

Biomechanics of the Knee

Knee: Largest & perhaps most complex joint in body.

2 separate joints in knee:
1) Femoral (flex) & tibial (ext) joints.

Situated between the two longest bones in the body—moment arms for bending moments are large.

Kinematics (study of motion w/r to forces causing motion)

- 3D motion is allowed at the knee but most occurs in one plane: flexion (flex-ext)
- Also allows movement in plane when (and only when) knee is flexed:
  - Internal/External rotation
  - Some very limited motion occurs in abduction/adduction (however, this is not voluntary for most part).

Ranges of motion (normal ranges)

0° flexion
0° ext rot 0° int rot

Knee angle

These values decrease when knee becomes less flexed.

Passive abduction/adduction—few degrees possible: max when knee is 30° flexed
None possible at

Ranges of motion during walking

Murray et al. (1967) Flex/ext N=60

Bone sizes: Slevens et al. (1948) Int/ext rot. ROM N=12

Kettlekamp et al. (1960) Slightly higher values for int/ext than Slevens

Both studies indicate:
- Occurs during knee in stance and end of swing phase before HS
- Occurs during knee in swing phase

Kettlekamp also measured ab/adduction ROM of other activities—see Tables!

Surface joint motion—what goes on between the surfaces of the femur and the tibia? Does one surface roll off the other during knee motion? Or does it slide along the other? Or some combination thereof?

Instantaneous center of rotation (ICR)
**Instantaneous Center of Rotation**

- Wheel spinning about its own axis: ICR
- Wheel w/o on ground: pure translation + ICR
- Wheel rolling + slipping on ground: ICR is undefined

Direction of the contact point displacement (see Fig.)

Examine the direction of movement of contact point (B) relative to the tibia surface.

If the direction of $\vec{B}$ is then we say the femur is "over the tibia" (normal)

Abnormal:
Example of Abnormal LCR pattern in "Bucket-handle" devangement of Knee (meniscus tear)

Screw-home mechanism (see Fig)
- used to determine if the normal screw home mechanism is intact. If not present, then may indicate altered surface joint motion. Damage to the surfaces may result over time.

However: Data from LaFortune PhD dissertations, Penn State (1984).

Used bone pins in living subjects during walking. Found of the screw home mechanism during walking. Also found skin moves a lot over the bones.

As knee moves from full extension to full flexion, the patella glides distally down the femoral condyle.

Patellofemoral pain is the most common knee ailment. Improper patella tracking as it moves down & up the groove between the femoral condyles can produce abnormal loading between patella & the femur.

Normal surface joint motion indicates gliding of patella over the femoral surface.
Biomechanics of the Knee (Incomplete Notes)

Note: These are figures and tables from Chapter 6 of old book.

**TABLE 6-1**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Range of Motion from Knee Extension to Knee Flexion (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>0–67*</td>
</tr>
<tr>
<td>Climbing stairs</td>
<td>0–83†</td>
</tr>
<tr>
<td>Descending stairs</td>
<td>0–90</td>
</tr>
<tr>
<td>Sitting down</td>
<td>0–93</td>
</tr>
<tr>
<td>Tying a shoe</td>
<td>0–106</td>
</tr>
<tr>
<td>Lifting an object</td>
<td>0–117</td>
</tr>
</tbody>
</table>

*Data from Ketelkamp et al., 1970: Mean for 22 subjects. A slight difference was found between right and left knees (mean for right knee 68.1 degrees, mean for left knee 66.7 degrees).
†These and subsequent data from Laubenthal et al., 1972. Mean for 30 subjects.

**TABLE 6-2**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Amount of Knee Flexion during Stance Phase of Walking and Running (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td>0–6</td>
</tr>
<tr>
<td>Free</td>
<td>6–12</td>
</tr>
<tr>
<td>Fast</td>
<td>12–18</td>
</tr>
<tr>
<td>Running</td>
<td>18–30</td>
</tr>
</tbody>
</table>

(Data from Perry et al., 1977. Range for seven subjects.)
Screw-home mechanism of the tibiafemoral joint. During knee extension the tibia rotates externally. This motion is reversed as the knee is flexed. A. Oblique view of the femur and tibia. Shaded area indicates the tibial plateau. B. Top view showing the position of the tibial plateau on the femoral condyles in knee flexion (left) and extension (right). The solid outlines represent the femoral condyles; the broken lines represent the tibial plateau. (Adapted from Hellest, 1974.)

Heller test. A. In a normal knee flexed 90 degrees the tibial tuberosity aligns with the medial half of the patella. B. When the knee is fully extended the tibial tuberosity aligns with the lateral half of the patella.

End Knee Part 1 (Anatomy and Kinematics)

Beginning page K11 will be Knee Part 2 (Kinetics)