USING INERTIA MEASUREMENT UNIT (IMU) FOR EXERCISE ANALYSIS.

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INTRODUCTION

Accelerosmt

- Widely used in sport science
- Measure physical activity (estimation of energy expenditure)
- Motion analysis (gait, running, vertical jumps)
  - Lometrix => Gait and running
  - Myotest => resistance exercises (squat and bench press), vertical jumps, running
- 3D accelerometer BUT no gyro
- Impossible to analyse movement in 3D
**INTRODUCTION**

- Inertia measurement unit (IMU)
  - 3D accelerometer
  - 3D Gyro
  - Wireless technology
  - Theoretically => 3D exercise analysis in the field and weight -room based environment
  - Relatively untested!
  - Aim of the study: Investigate relevance of IMU system in exercise analysis

**METHODS**

- IMU = Inertia link (Microstrain, USA)
- Triaxial accelerometer (range: ±5g)
- Triaxial gyro (range: ±300°/sec)
- Wireless (range: ±70m)
- Recording frequency = 100hz
- Attached on an elastic belt in the back (close CM)
- Data recorded with Microstrain software and analysed with Labview
## METHODS

### Signal analysis

**Customized Exercises Labview Applications**

- **Common part:** orientation matrix

\[
M = \begin{bmatrix}
\cos(y)\cos(\theta) & \sin(y)\cos(\theta) & -\sin(\theta)
\end{bmatrix}
\]

\[
= \begin{bmatrix}
\cos(y)\sin(\theta)\sin(\phi) - \sin(y)\sin(\theta)\cos(\phi) & \cos(y)\sin(\theta)\cos(\phi) + \sin(y)\cos(\theta) & -\sin(\phi)
\end{bmatrix}
\]

**Vertical** Acc (z)

**Lateral** Acc (y)

**Horizontal** Acc (x)

Where: Pitch = \(\theta\), Roll = \(\phi\), Tilt = \(\gamma\)

### Specific part adapted to exercise specifications

- Split exercises in different phases
- Quantify parameters of interest

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### Tests & Trials Nb

<table>
<thead>
<tr>
<th>Tests</th>
<th>Trials Nb</th>
<th>Familiarization</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VERTICAL JUMPS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SJ</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CMJ</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>DJ (30 cm)</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>HORIZONTAL JUMPS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6CJ</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>SBJ</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5AB</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>SJops (left+right)</td>
<td>2+2</td>
<td>2+2</td>
<td></td>
</tr>
<tr>
<td><strong>Sprint (20m)</strong></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Change of direction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCD (left+right)</td>
<td>2+2</td>
<td>2+2</td>
<td></td>
</tr>
<tr>
<td>DCD (left+right)</td>
<td>2+2</td>
<td>2+2</td>
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</tr>
</tbody>
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16 healthy male subjects (22±3yr; 1.76±0.12m; 72±13kg)

2 identical sessions 1 week apart
METHODS

Three investigations

1. Signal quality
2. Ability of IMU to analyse exercise
3. Inter-session reliability

RESULTS: SIGNAL QUALITY

Exercise with IMU

Recording (Microstrain software)

Wireless

Signal analysis

Influence wireless transmission & could favour data lost

LIMITS & TROUBLES

100hz is not enough...
Antenna position
Labtop performance

LabVIEW

Exercise Labview Applications (ELA)

Relevant parameters
Curves
Signal drift due to Integrals

Signal drift due to orientation error

IMU & EXERCISE ANALYSIS

RESULTS: SIGNAL QUALITY

- Signal drift
  - IMU system enables many measurements for each exercise to be quantified.

RESULTS: EXERCISE ANALYSIS

- Signal drift due to Integrals
  - 20m SPRINT
    - 1st Integral
    - 2nd Integral
  - Signal drift due to orientation error

- Conical
  - Concentric
  - Eccentric

- Displacement (m)
  - Concentric
  - Eccentric

- Power (w)
  - Concentric
  - Eccentric

- Acceleration (m/s²)
  - Concentric
  - Eccentric

- Velocity (m/s)
  - Concentric
  - Eccentric

- Displacement (m)
  - Concentric
  - Eccentric

- Power (w)
  - Concentric
  - Eccentric
RESULTS: EXERCISE ANALYSIS

- IMU system enables many measurements for each exercise to be quantified.

![Graphs showing IMU measurements](image-url)

- Peak and Valley measurements

![Average measurements](image-url)

- Average measurements
For multi-jump (5AB, 5hops, 6CJ) and Sprint exercises
• Analyse impulse by impulse

IMU & Exercise Analysis (Jidovtseff et al.)

IMU is able to analyse variation in horizontal acceleration during SPRINT
IMU is able to measure time variation of different phases during SPRINT

Investigate differences between subjects
Investigate lower limbs imbalance
RESULTS: RELIABILITY

- Reliability is inconsistent
  - **Good to Acceptable** (CV<20%)
    - Exercise and phases duration,
    - Impulse frequency
    - Velocity in the main axis
  - **Moderate to weak** (6%<CV<97%)
    - Acceleration
    - Power
    - Displacement

CONCLUSION

- Many perspectives for IMU in exercise analysis
- Fairly cheap, very light, field utilization
- Afford 3D exercise analysis
- Signal quality and reliability are insufficient

=> Technological improvements are still needed
THANK YOU FOR ATTENTION

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