VALIDATION OF A WEARABLE DEVICE FOR MEASURING KNEE ANGLE DURING LEVEL TREADMILL WALKING

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Introduction

100,000 total knee arthroplasty (TKA) procedures take place in the United Kingdom annually [1], and 94% of these procedures occur in individuals 50 years and older [2]. Clearly, the need for home-based rehabilitation is high, however, compliance is poor [2]. MotionSense™ (Stryker, US) is a wearable technology that remotely supports post-operative TKA rehabilitation. MotionSense™ continuously monitors knee motion remotely, enabling healthcare professionals to provide personalised rehabilitation. However, validation of this device against a known kinematic model in activities of daily living is important for confident interpretation of resulting clinical data. The aim of this study therefore was to validate the accuracy of MotionSense™ against a clinical motion capture standard.

Methods

Upon receiving NHS ethics approval, 20 able-bodied young individuals (age 24 ± 4 years, mean ± SD) and 14 older participants (71 ± 5 years) volunteered. Retroreflective markers and MotionSense™ sensors were attached to the lower limb. Volunteers walked for 5 minutes at a self-selected comfortable speed on a treadmill. Vicon PlugInGait™ determined knee flexion (100 Hz) and the MotionSense™ sensors exported data in real-time (~50Hz) to a mobile device on which a proprietary algorithm determined knee flexion. To time synchronise the technologies, data were up-sampled to 1000Hz, and cross-correlated. After a 1-minute acclimatisation period, 10 gait cycles were manually determined using heel strikes identified from foot marker trajectories via a bespoke graphical user interface. As the zero point for knee flexion depends both on marker and IMU placement, mean knee flexion was subtracted from each data set before calculating a root mean square error (RMSE) between the technologies. T-tests compared the older and the younger populations and significance was taken at the 5% level.

Results and Discussion

RMSE values demonstrate excellent agreement between the technologies below 3° (Table 1, Figure 1A).

Table 1. RMSE between Vicon and MotionSense™ for treadmill walking for the younger and older populations (mean ± SD)

	RMSE (°)	Pooled RMSE (°)
Younger	2.41± 0.85	2.40±0.77
Older	2.39±0.68	

No difference between older and younger participants was evidenced, despite older volunteers walking significantly slower than the younger volunteers (0.94 ± 0.12 ms^{-1} vs 1.17 ± 0.07 ms^{-1} , $p < 0.001$). RMSE values indicate the MotionSense™ platform performs better in comparison to comparable systems [3,4]. MotionSense™ does not require any form of calibration from the user, and the algorithm out-performed one method which involved functional self-calibration movements [3]. Greater RMSE values were observed just after heel strike in the weight acceptance phase and just after toe off (Figure 1B). This may be due to high frequency transients associated with heel strike and toe off, causing vibrations of the sensor.

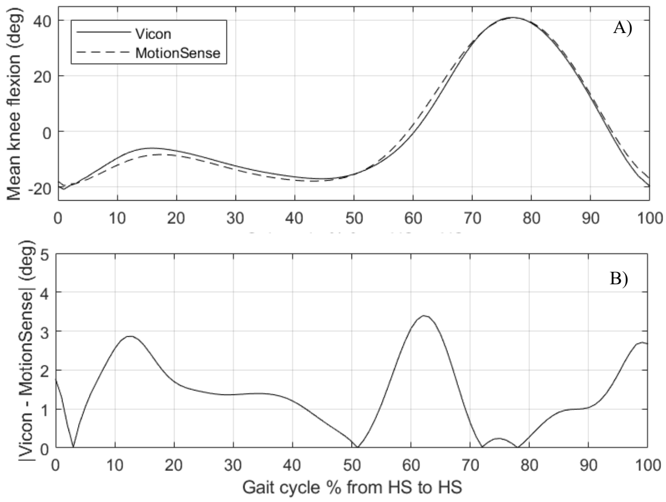

Fig 1. A) Comparison between the averaged Vicon and MotionSense™ measures for 10 gait cycles for 20 healthy young participants from heel strike to heel strike. B) Absolute difference between Vicon Motion Capture and MotionSense™ measurements for 10 averaged gait cycles for 20 healthy young participants.

References

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