Utility of portable inertial measurement unit (IMU) sensor system for spinal movement assessment in people with and without low back pain

Sheeran, L.[1,2], Sparkes, V.[1,2], Al-Amri M[1,2]

[1]Cardiff University, School of Healthcare Sciences, Cardiff, U.K.
[2]Cardiff University, Arthritis Research UK Biomechanics & Bioengineering Centre, Cardiff, U.K.

Introduction

Physical examination of spinal movement behaviour is a routine part of clinical assessment of low back pain (LBP). Typically this involves an observation of the patients' posture and movement behaviour and a visual estimate of range of motion and its quality. Portable sensor technologies offer an alternative with growing evidence of its use to evaluate spinal/pelvic movement behaviour in people with LBP[1].

Limited evidence exist as to whether sensors can used to obtain clinically useful measures of spinal movement behaviour to guide exercise management for LBP.

Purpose

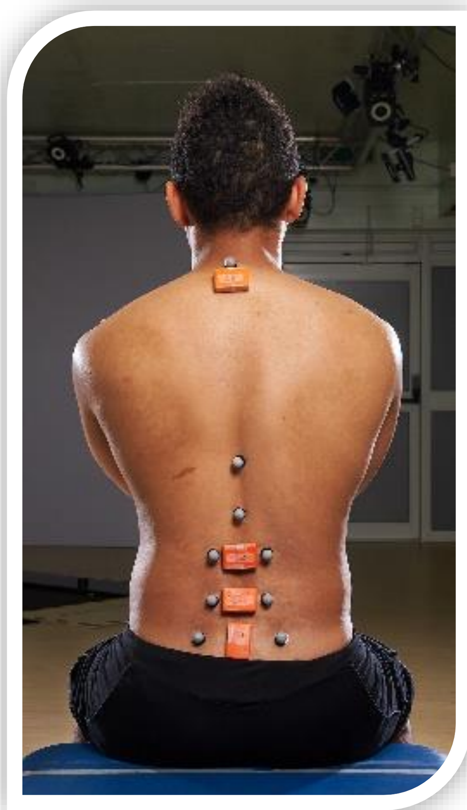
To demonstrate the application of portable inertial measurement unit (IMU) sensor system for spinal and pelvic regional movement analysis in people with and without LBP.

Methods

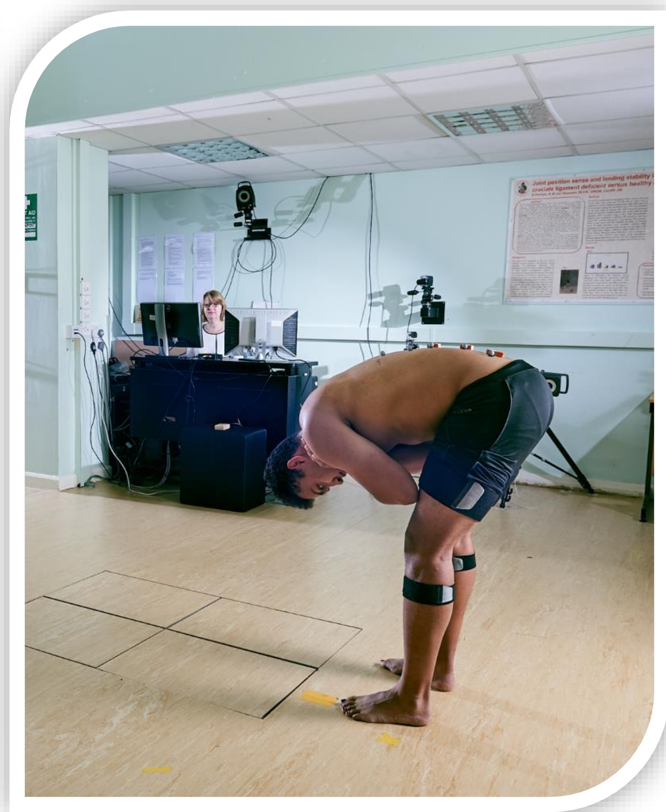
Observational cross-sectional study investigated spinal and pelvic kinematics of 62 participants with LBP (>8 weeks in duration, pain score of >4/10 on visual analogue scale) and 11 matched pain-free controls.

Four portable IMU sensors (Xsens technologies B.V., Netherlands) were affixed to the skin with double sticky tape over the participants' 1st thoracic spinous process to obtain trunk kinematics (T), 2nd and 4th lumbar spinous process for upper (ULx) and lower lumbar spine (LLx) kinematics and the sacrum for the pelvic kinematics[2].

Participants were asked to perform 10 repetitions of forward bend with no instructions provided. Minimum, maximum and mean range of motion (ROM) and respective coefficient of variation (CV) was calculated and compared between groups using independent t-test (alpha level $p<0.05$).



IMU Sensor placement



Forward Bend task performance

Results

Region	Variable	LBP (n=62) Mean (SD)	No-LBP (n=12) (Mean (SD)	Independent T-test p-value
ULx	Min ROM (deg)	-2.5 (5.1)	0.6 (3.7)	.030*
	Max ROM (deg)	81.9 (15.7)	99.8 (16.0)	.004*
	Mean ROM (deg)	84.9 (16.2)	99.2 (15.7)	.015*
	Mean ROM CV (%)	3.5 (2.2)	2.9 (1.3)	.300
LLx	Min ROM (deg)	-1.8 (4.2)	1.5 (3.4)	.011*
	Max ROM (deg)	62.4 (14.7)	78.9 (16.6)	.009*
	Mean ROM (deg)	64.3 (14.4)	77.5 (15.2)	.019*
	Mean ROM CV (%)	4.2 (4.0)	3.2 (1.4)	.115
Pe	Min ROM (deg)	-3.1 (8.1)	0.1 (3.7)	.041*
	Max ROM (deg)	44.6 (14.3)	55.6 (14.2)	.033*
	Mean ROM (deg)	47.7(13.6)	55.4 (12.6)	.084
	Mean ROM CV (%)	4.5 (2.5)	4.2 (2.3)	.652
Trunk	Min ROM (deg)	-0.8 (6.2)	-1.08 (2.6)	.760
	Max ROM (deg)	94.8 (12.4)	115.3 (25.9)	.027*
	Mean ROM (deg)	96.0 (14.7)	116.4 (26.3)	.029*
	Mean ROM CV (%)	3.7 (2.1)	3.1 (1.6)	.227

ULx= upper lumbar spine; LLx = lower lumbar spine; Pe = pelvis; deg = degrees; SD = standard deviation

- Compared to pain-free controls, people with LBP demonstrated significantly lower upper and lower lumbar ROM when bending forward ($p<0.05$).
- The LBP group had also significantly lower minimum and maximum pelvic ROM when bending forward, although the mean ROM was not different compared to pain-free controls.
- The trunk forward bend mean and max ROM in the LBP group was significantly lower with no difference in the minimum ROM value.
- The movement consistency over the 10 repetitions was similar with mean CV ranging between 2.9 - 4% across both groups.

Conclusions

This is a first to date study utilising multiple IMU sensors to evaluate spinal-pelvic kinematics during forward bend task in people with and without LBP.

This study demonstrates that people with and without LBP consistently adopt different movement strategies when performing typically perceived pain provoking forward bend task.

Relevance

Results demonstrate potential clinical utility of IMU sensors to evaluate spinal kinematics in LBP population.

All 3 spine sensors detected difference in mean and maximum ROM indicating potentially that a single IMU sensor may be sufficient for purpose of ROM estimation.

Further analysis are currently conducted to explore the utility of IMU sensor system for spinal assessment within subsets of LBP and as a form of movement feedback during exercise.

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1.Papi E., Koh W., McGregor, J Biomech (2017) 64,186-197
2.Hemming R., Sheeran L., van Deursen R., Sparkes V .ESJ (2018) 27(1),163-170

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