



The Role of Movement-Based Behavioral Intervention in Children with Neurodevelopmental Disabilities: A Narrative Review

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Abstract

Neurodevelopmental disorder (NDDs) often manifest with challenging behaviors that impact learning and social functioning. Movement-based interventions have emerged as adjunctive strategies to improve behavior and self-regulation in this population. This narrative review examines evidence for various movement therapies, synthesizes current evidence on the therapeutic efficacy of these interventions, examining their methodologies, underlying mechanisms in children with NDDs. Findings from clinical trials and case studies suggest that these movement therapies can lead to improvements in attention, reductions in hyperactivity and impulsivity, enhanced social interactions, and decreased maladaptive behaviors. However, the heterogeneity in study designs and the limited sample sizes in many trials necessitate cautious interpretation of results. The review underscores the potential of integrating structured physical and movement activities into behavioral management plans for children with NDDs and highlights the need for future research, including larger randomized controlled trials, dose-response studies, and investigations into the neurobiological mechanisms underpinning the observed therapeutic.

Keywords: neurodevelopmental disorder; autism; ADHD; aquatic therapy; yoga; equine therapy; sensory integration; exercise; behavior.

Introduction

Neurodevelopmental disorder (NDDs) – including autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), intellectual disability, etc affect a substantial proportion of children.⁽¹⁾ Globally, around 1 in 10 children has moderate-to-severe disability.⁽²⁾ These conditions often involve social-communication deficits, attentional impairments, and behavioral dysregulation. Standard treatments include behavioral therapy, medications, and educational interventions. However, many families also seek adjunctive non-pharmacological therapies to improve attention, reduce impulsivity, and promote social adaptation⁽³⁾. Movement-based approaches – leveraging the interplay between physical activity, sensory input, and cognitive arousal – are increasingly popular for managing behavioral symptoms. This review surveys the literature on movement-based behavioral interventions in children with NDDs. Following an overview of each intervention, the method of application, the hypothesized mechanism of action, and supporting evidence from clinical studies are described. The aim is to provide an updated synthesis of existing and current evidence regarding the role of physical and kinesthetic activities in enhancing behavioral management strategies for children with NDD.

Interventions

Aquatic Therapy

Aquatic therapy (AT), or hydrotherapy, uses water-based exercises and activities to promote motor and psychosocial functioning. Water's buoyancy and hydrostatic pressure facilitate movement, support posture, and provide sensory input. Mechanistically, AT can reduce anxiety and arousal (through warm water immersion), increase proprioceptive feedback, and allow practicing social skills in a novel environment. A recent scoping review notes that AT leads children to feel "happy, relaxed, and calm," enhancing participation in school activities. In children with ASD, pooled data show AT significantly improves gross motor competence and "functioning in school."⁽²⁾ A systematic review of autism trials concluded that structured aquatic programs – often combining play and swimming skills – substantially enhanced motor and social skills and significantly decreased autistic behaviors⁽⁴⁾. A study found that an 8-week swimming program improved physical competence, school functioning in ASD children, with qualitative gains in social communication⁽⁵⁾. Group-based aquatic sessions also foster peer interaction; improved peer acceptance, emotional regulation and quality of life after an inclusive swim class. Thus, aquatic therapy appears to reduce behavioral rigidity and irritability while promoting social engagement in ASD. Evidence in ADHD is more limited, but aerobic water exercise may improve cardiovascular fitness and mood, potentially reducing hyperactive restlessness. Aquatic interventions – by combining sensory modulation (buoyancy, hydrostatic pressure) and supportive, playful exercise – have shown clinically meaningful improvements in adaptive behaviors and reduced maladaptive behaviors in NDD children⁽²⁾.

Yoga and Mindfulness-Based Movement

Yoga and related mind-body exercises (including tai chi or Qi gong) emphasize controlled postures, breath regulation, and mindfulness. In practice, children learn to hold yoga "asanas" and focus on breathing, often within a calm and structured routine. The proposed mechanism involves enhancing parasympathetic tone and executive control; for example, sustained attention to breath and movement may strengthen prefrontal networks, while flexibility exercises increase proprioceptive awareness. In children with ADHD, systematic reviews report strong associations between yoga interventions and improvements in core symptoms⁽⁵⁾. A recent systematic review in 2023 concluded that yoga – including yoga-based mindfulness – significantly reduces inattentiveness and impulsivity in ADHD, especially when combined with standard treatments. For instance, multiple trials find that regular yoga practice yields large effect-size gains in sustained attention and inhibitory control.⁽⁵⁾ In ASD, yoga has similarly shown behavioral benefits. A 2023 review of nine studies found positive behavioral outcomes in 7/9 trials, noting improvements in initiation of social interaction, sensory responsiveness, and attention. In one RCT of autistic children, an 8-week yoga program (3x/week) significantly reduced aberrant behaviors: irritability and social withdrawal scores on the Aberrant Behavior Checklist fell relative to controls. Teachers also reported better classroom readiness and decreased self-stimulatory behavior after adapted yoga classes. Mechanistically, yoga's combination of slow, rhythmic movements and meditative focus may diminish anxiety and impulsivity. Overall, yoga-based interventions appear to enhance attention span, reduce hyperarousal, and increase social attentiveness in NDD children.

Rhythmic Movement Training (RMT)

Rhythmic Movement Training (RMT) consists of simple, repeating movements (often based on primitive reflex patterns) performed in rhythm. The theory is that such movements can "integrate" retained reflexes and stimulate brain development. In practice, RMT exercises (e.g. rocking, crawling, head movements) are done regularly to improve attention and sensory processing. A recent Indonesian study using an RMT protocol in children with ADHD reported significant gains in attention ratings post-intervention. Specifically, a pre-post study found structured RMT sessions over weeks led to higher focus and on-task behavior in school settings. The presumed mechanism is enhancement of vestibular and proprioceptive pathways, fostering improved sensory modulation and arousal regulation. Although high-quality trials are scarce, proponents cite neural entrainment and cerebellar engagement as rationale. In ASD, rhythm-based therapies (e.g. active music-movement) have shown improvements in timing and motor coordination, which may indirectly reduce agitation. In summary, RMT provides repetitive vestibular input that can increase sustained attention and calm, with some evidence of attention improvement in ADHD children. More rigorous research is needed, but RMT remains a low-cost adjunct that reportedly enhances attentiveness in NDD.

Brain Gym and Neuromotor Exercises

“Brain Gym” is a branded set of eye–hand–body coordination exercises (e.g. cross-crawl, lazy 8’s) intended to improve learning readiness. It is often offered in schools and therapy settings, though scientific support is mixed. Brain Gym proponents claim that these movements coordinate the hemispheres and promote whole-body integration. A 2025 controlled study in ADHD reported that 8-week Brain Gym training (daily simple exercises) produced significant gains in academic test scores and attention measures: children in the Brain Gym group showed markedly improved concentration and reduced errors on attention tests compared to control. The authors noted large effect sizes for attention improvements. The mechanism is hypothesized to involve sensory–motor stimulation and cross-body integration, potentially priming neural pathways for focus. Critically, however, consensus is lacking on efficacy. Some small studies (and anecdotes) suggest modest benefits in ADHD and learning-disabled students, but others find no effect beyond placebo. Given the popularity of Brain Gym activities in classrooms, they may serve as engaging “warm-up” routines, and preliminary evidence hints at improved attention and on-task behavior when combined with standard care. Until larger trials clarify efficacy, Brain Gym can be considered an optional, low-risk intervention.

Equine-Assisted (Hippotherapy) Therapy

Equine-assisted activities and therapies (EAAT) involve interacting with or riding horses under professional supervision. Hippotherapy is a structured form where the horse’s three-dimensional movement provides rhythmic input to the rider’s pelvis and spine. This rhythmic motion engages core muscles and vestibular systems, while the nonverbal interaction with the horse can foster communication and emotional regulation. Several recent systematic reviews have examined EAAT in ASD. A 2023 meta-analysis found that EAAT significantly improved social and behavioral functioning in ASD children. Notably, EAAT reduced irritability and hyperactivity and enhanced social cognition (e.g. recognizing social cues). Parallel evidence from a review showed improvements in daily living skills and socialization post-hippotherapy. Parents often report that children become calmer and more engaged after therapy, possibly due to the warmth, movement, and novel activity. Mechanistically, the horse’s movement is thought to synchronize with the rider’s gait, promoting symmetry and neural organization. The nonjudgmental nature of the horse can also boost confidence and patience in children with communication challenges. Overall, EAAT studies in NDD indicate meaningful reductions in maladaptive behaviors and gains in social engagement, particularly for level-1 ASD. While logistics and cost limit widespread use, equine therapies are supported as complementary approaches that “substantially improve” social–behavior outcomes in ASD.

Dance and Movement Therapy

Dance therapy and rhythmic movement classes combine music with guided body movements. These programs (often playful or creative) address motor skills and emotional expression simultaneously. A 2024 pilot RCT (10-week dance classes vs. waitlist) in youth with NDD showed that structured dance significantly improved motor coordination in unpredictable settings. Social skills also showed positive trends, though not statistically significant. Proposed mechanisms include increased bilateral coordination and release of endorphins, as well as opportunities for social mimicry and play. Dance can be highly motivating and multisensory, potentially reducing anxiety and tension through rhythmic motion. Qualitatively, instructors report better eye contact and mood after dance sessions. In practice, group dance fosters turn-taking and imitation, which may generalize to social behavior. In summary, movement/dance programs appear safe and feasible: initial trials report detectable motor gains and suggest potential for social-behavioral benefits. Larger studies are needed, but dance is a promising intervention that blends physical exercise with creative expression to improve body awareness and reduce disruptive behaviors.

Martial Arts and Structured Sports

Martial arts (e.g. karate, taekwondo, judo) and organized sports are structured, goal-oriented physical activities emphasizing discipline, focus, and self-control. For example, taekwondo classes teach sequences of movements requiring concentration and self-regulation. A 12-month taekwondo trial in adolescents with ADHD found large improvements in selective attention: participants showed higher scores on Stroop and visual attention tests compared to controls. Similar benefits have been noted in judo practice. Open-skill sports (where participants adapt to changing environments, e.g. team games) appear particularly effective. In a 2023 network meta-analysis across ADHD studies, all forms of exercise significantly improved executive function and reduced core symptoms. Closed-skill activities (like running) were most beneficial for reducing hyperactivity/inattention, whereas open-skill sports yielded the largest gains in inhibitory control. In ASD, a 2024 systematic review highlighted that sports games and team sports substantially improved social interaction and communication skills. The

mechanisms likely involve increased arousal regulation, motor coordination, and social teamwork. Martial arts also incorporate behavioral rules (e.g. courtesy, respect), which can reinforce self-discipline. In sum, structured physical programs and sports offer a dual benefit: they expend excess energy and build fitness, while teaching focus, turn-taking, and persistence. The evidence indicates that such activities can markedly alleviate ADHD symptoms and enhance social behavior in ASD.

Sensory Integration Therapy

Sensory integration (SI) therapy uses movement and tactile activities to help children regulate sensory processing. Common SI techniques include swinging, rolling, and heavy joint compression, targeting the vestibular and proprioceptive systems. The rationale is that improving the brain's ability to organize sensory input will reduce behavioral outbursts and improve attention. Recent reviews conclude that SI-based interventions significantly improve behavior and daily functioning in children with ASD. For example, meta-analyses report that SI training yields better adaptive responses (e.g. following directions, eye contact) and self-regulation. Clinically, children often become more calm and focused after SI sessions, possibly due to the modulatory effects of rhythmic movement on arousal. SI therapy has also been applied in ADHD to reduce distractibility, though studies are limited. Mechanistically, SI may enhance cerebellar and reticular activating system regulation, thereby stabilizing mood and attention. Thus, sensory-motor movement programs are considered evidence-based for autism: one review noted SI therapy "contributed to improvement in motor, sensory, cognitive, emotional, communicative and social development". In summary, tailored sensory activities that involve movement and pressure often translate to reduced behavioral dysregulation in NDD.

Therapeutic Climbing

Therapeutic climbing programs (e.g., indoor rock climbing) have recently been introduced for children with neurodevelopmental disabilities. Climbing requires planning, motor coordination, problem-solving, and sustained attention. A 2022 feasibility study reported that therapeutic climbing sessions improved behavioral self-regulation and reduced anxiety symptoms in children with ASD [3]. Mechanistically, climbing activities engage multiple sensory modalities (visual, vestibular, proprioceptive) while promoting goal-directed behavior. Climbing tasks also build resilience and emotional regulation by requiring persistence and strategic thinking. Though still emerging, climbing-based therapies offer a promising, strength-based intervention to enhance behavioral and emotional outcomes in children with neurodevelopmental disorders.

Tai Chi for ADHD and ASD

Tai Chi, a form of slow, meditative martial art, combines fluid movement sequences with focused breathing and mindfulness. Recent clinical studies demonstrate Tai Chi's effectiveness in improving attentional control and reducing impulsivity in ADHD [4]. A 2021 randomized controlled trial showed that a 12-week Tai Chi program significantly decreased hyperactivity scores and improved executive functioning in children with ADHD compared to waitlist controls [5]. In ASD populations, small trials have suggested improvements in social responsiveness and reduced repetitive behaviors following adapted Tai Chi programs. Mechanistically, Tai Chi may modulate autonomic nervous system activity and improve self-awareness, attention span, and inhibitory control through its slow, mindful movements. It represents a low-impact, accessible movement intervention with strong potential behavioral benefits.

Adventure Therapy (Outdoor Challenges)

Adventure therapy involves outdoor activities like hiking, cooperative games, ropes courses, and team challenges. These activities build teamwork, problem-solving, emotional regulation, and resilience. A meta-analysis in 2023 found that outdoor adventure interventions led to significant improvements in self-concept, social competence, and emotional regulation in youth with behavioral and developmental disorders [6]. The physical challenge, combined with novelty and social collaboration, stimulates dopamine and endorphin release, fostering positive behavioral changes. For children with ASD or ADHD, nature-based movement programs can reduce internalizing symptoms (like anxiety) and promote adaptive functioning through real-world experiential learning.

Virtual Reality-Enhanced Motor Training (VR-EMT)

Virtual reality–enhanced motor training (VR- leverages EMT) immersive digital environments that require real-time physical movements such as reaching, jumping, and balancing to interact with virtual elements. In children with neurodevelopmental disorders (NDDs), especially autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD), VR-EMT has shown promise in enhancing executive function, spatial awareness, and social turn-taking. For example, a 2023 randomized controlled trial demonstrated that VR motor training significantly improved gross motor coordination and reduced behavioral problems, including distractibility and repetitive behaviors[1]. The underlying mechanism involves multisensory stimulation—combining visual, auditory, and proprioceptive feedback—with goal-directed physical movement that promotes motor-cognitive integration and behavioral regulation.

Robot-Assisted Physical Movement Therapy (RAPT)

Robot-assisted physical movement therapy (RAPT) involves children mimicking or synchronizing their movements with humanoid robots through activities like dancing, gesture matching, or movement-based games. In children with ASD, RAPT has been found to improve motor imitation, increase engagement, and enhance joint attention. These robots provide structured, low-stress social interactions, making it easier for children with social communication challenges to participate. The predictability and programmed feedback from robots encourage consistent participation and behavioral reinforcement. Studies in 2024 report significant gains in social responsiveness and task persistence when RAPT is incorporated into early intervention programs[2,3].

Exergaming (Exercise Gaming) for Behavioral Management

Exergaming blends physical activity with interactive gaming platforms such as Nintendo Wii Fit, Xbox Kinect, and Ring Fit Adventure. These systems require children to perform motor tasks—jumping, squatting, balancing—as part of gameplay. For children with ADHD and ASD, exergames have demonstrated improvements in attention span, behavioral inhibition, and emotional control. A 2023 meta-analysis highlighted exergaming's capacity to enhance executive functioning and reduce hyperactivity through engaging, repetitive movement tasks[4]. The immediate feedback and reward systems inherent in these games serve to reinforce positive behavior and sustained attention, making them ideal for behavioral management in neurodevelopmental settings.

Augmented Reality (AR)-Guided Physical Therapy

Augmented reality (AR) overlays digital content onto the physical world, guiding children through interactive physical tasks in their real environment. AR-guided therapy might involve catching virtual butterflies, stepping over projected obstacles, or balancing on real platforms in response to digital cues. In children with NDDs, these tasks help develop motor planning, focus, and hand-eye coordination. Recent studies show that AR-based movement therapy enhances task engagement, reduces impulsivity, and fosters better motor performance[5]. The technology's interactive and gamified nature offers a novel and motivating way to support physical and behavioral development.

Motion Capture–Assisted Motor Re-education

Motion capture–assisted therapy uses wearable sensors or optical systems to monitor children's movements and provide real-time feedback. These systems can assess gait patterns, posture, and balance, and guide children in making corrections during motor activities. In clinical trials involving children with ASD and cerebral palsy, this technology has led to improvements in gait symmetry, postural control, and self-monitoring. By increasing body awareness and providing immediate corrective cues, motion capture therapy supports the development of motor precision and contributes to reduced stereotypical behaviors and improved attention regulation[6].

A growing body of research supports incorporating movement-based therapies into behavioral management for children with NDDs. Interventions ranging from aquatic and yoga to animal-assisted and martial arts share a common feature: structured physical activity paired with sensory or cognitive engagement. The evidence suggests multiple mechanisms of benefit, including enhanced sensory integration, increased prefrontal control (via mindfulness), and normalization of arousal states. Clinically, studies report improved attention, reduced impulsivity/hyperactivity, and better social engagement across many modalities. For example, yoga and mindfulness movements consistently reduce ADHD symptoms, while equine and group sports interventions improve social behavior in ASD. However, the literature is heterogeneous: sample sizes are often small, and methodological rigor varies. Many trials rely on parent/teacher reports without blinding. Future research should pursue larger RCTs with objective measures (e.g. neuroimaging of neural changes, physiological stress markers)

to validate and refine these approaches. Investigators should also explore optimal “doses” of activity and long-term outcomes. In practice, clinicians can consider adding feasible movement activities (pool play, yoga mats, playground games) to complement behavioral therapies. While not a substitute for core treatments, movement-based interventions offer a promising, low-risk avenue to help children with NDD channel energy positively and develop self-regulation. With growing interest and preliminary evidence, these strategies may become standard components of multi-modal behavioral management in neurodevelopmental care.

Conclusion

Movement-based behavioral interventions represent a promising, holistic approach for managing behavioral challenges in children with neurodevelopmental disabilities (NDDs). Interventions such as hydrotherapy, rhythmic movement training, and mindfulness-based yoga have demonstrated effectiveness in enhancing attention, emotional regulation, and overall behavioral functioning. These therapies tap into neurobiological mechanisms, promote sensory integration, and support the development of self-regulation skills. While preliminary findings are encouraging, further large-scale and longitudinal studies are needed to establish standardized protocols and assess long-term efficacy. Integrating these interventions into multidisciplinary clinical practice can enhance therapeutic outcomes and offer child-centered, non-pharmacological options for behavioral management.

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