



# MOTOR INTERVENTION AND AUTISM: ONE WAY, SEVERAL DOMAINS OF EFFECTIVENESS

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■ **KEYWORDS:** Autism spectrum disorder, Physical activity, Motor skill intervention, Developmental age, Childhood neuro and psychomotricity,

## ABSTRACT

*In the literature, a delay in the development and acquisition of motor skills is generally described in children with autism spectrum disorder, affecting between 50% and 80% of this population. In spite of this high frequency of occurrence, motor difficulties are not yet considered in the same way as the core deficits of this disorder (difficulties in social interaction, communication and behavior); additionally, there is not yet enough research about the efficacy of a specific intervention that can support the development of motor functions compromised in autism.*

*Recent findings, which support the correlation between motor domain and other areas of development (social and cognitive), together with other evidence that underline the benefits of practicing motor activities on the individual's well-being, lead us to re-evaluate the effects of motor intervention for autism.*

*To define the salient points of this kind of intervention, with particular attention to rehabilitation practice, a literature search was carried out on four different databases, which sifted through 602 bibliographic citations and found 10 studies that were able to meet the set research purposes.*

*This review showed that physical activity in autistic children not only improves motor performance, but also plays an important role in the social, cognitive and behavioural development, as well as helping to reduce some secondary or associated symptoms, such as stereotypies or sleep disorders.*

## INTRODUCTION

Autism Spectrum Disorder (ASD) is an early-onset neurodevelopmental condition characterised by a significant impairment in social interaction and communication and by the presence of restricted interests and repetitive and stereotyped behaviour. Its frequency is around 1% of the population and its symptoms have a significant impact on several areas of an individual's life (American Psychiatric Association, 2013).

In addition to the main symptoms, the literature also reports the possibility of cognitive, linguistic and sensory impairments (Casartelli & Molteni, 2014) as well as internal disorders (epilepsy, gastro-intestinal problems, sleep disorders, obesity).

From this complex and varied clinical picture, it is already clear that an integrated and effective treatment approach, covering all developmental compromised needs, is indispensable (Lai, et al., 2020).

Nowadays, pharmacological intervention can be used to reduce secondary or associated symptoms, but there is no approved medication that can directly decrease the central deficits of this disorder. (Lai, et al., 2020), (Lai, et al., 2014) Therefore, the definition and early implementation of a rehabilitation programme is crucial to address this disorder (Rogers, et al., 2014).

An in-depth knowledge of the autism's symptoms is fundamental as a guide to planning the intervention project. Given all these assumptions, the "motor cognition" hypothesis, recently put forward by the neurosciences, becomes relevant. This idea argues that the motor system is not only involved in the control and execution of movement, but can also mediate, in

a direct and pre-reflective way, the adaptation and understanding of our and others' behaviour. (Casartelli & Chiamulera, 2016), (Gallese, et al., 2009).

This correlation between motor and social domains allows to design an improved motor intervention for children with autism, that can support both the development of impaired motor skills and social abilities (Casartelli, et al., 2016).

Indeed, 50%-80% of people with autism have difficulties in developing and acquiring motor skills (Sanckack, et al., 2016), (Hilton, et al., 2012) and these difficulties, according to some authors, tend to translate over time into a significant decrease in physical activity, which increases the risk of obesity and clinical conditions associated with overweight (McCoy, et al., 2016).

Moreover, motor activities seem to be positively associated with increased cognitive performance in autistic individuals (Kramer & Erickson, 2007) (Russo, et al., 2007).

Despite these evidence in clinical practice, there is still little attention on motor intervention, compared to other types of autism treatment (Bremer, et al., 2015), (Casartelli, et al., 2016).

The main aim of this study is to carry out a literature search to assess the effects and benefits of physical activity and motor intervention on autistic children. Specifically, we are going to consider all the possible "outcomes" of these interventions.

Secondly, time frames and methods most related to the success of this approach will be considered.

**METHODS AND MATERIALS**

**Search strategy**

The literature search was conducted through four databases: primarily PubMed, secondarily Embase, Cinahl and Cochrane. Key words such as “physical activity”, “exercise”, “performance”, “motor skill”, “motor approach”, “motor intervention” were used, combined through the Boolean operator “AND” with “autism” or “autism spectrum disorder”.

The terms that produced the most appropriate and numerous results in PubMed were re-purposed in the other databases, after verifying the adequacy.

**Selection criteria**

The studies were chosen according to the following criteria: (1) Propensity based on the evidence pyramid’s hierarchy for: meta-analyses, systematic reviews, followed by randomised control trials, pilot studies and finally clinical studies. (2) Target population: studies including only subjects diagnosed with autism spectrum disorder or synonyms (old diagnostic classifications) with average age 0-18 years. (3) Type of intervention: studies that primarily focus on motor exercises or physical activity. (4) Studies published since 2015.

**Exclusion criteria:**

(1) Clinical studies with less than 20 participants. (2) Studies with other populations out of the autistic one. (3) Studies including subjects with an overall mean age above 18 years. (4) Studies with year of publication <2015. (5) Studies including only adolescents’ participants.

**Screening process**

To determine which articles from the initial keyword search should have been included in the study, a four-stage screening was conducted. In stage 1, all records found were entered into the Mendeley software (version 1.19.4), which automatically removed any duplicate citations. In stage 2, the title of each study was screened, looking for a match between it and the keywords used in the search. When the title seemed relevant, the article was selected to be added to a new collection. This was followed by stage 3, where all the abstracts of the newly saved articles were examined. When the abstracts did not contain enough information about the topic (motor treatment and autism) or all the inclusion criteria, the articles were immediately excluded. In stage 4, the remaining articles were read in their entirety to check their adequacy to the pre-established selection/exclusion criteria.

**Data extraction process**

In order to extract the data of specific interest, the information of each study was divided into 5 main categories: “authors and date”, “type of study”, “objectives”, “participants”, “method of data collection and analysis/intervention” and “findings and notes of interest”. In this discussion we chose to combine “method of data collection and analysis” with “intervention” to better balance the amount of information within the data extraction table. Indeed, in the systematic reviews chosen data collection and analysis are very well defined while there is less information regarding the specific intervention methodology. On the other hand, all the other types of studies analysed focus mainly on the conduction of the treatment.

Banca dati	Strategia di ricerca	Limiti
PubMed	"autism spectrum disorder" AND "physical activity"	Human, English, last 5 years and child (birth-18 years)
PubMed	"autism spectrum disorder" AND "exercise"	Human, English, last 5 years and child (birth-18 years)
PubMed	"autism spectrum disorder" AND "performance"	Human, English, last 5 years, review and child (birth-18 years)
PubMed	"autism spectrum disorder" AND "motor skill"	Human, English, last 5 years, and child (birth-18 years)
PubMed	"autism spectrum disorder" AND "motor intervention"	/
Embase	autism"+ all synonyms AND "physical activity"+ all synonyms	Embase not medline, 2018-2020, child* OR preschool* OR school*
Embase	"autism"+ all synonyms AND "exercise"+ all synonyms	Embase not medline, 2017-2020, child* OR preschool* OR school*
Cinahl (PICO)	"autism"(P) AND "physical activity"(I)	Human, apply equivalent, english, 2016-2020, all child
Cinahl (PICO)	"autism"(P) AND "exercise"(I)	Human, apply equivalent, english, 2016-2020, all child
Cochrane	"autism" AND "physical activity"	/
Cochrane	"autism" AND "exercise"	/

Fig. 1 - Bibliographic search strategy table.

**Definition of motor intervention/physical activity**

To better understand the reasons for favouring one study over another, it is good practice to define what is meant by motor intervention and physical activity. They refer to planned games, activities, sports and exercises involving a significant expenditure of energy, carried out in family, school or community setting, to improve physical and mental health (World Health Organization, 2010)

In the literature the attention to these aspects is often pay to different experimental designs related to specific sport practices and their positive impact on autism (e.g.: karate and autism). In this review these studies have been excluded, in favour of searches that summarise in a more exhaustive, comparable and reliable way the relationship between sport and autism.

**RESULTS**

Figure 1 summarises in table form the search strategy illustrated in the previous paragraph; it highlights the keywords, boundaries and databases used to identify the records.

This chart summarises in schematic form the different stages of the search conducted on the identified records.

The keyword database search produced 602 records (identification stage). By entering them into the Mendeley software, which automatically excludes duplicates, the number of these citations was reduced to 502. Subsequently, through a careful reading of the title and the abstract, 488 articles were excluded as irrelevant or not meeting the selection/exclusion criteria (screening stage). The remaining 14 articles were examined entirely: 2 were excluded because of their lower scientific evidence class compared to other two selected studies dealing with the same topic; 1 was deleted because of the low number of participants and another was discarded because it did not include any reference to specific outcome indicators (eligibility stage). In conclusion, the discussion of the results will refer to 10 articles (inclusion stage).

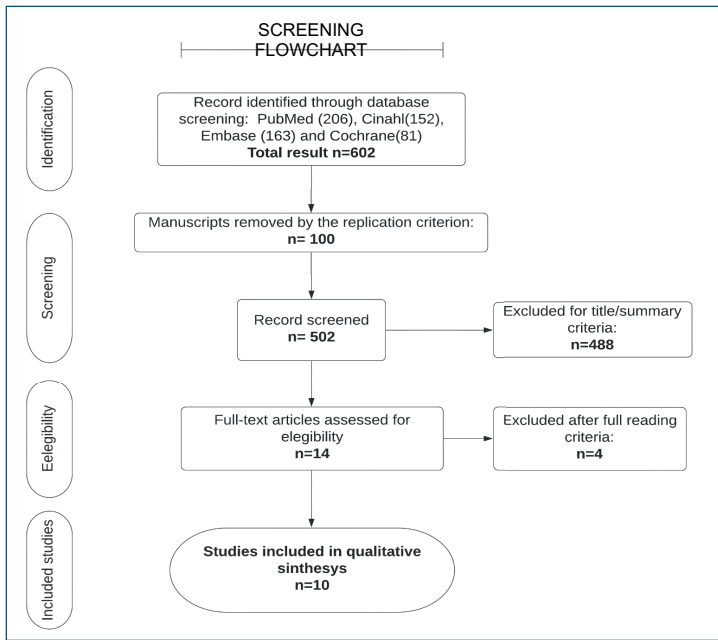


Fig. 2 - Flow chart of the literature screening process.

To identify salient data to meet the research purposes, the data extraction process was organised in a summary table, presented below.

**DISCUSSION**

The primary purpose of this review was to examine the effects and benefits of a motor approach in autistic children of developmental age; secondly, to define

the methods and time frames most associated with the success of this intervention, both in terms of functional and global outcome.

The results of this research are in line with recent evidence that emphasises the interconnection between the different functional domains of autistic subjects (Casartelli, et al., 2016) , (Kramer & Erickson, 2007) , supporting the idea that a change in one area, such as in the motor one, can produce a cascade effect at the level of other functions such as the social, behavioural, cognitive ones.

In the following paragraphs the emerging evidence will be discussed and organised in relation to the different outcome areas.

**Motor on motor**

The motor outcome was considered by 5 studies, compared to the 10 included in this paper. From all of these, as also reported in other works (Sam, et al., 2015) , motor intervention in children with autism improves their motor skills and decreases their deficits in acquiring and using them.

This conclusion is based on data from a total of approximately 2383 autistic children, a number which confers a certain degree of reliability to this result.

Specifically, it seems that depending on the type of physical activity proposed, there is an increase in certain motor skills compared to others. (Ruggeri, et al., 2020) , (Ketcheson, et al., 2017) .

In particular, horse riding seems to be associated with improved balance, general coordination and manipulative skills. (Ruggeri, et al., 2020) .

While a structured intervention through motor skill

**Data extraction table**

Authors and date	Type of study	Objectives	Participants	Method of data collection and analysis/ intervention	Results and notes of interest
(Huang, et al., 2020)	Meta-analysis	Assessing the effects of a physical intervention on children and adolescents with autism. In particular, the study tests the positive correlations of physical activity with social interaction, communication, stereotypical behaviour, sporting ability and the degree of autism.	197 autistic subjects divided into case-controls, examined for the associations of physical activity with the social interaction domain; 240 for the communication area; 146 for the effects on stereotypies; 172 for the motor skills' improvement; 107 to investigate the repercussions of the intervention on the degree of autism.	The authors search both 'commonly used' databases (e.g. PubMed) and Chinese databases such as CNKI or WanFang data. They selected 4 articles in Chinese and 8 in English. The cycle for the interventions ranges between 4 and 24 weeks with an average duration of 40-90 minutes per session. Physical activity is meant as any task that burns energy and activates muscle contraction.	The analysis of the data shows that physical activity in the autistic population (children/ adolescents) promotes and improves social interaction, the area of communication, the development of motor skills and reduces the degree of autistic symptoms. Specifically, in group motor activities, autistic children find the opportunity to experience sociality, not necessarily mediated by language. The activities must last at least 4-24 weeks with a frequency of 4-13 meetings per week to bring about a statistically significant improvement in the social domain. While to implement their motor skills significantly a 12 weeklong activity is needed: 45-75 minutes once or twice a week. In addition, motor activity 5-7 times a week, for about 90 minutes, shows a general decrease in autistic traits. The heterogeneity of studies has produced contradictory results regarding stereotyped movements, although, in general, continuous and frequent physical activity brings many benefits. The general limitations of the meta-analysis concern the precise definition of the type of rehabilitation activity and intervention that the subjects carried out.

<p>(Ruggeri, et al., 2020)</p>	<p>Systematic review</p>	<p>Evaluate the effect of a motor intervention/ physical activity on the motor skills of people with autism (learning motor strategies, acquisition of motor skills, maintenance of skills over time and generalisation to the adaptive context).</p>	<p>1173 children with autistic spectrum disorder in a range age from 3 to 19 years. 83% of the subjects surveyed were male. 82 typically developing children used as a control group (range 6-12 years of age).</p>	<p>From 6 databases, sifting through 7972 results, 41 studies were included in the search. The authors follow the “PRISMA” guidelines. A quantitative analysis of the data was not carried out due to the excessive heterogeneity of the studies. The types of intervention were divided into 6 groups:  1. motor activities (n=9), 2. motor skills intervention (n=7), 3. hippotera pia (n=6), 4. water intervention (n=5), 5. motor games (n=4) and 6. physical education (n=6) which were then brought back to 2 macro areas: motor competence (n=7) and motor skills acquisition (n=34).</p>	<p>The results show that each type of intervention contributes differently to the acquisition of certain motor skills. Furthermore, it is shown that the use of visual material to support the teaching of gestures and actions, opposed to verbal teaching alone, is more conducive to learning motor skills in individuals with autism. The operator variable in relation to “who teaches”, according to the data, does not contribute significantly to changing the outcome of the intervention. There are some limitations regarding the level of evidence of the individual studies and the methodology with which they are carried out, as there is a lack of a methodological protocol and a shared measurement of the outcome, which do not allow a precise definition of the limits and characteristics for a <i>gold standard</i> intervention.</p>
<p>(Ferreira, et al., 2019)</p>	<p>Meta-analysis</p>	<p>To evaluate what effect physical activity has on the stereotyped behaviour of autistic subjects.</p>	<p>129 children diagnosed with autism spectrum disorder (115 boys and 14 girls) with a mean age of 8.93±1.69 years.</p>	<p>The authors use the ‘PRISMA’ guidelines to guide the search and screening of articles. Furthermore, they use the “TREND statement” with a minimum criterion of 50% QoI to select quantitatively suitable studies for meta-analysis. Thus, 8 studies were included in the meta-analysis. These include motor interventions with varying intensity, duration from 8 to 48 weeks and frequency of 3 sessions per week.</p>	<p>The review shows that motor activity significantly reduces the number of stereotypical movements in autistic subjects, with a positive association between the intensity of motor activity and the reduction of stereotypies. One of the included studies also shows that even quiet aerobic activity (50-60% maximum age-calculated heart rate) can lead stereotyped behaviour. The limitations of this review are related to the temporal definition of the results. More data are needed to clarify whether the effect of the improvement persists (it seems 40 to 120 minutes) and which type of activity, frequency and duration of activity leads to greater effectiveness.</p>
<p>(Tse, et al., 2019)</p>	<p>Study randomization-controlled trial</p>	<p>Assessing the effect of physical activity on executive functions and sleep in children with autism</p>	<p>40 autistic subjects with a mean age of 9.95 years, randomly assigned to 2 groups (activity and control group).</p>	<p>The subjects assigned to the intervention group had to perform 24 basketball sessions (twice a week for 45 minutes each), divided into 10 minutes of warming up, 30 minutes of playing and 5 minutes of stretching. Conversely, the control group was not required to perform any specific physical activity. Sleep data were collected as a function of four parameters, while inhibition and working memory were examined for executive functions both before and after the administration of the intervention in both groups.</p>	<p>As hypothesised by the authors, motor intervention brings significant benefits for children with autism in both the area of sleep and executive functions. In particular, regarding sleep, there is an increase in the duration of sleep compared to the overall time spent in bed, the time needed to fall asleep decreases and there is less latency in the awakening phase. For executive functions, on the other hand, there are improvements only regarding inhibition, which is related to activities that specifically required controlling your own body and implementing a specific sequence to achieve a goal (inhibitory skills). The authors hypothesise a possible improvement of self-regulating abilities, which were not measured. The lack of improvement in working memory was instead attributed to the simplicity of the requests, which did not allow specific work on the function.</p>

(Zhao & Chen, 2018)	quasi-experimental desing	Assessing the effects of a structured mobility programme on communication and social interaction of children with autism	41 autistic children were divided roughly into a working group (n=21) and a control group (n=20). Average age of participants was 6 years.	<p>The motor intervention consists of 24 exercise sessions, each lasting 60 minutes, spread over 12 weeks.</p> <p>The proposed activities follow internationally recognised guidelines such as those of the DSM V or the '<i>Global recommendations on physicalactivity for health</i>'. Each session is divided into 4 phases: 1. warm-up, 2. formation of small groups and play, 3. activity carried out all together and 4. Relaxation and compensation.</p> <p>The experimental outcome has a strong social component as each activity sequence is punctuated by moments of interaction between peers (e.g. "high-five" and other forms of communing). To support the intervention, the TEACCH model (<i>Schopler</i>) is used with various forms of recommendation. Data was collected in three phases: before, during and after the intervention and analysed qualitatively and quantitatively.</p>	<p>The results of the study show that structured physical activity has real benefits on certain traits of autism.</p> <p>The intervention supports and encourages the social development of autistic children (e.g. increased eye contact), which is also related to the positive and safe environment of exchange.</p> <p>The repetitive and precise structure (same companions, same activities, same instructor and TEACCH method) is suggested as a valid way to grant the subject the degree of stability necessary to experience openness towards the other.</p> <p>There is also an increase in communication skills, following the intervention on motor skills. However, these goals do not exceed those achievable through other types of intervention.</p>
(Healy, et al., 2018)	Meta-analysis	Assessing the effects of physical activity in autistic subjects.	The studies in the review included a total of 1009 subjects in an age range of 2 to 22 years.	<p>The authors conducted the research following the 'PRISMA' guidelines. From a total of 967 records, 29 studies were included in the qualitative and quantitative review. Due to the diversity and insufficient number of studies, in accordance with the inclusion criteria, the authors chose to group the results under certain constructs (e.g. locomotor and manipulative skills, muscular strength and endurance, social dominance, etc.). P (value) set at 0.05. In order to meet the inclusion criteria, a study had to be done either in a school/institutional (PE) setting or in a recognised sports centre.</p>	<p>The results show an improvement in manipulative, locomotor, social and fitness skills and muscular strength/resistance for autistic subjects.</p> <p>Feedback underlines the potential of the motor approach for autism. In general, it seems that the intervention should last at least 16 weeks to achieve significant results.</p> <p>There are some limitations in the interpretation of the results because the studies considered are not randomised controlled and are not precise in delineating the type of intervention. This does not guarantee the reproducibility of the experience and a high degree of reliability of the relative results.</p>

<p>(Toscano, et al., 2018)</p>	<p>randomized controlled trial</p>	<p>Assessing the effects of a motorised intervention on the metabolism of individuals with autism, their disruptive traits and their quality of life</p>	<p>64 autistic children divided roughly into 46 cases and 18 controls, ranging in age from 6 to 12 years. In particular, 9 children were diagnosed with ‘Asperger’s syndrome’, 43 were diagnosed as autistic, and 12 others met the criteria for the category ‘developmental disorders without specification’.</p>	<p>To cushion the effects of exclusion and withdrawal of some participants from the intervention group, the authors of this study defined a causal allocation with an unbalanced ratio of 1 to 3 in favour of the case group. The children in the experimental group undertook a 48-week physical activity programme, including basic coordination and strength exercises. The programme was divided into 96 sessions of 40 minutes (2 sessions per week), to be carried out in a small group of children (max. 3): 5 minutes preparation, 30 minutes activity and 5 minutes relaxation, in which the caregivers also participated. The outcome indices are collected through biological tests and behavioural questionnaires.</p>	<p>The results show that this type of motor intervention helps to improve certain aspects of the metabolic profile, reduces the traits of the disorder and promotes a more positive perception of life quality. In particular, this treatment produced:</p> <ul style="list-style-type: none"> <li>- An increase in HDL-C and a decrease in LDL-C and general cholesterol levels;</li> <li>- A reduction in stereotyped behaviour and an increase in verbal and non-verbal communication skills;</li> <li>- A positive change in parents’ perception of their child’s autistic traits and quality of life.</li> </ul>
<p>(Ketcheson, et al., 2017)</p>	<p>Pilot study</p>	<p>Measuring the effects of intensive motivational treatment in autistic children with regard to their level of motor skills, physical activity and degree of socialisation.</p>	<p>20 autistic subjects (11 cases and 9 controls) aged between 4 and 6 years.</p>	<p>The instruments mainly used to monitor changes and the effectiveness of the motor programme are TGDM-2 (<i>Ulrich et. al</i>), a triaxial accelerometer and, only for the case group, POPE (<i>Dean and Chang</i>). The intervention group followed a motor programme of 4/5 days per week for a total of 8 weeks. The motor activity session is carried out in a 1:1 teacher-child ratio. The proposal of activities follows the PCRT method (“Classroom Pivotal Response Teaching”) of <i>Aubyn C. Stahmer</i>, a behavioural model carried out in a natural setting.</p>	<p>The results show significant differences in the experimental group (p value = 0.01) in the locomotor sphere (object control and general gross motor quotient). The improvement occurs and seems to settle after about 4 weeks of intervention; for the “control of the object” effective changes are recorded only between the 4th and 8th week, perhaps in relation to the greater complexity of the task. At the level of the social area, there is a reduction in the time spent (p value = 0.05) by each subject in solitary play and this openness can be associated with an improvement in motor skills in relation to the emerging ability to explore the environment.</p>
<p>(Bremer, et al., 2016)</p>	<p>Systematic review</p>	<p>Evaluating the effects of physical exercise on mental behaviour in autistic subjects.</p>	<p>Autistic individuals under 16 years of age</p>	<p>From 124 records through a selection process, 13 limbs were included for the review. Due to the heterogeneity of treatments and outcomes, a quantitative analysis of the data was not performed. Elected studies include 5 types of exercise: jogging, horseback riding, martial arts, yoga, dancing and swimming. Outcomes relating to stereotyped behaviour, attention and cognition and social-emotional behaviour are assessed.</p>	<p>Despite the poor definition of the method and the consequent variability of the results, the review shows that motor exercises can be used as a behavioural treatment for autistic people; in particular the practice of martial arts or equitation implies greater benefits than other exercises. The poor definition of the method does not allow the definition of precise time frames; it seems that stereotypes improve after 15 minutes of running; martial arts seem to be effective with 56 h of practice. There is also a lack of follow-up data. However, the authors point to certain associations: jogging, horse riding and martial arts have positive effects on the reduction of autistic stereotypes; yoga, dancing, martial arts, horse riding and swimming have positive effects on social-emotional skills, while jogging has positive effects on attentional skills and general cognition.</p>

(Bremer, et al., 2015)	Pilot study	To evaluate the effect of a motor intervention in autistic children and to study the outcome in terms of activity intensity.	9 autistic children aged 4 years (5 cases and 4 controls).	The experimental intervention lasts 12 weeks, 1 hour per week and works on motor and mental skills. The control group in the first phase does not participate in any type of intervention while in the second phase they participate in an intervention of different intensity (for 12 weeks 1h per week versus 6 weeks 2h per week).	The results show that the motor intervention produces significant differences in the motor area but not in the social or behavioural one. The intensity at which it is administered does not change the results. Improvements in motor skills persisted at follow-up (after 6 weeks). General limitations of the study are the small sample size and the duration of the intervention.
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**Tab. 1** - Data extraction table for the analysis of articles elected for review.

exercises promotes control over objects and the acquisition and use of new movement patterns. (Ketcheson, et al., 2017) . Exercises in water are more significant when the subjects lack some of the prerequisites necessary for motor development, such as muscle strength or joint flexibility. (Ruggeri, et al., 2020). . It is difficult to define the type of specific activity as in the article the method is generally not described in a way that makes it reproducible (methodological limitation).

Treatments usually produce significant improvements if they last at least 12 weeks, 45-75 minutes per session and are practised 1-2 times per week. However, there is still no unanimous agreement on the treatment's duration.

The study by Bremer and colleagues suggests that the total number of activity sessions is particularly significant for the development of motor functions, while the intensity and the duration are not relevant parameters (Bremer, et al., 2015) .

Instead, Ketcheson and collaborators argue that different skills have different inter-critical developmental times: a significant increase in locomotor skills occurs in the first 4 weeks of intervention, whereas one must wait a longer period (4-8 weeks) to see significant improvements in object control (Ketcheson, et al., 2017) .

Regarding the proposal presentation, it emerges that the use of visual material instead of the verbal one promotes a simpler acquisition of new motor schemes. On the contrary, the model mediating the proposals (video, person, robot or brother) is not so relevant for the final result. (Ruggeri, et al., 2020).

In conclusion, performing physical activity produces benefits over the motor domain of autistic children and good motor functioning facilitates autistic individuals in several adaptive functions ranging from socialisation, play, and daily autonomies (Ketcheson, et al., 2017) . However, better defined protocols are needed to increase the level of evidence for this approach, to optimise the timing of the intervention according to the purposes, and to construct motor interventions tailored to specific aspects.

### Motor on behaviour

One of the central features of autism spectrum disorder is behavioural impairment (American Psychiatric Association, 2013) . To address this, multiple intervention methodologies have been designed over time, most of which require a high degree of training

and intensive treatments to produce significant results (Bremer, et al., 2016).

4 studies out of 10 focused also on a behavioural outcome following motor intervention and in particular on the reduction of stereotyped behaviour.

Although there is no unanimous agreement, most of the articles report a reduction in stereotypies following motor intervention.

Among the articles which do not find a significant result, for example the study by Oriel and colleagues, included in the meta-analysis by Ferreira (Oriel, et al., 2011) it is important to underline the fact that the length of the intervention is probably insufficient.

Also in the Huang search the heterogeneity of the results is linked to the different methodologies used in the various studies, which do not always make them directly comparable (Huang, et al., 2020).

This lack of methodological homogeneity is also reflected in the time frame. Successful interventions range from 8 to 48 weeks, with a frequency of 1 to 3 days per week and a single session lasting between 15 and 90 minutes.

However, there appears to be an inversely proportional relationship between treatment intensity and the number of stereotypies. (Ferreira, et al., 2019) .

Although there are also studies that support the opposite view, quiet aerobic activity appears to reduce stereotypies considerably. (Nazemzadegan, et al., 2016).

However, a certain degree of activity seems to be necessary: running for 15 minutes can generate a change in stereotypes in the short term, whereas walking for the same amount of time cannot. (Bremer, et al., 2016).

The effects of the intervention last from 40 to 120 minutes after the activity, but data on time aspects and especially follow-up data are poorly considered.

To sum up, beyond the type of activity practiced (martial arts, aerobics, horse riding etc.), physical activity in autistic children can be helpful in the treatment of stereotyped behaviour.

This aspect becomes particularly relevant when stereotypies are very intrusive, as they have significant impact on the social environment and/or interfere with learning of the autistic child (Nazemzadegan, et al., 2016).

### Motor over cognitive

In recent years, studies have supported an association between aerobic activity and increased cognitive performance, as physical activity also increases and

modifies metabolism in the brain (Khan & Hillman, 2014).

This evidence is particularly interesting to explore in autistic subjects, where the presence of deficits in executive functions is described. (Russo, et al., 2007). Only one study, among those included in this review, tries to answer this question. Specifically, through a randomised-controlled trial, this experimental work investigates the effects of physical activity on executive functions: inhibition and working memory in children with autism.

The results show that physical activity produces a significant improvement in inhibition function, whereas the data do not reach the significance threshold for working memory (Tse, et al., 2019).

In the light of this, physical exercise alone, as a pure act that increases the metabolism, does not seem to be sufficient to create a permanent and significant change in executive functions.

Indeed, in the study the improvement in inhibition function seems to be linked to the type of exercises, which require fine control of the motor scheme, inhibiting all other movements (unnecessary or incorrect), in order to correctly complete the exercise (e.g. shooting a basket).

Instead, the simplicity of the instructions probably did not stimulate the working memory enough to obtain a significant improvement (Tse, et al., 2019). Further studies are needed to confirm these assumptions.

In relation to the highlighted improvement a motor intervention of 24 sessions (45 minutes each), spread over 12 weeks, seems to contribute to an increase of the inhibitory control skills of children with autism.

### Motor on socio-communicative

Persistent social and communication difficulties are one of the two key aspects characterizing autism (American Psychiatric Association, 2013), so much that the majority of rehabilitation and educational interventions for autistic children are always directed and focused on promoting the social domain of the individuals involved (Zhao & Chen, 2018), (Ketcheson, et al., 2017).

More than half of the studies included in this review, indeed, consider the effects of their own motor intervention on the social and communication skills.

Overall, the results suggest that a motor intervention has a significant and positive impact on socio-communicative development and that this improvement can be linked to two essential determinants.

In group motor activities, children with autism find opportunities to experience social interaction that is not necessarily mediated by verbal language (Huang, et al., 2020).

Having a large and robust motor repertoire makes it easier for children to explore the environment and relate to it (Ketcheson, et al., 2017).

In addition, the review also shows that a well-structured motor programme (same group, same activities and same instructor) seems to give children the degree of stability needed to open up to others (Zhao & Chen, 2018).

Indeed, this approach leads to lower times of solitary play (Ketcheson, et al., 2017), more communicative exchanges and an increase in eye contact (Zhao & Chen, 2018).

To achieve these improvements, motor interventions

should be carried out in groups and last at least 12 weeks (twice a week with a minimum duration of 24 minutes per session).

It is also stated at a methodological level that it is useful to mark out the activities, proposing interactive exchanges between peers and using every play opportunity to relate with others in an ecological manner (Zhao & Chen, 2018).

The results of the review thus seem to confirm that a group motor intervention can be a valid possibility to promote the development of social and communication skills in autism.

Only one of the studies analysed did not show any significant improvement, namely the pilot study by Bremer and colleagues in 2015, which involved a low number of participants (9) and few intervention sessions (12).

The centrality of sensorimotor experience, as a prerequisite and developmental factor to be interested in the world of things and people, is emphasised, confirming its highly adaptive value also as a tool for promoting the development of the deficient functions of children with autism.

### Motor and other

Motor intervention in children with autism leads to several results:

- Improve their metabolic profile (Toscano, et al., 2018);
- Reduce typical autism traits (Huang, et al., 2020), (Zhao & Chen, 2018), (Toscano, et al., 2018);
- Increase sleep quality and duration (Tse, et al., 2019);
- Promote a better perception of quality of life in the parents of these children (Toscano, et al., 2018);

For all these reasons, the intervention must be personalised, adapted and modified according to specific needs, while maintaining its general motor nature.

## CONCLUSIONS

In the light of the data that have emerged, proposing a motor pathway or the practice of physical activity/sport to a child with autism is certainly a resource in the intervention project, especially because of the multiple benefits showed in the study.

Although further studies are needed to better define the methodologies and implications of this type of intervention, the data presented in this review clearly show the potential of this route.

The research was carried out on the idea that a global approach is needed to promote the neurodevelopment of autistic individuals, because the various domains constantly interface and influence each other, and a change in one area has a knock-on effect on the others.

According to this perspective, the Developmental Neuro and Psychomotor Therapist (TNPEE) assumes the role of a Developmental Therapist who proposes a rehabilitation intervention through an integrated view instead of focusing on a single competence or function.

This figure, indeed, finds its natural and direct collocation in these data, because by definition and modality of its intervention it matches this fascinating perspective. Considering the reciprocal relationships between the different functions, in a developmental perspective and in relation to the characteristics of



a pathological development, is certainly a complex challenge. This complexity reflects the system within which rehabilitation in developmental age moves: the human mind and neurodevelopmental disorders. Therefore, although for now, we are still far from understanding all aspects of correlation between motor activity and autism. Nowadays, as therapists we can integrate some of the evidence described in this review in our practice, considering the motor intervention not only from a mere motor point of view. As professionals we could suggest families to encourage children to practice sport activities, given its positive effects in relation to weight control and the regularisation of sleep patterns, but also on social skills, as a proactive experience that allows children to connect

with the environment and others.

The review does not provide solutions, but it does offer suggestions for improvements in professional practice, which may be helpful, especially to the young patient, to significantly affect the natural history of his or her disorder.

More precise data, better defined methodologies, follow-up studies and well-structured experimental designs are needed to build a highly effective, reliable motor intervention that produces the greatest possible number of positive effects on children with autism. Meanwhile, we also need an open mind to research, careful to seize any new evidence to improve our everyday practice with children.

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