Interventions to improve motor, social and cognition in children with developmental delay: A systematic review

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Abstract: The aim of this review was to evaluate the effectiveness of physical therapy interventions reported for use in children with delayed developmental to improve motor skills, cognition, and social skills outcome. PubMed, PEDro, and Google scholar were systematically searched to source for full-text studies published in peer-reviewed journals from 2010 to 2020 for current physical therapy interventions in children with developmental delay. Outcomes were motor skills, social skills, and cognition ability. Results Searches identified 20 randomized trials including 1132 children with developmental delay. Interventions were various with different sample sizes. The most used intervention was dual task with video game/VR, skill instruction and massage therapy. Other interventions such as music therapy, equine, aquatic therapy were also found. Except aquatic therapy, all the interventions type showed to be effective to improve motor, social and cognition in children with DD. Results from this review reveal that dual task with video game/VR and massage therapy are effective to improve motor and cognition and skill instruction, education program including parents is more effective for social skills improvement. The other included interventions showed to be effective, but more evidence is needed.

Keywords: developmental delay; motor skills; social skills; cognition; physical therapy interventions

1. Introduction

In the clinical field and specially in the pediatric health area and literary texts, the term developmental delay (DD) is widely one of the most used word. By definition, the term developmental delay is used to design a child who does not reach developmental milestones comparing to other children of the same age range. It can be divided in three (3) categories (mild, moderate, severe) according to the degree of severity or in two (2) groups (single domain, multiple domain) according to the affected delay domain [1]. According to previous studies, developmental delay is not an isolated dysfunctional growing, but a compound group of development problems commonly identified during childhood. Generally, many elements such as genetic, childhood brain damage or disease, childbearing problem, malnutrition, or other diverse infancy conditions are closely related to children developmental delay [2].

Children with developmental delay frequently have delays in certain specific domains of early years, and these delays may extend to other domains of development. Developmental delay includes a various type of children with diverse disorders. Children with cognition and physical impairment can also be allocated to developmental disabilities. Additionally, children with problem of communication, retard into development of language abilities, social interaction and behavioral problems are also seen as developmental delay [3]. MacDonald and McIntyre added that children that struggling to share or express their emotions, having eye contact or proper gestures and other social deficits are diagnose as autism spectrum disorder (ASD) which can be consider as part of developmental delay [4].

According to the type and severity of the developmental delay, children may have intellectual disability, anxiety disorders, mental retardation, difficulties in their social environment and community due to the lack interaction and communication [5]. These troubles started at very early years of the growing period to early adulthood and doubtlessly continue endlessly. Commonly, down syndrome, epilepsy, intellectual disability, attention deficit hyperactivity disorder (ADHD), developmental coordination disorder (DCD), are associated to developmental delay and their main common problems are social skill motor and cognition deficit [6,7].

Motor skills or motor performance deficit is one of the main reported deficits in children with developmental delay. Motor skills deficit conducts to a loss of motor skills, balance impairment, and complications in daily activities. Furthermore, motor skills deficit also directly exert influence on children's health and the livelihood differently and in divers' aspects [8]. Functional activities such as walking, jumping, running, are fundamental for children's growing, maintaining interaction with the society, joining in sport or other activities [9]. They are also important to keep the children active and are fundamental to avoid or minimize the possibility of an unhealthy physical growing [10]. Additionally, with a normal motor function development, children are able to acquire new skills, be involved in their community, school programs and relaxation activities that can be benefit for a healthy growing toward adulthood [11]. These functional activities require gross motor skills which use generally large muscle groups to coordinate and effectively move the body [9]. Houwen et al. emphasized in the fact that motor skills are important for physical or social activity over and above emotional stability of the children in the growing

process [12]. However, deficit in gross motor activity may have negative effects on children abstaining from physical activities that can be harmful for the cardiopulmonary function associated to a high risk of chronic disease and unfavorable in emotional and social development [13,14].

Social development has been considered as the ability to experience new emotions, manage, reveal, and share them with others. It is the capacity to range over the environment, interact with the society according to the ethical and cultural customs. Williamson et al reported that normal mental health, welfare, successful academic records, are deeply related to early years social and emotional development which are the fundamental factors [15]. Westgard & Alnasser added that not only social-emotional skills but also sensory, motor, cognition skills are essential for a normal child growing. Additionally, promoting good infancy development has a long-term positive effect on the children health and in the society as well [16]. In another previous study, it has been recommended that social skills and cognitive ability have to be considered as one of the major and key outcomes for interventions on children with developmental delay [17].

In several different studies, motor, social and cognition ability were highly improved after physical therapy interventions and proves his effectiveness on children with developmental delay. The main discovers are decreasing of motor deficits and improvement of motor skills, cognitive ability, behavioral ability, daily living ability, social and emotional function. Only very few revealed systematic review and meta-analysis evaluating the efficiency of physical therapy interventions on motors, social skills or cognitions were found. Bishop & Pangelinan in a previous systematic review evaluated motor skill interventions on children with motor and cognitive disabilities [18]. Another systematic review meta-analysis conducted by Lucas, Barbara R., et al. analyzed interventions on motor skills and Preston, Nick, et al. systematically investigated a randomized controlled trials reviewing motor skill programs for children with developmental coordination disorder and included motor skills and cognition as outcomes [11,19].

As shown above, the majority of these systematic reviews focused on one outcome at once or at least two outcomes such as motor performance or cognition ability. Unfortunately, a review resuming the efficacy of current physical therapy interventions aimed to increase or improve especially motor skills, social skills, and cognition ability in children with developmental delay is not yet proven.

The first purpose of a systematic review is to provide an overview and recap of all the effective accessible research evidence and not to hand over all the available research despite of quality. Therefore, the purpose of this paper was to review the current literatures and identify the effectiveness of divers' types of physical therapy interventions reported use in children with delayed developmental for motor skills, cognition, and social skills outcome. Secondly, to supply some viable and feasible evidence for farther therapeutic practice.

2.Method

2.1.Search strategy

A systematic review of articles published between January 2010 and 2020 was conducted using the electronic databases PubMed, PEDro and, Google Scholar. The searching terms were choose to include the target population (‘developmental delay, developmental disabilities, developmental disorder’), and outcome type (‘motor skill*’ OR ‘ social skill’ OR ‘cognition’), AND (‘intervention ’OR ‘therapy’ OR ‘exercise’ OR ‘treatment’). The titles and abstracts of articles linked by the electronic search were established to decide whether the article met our inclusion criteria.

2.2.Inclusion and exclusion criteria

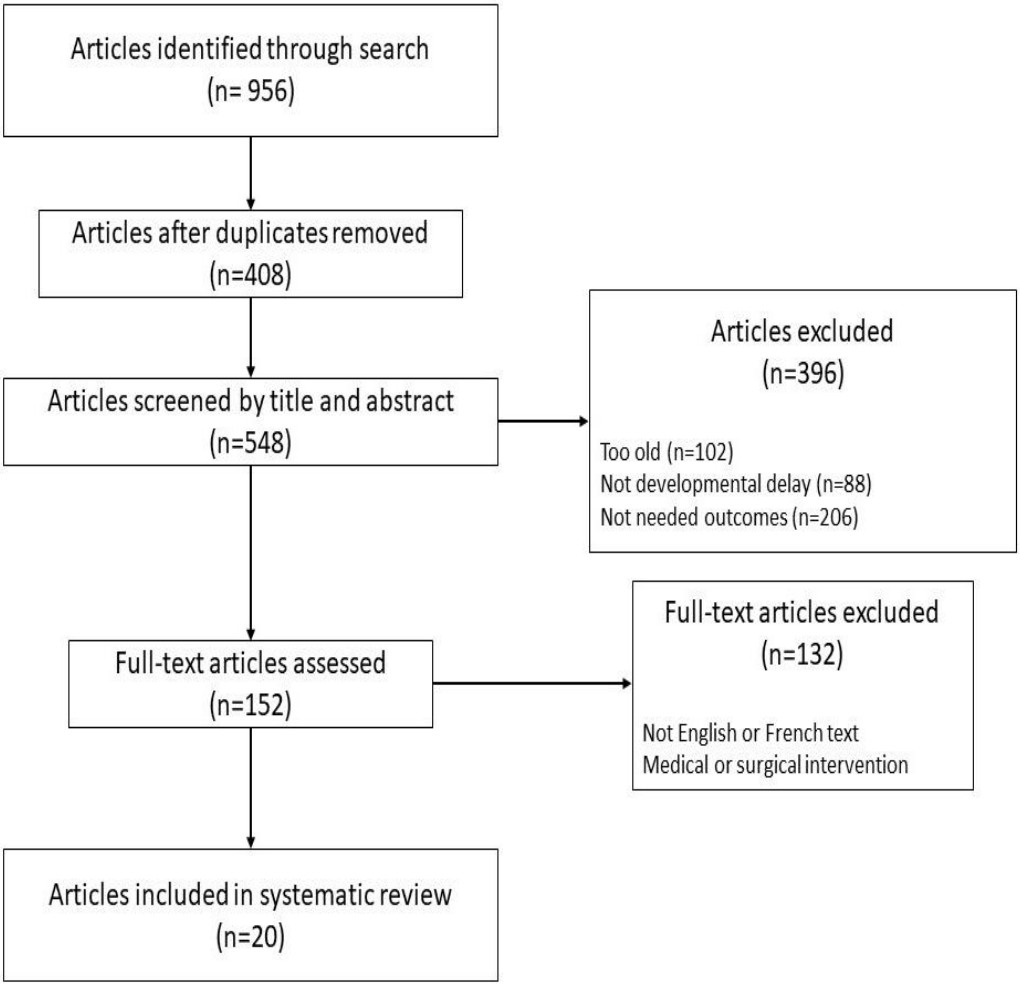
Articles were included if (1) they were full articles, published in English or French, (2) study poulation were children diagnosed with all type of DD such as autism, down syndrome etc., and aged between 0 and 18 years; (3) they affirmed the intervention's efficacy or effectiveness for the improvement of at least one of the designed outcomes (motor skills/ motor performance, cognition or social skills). Articles were excluded if they were non full text, or opinion articles, if there used medical or surgical interventions, interventions without any of our target outcome measures that are motor skills, cognition, or social skills.

2.3.Type of interventions and outcomes

In the current review, we included any physical therapy intervention according to the inclusion outcome. Studies comparing physical therapy interventions with traditional or standard care, home-based training, and enhanced physical therapy formats with additional devices were included. Interventions including drug or medication were excluded as these were considered as adjunct interventions and are one of the exclusion criteria. The target outcomes were motor skills/ motor performance, social skills/socialization, and cognition

2.4.Data extraction

All the data from studies that met at least one of the inclusion criteria were extracted and contain follow information: author names, date, participant characteristics, intervention type, time, frequency. Table 1 summarizes the information's of the included studies and provides information regarding the participants, study design, interventions, and main outcomes by authors. Records identified by searches were imported into Microsoft Excel and duplicates removed. Within this database, studies that did not fulfil the inclusion criteria or clearly not relevant were excepted and the reasons for exclusion were recorded.



[Figure 1] Research procedure

3.Result

After a methodical overview of the included studies, several and various types of exercises have been used effectively as interventional methods in children with developmental delay. The research using the keyword terms filtrated 956 studies from the electronic research database. After removed duplicated articles and review titles and abstracts according to the inclusion criteria, 152 were selected and assigned as potential and a full text were acquired. Finally, 20 studies were eligible by satisfying our inclusion criteria and were included in the study. The organization chart (Figure 1) shows the study procedure.

The included studies analyzed a total of 1132 participants, limit from 1 to 18 years (age not reported in 7 studies). There were more patients with autism than the other type of DD. The intervention duration ranged between two weeks and six months. As all the included studies were in between the last past 10 years, the included interventions also had been conducted in the same period of time (from 2011 and 2020). Included studies were from USA (n=7), Taiwan (n=3), South Africa (n=2), Sweden (n=2), Iran (n=1), Spain (n=1), Chine (n=1), Italy (n=1), Australia (n=1), Egypt (n=1).

The treatment approaches used was almost different each other and various. Five (5) of the twenty interventions were based on dual task oriented with video game/virtual reality and computer-based treatment [21,26,29,35,37], three (3) on verbal skill instruction and education program [25,27,28] and three (3) others on massage therapy[33,34,39]. The remaining nine (9) interventions was reported in only one study each of them: equine assisted therapy [20], auditory rhythmic stimulation [22], aquatic exercise program [23], physical activities (running, jumping etc.) [24], ball exercises [30], Early intensive behavioral intervention (EIBI) [31], music therapy [32], Body weight supported treadmill training (BWSTT) [36], Core stability training program and task-oriented motor training program [38].

In the present study, the included interventions diversified over studies according to several factors. The duration of interventions ranged from six sessions to twenty-five sessions and the frequency was ranged from twice a week to five times a week, with 10 minutes to 1 hour for each session. Among the 20 interventions included in the review, fourteen (14) assessed motor skill and a total of thirteen (13) reported a statistically positive and significant improvement after the intervention. Nevertheless, in one (1) study that assessed motor performance, there was not significant statistical change. Eight (8) studies evaluated the result of physical therapy intervention on socialization/social skills of children with developmental delay. All the studies reported remarkable effects and positive results at the end of the program. However, it should be noted that one (1) of the studies was a pilot study. Among all the studies that assessed cognition, four (4) (80%) of the five (5) studies showed statically improvement and the last one did not provide statical results.

In order to measure the outcomes, varied assessment scales were used. For the motor outcome, the trials used different assessment scales in order to measure fine motor, gross motor, motor coordination, motor skills. Bruininks-Oseretsky Test of Motor Proficiency 2nd Edition (BOT-2) was to most used assessment scale and was found in six (6) studies. Test of Gross Motor Development-3 (TGMD-3), Brunet-Le´zine Early Childhood Psychomotor Development revised scale, and Movement Assessment Battery for Children-2 (MABC-2) was used in one (1) study each. Common standardized measurement scale such as Social Responsiveness Scale (SRS), Family Strain Index, Gilliam Autism Rating Scale Tool-Second Edition [GARS-SE], Brunet-Le´zine Early Childhood Psychomotor Development revised scale, MSEL (Mullen, 1995), that specifically determines the social and cognition ability of children were included.

The main purpose of this study was to systematically examine the effectiveness of the evidence associated to physical therapy interventions assigned to improve motor, social and cognition in children with developmental delay. To our knowledge there was not a previous a systematic review that examined the effectiveness of physical therapy interventions on these particular outcomes. N the present paper, 20 studies were recognized as meeting the inclusion criteria of the present study. In this highly focused review on children with DD, we can notice that studies differed remarkably according to the study design (sample size, age, sex) and the applied exercise (type, time, frequency). Nonetheless, all the studies except one reported an improvement in motor skills/motor performance, social and cognitive ability correlated to children with DD using various interventions, such as dual task with video game/VR, massage therapy, skill instruction/education program.

From the twenty entries analyzed in this review, there were 14 studies (70%) that inspected the effectiveness of interventions on motor skill/ motor skill in children with autism, down syndrome, and DCD. Regarding the characteristics of the interventions, studies included dual task with interactive games, massage therapy, equine-assisted therapy, aquatic therapy, treadmill, and physical activities. Overall, the majority of interventions focused on dual task associated with video games such as Xbox Kinect, Nintendo Wii, VR and was the most used intervention technique (total n = 4) in this review. All of the four (4) studies showed a greater improvement on motor performance (fine motor, gross motor), muscle strength and cardiorespiratory function and promoting participation in children with DD. Several previous studies provided evidence to support the beneficial effects of dual task associated with video game/VR on children. It is revealed that practicing exercise using dual task with interesting 2D or 3D virtual environment or game influences the human brain in various domain and specifically in the frontal lobe, temporal lobe and the volume of the basal ganglia and as well the development of cortical thickness [40,41]. That leads to an improvement of motor skills in children. Other reviews using video game intervention in cerebral palsy's patient also showed a similar result to the present study [42]. They reported that intervention using virtual reality technique can be beneficial to improve physical activity performance in children with cerebral palsy or other brain damage. Furthermore, Hickman, Robbin, et al in their meta-analysis reported that intervention using video game is practical and may be effective for increasing physical activity and may be beneficial to children with developmental delay [43]. According to the number of studies and quality of the results, these evidences are sufficient to affirm the effectiveness of dual task oriented with video game/VR devices to improve motor performance/motor skill in children with developmental delay.

Another study focused on improvement of cognition highlighted the use and the efficacy of computer-based cognitive training on children with cognition problem such as DD and ID. Effective for improving motor skills,

dual task using games or VR demonstrated highly encouraging and promoting results [35]. However, this is the only one study using computer-based cognitive training following the inclusion criteria of our study. More evidence is required to affirm his effectiveness on children with developmental delay.

In our review we identified three (3) studies that included massage therapy as intervention for motor skills, cognition, and social improvement. Physical therapy intervention using massage technique is considered as a simple, inexpensive, and practical intervention for children with DD. One of the three studies confirmed that massage therapy enhanced the sensory and motor ability on children with DD but did not mention about social and cognition changes. Additionally, it is reported that body massage for children with developmental delay particularly those with sensory sensitivity or motor deficit at home or in the clinal field home provided by therapist or parents is recommended [33]. Another study conducted by Silva et al. reported that following a qigong massage at home on 28 children with DD presented positive changes on motor skill and cognitive ability in children with developmental delay [39]. However, Pinero-Pinto et al. recently reported that a 10min massage for 5 weeks on down syndrome children showed an improvement of motor and social skills but has a short-term effect [34]. This is consistent with another previous study conducted by Ho et al reporting that massage therapy is consider as a prospective intervention technique to further motor outcome in children with motor performance but did not mention about the long term effect of massage therapy [44]. Moreover, massage therapy should be use as additional intervention to conventional or other intervention program to be more effective.

Physical therapy using exercise as intervention is recommended for improving motor skill/motor performance on healthy adolescent as well as on patients with neuromuscular disorders. In this review, we found two (2) studies assessing table tennis, pleasure, other complex activities, and ball exercise as intervention for motor skills and cognition ability. After 12 weeks of training, children showed and improvement of both outcomes [24,30]. Ketcheson et al. reported that for children with autism spectrum disorder, early intervention plays a vital role and motor exercise program might be include [25].

In the current review, a total of three (3) studies assessed social skills of children with DD using skills instructions and education program. All showed a positive result on children after sufficient education sessions and the treatment program. It has been suggested that direct and exhaustive instructions with the assistance of parent's instructions come up with positive results in children with ASD [25]. Olsson et al. proved that social skills group training is effective for improving social skill for children with autism but emphasized on the presence and the role of the parents in the process [27]. Another study suggested to involve not only parents but also school staff or people surrounding the child in the education program to have a better result for school going age children or adolescent with down syndrome, autism, and intellectual disability [28]. We can conclude that skill instruction, education program should be the effectiveness intervention for improving social ability for children with DD and parents, school staff and other people living around the children might follow the education program.

Borgi et al. showed that following a specific equine-assisted therapy, children with autism achieved a significant improvement not only in their motor abilities but also social skills. During equine training, children face new environment and challenges. That is favorable for a skill acquisition [20]. According to Kwon et al. as much as the exercise is high challenging as much are the possibilities to learn and acquire new skills during task-oriented training. Additionally, the exercise is continuous and suitable as much as the children can continue to learn and develop their problem resolving ability [45]. In this review, only one study conducted on children with autism used equine assisted therapy and showed a positive result. However, additional evidence is required to clearly demonstrate and affirm the effectiveness of equine assisted therapy in other type of DD children.

A randomized control study on children with autism ranged from 8 to10 years with various characteristics and provided auditory rhythmic stimulation during gait training for the experimental group was conducted by El Shemy and El-Sayed. The children have improved their gross motor skills, strength, balance auditory function and coordination after 3 months of training [22]. In another study, LaGasse statically demonstrated a positive effect of music therapy, but it supports additional evidence on the practice of music therapy group training for social skills in children with developmental delay [32].

A study by Maria A. Fragala-Pinkham tested the effects of aquatic therapy in children with autism and assumed that it conducts to an improvement of endurance and swimming skills but not difference from the baseline after 14 weeks of aquatic training [23]. Only one study examined the effectiveness of aquatic therapy on motor, cognition on children with DD and did not show an improvement. As there is a weak of evidence, we cannot conclude that aquatic therapy is not effectiveness for motor, social and cognitive ability in children with DD but there is a need for more future research on the topic.

Our study has several limitations. First, after applying the inclusion and exclusion criteria, only a restricted number of published articles examined the physical therapy interventions on motor, social and cognition in

children with DD were found and included in the present study. Second, there were no studies that clearly examined gender distinctions in children with down syndrome and autism. Specially in physical activity such as motor skill and fitness, gender differences may be essential as autism sex ratio is 3:1 and down syndrome also is more familiar in boys than girls [46,47]. Third, the current review also involved studies that did not performed a priori sample size calculations due to the type of populations recruitment in some studies. This could have introduced a bias in the effect of the interventions. Finally, there is insufficient long-term follow up for certifying the prolonged the safety and the effects. Future research should pay attention to these aspects to minimize the biases. Despite these limitations, our study focused on a particular age range (1~18) and included only randomized control trials except one pilot trail that had also been included.

5.Conclusion

The present systematic review investigated the effectiveness of current physical therapy interventions that aim to improve motor skills, social skills, and cognition on children with developmental delay. According to the results, among the several effective interventions, we noticed that dual task-orientated approaches such as motor training combined with video game or VR (Wii, Nintendo) and massage therapy which is done every day for at least 10min combined with conventional or other intervention yield positive benefits to improve motor skills in children with developmental delay such as autism and down syndrome. In addition, it was observed that education program and skill training program involving at least parents or care helper reported to be the most effective intervention for the improvement of social skill in children with deficit. More evidence is required but up to date, after analyzed the studies, computer-based cognitive training including a combination of visual and auditory assigned to train a large domain of cognitive ability is potentially effective for improving cognition ability on children with developmental delay. Except all the interventions mentioned in this review, aquatic therapy due to lack of evidence and studies on the topic is not considered as an effective intervention for improving motor, social and cognition on children with DD. Although, further investigations are needed to clarify his effectiveness. However, some question still remains such as the appropriate video game type or device type, duration, and frequency of those interventions.

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[Table 1] characteristics of the included studies

Author(s) (year)	Study design	Subject number	Age	Subjects	Interventions	Outcomes
Borgi, Marta, et al (2016)20	RCT	28	6-12	Autism	Equine-Assisted Therapy	Communication, Daily Living Skills, Socialization, and Motor Skills
Edwards, Jacqueline, et al. (2017)21	RCT	11	6-10	Autism, DD	Active video game(Xbox Kinect)	GrossMotor Development, perceived OC skills

El Shemy, S.A., El-Sayed, M.S. (2018)22	RCT	30	8-10	Autism	Rhythmic auditory stimulation	Fine manual control, manual coordination, body coordination, and strength and agility)
Maria A. Fragala-P (2011)23	Non-randomized control trial	12	6-12	Autism	Aquatic exercise program	Cognition, motor skill, cardiopulmonary endurance, mobility skill
Pan, Chien-Yu, et al. (2017)24	RCT	22	-	Autism	Physical activities	Motor skills, cognitive function
Ketcheson, L., Hauck, J. and Ulrich, D. (2017)25	RCT	20	4-6	Autism	Motor skill instruction	Motor skills, physical activities, socialization
Ferguson, G. D., et al. (2013)26	RCT	46	-	DCD	Dual task oriented (Neuromotor Task Training (NTT) and Nintendo Wii)	Motor performance, isometric strength, and cardiorespiratory fitness
Olsson, Nora Choque, et al. (2017)27	RCT	296	8-17	Autism	Social skills group training (KONTAKT)	Social skills
Oxelgren, Ulrika Wester, et al. (2019)28	Non-randomized control trial	60	6-18	Down syndrome, Autism	Education program for parents and school staff	Social, communication and daily activity skills
Lin, Hsiu-Ching, and Yee-Pay Wuang. (2012)29	RCT	22	-	Down syndrome	Treadmill, Virtual Reality	Motor skills, muscle strength, agility
Nazemzadegan, Gholamhosein, et al. (2016)30	RCT	16	-	Autism	Ball exercises	Adaptive Behavior

Reichow, Brian, et al. (2012)31	SR	219	-	Asperger's disorder, pervasive developmental disorder — (PDDNOS)	Early intensive behavioral intervention (EIBI)	Adaptive behavior, intelligence; social skills, and communication and language skills
LaGasse, A. Blythe. (2014)32	RCT	17	6-9	Autism	Music therapy	Social behavior& communication
Lu, Wei-Peng, et al. (2019)33	RCT	36	1-3	DD	Massage therapy	Motor (gross and fine motor), cognitive, language (comprehensive and expressive), social development
Hernandez-Reif, Maria, et al. (2006)34	RCT	21	-	Down syndrome	Massage therapy	Motor function, muscle tone
Siberski, James, et al. (2015)35	RCT	145	-	ID, DD	Computer-Based Cognitive Training	Cognition & intellectual ability
Lowe, Leah, Amy Gross McMillan, and Charlotte Yates. (2015)36	RCT	24	2-5	DD	Body weight supported treadmill training (BWSTT)	Gross motor skill & gait ability
Bonney, Emmanuel, Gillian Ferguson, and Bouwien Smits-Engelsman. (2017)37	RCT	43	13-16	DCD	VR(Nitendo Wii), & task-oriented functional training (TFT)	Muscular strength, aerobic endurance
Au, Mei K., et al. (2014)38	RCT	22	6-9	DCD	Core stability program & task-oriented motor training program	Motor skills
Silva, Louisa MT, et al. (2012)39	RCT	28	-	DD	Qigong massage	Motor & sensory skills

RCT: randomized control trial, DD: developmental delay, DCD: Developmental Coordination Disorder, ID: Intellectual Disability