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Quantitative assessment of tip toe behavior in individuals with autism spectrum disorders using a structured methodology: comparison between video-recording and wearable sensor approaches.

Valagussa Giulio[1,2], Molteni Luca Emanuele[1], Boccotti Martina[1], Andreoni Giuseppe[3,4], Grossi Enzo[1]

(1) Villa Santa Maria Foundation – Autism Research Unit; (2) University of Milano-Bicocca – School of Medicine and Surgery; (3) Politecnico di Milano - Department of Design, Milano, Italy; (4) Scientific Institute IRCCS "E.Medea" - Bioengineering Laboratory, Bosisio Parini, Lecco, Italy.

BACKGROUND AND OBJECTIVES

- ✓ Tip-toe behavior (TTB) is showed by about 20% of individuals with ASD and is poorly quantified with structured methods[1].
- ✓ In a previous study, we proposed a standardized method to quantify TTB during static and dynamic tasks using a video-recording approach in an ecological setting[2]. This testing approach is very time-consuming and operator dependent requiring an operator to review the videos and computing the parameters.
- ✓ To overcome these limitations, an instrumental approach using wearable sensors (WS) and an automated calculation system was developed and applied. Moreover, WS approach would also permit monitoring gait for a longer time during the day.
- ✓ **Objective**: this study aims at implementing a WS-based protocol for the quantitative assessment of TTB and its validation by the comparison with the reference video-recording approach.

MATERIALS AND METHODS

- ➢ Individuals with ASD diagnosed according to DSM-5 criteria and a diagnosis confirmation using the Autism Diagnostic Observation Schedule (ADOS) were involved in the study.
- ➢ TTB was quantified during structured static and dynamic tasks using a video-recording approach, previously described[2]. All the tests were performed without shoes albeit with "Sensoria® Smart Socks".
- ➢ The dynamic test consists in transporting 1 object (e.g. puzzle piece, Lego®) from the therapist to the playing table situated 2 meters away and back again 15 times (see Figure 1).
- ➢ The static test consists in playing while standing in front of a table for 3 minutes (see Figure 1).
- ➢ Both assessments were repeated on three different days for each individual (9 assessments).
- ➢ "Sensoria® Smart Socks" (SSS) are the validated WS[3] used during the video-recorded tests. In this way, we were able to collect data obtained from video-recording and WS approaches at the same time.
- ➢ The result of the video-recording and WS approaches were analyzed.
- ➢ In the WS approaches we used two different analysis, in the first analysis the signal of SSS was processed directly, in the second analysis the signal was filtered and normalized before identifying the TTB steps.
- ➢ The intraclass correlation coefficient - ICC (two-way mixed effects model, absolute agreement, single measurement) was calculated using SPSS ver. 23, to assess the reliability between the video-recording and SSS approaches in quantifying the mean percentage of toe steps and the mean percentage of the time spent in TTB.

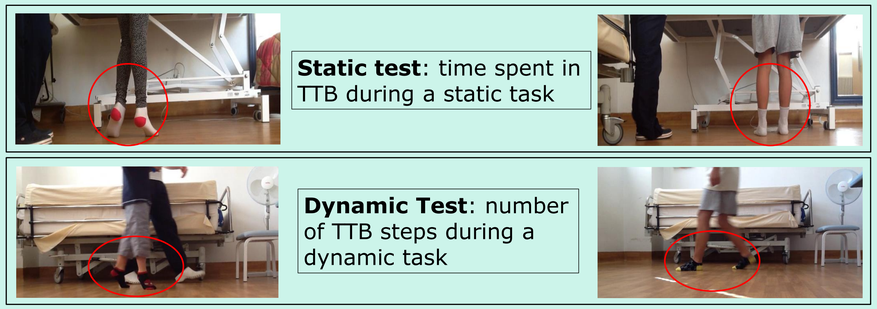

Figure 1: static and dynamic tests

RESULTS

- ✓ We assessed 3 individuals with ASD and TTB.
- ✓ The age was 10.9 yrs, 12.8 yrs and 13 yrs (3/3 males); their ADOS calibrated severity score was 9, 10 and 8, respectively.
- ✓ The normal distribution of data was confirmed (Shapiro-Wilk test $p > 0.05$).
- ✓ The ICC values of the mean percentage of the toe steps during the dynamic test and the mean percentage of the time spent in TTB during the static test were 0,862 (good) and 0,870 (good), respectively[4].

		Static Test - % of the time spent in TTB			Dynamic Test - % of the toe steps		
Subject	**Acquisition**	**Video-Recording**	**SSS 1st analysis**	**SSS 2nd analysis**	**Video-Recording**	**SSS 1st analysis**	**SSS 2nd analysis**
1	**Session 01**	0.56%	0.35%	0.02%	58.82%	63,79%	55.41%
2	**Session 01**	37.78%	7.13%	26.61%	98.28%	79,79%	84.46%
3	**Session 01**	30.00%	34.47%	34.65%	41.38%	59,83%	46.62%
1	**Session 02**	1.11%	13.68%	12.93%	7.29%	27,96%	21.43%
2	**Session 02**	0.00%	0.00%	0.00%	98.13%	96,30%	62.67%
3	**Session 02**	44.44%	45.64%	49.81%	44.90%	59,83%	52.00%
1	**Session 03**	0.00%	7.57%	16.85%	24.68%	30,38%	40.85%
2	**Session 03**	21.11%	3.18%	15.34%	100.00%	64,10%	99.17%
3	**Session 03**	32.22%	48.88%	44.08%	57.33%	64,29%	63.51%
		ICC with respect to	**0.717**	**0.870**	**ICC with respect to**	**0.806**	**0.862**

Table 1: *values of the mean percentage of the time spent in TTB during Static Test and the mean percentage of the toe steps during Dynamic Test measured with Video-Recording and SSS.*

CONCLUSIONS

- ➢ The "Sensoria® Smart Socks" used for the quantitative assessment of TTB in individuals with ASD showed **good reliability** compared to the reference video-recording approach during static and dynamic tests. The results of this preliminary study support further research on a larger sample.

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Corresponding author: giulio.valagussa@gmail.com