizzano su un lavoro ad alta intensità come HIIT, altri autori preferiscono focalizzarsi sull'ambiente come elemento essenziale della ricerca.

KEYWORDS
Physical exercise, ADHD, sport activity, health, benefits.
Esercizio fisico, ADHD, attività sportiva, salute, benefici.

* Attribution of the parties. This study, although being the result of common elaboration and sharing of formulation and contents, can be attributed as shown below: Manuela Valentini: first section. Nicolas Toniol: second section.

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1. Introduction

The Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) classifies attention-deficit hyperactivity disorder (ADHD) as a neurodevelopmental disorder and defines it as 'a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development and negatively impacts directly on social and academic/occupational activities' (Diagnostic and Statistical Manual of Mental Disorders [DSM V], 2013). The World Health Organization calls it Hyperkinetic Disorder (World Health Organization [WHO], 1993).

In addition to the above two definitions, owing to the complexities of the problem, several researchers have given their contribution to the definition of the disorder.

It has been maintained that ADHD is not to be considered as an illness, but as a group of syndromes which lead to a range of common behavioural disturbances of the psychological emotive and learning type (Furman, 2005, p. 994).

Since Clouston and Still published their pioneering text (translated and published in Italy by Fedeli in 2008), it has become evident that the disorder can be be defined by three symptoms: lack of attention, high levels of activity and both cognitive and behavioural impulsivity (Arcangeli et al., 2008, p. 174).

There are three types of ADHD: the first shows a predominance of lack of attention, the second a predominance of hyperactivity and impulsivity and the third presents a combination of the two. The diagnosis is based on recurrent symptoms lasting for over six months (Parekh, 2017 p. 3).

As regards hyperactivity and impulsivity, the symptoms are the following: restlessness, continuously touching one's hands, difficulty in keeping still while sitting down, endless talking, difficulty in waiting for one's turn, interrupting and butting in on other people's conversations. Lack of attention is characterized by the following symptoms: overlooking details, making many mistakes while doing one's homework, having a grasshopper mind (being easily distracted) and avoiding tasks requiring concentration (Parekh, 2017 p. 4). Such difficulties frequently lead to family, school and social interaction problems.

ADHD is first seen during school years and continues in 65% of cases into adult life (Agnew-Blais et al., 2016, p. 713). This behavioural disorder involves forty million people worldwide, 6/7% of which are children (WHO, 1993), with a slight prominence of boys over girls and with gender differences between the two. For example, boys tend to be more hyperactive, while girls tend to suffer more from high levels of lack of attention. (Mayo Foundation for Medical Education and Research [MFMER, 2018). In addition to that, the highest percentage of people within the ADHD forty-million figure is found in the States, where one child in twenty is affected by it (Faraone, et al., 2003, p. 105). Approximately 2 million more U.S. children/adolescents aged 4 to 17 years had been diagnosed with ADHD in 2011, compared to 2003 (Visser et al., 2014, p. 34). This increase is thought to be due to environmental factors, although the direct causes have neither been fully understood nor as yet verified.

However, there has been an advancement in research, which has produced notable papers. Relevant related research in Genetics has confirmed the crucial role of dopamine (Marzocchi & Bacchetta, 2011 p. 309). Molecular genetic studies have identified three genes which are likely to be responsible for ADHD. They are the D4 and D2 receptor genes of dopamine and also the gene which carries dopamine (Faraone & Biederman, 1998 p. 104). Other researches have highlighted instead the importance of environmental factors, which are not shared by all: it is

estimated that low weight at the time of birth is the main cause in 16% of cases (Marzocchi & Bachetta, 2011 p. 309). Studies in the field of neurobiology have revealed the structural and functional anomalies in four cerebral regions - the prefrontal cortex, the basal ganglia, the cerebellum and the corpus callosum. It is precisely these areas which constitute the neural base of the neuropsychological functions which are found to be lacking in subjects with the disorder (Marzocchi & Bacchetta, 2011 p. 309). Also precise executive functions, which is to say a series of abilities which are essential to the organization and planning of problem solving behaviour (Arcangeli et al., 2008, p. 153): Abilities such as the capability of using work memory, of self-control of feelings, excitement, motivation, behavioural awareness and turning speech into a personal experience (Barkley, 1997 p. 65).

Various studies have shown how physical exercise "regarded as a series of programmed, structured and repeated physical activity" (Caspersen et al., 1985, p. 128) is fundamental to improve the above- mentioned executive functions, thus leading to the improvement of the quality of life in people affected by ADHD. In order to program physical exercise it is necessary first to decide who is to be targeted in this case ADHD children, then to define the objectives to be reached - improving the executive capabilities, after that, to find out the means to be used and finally the duration of the activities. In this phase it will be possible to use either large or small exercise machines and free-body movements. Above all it will be essential to decide the intensity of working out, and whether to prefer aerobic or anaerobic exercises. In this case, scientific research led by Best in 2010 has emphasized the positive relation between aerobic activity and executive functions. Others (Diamond & Lee, 2011) have shown that different types of physical activity, such as martial arts, yoga-meditation produce different effects on executive functions.

Diamond hypothesises that executive function development through physical activity is intimately linked to the conditions in which children find themselves while working: whether they are happy with and proud of what they are doing, in a good working relationship with their companions and emotionally involved (Tortella & Fumagalli, 2014, p. 10).

The physical activity proposed needs to be stimulating, flexible, gradable in difficulty, never boring, but offering constant learning with both tasks and new challenges which will have to be repeated in order to be learned (Tortella & Fumagalli, 2014, p. 10). Good motivation and knowing how to motivate are universally known to be fundamental in reaching proposed objectives in terms of physical exercise, facing difficulties and above all in reaching the objectives in everyday life.

For these reasons, the aim of this article is to study and analyze in depth the various research projects concerned with the use of motor activity for the improvement of some aspects of ADHD syndrome in the formative years.

2. Methods

A bibliographic survey was undertaken between July and October 2017 using various search engines such as Sabinet, Springer Link, Pubmed, Saje journals, etc. using the following key words: physical exercise, ADHD, executive function, children, sport and training. All the documents were translated and studied and those which satisfy the specific criteria are shown in Table 1.

INCLUSION CRITERIA	EXCLUSION CRITERIA
Age between 5 and 18 years	Documents that focus their study on the use of drugs
Participants diagnosed with ADHD, both, boys and girls	All types of intervention that do not specify the duration of the exercise, the duration of the experiment
Minimum duration of the experiment: 3 weeks	Studies on more age groups
Number of participants not less than 10	ADHD associated with other deficits
Only English scientific documents	Unpublished data
Publications from 2000 to 2017	

Table 1. Inclusion and exclusion criteria (Source: own elaboration)

Inclusion Criteria

Studies showing a relationship between physical exercise and ADHD are presented which concentrate on formative years, from birth to adolescence, during which most achievements, learning and cognitive modifications occur (Sportsigrazie, 2018), more precisely observations on subjects aged from 5 to 18. The research papers are all in English, have been published in scientific journals and were written between 2000 and 2017. Other important criteria are the duration of the experiment, which in our case varies from 3 to 12 weeks and the type of physical exercise proposed. In most cases exercises are of the aerobic type, which involves burning fat and glucose. A physical performance is called aerobic when oxygen turns glucose and fat into energy and helps to keep movements at a low intensity for a long time (Jack Ransone, 2016, p.1). The studies reported include group studies, individual studies, control group studies and studies on people who do not suffer from ADHD, both male and female.

Exclusion criteria

Studies focus on the use of medicines have not been taken into consideration, for example "Exercise impact on sustained attention of ADHD children, methylphenidate effects" (Tantillo et al., 2009) and "Exercise impact on sustained attention of ADHD children, metylphenidate effects" (J.Medina et al., 2010). Documents in which ADHD formed part of a more complicated clinical picture were also not used, as in the case of ADHD associated with autism or obesity ("Prevalence of overweight in children and adolescents with attention deficit hyperactivity disorder and autism spectrum disorders: a chart review" C.Curtin et al., 2005). Finally, researches which concentrated on a wider age range including adult and/or elderly people were excluded, as for example in the case of "Physical exercise and executive functions in preadolescent children, adolescents and young adults: a meta-analysis" (L.Verburgh et al., 2014) in which the experiments concentrate on adults and adolescents.

The above criteria were chosen in order to determine whether the prescription of physical exercise without the use of medicines could produce an improvement in children suffering from ADHD.

Author Year	Place	N.	Age	Activity	Period	Result	Search engine	Journal
Reif et al. 2001	U.S.A.	13	12-18	Tai Chi lessons twice a week	5 weeks	After the 10 Tai Chi sessions the adolescents displayed less anxiety, improved conduct, less daydreaming behaviours, less inappropriate emotions, and less hyperactivity. These improved scores persisted over the 2-week follow up (no Tai Chi period).	Science Direct	Journal of Body work and therapy
Haffner et al. 2006	Germany	19	8-11	Group 1 yoga Group 2 normal motor activity 1 hour of lesson twice a week	8 weeks	the yoga training was superior to the conventional motor training, with effect sizes in the medium-to-high range can be an effective complementary or concomitant treatment for this disorder.	Europe PMC	Z Kinder Jugendpsychiatr Psychother
Mehta et al. 2011	India	64	6-11	Yoga meditation combined with behavioral therapy	6 weeks	The 90% of the children had improvements. According to teachers and parents, 39% of children have had a behavioral improvement.	National Center of Biotechnology information	ISRN Pediatrics
Van der Oord et al. 2012	Holland	22	8-12	Yoga meditation, breathing meditation with bells 8 sessions	8 weeks	13 males and 5 females have completed the test with significant improvements as regards the attention the	Springerlink	Journal of Child and Family Studies

				of 90 minutes		hyperactivity and impulsivity. Same result for parents.		
Van de Weijer - Bergsma et al. 2012	Holland	10	11-15	1 hour and a half of session including meditation breathing exercises alternated with specific exercises for children with ADHD. The treatment is based on the awareness program developed for children with ADHD. Participate also parents.	8 weeks	Before and after training, the attention and executive functions are improved and the problems of behavior are decreased. Immediately after the 8 weeks have occurred these improvements while 16 weeks after the improvements have disappeared.	Springerlink	Journal of Child and Family Studies
Chou & Huang 2017	Taiwan	49	8-12	1st group yoga exercises twice a week, 40 minutes for sessions 2nd control group	8 weeks	Yoga exercise can be utilized as an alternative treatment for children with ADHD to reduce attention and inhibition problems.	Pubmed	PeerJ

Table 2. Motor activity research using oriental disciplines - Research in chronological order (Source: own elaboration)

Many studies have been designed around activities such as meditation, yoga and thai chi. These are disciplines characterized by knowledge and awareness of one's body, breathing, calm, serenity and slowness of movement, all of which are lacking in various degrees in ADHD children.

Six studies were examined, the first from 2001 by Reif et al. in which the subjects are adolescents practicing thai chi. The results were encouraging, with better control and lower levels of anxiety and hyperactivity reported. Other experiments, such as those by Mehta et al., 2011 or Van der Oord et al., 2012, although using different methods and objectives, produced the same results.

Both experiments involved children, but while in the first meditation and therapy were used together, in the second meditation and breathing exercises were adopted. In both cases these techniques brought an improvement in behaviour and also in regard to hyperactivity, impulsiveness and level of attention. The experiments by Van de Weijer Bergsma et al., 2012 showed the identical result using in this case yoga and meditation together with specific exercises. Haffner et al., 2006 and Chou et al., 2017 focus their experiments on yoga. Both working groups used these activities but then analysed in different ways. The first group used a comparison with a group undergoing normal motor activities and the second with a control group. The final results of both were same in being accompanied by specific treatment.

Considering that the researchers worked on a delicate and unfamiliar theme, some questions came to mind. It is important to know whether, after the period of study, the benefits acquired persisted taking a long term view. Furthermore a knowledge and ability in these activities is necessary in order to maximize all the possible benefits. A further weak point is the scarcity of experiments using youth in adolescence, a stage of development which is too important to be ignored.

The strong points are: studying the benefits through disciplines regarded as innovative in the West which not only prescribe movement but the use the whole body. In fact, more than just teaching a certain type of physical activity, these teach a real and genuine art based on values such as respect, obeyance of the rules, humility, friendship, commitment, all of which are necessary for today's children to become full adults and tomorrow's citizens.

To go further it would be interesting to analyze how surroundings can influence practice. We know how much nature is a fundamental element and an almost integral part of these disciplines. It would be interesting to know if and how the results vary according to where the activities were undertaken.

Author Year	Place	N.	Age	Activity	Period	Result	Search engine	Journal
Chang et al. 2014	Taiwan	27	5-10	1st group 2 sessions a week in water. 90 minutes of lesson (5minutes of warm up) 40 min. of aerobic exercise 40 min. motor perception 5 min. of cool down. 2nd group maintain their afterschool activities.	8 weeks	Group 1 improvement of the motor skills of the coordination and of the reaction time associated to the stimulus	Oxford Academic	Archives of Clinical Neuropsychology
Huang et al. 2014	Taiwan	32	7-9	1st group aerobic activity in water 2nd control group.	8 weeks	Aerobic exercise can enhance executive functions	Sage Journals	Journal of Attention Disorders

Table 3. Physical activity research in water - Research in chronological order (Source: own elaboration)

Two studies concentrated on physical exercise in water exploiting some properties of this element such as Archimedes' principle, the sensation of relaxation and lightness, different workings of the muscle groups and the slower speed of movement. The experiments were very similar, were done in Taiwan in 2014 and both used a study group given aerobic activities in water and a control group. The study by Chang et al. 2014 showed an improvement in motor activities, in coordination and the reaction time to a given stimulus. These same results were highlighted by the no go test which was performed at the end of experimentation. Huang et al., 2014 did an analysis using the electroencephalogram in which it was possible to see, after several sessions, how aerobic exercises can develop executive functions.

Very little research in this field has been found and in this case, also, we don't know if and how soon after the end of the experiments the benefits decreased. Another aspect to emphasize is the need to have the prerequisites to be able to undertake the activity to full advantage, for example to be fearless in water, to know how to float well and to have access to the appropriate facilities. Lastly, given the lack of studies involving adolescents, it would be interesting to know if the results obtained with chldren between 5 and 10 years old were similar to those with older children. A possible starting point for further study would be to find out if the use of music, as in the case of many activities in water such as water gym, water bike, water trekking and so on, could improve performance and benefit children affected by ADHD still further.

Author year	Place	N.	Age	Activity	Period	Result	Search engine	Journal
Shaffer et al. 2001	U.S.A.	56	6-12	1st group 1 one hour of metronome training method 2nd control group 3rd group participate in a selection of video games for the PC	3/5 weeks	The Interactive Metronome training appears to facilitate a number of capacities, including attention, motor control, and selected academic skills.	The American Occupational Therapy Association	The American Journal of Occupational Therapy
Kang et al. 2011	Korea	28	8-10	Group 1 90 minutes of athletics twice a week group 2 receives education on behavioral control	6 weeks	The results demonstrated a positive correlation with sports and improvement in attention symptoms, cognitive symptoms and social skills. That therapy in the form of athletic activity may increase social competency in children with ADHD, as demonstrated by improved cognitive functions.	Refdoc	International Journal of sports medicine
Elham et al. 2013	Iran	26		1st group aerobic exercise / therapy of game 2nd group control group. 3 sessions a week from 45 to 60 minutes	8 weeks	Although group-based play therapy had greater impact on improving the balance of children with ADHD, aerobic exercise program had significant effects on improving static balance	Scientific Information Database	Journal of Research in Rehabilitation on Sciences
Lee et al. 2015	Korea	12	6-10	1st group 60 minutes of exercise 10 minutes warm up 40 minutes to	12 weeks	The first group showed improvements in strength in muscle lengthening and cardio-respiratory resistance. There is an improvement in	J Stage	Journal of Phyisical Therapy Science

				central part 10 minutes cool down three times a week. The exercises consist of jumping rope and exercises combined with the ball. 2nd control group		the physical form and on neurotransmission .		
Ziereis et al. 2015	Germany	43	7-12	1st group manual exercises with the ball, balance and manual dexterity 2nd group training in sports 3rd control group	12 weeks	Physical activity has a positive effect on executive functions of children with ADHD, regardless of the specificity of the physical activity. It can be used as a complementary or non-pharmacological alternative treatment.	Science Direct	Research in developmental disabilities
Bustamante et al. 2016	USA	35	6-12	2 hours and 45 minutes for five times a week. The two groups play 15 minutes of recreation, 45 minutes of homework and 15 minutes of gym for group 1 while 15 minutes of sedentary game for group 2. After, 60 minutes divided in 30 minutes of	10 weeks	Both groups have an improvement in physical capacity, a lower risk of chronic diseases, an improvement in the mood of psychophysical wellbeing, a decrease in anxiety, improves mental health and better sociality.	Pubmed	Medicine and science in sports and exercise

				game structured and 30 minutes of free play.				
Pan et al. 2016	Taiwan	32		Table tennis exercises with the 1st group that is followed with specific treatments while the 2nd group no	24 weeks	Sports such as table tennis improve motor skills, social behaviors and executive functions	Pubmed	Research in developmental disabilities
Benzing & Schmidt 2017	Switzerland	66	8-12	1st group physical exercise through games 3 sessions a week from 30 minutes 2nd control group	8 weeks	May have improvements in executive functions in sporting performance but are only envisaged	Biomed Central	BMC Pediatrics

Table 4. Motor activity research through play and sport - Research in chronological order (Source: own elaboration)

No less than 8 studies prescribe game therapy as opposed to sport. Two of these (Benzing & Schmidt 2017 and Shaffer et al., 2001), use video and videogames, which are very fashionable these days. Both studies make a comparison with a control group at the end of the experiment to determine the benefits and possible differences. For Benzing & Schmidt 2017 the improvements in executive functions and sports performance are merely conjectural, whereas Shaffer shows a real improvement in attention and motor control.

The other six pieces of research are based around physical activity mostly using games and/or sport. Examples are Kang et al., 2011, which proposes athletics and Pan et al., 2016 preferring ping-pong. Despite the differences in these activities, the result is the same: an increase in sociability, in the cognitive functions and in attention.

Ziereis et al., 2015 and Lee et al., 2015 have proposed very similar exercises, but nevertheless have sought to emphasize different aspects. In fact Ziereis et al., 2015 using a comparison between different groups, has shown how there is an improvement in executive functions which is not dependent on the type of activity. Lee et al., 2015 has shown how ball games and rope skipping can improve physical fitness in terms of lung capacity and a healthy heart, muscular srength and stretching ability.

The last of the studies under consideration is that by Bustamante et al., 2016 in which two groups of children living in a very poor district were selected. The chil-

dren were studied by eight experienced graduates in Kinesiology Premedicine and Psychology in the ratio of 1:4 or 1:6. Activity sessions lasted two hours 45 minutes, the only difference being that the first group did, during this time, 15 minutes in the gym while the second group did 15 minutes of sedentary games. . As table 4 shows, the final result showed an improvement in both groups, both in terms of their mood and mental attitude and of their physical abilities.

The positive results which emerge are the following:

1) The quantity of evidence confirming the fundamental and integral role played by play in human growth and development;
2) The possibility, through the practice of one's favourite sport, to achieve optimum results;
3) The low cost involved in sports activities and the availability of resources. This means that even the poorest communities, as in the case study of bustamante et al., 2016 can feel the benefits.

From the negative point of view we find the lack of a long-term research plan and a scarcity of work done with adolescents.

It would be interesting to compare the results obtained using individual sports with those using team sports. For the latter no records are available despite the fact that the numerous advantages are generally known. It is seen that the practice of team sports, besides developing sense of responsibility, determination and commitment, encourages, through collaboration, the sense of group belonging, team spirit and last but not least of fair play.

Author Year	Place	N.	Year	Activity	Period	Result	Search engine	Journal
McKune et al. 2003	South Africa	19	5-13	Five days a week 60 minutes of exercise 20 minutes at 50-75% maximum heart rate	5 weeks	After 5 weeks there was an improvement in behavior	Sabinet	South Africa Journal of Sport Medicine
Taylor & Kuo 2009	U.S.A.	17	7-12	1st group 20 minutes of walking in nature. 2nd group 20 minutes of walking in a city Once a day	30 days	The results show that children focus better after a walk to the park than a walk in the city	Sage journals	Journal of Attention Disorders
Verret et al. 2010	Canada	21	7-12	1st group 45 minutes of physical activity three times a week including warm up aerobic activity muscle strengthening and exercises to improve motor skills 2nd control group	10 weeks	Physical exercise brings benefits in terms of muscle capacity, motor skills and behavioral skills	Academia edu	Journal of Attention Disorders

Ahmed & Mohamed 2011	Egypt and Saudi Arabia		11-16	three sessions a week of aerobic exercise 4 sessions from 40 minutes 6 sessions from 50 minutes which include exercises for the upper limbs the trunk the neck	10 weeks	At the end of the experiment there will be an improvement in attention to motor skills and behavior	Lifesciencesite	Life Science Journal
Smith et al. 2013	U.S.A.	17	8-9	26 minutes of daily physical activity from moderate to intense after school	8 weeks	Exercise shows promises to address the symptoms of ADHD	Sage Journals	Journal of Attention Disorders
Meßler et al. 2016	Germany	28	8-13	4 series * 4 minutes interspersed with 95% of the maximum heart rate or a multimodal therapy	3 weeks	Multimode therapy together with HIIT improves motor skills certain aspects of quality of life, attention and health	Pubmed	Journal of attention disorder
Memarmoghaddam et al. 2016	Iran	40	7-11	1st group 90 minutes of scheduled exercise 2nd control group. After that are evaluated on the test Go no Go test and Stroop Test.	8 weeks (24 sessions)	A physical activity organised helps to improve the executive functions of children with ADHD	Pubmed	Journal of Medicine and Life

Table 5. Other activities: High Intensity Interval Training (HIIT), walking, aerobic activity - Research in chronological order (Source: own elaboration)

The fifth and last table shows seven articles which are not included in the preceding tables owing to the fact that they show different characteristics.

The first two studies are based on aerobic exercises, Verret et al., 2010 couples this with work on strengthening and target exercises, and Mohamed et al., 2011 couples this with upper body exercises. Both report an improvement in motor ability and in behaviour.

Other studies have shown the benefits to be derived from high intensity work sessions. Among these is the work of Mckune et al., 2003 which as part of the 60 minutes sessions, includes 20 minutes at high intensity (up to 75% of the maximum cardiac frequency). Similar work by Meßler et al., 2016 is based on interval training at the standard 95% cardiac frequency, coupled with multimodal therapy. Both studies report a similar improvement in health and behaviour. Lastly a study by Smith et al., 2013, done as an after school activity, proposes physical activity

which ranged from the lowest to highest intensity without, however, specifying the cardiac frequency. The study by Smith et al., 2013 despite using high intensity training like the preceding studies, demonstrated that these type of exercises are too general and fail to target the specific problem of ADHD.

The final piece of research selected is that done by Taylor & Kuo 2009, a unique and very interesting study in which environment and surroundings are at the centre of the experiment. The researcher wanted to find out to what extent the environment conditions the feelings of children affected by ADHD.

The use of varied training methodologies such as interval training, aerobic exercise, muscle strengthening and medium/high intensity exercise is a positive feature. So is the use by some researchers of control groups which help to reinforce the results and to carry out successive data comparisons. The scarcity of research results together with the fact that, despite having some aspects in common, they differ one from another is a weakness. Further studies are needed using the same activity types to confirm the results. Other problems are the lack of a long term view and the lack of work done with adolescents.

3. Conclusion

In accordance with the studies examined, one can draw the conclusion that children affected by ADHD who are given physical activity, irrespective of the type of physical exercise done, experience an improvement above all, but not only, in executive functions. An improvement in motor ability, general health, social behaviour and attention is also shown. On the other hand it would be interesting to know if these benefits are permanent – the majority of studies do not consider this. Another defect is the lack of attention given to the period of adolescence – only three studies take this important period into consideration. The lack of data from experiments using music, which is well known to influence not only performance but also feelings, is another deficiency. There is, finally, a lack of experimentation on strictly individual exercises. It would be useful to be able to compare the results of physical exercise done by individuals with those performed by groups.

On the positive side, we have a considerable number of studies on the 8 to 12 years age group. These research studies uses both males and females and were done in different countries. Another advantage is to have tried numerous different activities to try to understand which is the physical exercise most beneficial for children affected by ADHD.

A possible starting point for new research could be to investigate how the environment, in particular the natural environment, positively affects the subjects and their conditions. Taylor & Kuo et al., 2009 have shown how the simple motor activity of walking, if done in a natural environment, can bring great benefits. Another suggestion is to discover if physical exercise gives the same results to individuals as it does to groups and if or not feelings/emotions influence the entire experiment. Lastly it would be interesting to be able to apply the exercises which have been studied to adolescents, because as has been already said, this is a crucial period for the growth and development of every individual.

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