

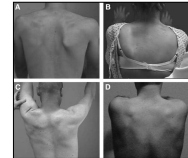
## 3D wireless measurement of scapular movement

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## Problem

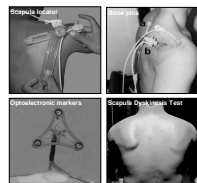
- Important role scapula in shoulder function
  - Scapular dyskinesis
  - Relationship to pathology?
  - (Ab)normal movement pattern?
  - Effect of treatment?



Kibler et al. 2009, 2010, 2012; McClure et al. 2009; Tate et al. 2009

## Problem

- Need for objective, reliable and easy-to-use instrument to measure 3D scapular movement
- To direct and evaluate interventions of scapular dyskinesis
- Short-comings current measures



Messers et al. 2007, McClure et al. 2001, Van Andel et al. 2009, Warner et al. 1990, Tate et al. 2009, Kibler et al. 2009, Ludwig et al. 2011

## Introduction

## Study aim

To assess the intra- and inter-observer reliability, the precision, and the validity of a wireless IMMS-based measurement of 3D scapular motion in healthy subjects and shoulder patients



## Introduction

## New ambulatory system

- Inertial and Magnetic Measurement System (IMMS)
  - Accelerometers
  - Gyroscopes
  - Magnetometers
 } *body segment orientation*
- → wireless
- → easy to apply
- → fast measurement
- Protocol for scapular measurement (iseos)
  - Cutti et al. 2008, Patel et al. 2012 (not wireless)



## Methods

## Subjects

- 20 healthy subjects:
  - 2 days (T0 & T1), 2 experienced physiotherapists (KH & SW)
  - Reliability and precision
- 4 wireless IMMS sensors (MTw) & software (iseos protocol)
  - Xsens Technologies B.V., Culb et al. 2008
  - Scapula, thorax, upper arm, (lower arm)



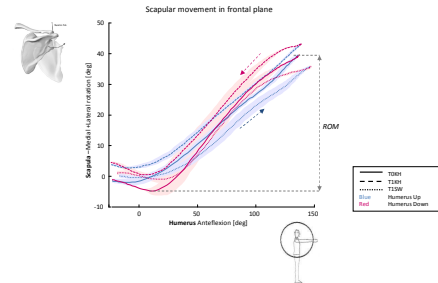
## Measurements

- Movements:
  - Anteflexion & abduction (3x5)
- Positioning and calibration prior to measurement
- Total duration measurement: 20 minutes



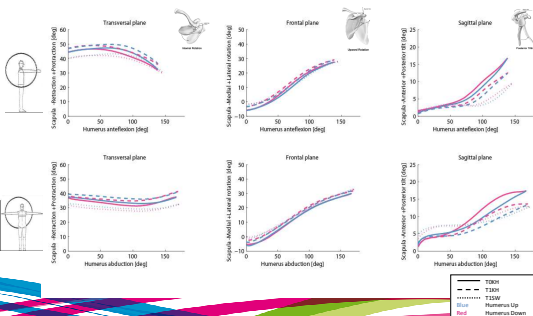
## Methods

## Anteflexion example



## Results

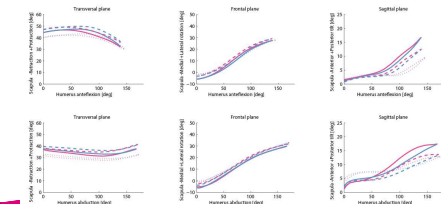
## Mean joint angles



## Results

## Reliability

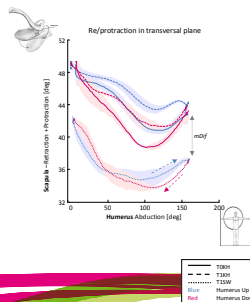
- Intraclass correlation (ICC)
  - $0.73 \pm 0.12$
  - intra = inter
  - lowest ICCs for ant/posterior tilt



## Results

## Precision (measurement error)

- Standard error of measurement (SEM)
  - $\sim 4^\circ$  (1-8°)
- Smallest detectable difference (SDD)
  - $\sim 10^\circ$  (5-21°)
  - highest for re/protraction (smallest range of motion)
- Mean difference (mDiff)
  - $1-7^\circ$
  - highest for re/protraction
- Difference in range of motion (dROM)
  - $3-5^\circ$
  - highest for ant/posterior tilt (lowest reliability)



## Results

## Discussion

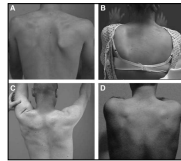
- Scapular motion during dynamic tasks can be measured easily using wireless IMMS
- Differences between observers through:
  - Positioning sensors
  - Calibration sensors (sensor to body segment)
- Comparison with literature:
  - SEM  $\leq$  optical system van Andel et al. 2009
  - SEM = wired IMMS Patel et al. 2012



## Clinically applicable?

### Patients

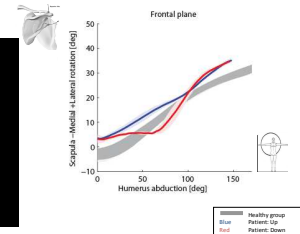
- Errors small enough to measure scapular dyskinesis?
- Study in patients with shoulder pathology and dyskinesis
  - Currently 8
- Comparison to:
  - Scapula dyskinesis test *McClure and Tate et al. 2009*
  - Healthy subjects



## Patient example 1

### Patient

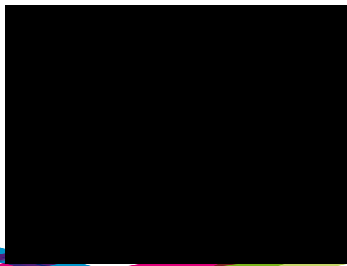
- Disturbed movement pattern during adduction
  - Downward rotation



## Patient example 2

### Patient

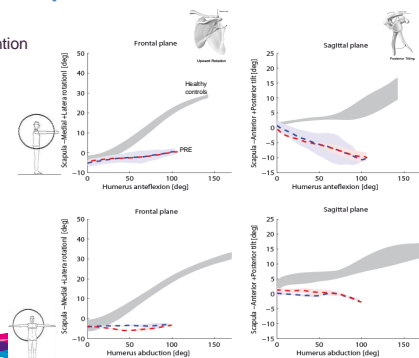
- Instability and hypermobility, resulting in luxation



## Patient example 2

### Patient

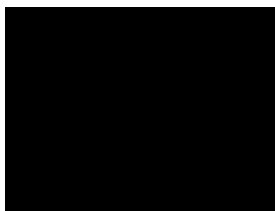
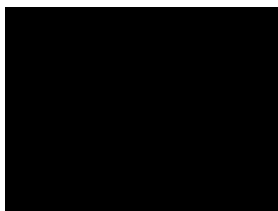
- Pre-intervention



## Patient example 2

### Patient

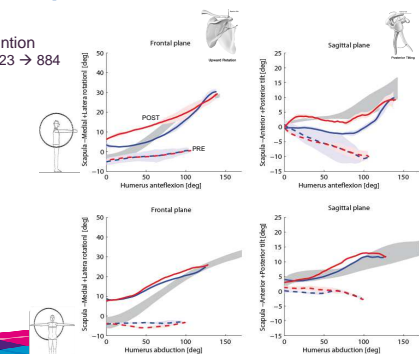
- Intervention
  - Continuous muscle control, cuff coordination, force, stability



## Patient example 2

### Patient

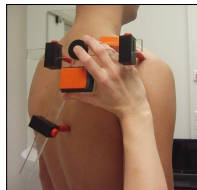
- Post-intervention
  - WOSI 1823 → 884



## To improve...

### Discussion

- Quality of measurement:
  - Use of scapula locator for calibration to improve measurement in static position Masters et al. 2007
- Positioning sensors:
  - Smaller sensors available
  - Placement e.g. on acromion?
- Studies in specific patientgroups
  - E.g. shoulder instability



## Wireless IMMS for clinical use

### Take home



Scapular motion during dynamic tasks can be measured easily using wireless IMMS

Improvement scapular joint angle measurement via the use of a scapula locator

We will follow up by studies on scapular dyskinesis assessment, its relation to pathology and effects of treatment

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