**3D Motion Capture: Technical details**

<table>
<thead>
<tr>
<th>Recording date</th>
<th>Data sampling rate</th>
<th>Recording time</th>
<th>Average cadence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015/10/15</td>
<td>50 Hz (frames/s)</td>
<td>8.02 s</td>
<td>92 rpm</td>
</tr>
</tbody>
</table>

Min: 92 rpm | Max: 93 rpm

**Bike info**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Frame model</th>
<th>Frame size</th>
<th>Stem length</th>
<th>Handlebar</th>
<th>Saddle</th>
<th>Crank length</th>
<th>Pedal type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>- mm</td>
<td>-</td>
<td>-</td>
<td>175 mm</td>
<td>-</td>
</tr>
</tbody>
</table>

**Main adjustments**

<table>
<thead>
<tr>
<th>Handlebar height</th>
<th>Saddle height</th>
<th>Saddle setback</th>
</tr>
</thead>
<tbody>
<tr>
<td>- mm</td>
<td>- mm</td>
<td>- mm</td>
</tr>
</tbody>
</table>

**Fitter notes**

<table>
<thead>
<tr>
<th>Notes</th>
<th>Bike size assessment</th>
<th>Bike adjustments assessment</th>
<th>Cycling performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>- / 5</td>
<td>- / 5</td>
<td>- / 5</td>
</tr>
</tbody>
</table>
### Lower Limb Kinematics – Feet & Ankles

#### FOOT ROTATION

<table>
<thead>
<tr>
<th>Side</th>
<th>Rotation Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>External rotation (min angle with bike)</td>
<td>3 °</td>
</tr>
<tr>
<td></td>
<td>Internal rotation (max angle with bike)</td>
<td>5 °</td>
</tr>
<tr>
<td></td>
<td>Total rotation range</td>
<td>2 °</td>
</tr>
<tr>
<td>Right</td>
<td>External rotation (min angle with bike)</td>
<td>-6 °</td>
</tr>
<tr>
<td></td>
<td>Internal rotation (max angle with bike)</td>
<td>-4 °</td>
</tr>
<tr>
<td></td>
<td>Total rotation range</td>
<td>2 °</td>
</tr>
</tbody>
</table>

#### FOOT ANGLE TO HORIZONTAL

<table>
<thead>
<tr>
<th>Side</th>
<th>Angle Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>Min/max angle to horizontal</td>
<td>0 °/49 °</td>
</tr>
<tr>
<td></td>
<td>Crank @ left min/max angle to horizontal</td>
<td>87 °/293 °</td>
</tr>
<tr>
<td></td>
<td>Angle to horizontal range</td>
<td>49 °</td>
</tr>
<tr>
<td></td>
<td>Angle to horizontal - Crank @90°/@270°</td>
<td>1 °/48 °</td>
</tr>
<tr>
<td>Right</td>
<td>Min/max angle to horizontal</td>
<td>2 °/49 °</td>
</tr>
<tr>
<td></td>
<td>Crank @ right min/max angle to horizontal</td>
<td>101 °/290 °</td>
</tr>
<tr>
<td></td>
<td>Angle to horizontal range</td>
<td>47 °</td>
</tr>
<tr>
<td></td>
<td>Angle to horizontal - Crank @90°/@270°</td>
<td>2 °/47 °</td>
</tr>
</tbody>
</table>

#### ANKLE FLEXION

<table>
<thead>
<tr>
<th>Side</th>
<th>Flexion</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>Max flexion</td>
<td>81 °</td>
</tr>
<tr>
<td></td>
<td>Max extension</td>
<td>104 °</td>
</tr>
<tr>
<td></td>
<td>Range of motion</td>
<td>23 °</td>
</tr>
<tr>
<td>Right</td>
<td>Max flexion</td>
<td>79 °</td>
</tr>
<tr>
<td></td>
<td>Max extension</td>
<td>104 °</td>
</tr>
<tr>
<td></td>
<td>Range of motion</td>
<td>25 °</td>
</tr>
</tbody>
</table>

#### ANKLE LATERAL OSCILLATION

<table>
<thead>
<tr>
<th>Side</th>
<th>Position in relation to bike (mean)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td></td>
<td>143 mm</td>
</tr>
<tr>
<td></td>
<td>Total swing range</td>
<td>23 mm</td>
</tr>
<tr>
<td>Right</td>
<td></td>
<td>178 mm</td>
</tr>
<tr>
<td></td>
<td>Total swing range</td>
<td>14 mm</td>
</tr>
</tbody>
</table>
Lower Limb Kinematics – Knees

KNEE FLEXION

Left knee flex/extension
77 °/ 152 °
Crank @ left knee flexion/extension
347 °/ 164 °
Range of motion
75 °

Right knee flex/extension
77 °/ 151 °
Crank @ right knee flexion/extension
346 °/ 165 °
Range of motion
74 °

KNEE ANGLE IN RELATION TO CRANK ANGLE

This graph is used for symmetry assessment. The relationship between knee and crank angle would ideally describe overlapped curves.

KNEE LATERAL OSCILLATION

Left knee position in relation to bike (mean)
130 mm
Total swing range
12 mm

Right knee position in relation to bike (mean)
154 mm
Total swing range
14 mm

KNEE TO M5 LATERAL OSCILLATION

Mean left foot position in relation to left knee
48 mm
Total distance range
23 mm

Mean right foot position in relation to right knee
34 mm
Total distance range
19 mm
ANKLE TO KNEE LATERAL DISTANCE

Mean left ankle position in relation to knee
13 mm
Total distance range
18 mm

Mean right ankle position in relation to knee
23 mm
Total distance range
8 mm

KOPS (KNEE OVER PEDAL SPINDLE) DISTANCE

Mean left KOPS
-35 mm

Mean right KOPS
-53 mm

KOPS is defined as the average distance between the tibial tuberosity and the pedal axle in the antero-posterior direction, with a crank angle of 90°. As for the interpretation of the sign (positive or negative):
- When the knee is ahead of the pedal axle, the KOPS is positive.
- When the knee is behind the pedal axle, the KOPS is negative.

KNEE TRAJECTORIES (FRONT VIEW)

Left knee angle with vertical
0°

Right knee angle with vertical
1°
Lower Limb Kinematics – Thighs

**THIGH TILT**

| Direction | Min Angle | Max Angle | Range
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>19°</td>
<td>65°</td>
<td>46°</td>
</tr>
<tr>
<td>Right</td>
<td>21°</td>
<td>67°</td>
<td>46°</td>
</tr>
</tbody>
</table>

Lower Limb Kinematics – Hips & Pelvis

**HIP FLEXION**

| Direction | Flex/Extension | Crank @ Hip Flex/Extension | Range
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>128°/171°</td>
<td>14°/181°</td>
<td>43°</td>
</tr>
<tr>
<td>Right</td>
<td>127°/174°</td>
<td>11°/184°</td>
<td>47°</td>
</tr>
</tbody>
</table>

**HIPS CENTER TO BOTTOM BRACKET AP DISTANCE**

<table>
<thead>
<tr>
<th>Direction</th>
<th>Minimum Distance</th>
<th>Maximum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>182 mm</td>
<td>206 mm</td>
</tr>
<tr>
<td>Right</td>
<td>209 mm</td>
<td>222 mm</td>
</tr>
</tbody>
</table>

**ANKLE TO HIP LATERAL DISTANCE**

<table>
<thead>
<tr>
<th>Direction</th>
<th>Mean Position</th>
<th>Total Distance Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>-10 mm</td>
<td>13 mm</td>
</tr>
<tr>
<td>Right</td>
<td>-1 mm</td>
<td>8 mm</td>
</tr>
</tbody>
</table>
Bike fitting (body & floor)

**HIPS CENTER VERTICAL TRAVEL**

- Total vertical travel (range of motion): 6 mm

**HIP SETBACK**

- Mean hips center setback: 74 °

**PELVIS ROTATION**

- Left/right rotation (mean): -1 ° / 5 °
- Total rotation (range of motion): 6 °

**PELVIS LATERAL OSCILLATION**

- Left swing (mean): 17 mm
- Right swing (mean): 26 mm
- Total swing (range of motion): 9 mm
- Pelvis position in relation to bike: 21 mm

**Trunk Kinematics**

**HIP TO SHOULDER TILT**

- Minimum left hip-shoulder angle: 52 °
- Maximum left hip-shoulder angle: 55 °
- Range of motion: 3 °

- Minimum right hip-shoulder angle: 49 °
- Maximum right hip-shoulder angle: 52 °
- Range of motion: 3 °

**TRUNK TILT (SACRUM-NECK)**
Average trunk angle to horizontal (Sacrum to neck segment)

- **40°**
- Range of motion **23°**

**Back & Shoulders Kinematics**

**BACK VERTICAL OSCILLATION**

**HIP – SHOULDER – ELBOW**

- Minimum left hip-shoulder-elbow **60°**
- Maximum left hip-shoulder-elbow **62°**
- Range of motion **2°**

- Minimum right hip-shoulder-elbow **66°**
- Maximum right hip-shoulder-elbow **68°**
- Range of motion **2°**

**SHOULDER LATERAL OSCILLATION**

- Left swing (mean) **13 mm**
- Right swing (mean) **32 mm**
- Total swing (range of motion) **19 mm**
Average shoulder position in relation to bike

23 mm

**Arms Kinematics**

**ELBOW FLEXION**
- Average left elbow flexion: 137°
- Range of motion: 10°
- Average right elbow flexion: 149°
- Range of motion: 14°

**FOREARM TILT**
- Min left forearm angle to horizontal: 27°
- Max left forearm angle to horizontal: 31°
- Range of motion: 4°
- Min right forearm angle to horizontal: 39°
- Max right forearm angle to horizontal: 43°
- Range of motion: 4°

**SHOULDER TO WRIST LATERAL DISTANCE**
- Mean lateral distance between left shoulder and wrist: -16 mm
- Range of motion: 32 mm
- Mean lateral distance between right shoulder and wrist: -15 mm
- Range of motion: 33 mm
Automated anthropometry measures

Upper arm length
(Shoulder to elbow segment)

337 mm 287 mm

Forearm length
(Elbow to wrist segment)

242mm 261mm

Spine length
(Sacrum to neck segment)

557 mm

Shoulder distance
(Right shoulder to left shoulder segment)

374 mm

Thigh length
(Hip to knee segment)

398 mm 409 mm

Tibia length
(Knee to ankle segment)

388 mm 398 mm

Hip to wrist - vertical
(Mean distance from hip to wrist)

69 mm 86 mm

Hip to wrist - horizontal
(Mean distance from hip to wrist)

588 mm 589 mm

Notes: