Is Autism a Movement Disorder?
Consideration of Motor Deficits and Motor Interventions for Autism Spectrum Disorder

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Purpose: Create a dialogue about the need for a broader theoretical approach to ASD

Objectives:
- Discuss diverse paradigms regarding ASD
- Explore motor impairments seen with ASD
- Implications of motor impairments for diagnosis and treatment of ASD
What is Autism?

- A developmental disorder?
  - Symptoms begin early in childhood (before are 3yrs)

- A disorder of social interaction & communication?

- A psychological disorder?

- A spectrum disorder?

- A genetic disorder?

- A sensory disorder?

- Movement disorder?
Diagnostic Criteria: DSM-IV

Qualitative impairment in social interaction:
- Impairment of nonverbal behaviors (ex: gaze, facial expression, body posture, gestures)
- Failure to develop peer relationships
- Lack of spontaneous seeking to share enjoyment, interests, or achievement with others
- Lack of social or emotional reciprocity

Qualitative impairment in communication:
- Delay in or total lack development of spoken language
- If speech present, marked impairment in initiation and maintenance of conversation with others
- Stereotyped or repetitive use of language or idiosyncratic language
- Lack of varied, spontaneous make-believe play or social imitative play

Restricted and stereotyped pattern of behaviors, interests, or activities:
- Preoccupation with 1+ stereotyped and restricted pattern of interest that is abnormal in intensity or focus
- Inflexible adherence to specific, nonfunctional, routines or rituals
- Stereotyped and repetitive motor mannerisms
- Persistent preoccupation with parts of objects
Motor Impairments
Purposed Motor Impairments...

- Flexion Dystonia
- Odd Hand & Body Postures
- Abnormal Muscle Tone
- Grinding of Teeth
- Grimacing
- Absence of Facial Expression and Gestures
- Lack of Eye Contact
- Motor Ticks & Flapping
- Choreiform & Athetoid Movements (involuntary writhing or dance-like movements)
- Dyskinesia (reduction in quantity of movement)
- Motor Stereotypes
- Vocal & Verbal Tics
- Loss of Associated Movements (ex: lack of arm swing with gait)
- Impaired Postural Stability
- Impaired Motor Learning
- Slowness of Spontaneous Movements
- Motor Planning Difficulties (dyspraxia)
- Repetitious Spontaneous Movements
- Gait Disturbances (decreased speed, shuffling, toe walking, increased variability of step length, increased lateral)
- Atypical Speech Melody and Volume Regulation
- Catatonic Excitement
- Hyperkinesia (constant movement)
- Freezing
- Bradykinesia (slow movement)
- Impaired Imitation
- Lack of Initiation
- Motor Coordination Deficit
- Delayed Attainment of Motor Milestones
- Decreased physical activity
- Balance Dysfunction
Prevalence of Motor Symptoms

Blanket statements that individuals with ASD show deficits in communication, language, and flexibility of interests in the face of “normal motor development” are common, yet the following findings indicate otherwise...

- Motor impairments in 50% of children with Asperger’s and 67% in children with Autism (1995)\(^\text{14}\)
- 60% of children with ASD qualify for early intervention based on motor performance alone (25% delay). No children with ASD (n=56, ages 21-41 months) were classified as having normal/average motor skills on both assessments when tested using the Bayley Scales of Infant Development and the Peabody Developmental Motor Scales (2007)\(^\text{24}\)
- 79% of individuals on the spectrum have motor impairments and at least 10% are borderline (2008)\(^\text{7}\)
- Motor coordination deficits are pervasive (systematic review, 2010)\(^\text{6}\)
Developmental Coordination Disorder: A marked impairment in the coordination of the movement of voluntary muscles that has a significant negative impact on performance of ADLs including dressing, feeding, bike riding, and academics (poor handwriting)

Motor Coordination Impairment in ASD

- Motor coordination impairments are pervasive across diagnoses on the spectrum, not only in individuals on the spectrum who have intellectual impairments
- Motor coordination impairments seen in all age groups
- Motor coordination impairments should be considered a cardinal feature of ASD
Motor Planning/Praxis \(^1,8,15,26,30\)

- Gesturing impairments include gesturing to command, with imitation, and gestured tool use, suggesting a generalized impairment of praxis rather than a specific impairment of imitation \(^{15}\)

- Modulation of automatic locomotor patterns is not performed as accurately in individuals with ASD \(^{30}\)

- Individuals with ASD show greater than average reliance on proprioception for self-generated movements \(^8\)
Gait\textsuperscript{10,30}

• Reduced mean step length, increased irregularity in gait, and increased lateral oscillation in gait were noted\textsuperscript{30}

• Individuals with high-functioning ASD and Asperger’s syndromes show\textsuperscript{10}
  • increased difficulty with balance and gait
  • difficulty with negotiation of the physical environment
  • greater overflow of movements during stressed gait maneuvers (heel walking, toe walking, tandem gait…)
  • decreased gait speed

• Individuals with ASD who are on stimulant medication have increased gait abnormalities\textsuperscript{10}
  • Could indicate that gait abnormalities are more severe in individuals on the spectrum who also have hyperactivity and/or impulsivity
Balance\textsuperscript{10,24}

- Children with high-functioning Autism and Asperger’s syndrome score significantly lower on balance tasks (ex: sequential hopping, single leg stance) than same-aged, IQ-matched peers\textsuperscript{10}

- Young children with ASD (ages 21-41 months) show below average performance in motor domains of developmental scales (Bayley and PDMS)\textsuperscript{24}
  - Preschool motor skills require more balance and motor planning than earlier motor skills like walking and crawling
Consequences of Motor Impairments
Physical Activity$^{18,19,20}$

- Children with ASD engage in less physical activity$^{18}$
  - Children with ASD engaged in 27.8min compared to 35.04min of moderate-to-vigorous physical activity at recess
  - Early primary children with ASD show relatively lower levels of physical activity compared to their peers than late primary children with ASD
  - Children with ASD are less likely to participate in afterschool activities that promote physical activity

- Determinants of physical activity$^{20}$
  - Youth age (physical activity decrease in adolescence)
  - Pursuit of sedentary activities (interest in sedentary activities)
  - Parent physical activity and support were not found too be as important as with peer without ASD

- Physical activity preferences$^{19}$
  - Even when presented with the same opportunities for physical activity as other school children (ex: PE), children with ASD are less active
  - Elementary school aged children with ASD are more active than older school-aged children with ASD because they engaged in individual play with playground equipment at recess
  - Children with ASD generally prefer individual physical activity options (ex: swimming, running, martial arts) over group activities
Predictive relationship between motor skills in children with ASD and other domains such as vocational and leisure skills 5 years later\textsuperscript{22}
Behavioral

- Symptoms improve with physical activity\textsuperscript{12}
  - Most common behavior improvement associated with increased physical activity was a decrease in stereotypy or self-stimulatory behavior
  - Other positive findings:
    - decreased self-injury
    - decreased aggression
    - decreased classroom disruptive behavior
    - increased physical fitness
    - improved academics (increased time spent on academic tasks, increased response to academic demands/questions, increased accuracy/correctness)
    - increased social development
Motor impairments in individuals with ASD in preschool years may impact social development and play skills development (further research needed)\textsuperscript{24}

Coordinated mobility and hand manipulation skills are critical to quality of life\textsuperscript{27}

In children without ASD, early (preschool) gross motor stability predicts school-age anxiety and depression\textsuperscript{23}

Does this apply to children with ASD as well?
Movement Disorders
What is a Movement Disorder?

- A movement disorder: neurological condition that affects the quality, speed, frequency, or ease of movement.
  - Atypical movement is not primarily the result of weakness, abnormal muscle tone, or decreased flexibility/range of motion

- Examples: ataxia, Huntington’s Disease (chronic progressive chorea), Parkinson’s disease, Tourette’s syndrome, tremor, restless leg syndrome
Brain Structure
Diffuse Changes

- Broad areas of disarranged neuronal organization and cortical connectivity
  - Abnormal transmission in serotonergic, dopaminergic, and GABAergic systems
  - Increased reliance on alternative motor pathways
  - Reduced corpus callosum volume and increased total brain and cerebellar volumes
  - Abnormal movement related potentials in the basal ganglia, thalamus, and supplementary motor areas
Cerebellum

- 95% of autopsies show cerebellar malformation$^2$

- Diffuse decrease in Purkinji cell number in vermis and hemispheres of cerebellum
Overall basal ganglia volume is similar to general population, but the shape is different\textsuperscript{25}
- Right caudate nucleus, putamen, and globus pallidus show irregularities in boys with ASD
- Studies showed that irregularities in these structures correspond with impairments of basic motor control, praxis, reciprocal social interaction, & communication skills in boys with ASD
- Inefficient connections between basal ganglia and cerebral cortex

Great reliance on proprioception for internal models → greater impairment in generalized motor function, social interaction, and imitation/praxis\textsuperscript{8}
- Increased association between self-generated motor commands and proprioception
- Increased dependence on cortical regions that use intrinsic coordinates to guide movement (M1 and somatosensory cortex); decreased reliance of systems using extrinsic coordinates (premotor and posterior parietal)
Onset of Brain Changes

Brain changes associates with ASD likely have prenatal-origin

- Olivary climbing fibers to the Purkinji cells are preserved in the face of reduced Purkinji fibers--> suggest onset before 28-30weeks gestation\(^\text{19}\)
- Lack of glial hyperplasia in face of reduced number of Purkinji cells--> sign that abnormality occurs early in development\(^\text{19}\)
- No adult lesion produces autistic symptoms\(^\text{16}\)
A Change in Perspective
Interpretation of Symptoms

- Impaired/decreased navigation of environment
  - Behavioral explanation: Individual is unmotivated or disinterested in surroundings
  - Motor-based explanation: Individual is struggling to initiate movements that would allow for exploration and development of interests
  - Would you say an individual with Parkinson’s disease is unmotivated to explore their environment?

- Repetitive movements
  - Behavioral explanation: Behaviors are volitional, individual is *seeking* stimulation
  - Motor-based explanation: Individual has an impairment of motor selection and motor planning, individual has difficulty modifying an action sequence
  - Would you say someone with Huntington’s disease has self-stimulatory behaviors? How about someone with a cerebellar tumor?

- Lack of reciprocal interaction/play
  - Behavioral explanation: Child has anti-social behavior
  - Motor-based explanation: An over-reliance on internal models of movement (proprioception) makes it difficult for the child to react affectively to interaction attempts and to learn early social behaviors which are largely movement-based

- Absence of facial expression
  - Behavioral explanation: Flat affect, anti-social behavior
  - Motor-based explanation: Individual struggles to control subtle movements of facial muscles
  - Would you consider flat affect to be an anti-social behavior in someone with Parkinson’s disease?
A Mixed Paradigm
Mixed Paradigm

- Implications of having a movement disorder during development?
- How are social and motor development inter-related?
- What would a conceptual picture of ASD look like?
Implications for Clinical Practice
Interdisciplinary Team

Who is on the team?
- Should there be a motor specialist?
Diagnosis

- Should we screen for motor impairments in diagnosing ASD?

- Could we diagnose ASD earlier?
  - If brain changes are occurring in gestation, are there earlier symptoms of these changes? Does it matter?
  - Research looking at early motor impairments in individuals later diagnosed has not yet found any early motor signs that predict ASD\(^\text{17}\)
Interventions
Interventions that Target Motor Impairments

- Hippotherapy/Horseback riding: provides high repetition challenges to postural control\(^2\)
- Body Awareness Activities: Increase awareness of where body is to decrease reliance on movement for this information\(^{26}\)
  - Ex: tactile inputs (brushing, buzzing), deep massage, “heavy work”
- Combined practice of cognitive and motor tasks to improve dual-tasking\(^{26}\)
  - ex: Jumping rope while reciting state capitals, basketball drills while counting
- Cognitive strategies to improve initiation of movement and motor planning
  - ex: Teach rhymes or songs that correspond to movement sequences for complex/multi-segmental movements (ex: throwing a ball)
Interventions to Increase Physical Activity

- Use visual supports (picture exchange, picture schedule, task cards, visual warning devices + boundaries) to improve participation in PE class\textsuperscript{5,28}
- Use ear plugs in gym to reduce noise\textsuperscript{28}
- Warm up to a melody to improve fluidity of movement\textsuperscript{28}
- Gradually reduce prompting from physical guidance --> modeling --> picture --> verbal --> gesture\textsuperscript{12,28}
- Encourage self-monitoring of participation\textsuperscript{12}
- If goal is physical activity, choose individual, receptive activities like running, swimming, or table tennis rather than team sports
Interventions to Reduce Impact of Motor Impairments

- Use of assistive mobility devices (ex: scooter boards) early on to promote exploration
- Assistive devices to improve safety and balance (ex: cane, walker)
- Devices to improve gait speed or fluidity of movement (ex: metronome or music)
- Impact of motor therapies on both motor symptoms and core characteristic of ASD
Future Research

- Do we see motor signs earlier than other signs?
- Could there be pharmaceutical interventions similar to those used in PD?
- Does motor intervention early on effect functional independence, communication, emotional symptoms?