DEPARTMENT OF BIOMEDICAl ENGINEERING

University of Strathclyde Engineering

Validation of an IMU wearable during treadmill walking

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Introduction

TKA is an effective surgery in decreasing morbidity linked to osteoarthritis and restoring knee functionality and range of motion (ROM) [1]. An indication of better knee mobility recovery is seen by greater knee movement postoperatively. TKA procedures are increasing, with over 400,000 surgeries taking place worldwide each year [2], and 100,000 procedures taking place in the United Kingdom [3].

Successful outcomes depends on post-operative rehabilitation. In addition to clinical sessions, home or community-based rehabilitation may improve outcomes, however, outcome monitoring and compliance is poor. Wearable technologies present a solution, by remotely monitoring and assessing patient progress through cloud technologies.

EnMovi Ltd* developed a wearable device, called MotionSense™ which remotely supports post-operative knee replacement rehabilitation, providing personalised rehabilitation, tracking of home exercises, and enabling healthcare professionals to continuously monitor rehabilitative progress remotely.

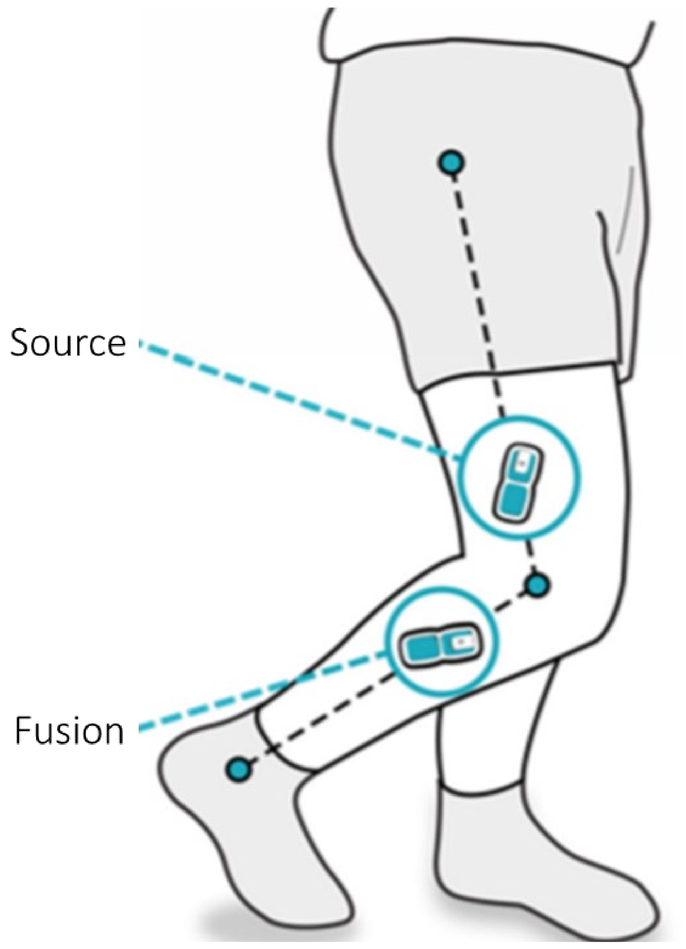

Figure 1. MotionSense wearable sensor attached above and below the knee joint.

Research Aim

This ongoing study aims to collect data using the MotionSense™ sensors to enable the development of AI algorithms to classify knee function and monitor movement. The accuracy and reliability of data will be validated against the gold standard Vicon motion capture system, and across many ADL's for performance of all abilities to be monitored accurately during rehabilitation.

*** Now Stryker Corporation**

References

[1] H. D. F., H. C. R., B. R., S. A. H. R. W., and P. J. T., "Dealing with the predicted increase in demand for revision total knee arthroplasty," *https://doi.org/10.1302/0301-620X.97B6.35185*, vol. 97-B, no. 6, pp. 723–728, Jun. 2015, doi: 10.1302/0301-620X.97B6.35185.

[2] L. Atallah, G. G. Jones, R. Ali, J. J. H. Leong, B. Lo, and G. Z. Yang, "Observing recovery from knee-replacement surgery by using wearable sensors," in *Proceedings - 2011 International Conference on Body Sensor Networks, BSN 2011*, 2011, pp. 29–34, doi: 10.1109/BSN.2011.10.

[3] D. F. Hamilton *et al.*, "Targeting rehabilitation to improve outcomes after total knee arthroplasty in patients at risk of poor outcomes: Randomised controlled trial," *BMJ*, vol. 371, Oct. 2020, doi: 10.1136/bmj.m3576.

Methods

Two sensors are placed on the skin above and below the knee (figure 1). The hardware measures both acceleration and rate of rotation with knee angle determined and activity classified via a proprietary AI algorithm.

There are two groups of participants, one group of TKA participants and an aged-matched healthy control group. The control group will be used to validate the accuracy and repeatability of the sensors against Vicon motion capture and is also a comparative data set to determine how close a TKA patient is to full recovery. PROMS data will be taken from the TKA group which may enable future prediction of PROMS outcomes flagging of dissatisfaction earlier in the rehabilitation process.

All participants will be asked to complete a variety of indoor activities of daily living (ADL). Measures will be recorded on 3 separate occasions for the TKA group: Pre-operatively, 1 week post operatively and 12 weeks post operatively. The control group only have their data collected once.

Initial Results

A pilot study was carried out comparing treadmill walking between 20 healthy younger participants (age 24 ± 4 years, mean ± SD) against 14 healthy older participants (71 ± 5 years). Root mean square error (RMSE) data demonstrated excellent agreement between the devices with a pooled RMSE < 3.5° (Table 1).

Participants	RMSE (deg)	Pooled RMSE (deg)
Younger	11.73 +/- 9.14	0.83
Older	5.32 +/- 2.72	0.92

Table 1. RMSE between Vicon and MotionSense for treadmill walking between older and younger participants

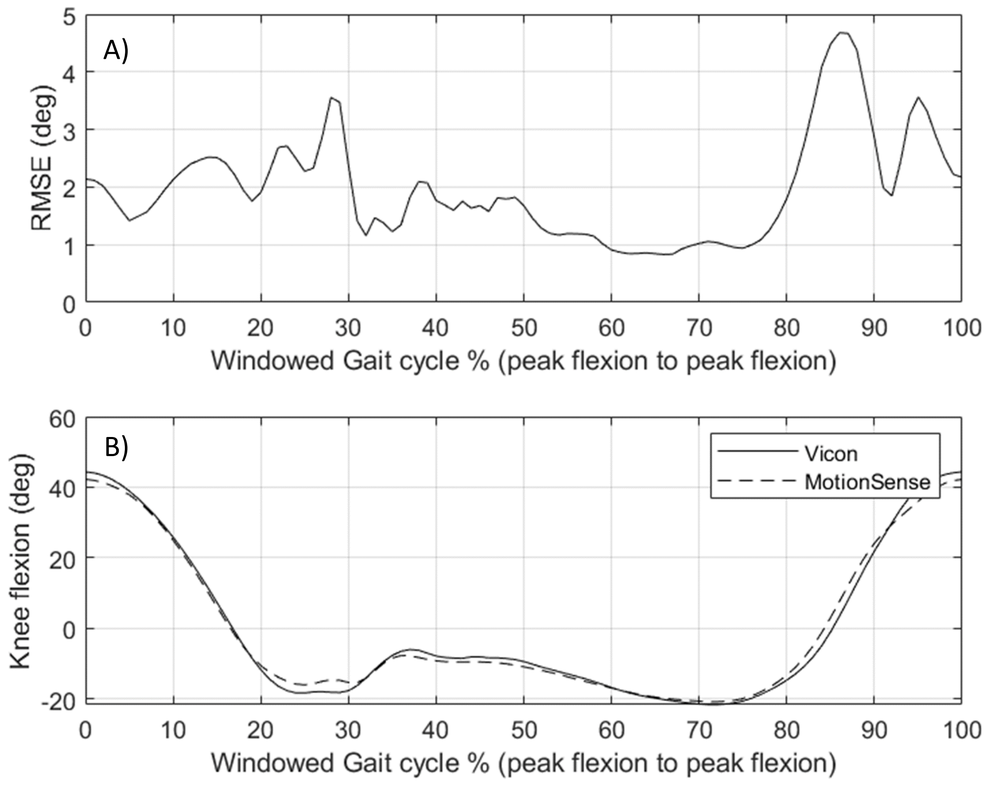

Figure 2. A) RMSE between the two technologies, B) Comparison between Vicon and MotionSense™ from peak flexion to peak flexion for one older participant

Discussion and Conclusion

MotionSense™ performed accurately during treadmill walking in both older and young populations. The difference between the technologies may be considered clinically negligible given the inherent variation in such analyses.