

ABSTRACT

TITLE: Comparing human visual extraction and automated markerless gait analysis for quantitative assessment of toe-walking in autistic individuals with intellectual disability.

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TOPICS: autism spectrum disorder, intellectual disability, machine learning, toe-walking assessment

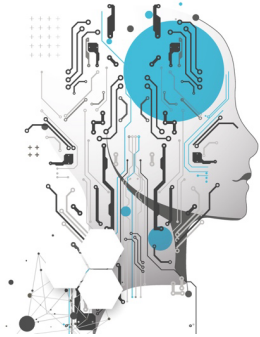
Structure the contribution according to the following sections:

OBJECTIVES:

This preliminary study aims (1) to implement an automated markerless gait analysis system (MGAS) approach to quantify toe-walking (TW) in individuals with autism spectrum disorders (ASD) and intellectual disability, (2) to validate it by comparing the results with those obtained using the reference video-recording approach.

MATERIALS:

We conducted a preliminary study on 10 individuals diagnosed with ASD (DSM-5 criteria),



confirmed through the Childhood Autism Rating Scale (CARS-2). Intellectual disability was assessed through the Vineland-2.

We used the validated automated MGAS Openpose¹ to analyse a standardised video-recorded test².

METHOD:

TW was assessed using a modified version of a TW structured video-based coding protocol, based on standardised video-recordings². Participants transported an object (e.g. Lego®) from a therapist to a table 3 meters away and back again 10 times barefoot (wearing socks). This was repeated on three days, totalling 30 tests.

A trained therapist calculated the percentage of toe steps among the total number of performed steps by observing the video².

In parallel, videos were analysed using the MGAS OpenPose¹. Kinematic data were processed using a pre-trained Bayesian machine learning algorithm to detect total steps and the percentage of toe steps automatically.

The agreement between MGAS and therapist evaluations was assessed using the Spearman correlation test and Bland-Altman plots.

RESULTS:

Participants (mean age: 8.98 ± 2.3 years; 9/10 males) had a mean CARS-2 total score of $54.4 (\pm 9.13)$ and a mean Vineland-2 total quotient score of $28.1 (\pm 13.92)$. Five participants presented TW.

The normal data distribution was not confirmed (Shapiro-Wilk test $p < 0.05$). The Spearman coefficient showed a very strong correlation³ ($\rho = 0.98$, $p = 0.01$) for the total number of steps, and a strong correlation³ ($\rho = 0.78$, $p = 0.01$) for the percentage of toe steps. Bland-Altman analysis resulted in an upper LOA below 5.8 and a lower LOA above -6.3 for the total number of steps, and an upper LOA below 0.34 and a lower LOA above 0.17 for % of tip-toe steps.

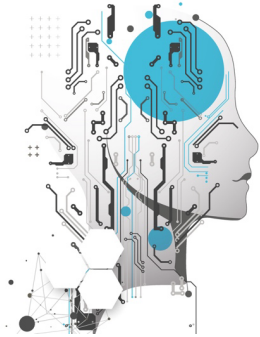
DISCUSSION:

The results suggest that the MGAS OpenPose could be used with individuals with ASD to monitor TW in a clinical setting in time.

CONCLUSIONS:

The MGAS OpenPose used for the quantitative assessment of TW in individuals with ASD and intellectual disability showed excellent reliability for the total number of steps and good reliability for the percentage of tip-toe steps compared to the reference therapist's visual assessment. Further research is required to confirm the results of this preliminary study.

REFERENCE



Milan
University of Milano-Bicocca
15th - 17th October 2025

NeuroMI
Milan Center for Neuroscience
2025

**Artificial Intelligence
for Neuroscience:**
from basic research
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- 2) Valagussa, G., Purpura, G., Balatti, V., Trentin, L., Signori, A., & Grossi, E. (2024). Quantitative assessment of tip-toe behavior in individuals with autism spectrum disorder and intellectual disability: A cross-sectional study. *Autism research : official journal of the International Society for Autism Research*, 17(2), 311–323. <https://doi.org/10.1002/aur.3072>
- 3) Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Routledge. <https://doi.org/10.4324/9780203771587>