A consumer-grade wearable technology is valid for the assessment of walking gait "in the wild"

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INTRODUCTION

The clinical biomechanical analysis of gait can be an important tool for identifiaction of disease, physical deterioration, and gait abnormalities. Traditional gait analysis is typically lab-based, requires trained staff, and costly equipment, with single and sporadic assessments only showing a snapshot of the patient's gait. One approach that has been strongly advocated to overcome many of these limitations is the use of wearable sensors to perform in-field gait analysis for an extended period of time. Pressure-based insoles have been proposed as an effective method of portable gait analysis, typically targeting the calculation of spatiotemporal gait metrics. The purpose of this study was to evaluate whether the low cost and commercially available NURVV system is valid for the assessment of clinical gait parameters.

METHODS

Twelve healthy males (6) and females (6) walked on a split belt instrumented Bertec treadmill sampling at 1000 Hz. Participants wore a pair of NURVV run insoles inside modified Nike Free run trainers and a set of reflective markers were attached on both limbs (Figure 1). A 12-camera Qualisys motion capture system sampling at 250 Hz collected marker positions as participants completed a multi-stage walking protocol. Speeds ranged from 3-6 km/h, including trials where the participant was asked to imitate a limp on each leg. Using treadmill force data, initial foot contact and toe off events were taken when the vertical force exceeded and dropped below 40 N, respectively. Footstrike type was classified [1] from foot angles calculated in Visual3D using a modified version of the IOR foot model [2]. Timelines were synchronised and these results were compared to those output from the NURVV system that combines pressure data from 16 sensors with inertial measurement unit data to calculate real time metrics. Average Error, Limits of Agreement (LoA), Mean Absolute Percentage Error (MAPE), and Typical Error (TE) were calculated to compare lab-based and wearable systems.

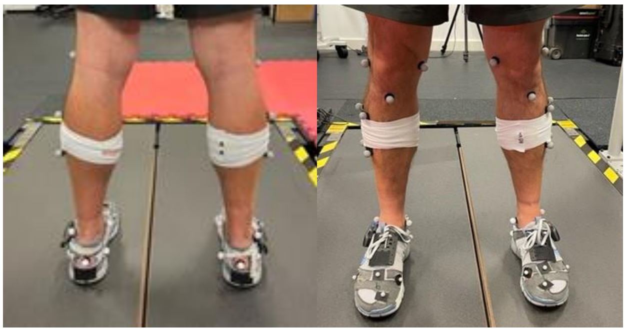

Figure 1 Experimental set-up and marker-set

RESULTS AND DISCUSSION

Identification of stride time and therefore cadence and stride time asymmetry by the NURVV system proved most accurate (Table 1). A small systematic error was seen in ground contact time, likely due to inaccurate identification of toe off timing, which in turn affected estimation of stance time (%) and swing time. These results are comparable to similar technologies previously tested. [3] On average the NURVV system overestimated walking speed in comparison to treadmill speed. However, participant positioning on the treadmill was not controlled for, which could limit the confidence in the comparison. Finally, the two systems had a 97.7% agreement on footstrike type with less than 0.1% of foot contacts being out by two classifications (i.e forefoot-heelstrike).

CONCLUSIONS

The NURVV system showed high agreement with the criterion lab-based measures. This system could be used as an effective tool to perform continuous and long-term gait analysis more easily on clinical populations in their daily life.

REFERENCES

[1] Altman et al. *Gait & Posture* **40**: 298-300.
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Table 1: Descriptive statistics evaluating the comparison of the NURVV system and criterion instrumented treadmill data. Positive values indicate larger NURVV system values

Metric	Average Error	LoA	MAPE range	TE range
Cadence (spm)	+ 0	[-3.7, 3.8]	1.0 – 1.9%	1.0 – 1.6
Ground Contact Time (ms)	- 22	[-83, 40]	3.2 – 6.1%	9.6 – 12.2
Stance Time (%)	- 1.9	[-8.0, 4.1]	3.4 – 6.2%	1.0 – 1.42
Stride Time Asymmetry (%)	+ 0	[-1.6, 1.7]	-	0.3 – 0.7
Stride Time (ms)	+ 0	[-9, 9]	0.2 – 0.5%	1.7 – 5.7
Swing Time (ms)	+ 21	[-40, 83]	4.8 – 10.5%	10.0 – 13.1
Walking Speed (m/s)	+ 0.28	[-0.20, 0.75]	-	0.08 – 0.22