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NEURODIVERGENT VISUOMOTOR DEVELOPMENT

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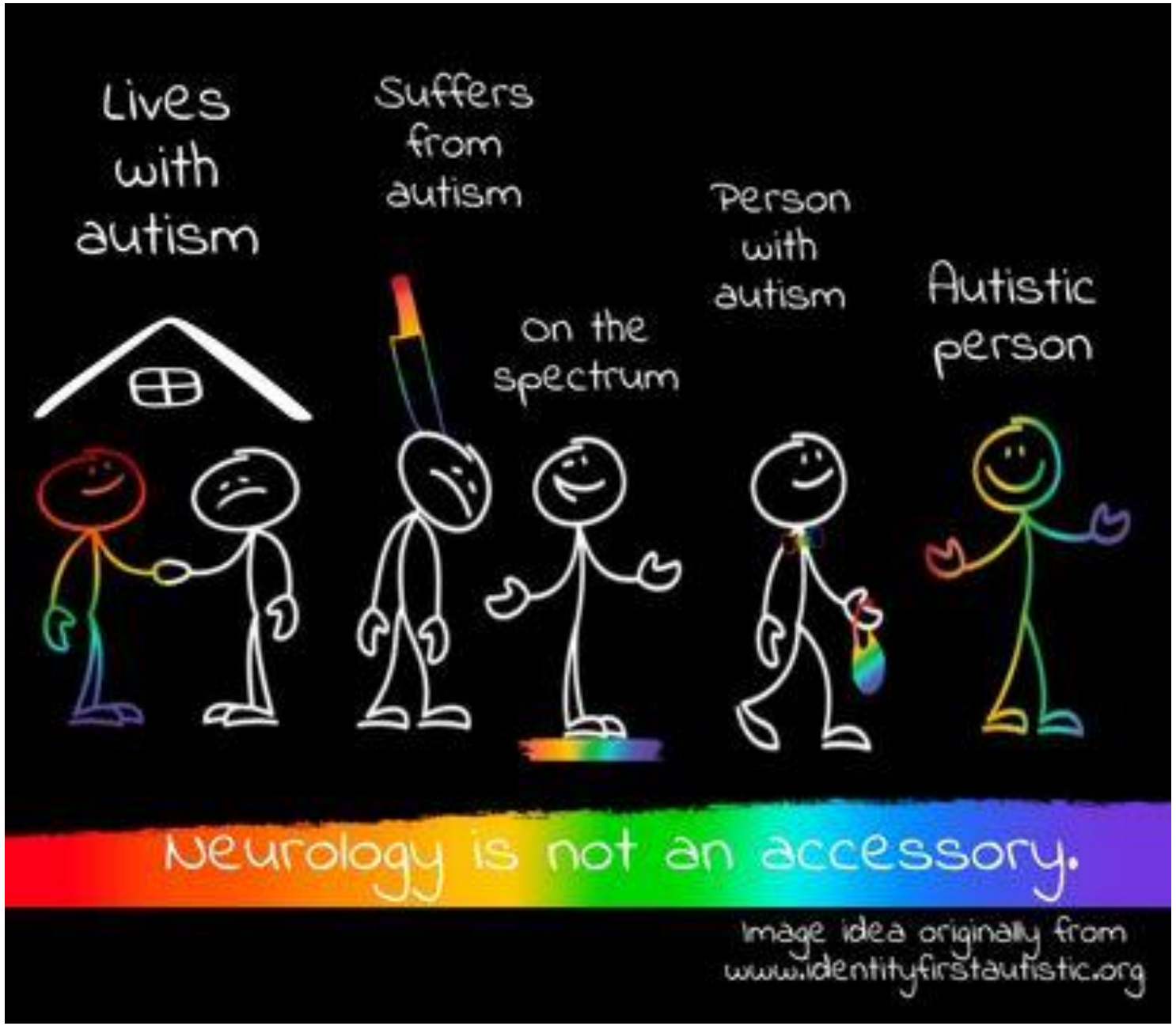

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We use identity-first language when talking about neurodivergence.

We also respect individual language preferences!

For more information, visit:

askautisticadults.org/autistic-vs-with-autism%3F
or
www.identityfirstautistic.org

and read these excellent papers:

Bottema-Beutel et al. (2020) *Autism in Adulthood*

Botha et al. (2021) *Journal of Autism & Developmental Disorders*

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Translational

Basic Mechanisms → Clinical Applications → Community Impact

Multidisciplinary

Biomechanics	Psychology	Public Health
Computer Science	Physical Therapy	Public Agencies
Neuroscience	Occupational Therapy	School Systems
Kinesiology	Medicine	Cultural Institutions

Lifespan

What is neurodivergence?

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Framework of *inclusion*, not a construct used for differential diagnosis or exclusion.

This means there's not a "defined list", it is meant to encompass anyone whose brain works differently from typical, whether that difference is inherent or acquired.

That said…

What is neurodivergence?

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…conditions common among those who describe themselves as neurodivergent include (but aren't limited to):

- Autism
- Attention-deficit hyperactivity disorder (ADHD)
- Developmental coordination disorder (DCD) or dyspraxia
- Down syndrome
- Dyscalculia (difficulty with math)
- Dysgraphia (difficulty with writing)
- Dyslexia (difficulty with reading)
- Intellectual disabilities
- Prader-Willi syndrome
- Sensory processing disorders
- Social anxiety (a specific type of anxiety disorder)
- Tourette syndrome
- Williams syndrome

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Neurodivergent motor features

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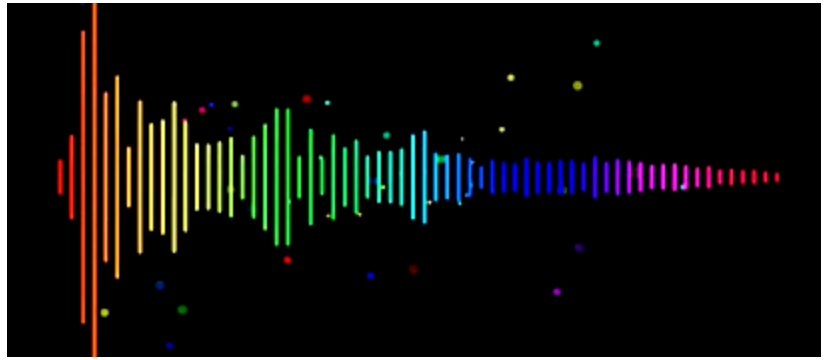
Broad spectrum of ability & disability in neurodivergence

- Delays in meeting **motor milestones**
- **Hypotonia** (laxity/floppiness) or **hypertonia** (ridigity/spasticity)
- Differences in **motor planning or learning**, especially in new situations
- Differences in **coordination** of body segments/limbs
- **Toe walking** or other differences in **gait**
- Differences in **visual-spatial reasoning**
- Differences in **proprioception**
- Problems with **balance** and **postural control**
- Increased risk of **trips, slips, stumbles, collisions, and falls**



Why does motor matter?

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Visuomotor skills are necessary building blocks…

- In infancy for **language & cognition** (Smith et al., 2018)
- In childhood for **school readiness & handwriting** (Fears & Lockman, 2018; Cameron et al., 2016)
- In adolescence & adulthood for **social interaction** (Vogt & Thomaschke, 2007) **self-care/living skills** (Land & Hayhoe, 2001), & **driving** (Cunningham et al., 2001)

…but motor skills don't happen in a vaccum!

Key systems for movement…

Vision – how the eye moves, how we process and filter visual input

Do you stop moving when you sneeze? Do you have difficulty judging distances or sizes of things? Do you get distracted by “visual noise”?

Proprioception – our sense of where our body is and how it moves

Do you ever run into walls when turning a corner? Hit your hip on the same cabinet? Pinch your finger in a drawer when closing it? Step onto a different surface and feel unsteady?

Vestibulation – our sense of equilibrium and motion

Do you feel dizzy or nauseated when riding in a car or turning your head rapidly?

…and don’t forget nociception, interoception, olfaction, audition, and cognition!

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Postural control activity

You can remain seated, or stand.

Everything is an "if you can"…try things to your tolerance/ability ☺

- First, keep both feet on the floor or on your footrest(s)…
  - Put your hands down to your sides or in your lap…try not to use your arms.
  - Notice your body – how much is it moving/swaying?
  - How hard to you have to work to stay still? What strategies are you using?
- Now, try closing your eyes or lifting one foot…
  - Notice your body again – how much is it moving/swaying now?
  - Try gently shaking your head, and check in with your body again…

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Lifespan motor problems common in neurodivergence

Infancy & Early Childhood	Middle & Late Childhood	Adolescence & Young Adulthood	Adulthood & Aging

Motor Problems & Daily Living

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Classrooms are not accessible (inflexible seating, standing podiums, narrow pathways).

I have trouble coordinating my fingers so learning to play an instrument is hopeless.

I have difficulty navigating steps and I can't live in places with ice or harsh winters because I fall on slippery surfaces.

I'm able to make my body work on some days or in some contexts, but not always.

There are so many barriers to furniture/space accommodations…it would be nice to have multiple chair options or more work from home flexibility, but it requires too much effort, so eventually you give up.

I've tried yoga and jogging for exercise, but any type of physical activity is immediately exhausting.

<u>Learning about proprioception and interoception has been empowering.</u>

U-M MVD Lab Community Advisory Team & other community members

Identifying Motor Problems

Autism

"Deficits in social communication & social interaction"

- Includes social use of gaze, but not other problems with visual attention

"Restricted, repetitive patterns of behavior or interests"

- Includes stereotyped motor behaviors, but not specifically motor coordination problems or oculomotor features

DCD and ADHD can be diagnosed as co-occurring with autism (& other conditions)!

IMPACT: Motor problems in autism are overlooked or left unaddressed as core symptoms are prioritized.

Motor Difficulties in Autism

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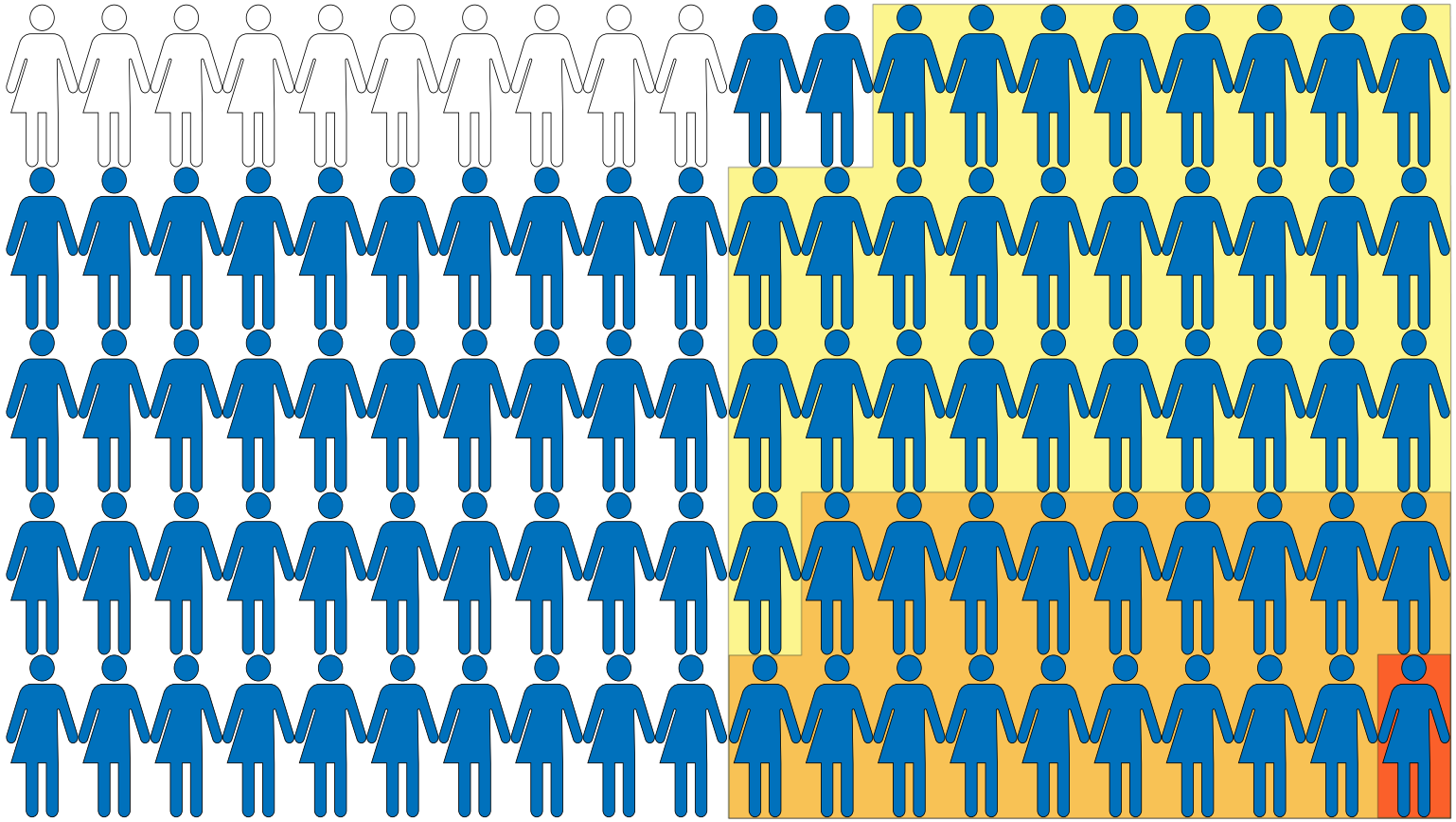
90% have significant motor differences that can cause problems with mobility, safety, and comfort (Miller et al., 2021)

Diagnosis & intervention is limited (Zablotsky et al., 2015)

- 48% receive OT
- 19% receive PT
- Only 1% receive a motor-specific diagnosis

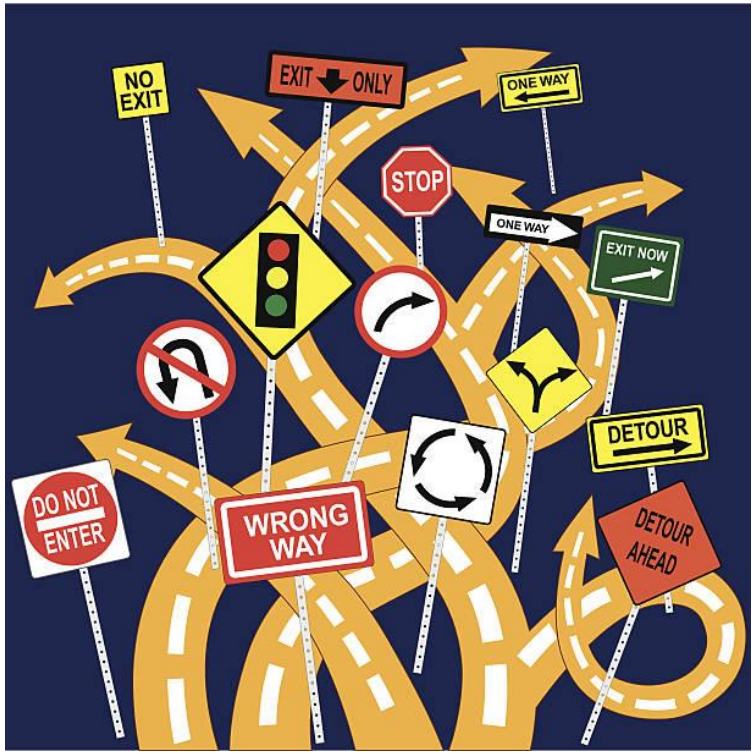


What's the process?

Striking lack of uniformity in how & which families access motor assessment and accommodations or interventions across different neurodivergent communities.

This is particularly evident when comparing access to support for motor versus behavioral or social-communication needs.

"Luck of the draw" whether you enter the care pipeline through a service that regularly assesses motor (e.g., neurology) or not (e.g., psychology).



Real-world application

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Atypical visual and motor control can be **identified early**…

- Visual and motor problems are detectable earlier than core symptoms
- May be identified by caregivers and reported to clinicians/teachers

…but not usually prioritized for intervention (McLeod et al., 2017)

- Lack of feasible, evidence-based interventions validated for use in populations like autism and ADHD that are not typically thought of as motor conditions
- Critical for activities of daily living, communication, & functional ability (Nebel et al., 2016; Georgopoulos & Grillner, 1989)

IMPACT: Unaddressed motor problems can limit quality of life and ability, and increase risk of falls/injury across the lifespan.

Consequences of Ignoring Motor Problems

DCD Twitter Motor Themes

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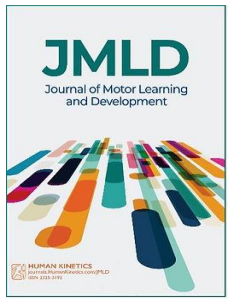
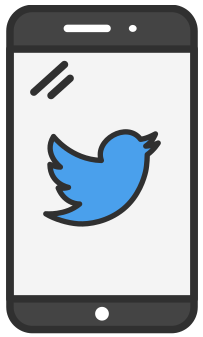
Theme	Paraphrased Examples
General Motor Skills	I find dyspraxia hard to deal with all the time. It impacts every aspect of my life. Completing tasks can be overwhelming and takes time.
Coordination	I hurt myself making toast, fell out of the chair, hit the table, and scraped my foot. I have lots of bruises on my legs from bumping things.
Fine Motor Skills	Automated steering in video games would be helpful – dyspraxia makes it hard to keep the car on the road. I couldn't use adult scissors until I was a teenager.



#DCD/Dyspraxia in Real Life: Twitter Users' Unprompted Expression of Experiences With Motor Differences

Priscila M. Tamplain,[1] Nicholas E. Fears,[2,3] Promise Robinson,[1] Riya Chatterjee,[2] Gavin Lichtenberg,[2] and Haylie L. Miller[2]



#Dyspraxic
#Dyspraxia
#DCD

Autistic Twitter Motor Themes

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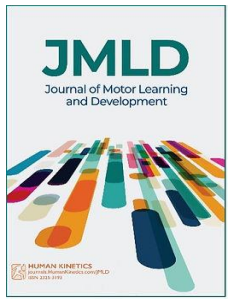
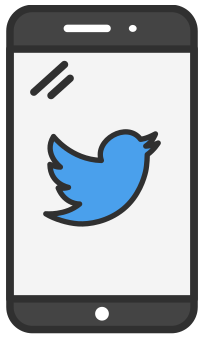
Theme	Paraphrased Examples
Manual Dexterity	Typing messages can be hard because my fingers won't press the right button or will keep pressing a button
Lower Extremity Movements	People have told me I walk differently, but I haven't noticed or know how that can be true
Oral Motor Skills	I have trouble eating, I choke on things like spit and food and I tend to bite my lips while eating.



Identity and Discourse Among #ActuallyAutistic Twitter Users With Motor Differences

Riya Chatterjee,[1] Nicholas E. Fears,[1,2] Gavin Lichtenberg,[1] Priscila M. Tamplain,[3] and Haylie L. Miller[1]



Co-occurring DCD…?

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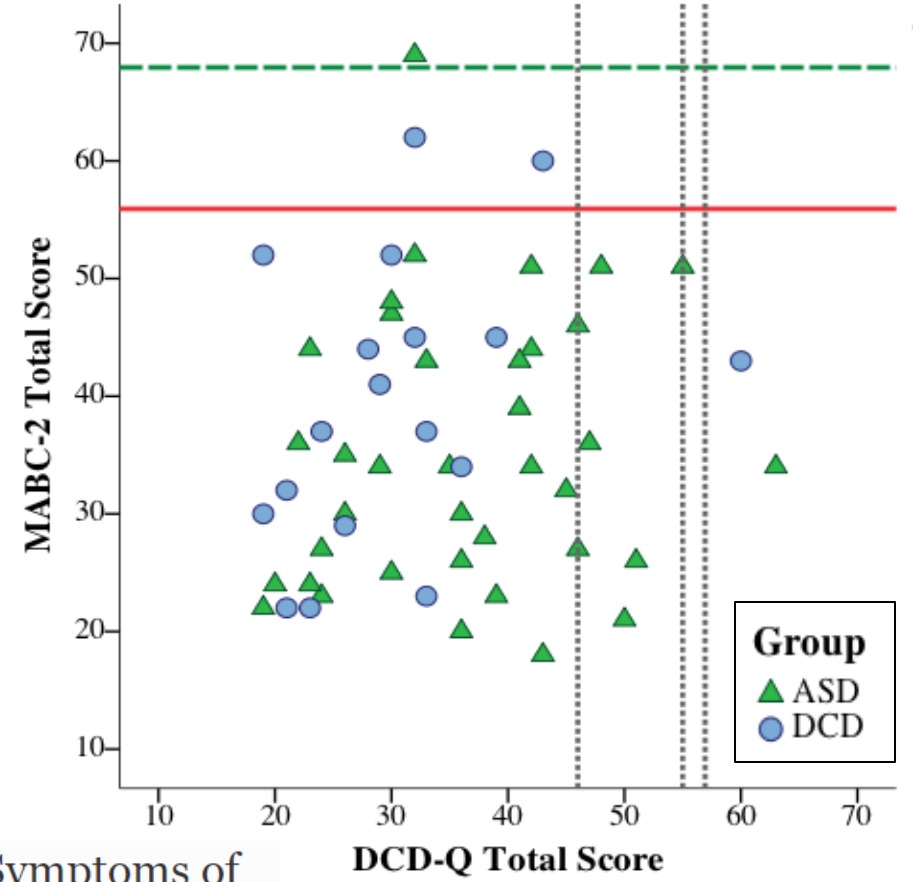


Shared Features or Co-occurrence? Evaluating Symptoms of Developmental Coordination Disorder in Children and Adolescents with Autism Spectrum Disorder

Haylie L. Miller, Gabriela M. Sherrod, Joyce E. Mauk, Nicholas E. Fears, Linda S. Hynan & Priscila M. Tamplain

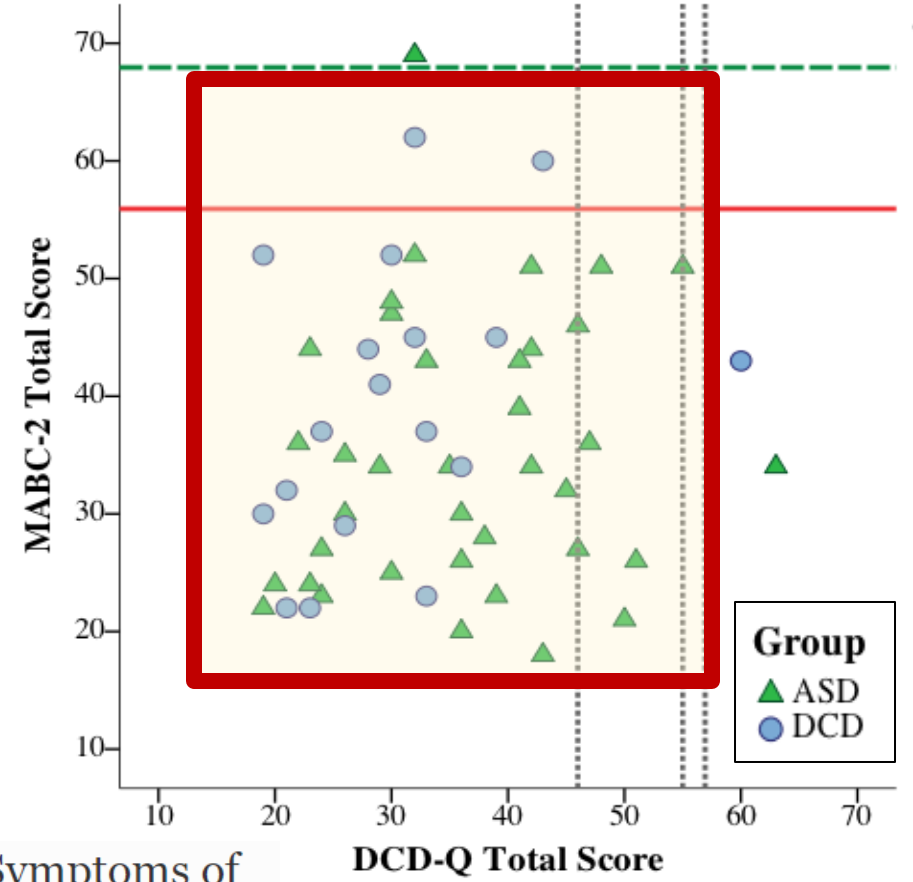
DOI: 10.1007/s10803-020-04766-z

Co-occurring DCD…?

97% of ASD group met criteria for DCD on parent-reported (DCD-Q) and observational (MABC-2) measures of motor problems!

35-85% elsewhere (Licari et al., 2020; Green et al., 2009; Miyahara et al., 1997)

…or similar behavioral features driven by different mechanisms?



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Co-occurring ADHD

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Many neurodevelopmental conditions co-occur, and ADHD is no exception!

- Estimated 40-70% co-occurrence of autism and ADHD
- Estimated 50% co-occurrence of DCD and ADHD

Children with ADHD have visuomotor features similar to DCD and autism

- Delays in meeting motor milestones (Miller et al., 2020)
- Difficulty with fine motor coordination (Mokobane et al., 2019)
- Differences in planning, performance monitoring, sensory processing, visual attention (Lau-Zhu et al., 2019)

YET, recent research suggests that the majority of **caregivers of children with ADHD do not know** about its motor features, or about DCD (Meachon et al., 2025)

Broad Impact

Motor problems have broad, lifelong consequences!

Persist from early childhood through adulthood and aging

Can limit ability, independence, developmental opportunities, & even communication skills (Pavão et al., 2014; Hsieh et al., 2002; Mache & Todd, 2016; Nebel et al., 2016; Georgopoulos & Grillner, 1989)

Can reduce mental health and quality of life (Tamplain & Miller, 2021)

Can increase risk of social isolation (Piek et al., 2005; Poulsen et al., 2008)

Can reduce engagement in physical activity & overall fitness (Tyler et al., 2014)

Negatively impacts many domains of health & can increase risk of chronic conditions (Cairney et al., 2011; Hamm & Yun, 2017; Carson et al., 2010; Hendricks et al., 2014)

Broad Impact

Poor motor skills have broad lifelong consequences!

- Can limit ability, independence, developmental opportunities (Pavão et al., 2014; Hsieh et al., 2002; Mache & Todd, 2016)
- Can reduce mental health and quality of life (Tamplain & Miller, 2021)
- Persist from early childhood through adulthood and aging
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What Can We Do to Promote Mental Health Among Individuals With Developmental Coordination Disorder?

Priscila Tamplain & Haylie L. Miller

DOI: 10.1007/s40474-020-00209-7

So now what?

Evidence-based intervention

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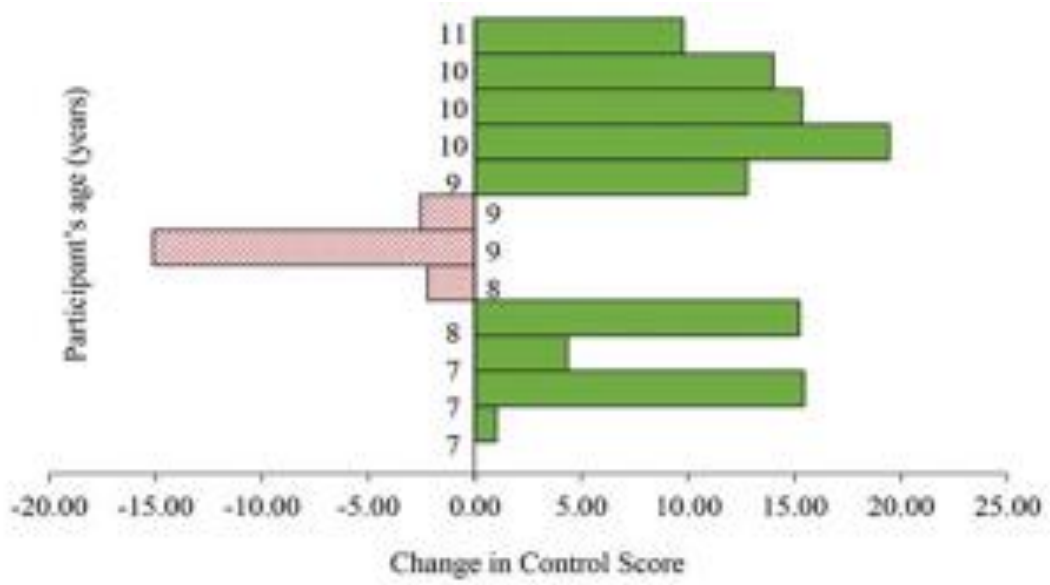
Group-based motor interventions that are primarily delivered through play can improve dynamic postural control!

These interventions also have a secondary positive effect on social-communication skills.



Preliminary Improvements in Dynamic Postural Control after A Group-based Intervention Program for Children with Developmental Coordination Disorder: A Brief Report

Priscila Tamplain [1], Gabriela M Sherrod [2], Chadwick Fuchs [1], Haylie L Miller [2]

DOI: 10.1080/17518423.2020.1819463

Evidence-based intervention

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Systematic reviews and meta-analyses have shown that:

- Exercise interventions improve fundamental motor skills including locomotor skills, object-control, and stability (Healy et al., 2021; Ji et al., 2023)
- Physical activity interventions improve autistic young adults' physical fitness, motor skills, psychological function, and quality of life, especially when paired with dietary changes and lifestyle modifications (Shahane et al., 2023)
- Effectiveness improves with visual vs. verbal instruction (Ruggeri et al., 2019)
- Fine motor interventions improve skills in ADHD (Lelong et al., 2021)

Evidence-based intervention

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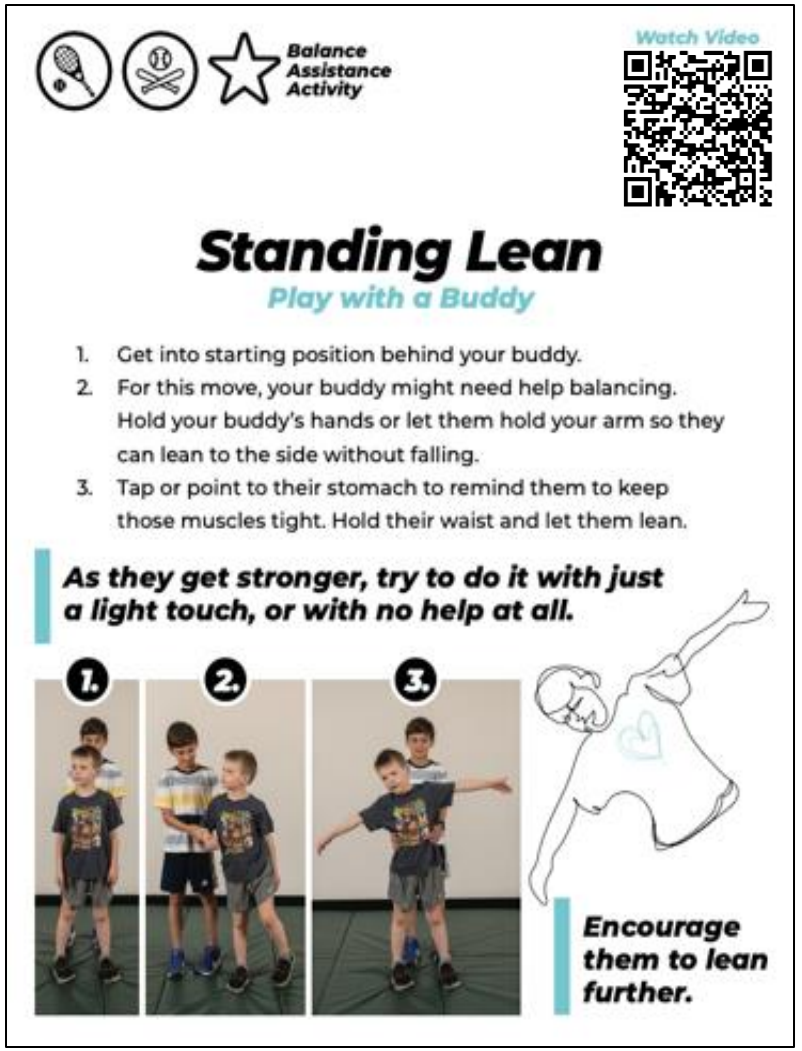
The types of effective interventions identified in these reviews include:

- General motor skills intervention
- Physical therapy
- Occupational therapy
- Yoga
- Aquatic therapy
- Exergaming
- Physical education (general or adapted)
- Equine-assisted therapy/therapeutic horseback riding

Evidence-based intervention

Instructional strategies for neurodivergent people:

- Low instructor-student ratio (<1:3) (Bremer et al., 2015; Guest et al., 2017; Weber & Thorpe, 1992)
- Task modifications based on dynamic systems theory (Colombo-Dougovito et al., 2019)
- Peer tutoring (Bremer & Lloyd, 2016)
- Pivotal response teaching (Ketcheson et al., 2017)
- **Verbal, visual, and physical prompts** (Bittner et al., 2019; Bremer & Lloyd, 2016; Bremer et al., 2015)
- **Visual schedules** (Bremer & Lloyd, 2016)
- **Picture exchange systems** (Bremer & Lloyd, 2016)



Structured Relaxation & Rest

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Choose **warm-up, cool-down, or transition activities** that are low-arousal & calming

- Socially-appropriate way to control emotions when upset or stressed
- Use when the individual loses focus or becomes too excited
- Good way to end class or a session, and transition to the next activity/environment
- Progressive relaxation, yoga, tai chi, static stretching, imagery, impulse-control games

These are obviously great in a clinical or PE setting, but physical activities are also useful in the classroom for physical & emotional self-regulation, so **teachers/caregivers can also use these tools**!

Organization & Structure

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Follow a **Universal Design for Learning** framework…

- Set activities in learning stations
- Use differentiated instruction, concrete examples
- Facilitate peer instruction & cross-age tutoring
- Provide opportunities for partial participation/modifications
- Use ecological task analysis to identify all areas that may require support
- Be consistent & predictable, move from familiar to novel
- Encourage choice-making & agency
- **Resist the urge to over-control "Behaviors"**

Some considerations…

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Sensory needs/preferences differ for each person – try not to force neurotypical norms!

Motor & sensory differences may lead to **faster or more frequent fatigue**

May need to leave a space when overwhelmed

Repetitive motor movements have many functions…can signal excitement, joy, distress, etc., & can help with self-regulation, comfort, focus, or stress relief

Interpretation or production of **nonverbal cues** may differ

- Facial expressions, body postures, proximity, use of gaze, gestures

Balance differences may lead to **instability, fall or injury risk**

Coordination differences may increase likelihood of **drops, spills, or the need for assistance with carrying or shelving items**

Co-occurring conditions can exacerbate fatigue/pain, including Ehlers-Danlos and other conditions that involve chronic pain, vestibular disturbance, or joint laxity

Managing Sensory Needs

Check in during the day – how are each of your sensory systems functioning?

- Are you close to overwhelm?
- Are you understimulated?
- What needs may not be met?

Try setting an alarm or calendar reminder!

Don't forget to explain clearly how this connects to movement!

Recommendations

Provide a safe space for **self-regulation & stimming**

The more regulated/comfortable someone is, the easier it is to work or learn
This may require specific furniture, lighting, sound, scents, food storage, etc.

****It does not have to be a "quiet room"!****

Identify **motor & sensory demands** of tasks, not just cognitive/social

Provide opportunities for **relaxation, physical rest, decompression**

Determine what support is needed to **make *all activities* accessible**

This can require some creativity, but you can do it! (And I can help if you need support!)

Make sure people do not feel stigmatized for info processing or motor differences ***(safeguard against psychological/emotional harm)***

Looking to the future…

Opportunities:

- Motor problems detectable prior to core symptoms, and observable across multiple ages/stages
- Precise tools available for quantifying deviation from neurotypical trajectory
- Motor interventions appear to be flexible, effective, and acceptable

Challenges:

- Feasibility of paradigm shift away from social-communication focus
- Feasibility of translating tools for motor assessment to clinical practice
- Specification of underlying mechanisms *and their interaction*

Participate in our research!

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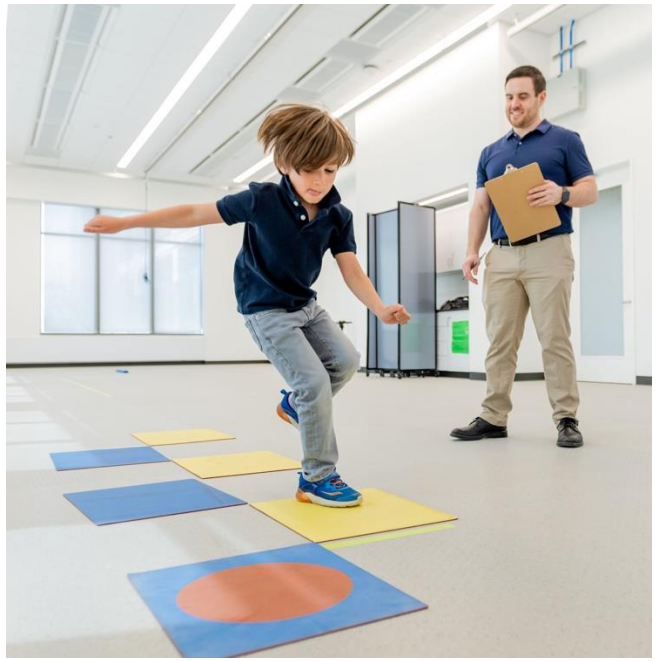

There are many ways to get involved in research!

We can test at sites in the community or at UMich.

Options range from 45 minutes just one time to multiple hours annually, and we pay participants for their time.

Acknowledgments

Mentors & Collaborators

- James Ashton-Miller, MSME, Ph.D. (UMich)
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- W. Paul Bowman, M.D. (UNTHSC)
- UNTHSC TCHD program faculty
- UT Southwestern Center for Translational Medicine/CTSA KL2 program faculty

Team Members

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It is our honor and privilege to continue learning from the community.

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