**Title**: Autistic individuals show increased variability of spatiotemporal dimensions of gait from childhood through adulthood

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**Introduction**: Sensorimotor issues, including gait atypicalities, are prevalent in autistic individuals and are associated with poorer social-communication and adaptive skills, highlighting their clinical significance1,2. While gait issues are commonly reported in autism, findings are inconsistent across studies. These inconsistencies likely reflect, at least in part, differences in sample ages – walking undergoes complex maturational changes from the first year of life into adulthood3 – and in the spatiotemporal gait variables that are selected for analysis, as separate component gait processes may be variably affected across individuals (e.g., 4). The objective of the present study was to define autism-associated differences in gait function across a broad range of ages and parameters.

**Method**: Sixty autistic individuals (ages 4-35 years) and 53 age-, sex-, and IQ-matched neurotypical controls completed trials of unconstrained walking (3-5 meters depending on site) at a self-selected pace. Motion capture cameras tracked 16 reflective markers attached to participants’ major joints. Common spatiotemporal metrics of gait were derived from the motion capture data and analyzed with multivariate analysis of covariance. Gait variables that were significantly different across groups were included in a canonical correlation analysis with demographic variables (group, age, sex, IQ) to derive a composite gait score that accounted for multicollinearity across discrete gait and demographic variables. Composite gait scores were examined in relation to age and autistic traits.

**Results**: Seven variables relating to variability (standard deviation; SD) of gait component processes differentiated autistic and neurotypical individuals: cadenceSD (F=5.63, pFDR=.03), step widthSD (F=8.02, pFDR=.01), step velocitySD (F=10.24, pFDR=.01), hip angleSD at heel-strike (F=8.55, pFDR=.01), hip angleSD at toe-off (F=13.21, pFDR=.004), and knee angleSD (F=8.48, pFDR=.01) and ankle angleSD (F=5.07, pFDR=.04) at heel strike. These seven variables were subsequently included in the canonical correlation analysis. One canonical variate, referred to as “composite gait variability”, explained significant variance in the data (F=2.82, p<.001). Autistic individuals showed higher composite gait variability than neurotypical individuals (t=3.76, p<.001, *d*=.727), and the composite gait variability dimension showed a larger effect size than group comparisons of each discrete gait variable (*d*s ≤ .628). Composite gait variability was inversely associated with age across both groups (ρ=-0.38, p=.005) and positively correlated with more severe ritualistic behaviors in autism (ρ=0.37, p=.01).

**Discussion:** Findings that gait variability selectively differentiated autistic from neurotypical individuals are consistent with prior studies reporting increased variability of spatiotemporal dimensions of gait in autism5. Importantly, our composite gait variability dimension was more robust to autistic gait differences than any discrete gait variable suggesting that gait in autism is characterized by elevated spatiotemporal variability across multiple parameters. While gait variability was elevated in autism, it showed similar age-related reductions in autism and neurotypical development suggesting that differences are persistent across childhood and adulthood. The relation of composite gait score to repetitive behavior in autistic individuals suggests that gait issues may share important neurodevelopmental mechanisms with core autistic traits.

**References:**

1 Estes A, Zwaigenbaum L, Gu H, St. John T, Paterson S, Elison JT, *et al.* Behavioral, cognitive, and adaptive development in infants with autism spectrum disorder in the first 2 years of life. *J Neurodev Disord* 2015;**7**:24. https://doi.org/10.1186/s11689-015-9117-6.

2 Wilson RB, Burdekin ED, Jackson NJ, Hughart L, Anderson J, Dusing SC, *et al.* Slower pace in early walking onset is related to communication, motor skills, and adaptive function in autistic toddlers. *Autism Res Off J Int Soc Autism Res* 2024;**17**:27–36. https://doi.org/10.1002/aur.3067.

3 Voss S, Joyce J, Biskis A, Parulekar M, Armijo N, Zampieri C, *et al.* Normative database of spatiotemporal gait parameters using inertial sensors in typically developing children and young adults. *Gait Posture* 2020;**80**:206–13. https://doi.org/10.1016/j.gaitpost.2020.05.010.

4 Pauk J, Zawadzka N, Wasilewska A, Godlewski P. Gait deviations in children with classic high-functioning autism and low-functioning autism. *J Mech Med Biol* 2017;**17**:1750042. https://doi.org/10.1142/S0219519417500427.

5 Lum JAG, Shandley K, Albein-Urios N, Kirkovski M, Papadopoulos N, Wilson RB, *et al.* Meta-Analysis Reveals Gait Anomalies in Autism. *Autism Res* 2021;**14**:733–47. https://doi.org/10.1002/aur.2443.

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