A NEW ELECTRONIC SPINAL MOBILITY INDEX FOR AXIAL SPONDYLOARTHRITIS USING INERTIAL MEASUREMENT UNIT SENSORS

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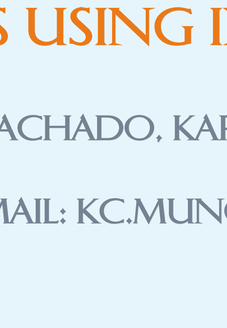
INTRODUCTION

- In 2016, the highest prevalence of spondyloarthritis was in North America and Europe, 1.35% and 0.54% respectively (Stolwijk et al., 2016)

- A key outcome measure for axial spondyloarthritis (axSPA) is spinal mobility, but this is highly variable and subjective when assessed using conventional tools, e.g. goniometer (Mancini and Horak, 2010)

- Cervical rotation is the only movement test measured in degrees in the BASMI

- Inertial Measurement Unit (IMU) sensors can attain accurate measures of body motion.



axSPA

Goniometers

AIM:

Evaluating the reliability of IMU attained measurements (from movement tests performed by axSpA participants) against measurements attained from conventional BASMI, the 'Truth' dimension of the OMERACT filter (Wells, Beaton, Tugwell, et al., 2014)

IMUs

MATERIALS AND METHODS

- Key points of our methodology are summarised in Diagram 1

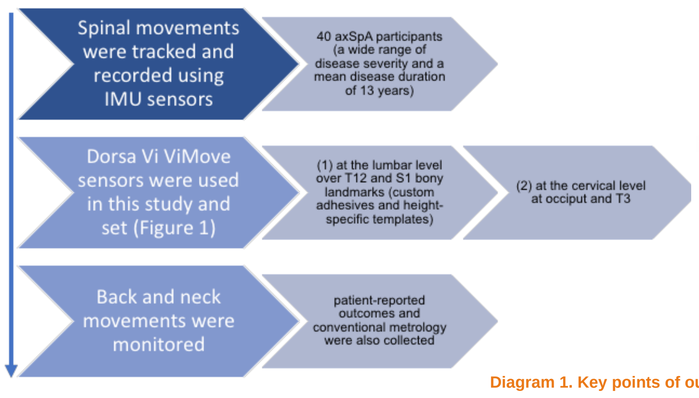


Diagram 1. Key points of our methodology

- Intra-rater, inter-rater and test-retest - with a two week gap between tests - reliability tests were performed in a sequence (Figure 2).

Lumbar and cervical angles were attained and analysed using Intraclass Correlation Coefficients (ICCs)	The six attained values were employed to calculate the "IMU-ASMI" composite score	Pearson correlation coefficients with BASFI were calculated
• The maximum Range Of Movement (ROM) for anterior flexion/extension (Flex), lateral flexion (Left+Right) and rotation (Left+Right) for the lumbar and cervical regions	• It references equivalent ROM values from normal participants in an earlier criterion validity study	• This was done for each component as well as the overall score

Diagram 2. Summary of the analysis conducted

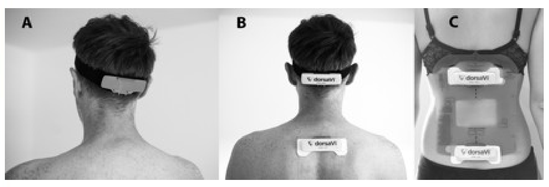


Figure 1. A: Clip-in Baseplate for sensor: B: Positioning of cervical sensors (occiput, T3) C: Positioning of Lumbar sensors using height specific template (T12, S1)

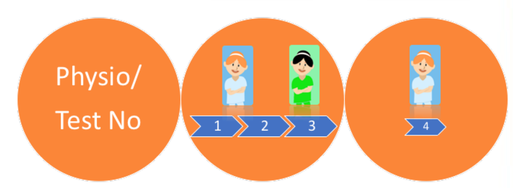


Figure 2. Sensor test schedule sequence

RESULTS

- Pearson correlations for IMU and conventional measurements are shown in Tables 1 and 2

	Cervical IMU			Lumbar IMU			
Movement	Flex	Lat	Rot	Flex	Lat	Rot	IMU-ASMI
Intra-rater	0.95	0.87	0.97	0.89	0.84	0.76	0.96
Inter-rater	0.96	0.96	0.97	0.94	0.94	0.77	0.98
Test-retest	0.92	0.84	0.96	0.91	0.94	0.81	0.97

Table 1. Reliability ICCs for IMU test

	Cervical IMU			Lumbar IMU			
Movement	Flex	Lat	Rot	Flex	Lat	Rot	IMU-ASMI
Intra-rater	N/A	N/A	0.96	1.00	0.94	N/A	0.97
Inter-rater	N/A	N/A	0.91	0.68	0.96	N/A	0.98
Test-retest	N/A	N/A	0.79	0.73	0.91	N/A	0.96

Table 1. Reliability ICCs for conventional spinal test

Sensor tests show excellent reliability

Potential 'floor' effects were seen with some cervical tests, & 'ceiling' effects with some lumbar tests. No such issues were seen with composite IMU values

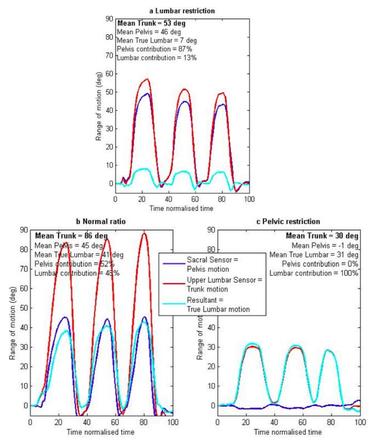
IMU measures showed reliable equivalence with the comparable BASMI measurements (correlating closely)

- Cervical rotation, side flexion, lumbar flexion and cervical flexion with values of r equals to 0.85, 0.84, 0.62 and 0.65 respectively
- The mean BASMI was 4.8 (range from 1.2 to 8.4)

The IMU-ASMI score

- The mean IMU-ASMI score was 4.0 (range from 0.1 to 9.3)
- The correlation between BASMI and IMU-ASMI was 0.88. The correlation between BASFI and BASMI was 0.68 and between BASFI and IMU-ASMI is 0.71

Diagram 3. Summary of the Findings



Examples of Lumbo-pelvic restriction observed on this study

- Lumbo-pelvic restriction unforeseen patterns were found: The mean contribution to the lumbar flexion by the pelvic movement was 52.6%
- 15 out of 40 participants had an abnormal Lumbo-Pelvic Rhythm (LPR): There were identified 7 individuals and 8 individuals with lumbar and pelvic restrictions respectively
  (1) Of these individuals: 12 had trunk flexion <70 degrees.
  (2) In those with trunk flexion >70 degrees, 22 out of 25 had a normal LPR

DISCUSSION AND CONCLUSION

Test-retest reliability of individual cervical movement tests was good to excellent (ICCs >0.8), superior to those reported by Theobald, Jones and Williams (2012)

- Lumbar movement tests had slightly lower test-reliability (ICCs >0.7), similar to the findings reported by Ronchi et al. (2008) and Laird, Kent and Keating (2012) using the same sensor setup
- Combining the right and left or flexion/extension movements improved reliability, probably because it is difficult for assessors to appraise the return to the exact midline point

Both intra-rater and inter-rater reliability were excellent

- Cervical movement tests were more reliable than lumbar spine movement tests
- The variability in lumbar measurements was due to biological variability rather than sensor error. Laird, Kent and Keating (2012) suggested that it was due to inherent variability in the 'lumbo-pelvic rhythm'

IMU sensors tests are of clinical relevance, because they give a detailed overview of movement limitations in degrees by region and movement type

IMU measures showed reliable equivalence with the comparable BASMI measurements, correlating closely

- Lumbo-Pelvic Restriction patterns that were unexpected were found
- IMU sensors were highly reliable in measuring spinal movements for axSPA patients

Acknowledgements

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