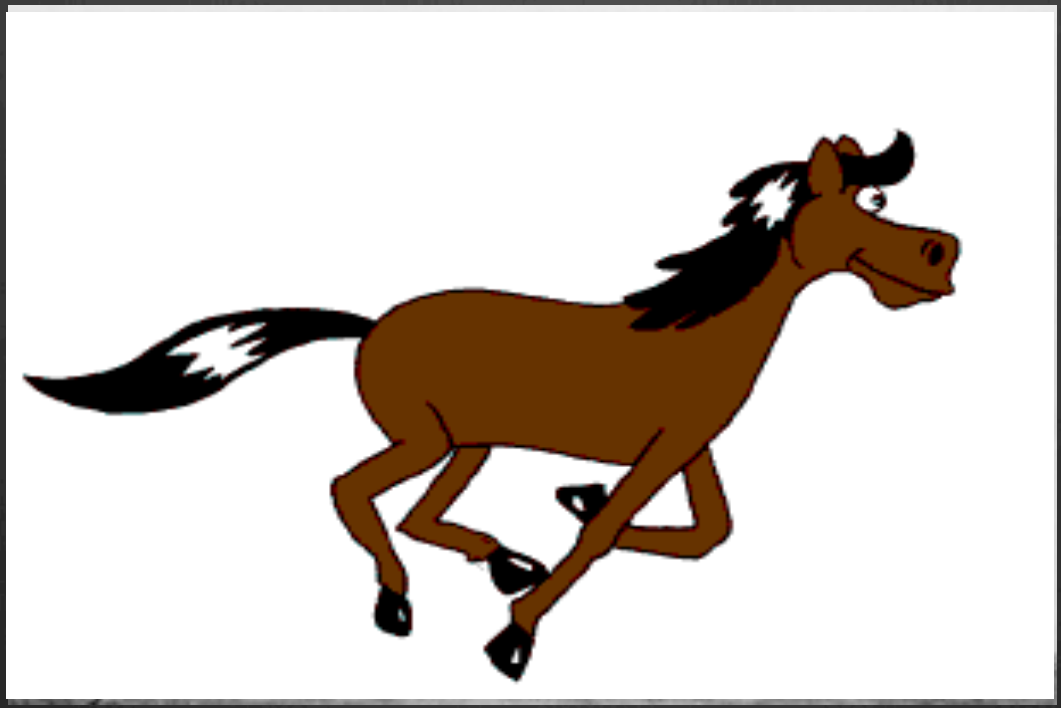
Why do we want to capture the motions?

Does the galloping horse ever lifts all four feet completely off the ground? Eadweard Muybridge



What is Mocap?

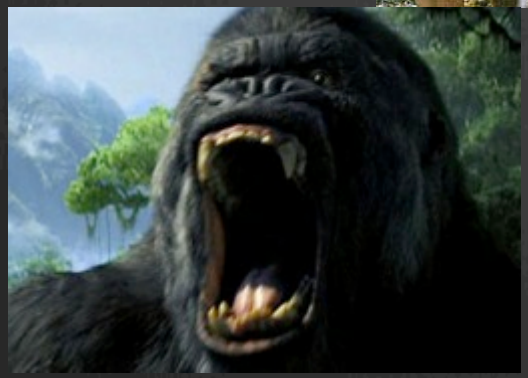
- Motion capture (mocap) is sampling and recording motion of humans, animals, and inanimate objects as 3D data.
- The data can be used to study motion or to give an illusion of life to 3D computer models.

Applications

- Entertainment
- Arts/ Education
- Science/ Engineering
- Medicine/ Sports

Entertainment: Live Action Films

- Computer generated characters in live action films (e.g ***Star Wars PrequelsThe Lord of the Rings, King Kong Pirates of Caribbean***)



Entertainment: 3D computer animations

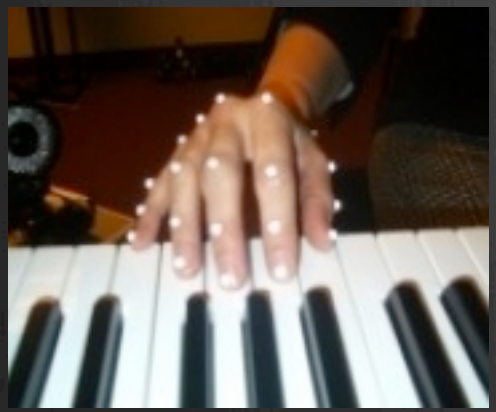
- Characters in computer animated files (e.g. **Polar Express**, **Monster House**)

Entertainment: Video Games

- Video games by Electronic Arts, Gremlin, id, RARE, Square, Konami, Namco, and others, (e.g. **Enemy Territory, Devil May Cry**)

Arts / Education

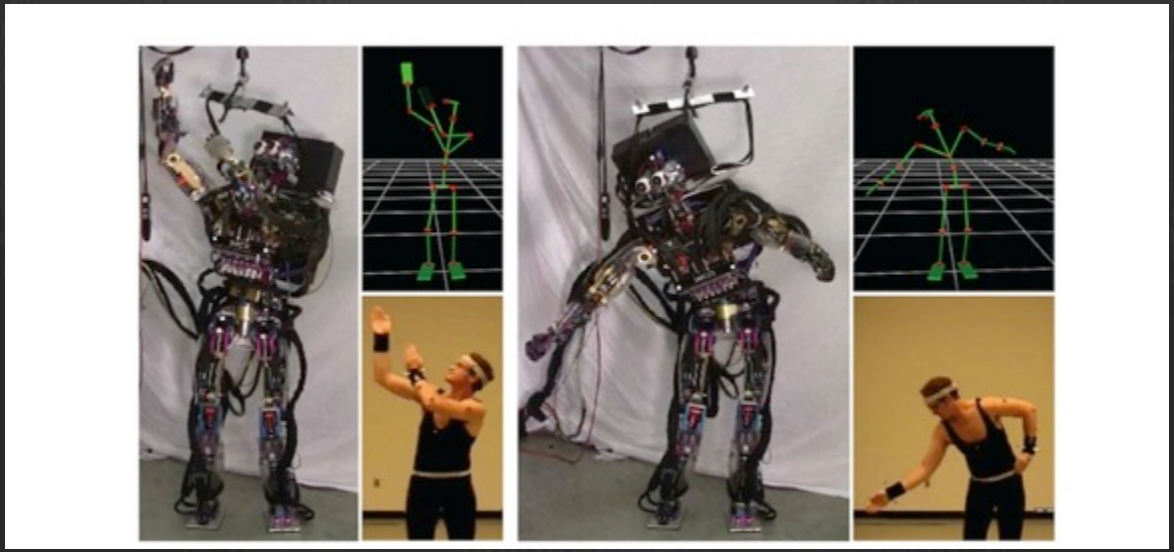
- Dance, music and theatrical performances



Science / Engineering

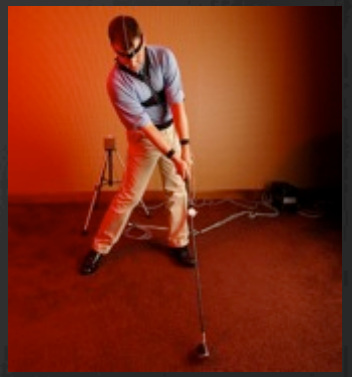
- Computer Science (e.g., human motion database, indexing, recognitions)

- Engineering (e.g., robot developments)



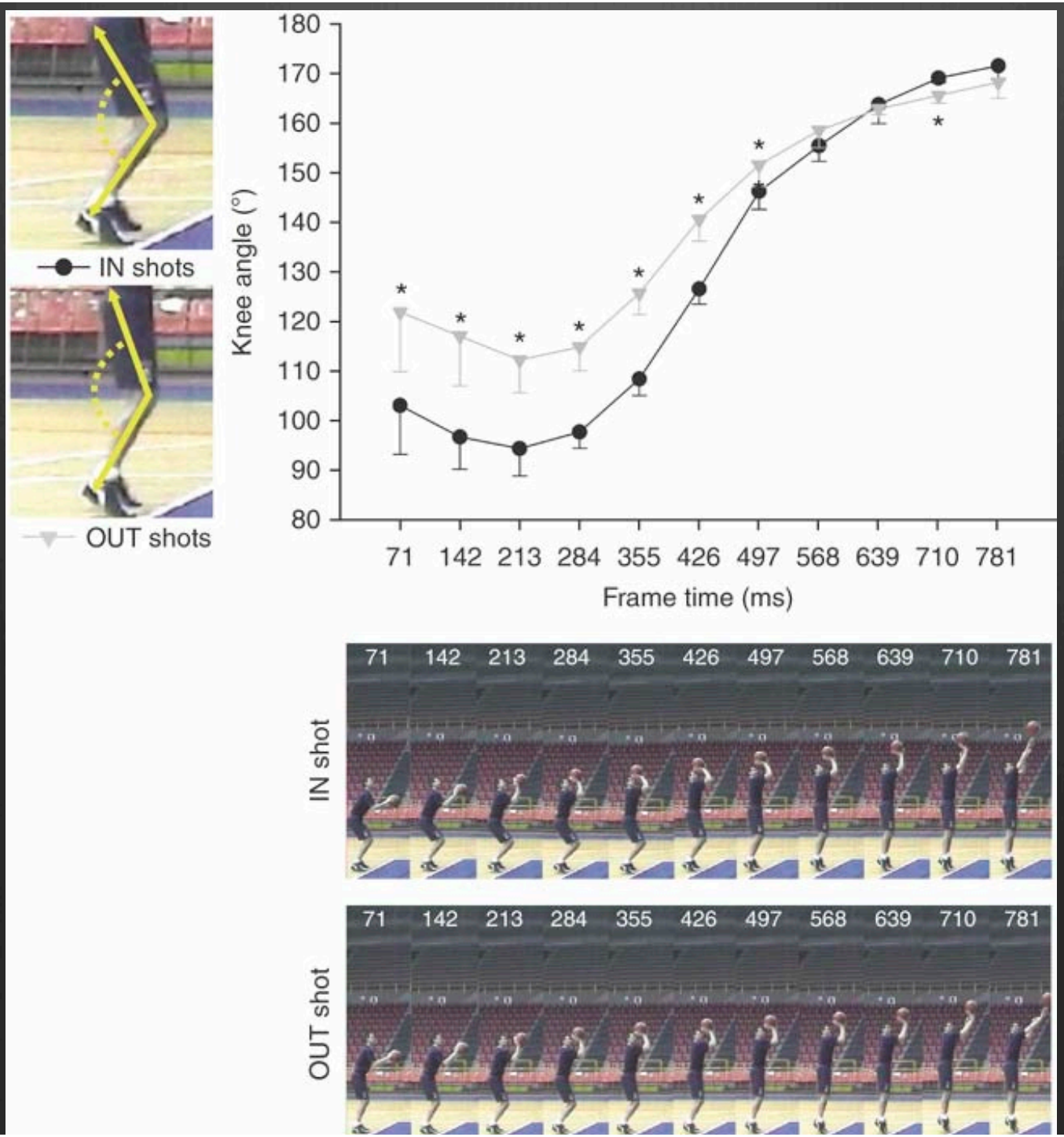
Medicine / Sports

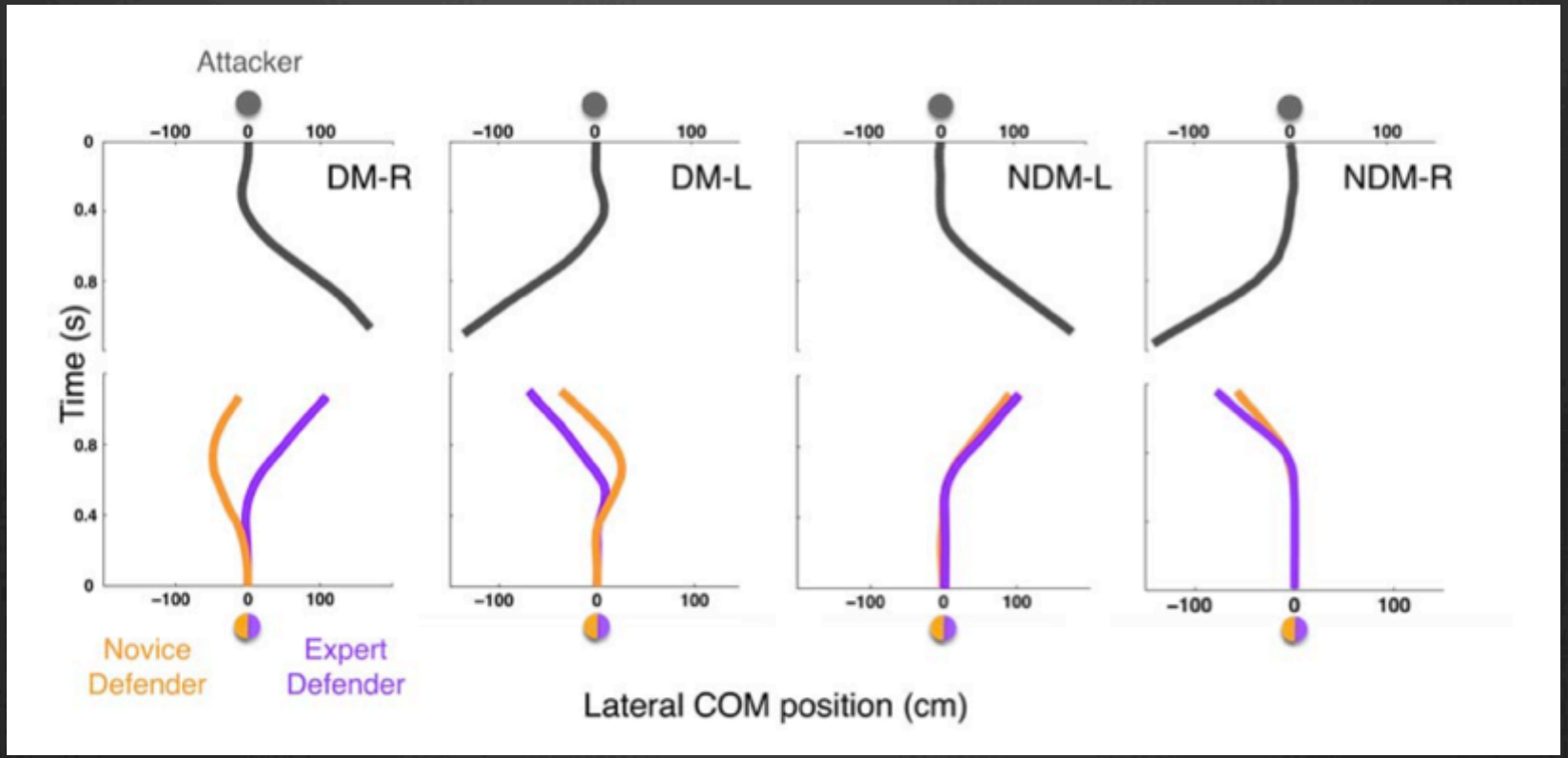
- Medicine (e.g., gait analysis, rehabilitation)
- Sports (e.g. injury prevention, performance analyses, performance enhancement)



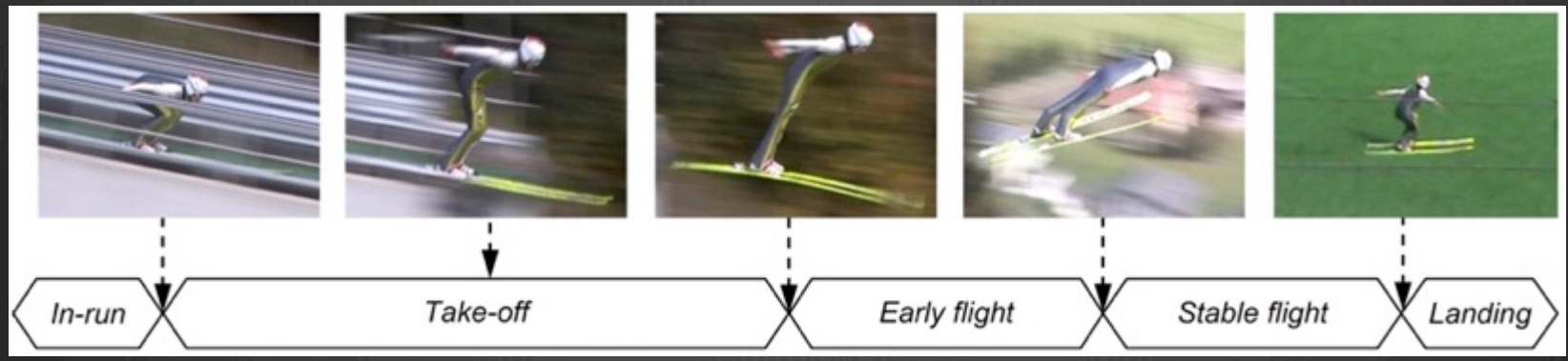
What lifting kinematics (techniques) can minimize mechanical stress on the low back?

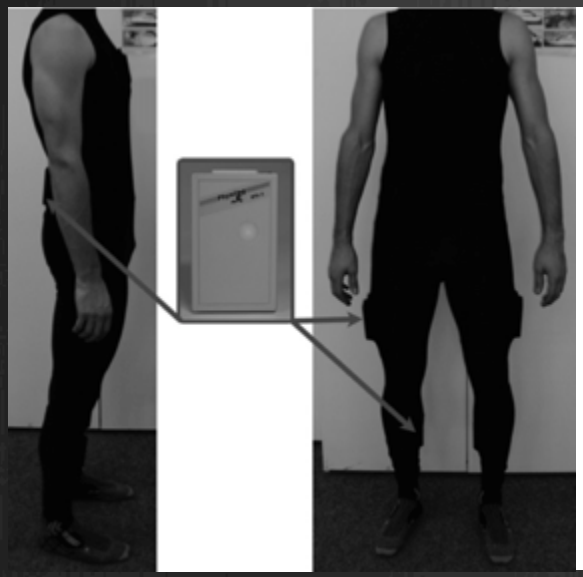
Pitching can lead to stress injuries of the elbow and shoulder joints. What pitching technique characteristics minimize the mechanical stresses to these joints?

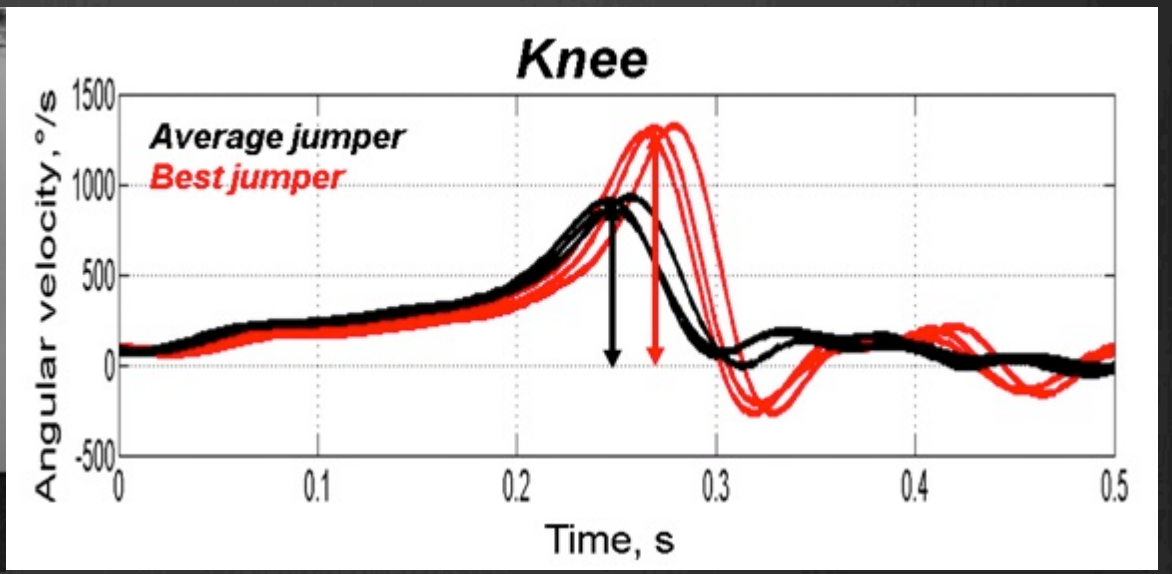

IN shots
OUT shots
Knee angle (°)
180
170
160
150
140
130
120
110
100
90
80
71 142 213 284 355 426 497 568 639 710 781
Frame time (ms)
IN shot
OUT shot
71 142 213 284 355 426 497 568 639 710 781


Attacker
DM-R
DM-L
NDM-L
NDM-R
−100
0
100
Time (s)
0
0.4
0.8
Novice Defender
Expert Defender
Lateral COM position (cm)

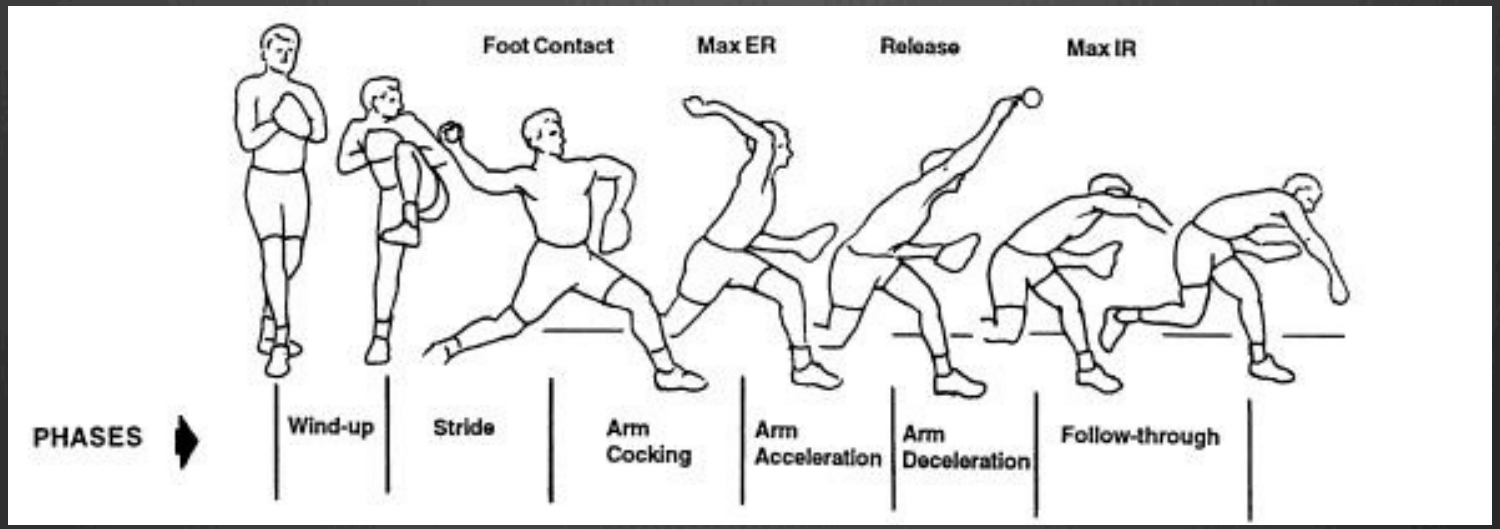
Ski jump


In-run
Take-off
Early flight
Stable flight
Landing




Knee
Average jumper
Best jumper
Angular velocity, °/s
1500
1000
500
0
-500
0
0.1
0.2
0.3
0.4
0.5
Time, s

Differences between athletes and novice athletes



Momentum builds with each body movement causing the kinetic energy of the ball to increase and reach a peak at the release point. The release point is where the hand reaches maximum velocity.

Dynamics of the Shoulder and Elbow Joints of the Throwing Arm During a Baseball Pitch

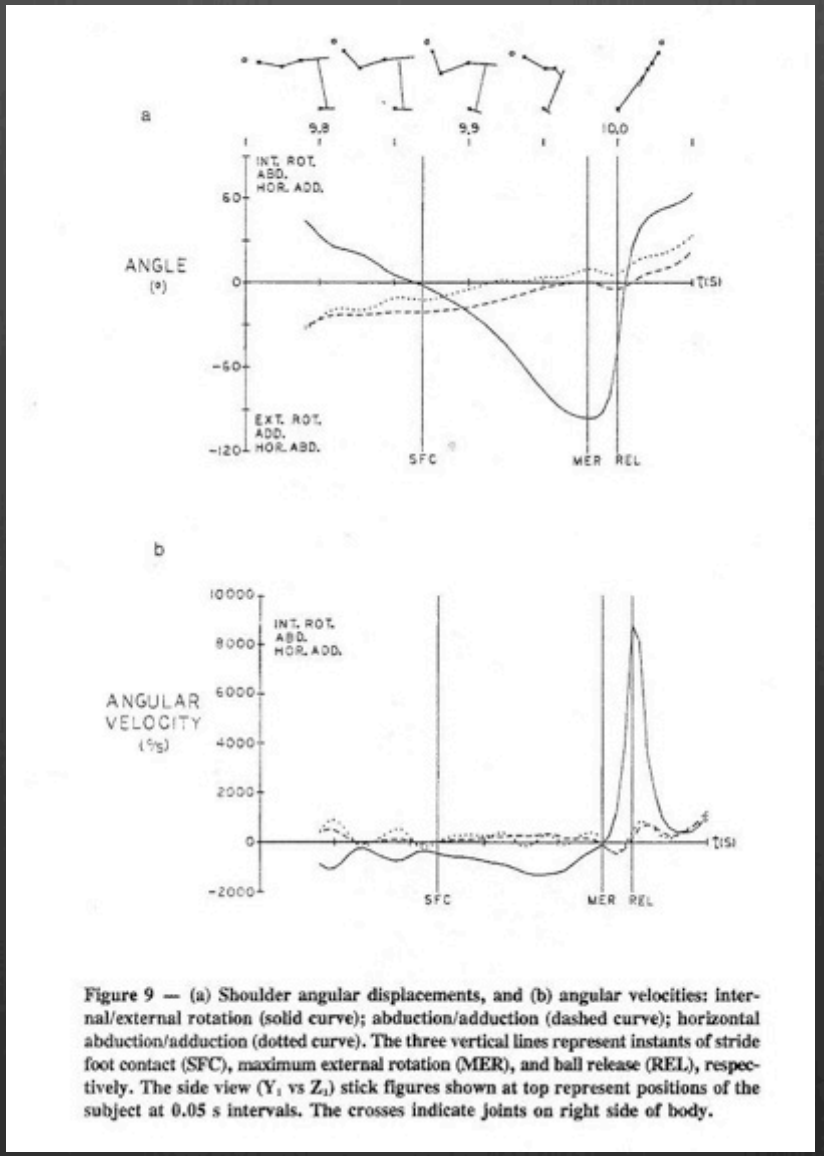
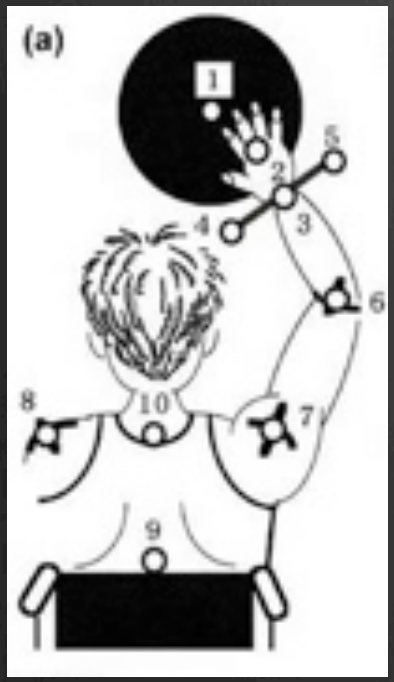


Figure 9 — (a) Shoulder angular displacements, and (b) angular velocities: internal/external rotation (solid curve); abduction/adduction (dashed curve); horizontal abduction/adduction (dotted curve). The three vertical lines represent instants of stride foot contact (SFC), maximum external rotation (MER), and ball release (REL), respectively. The side view (Y_1 vs Z_1) stick figures shown at top represent positions of the subject at 0.05 s intervals. The crosses indicate joints on right side of body.

A kinematic study of the upper-limb motion of wheelchair basketball shooting in tetraplegic adults



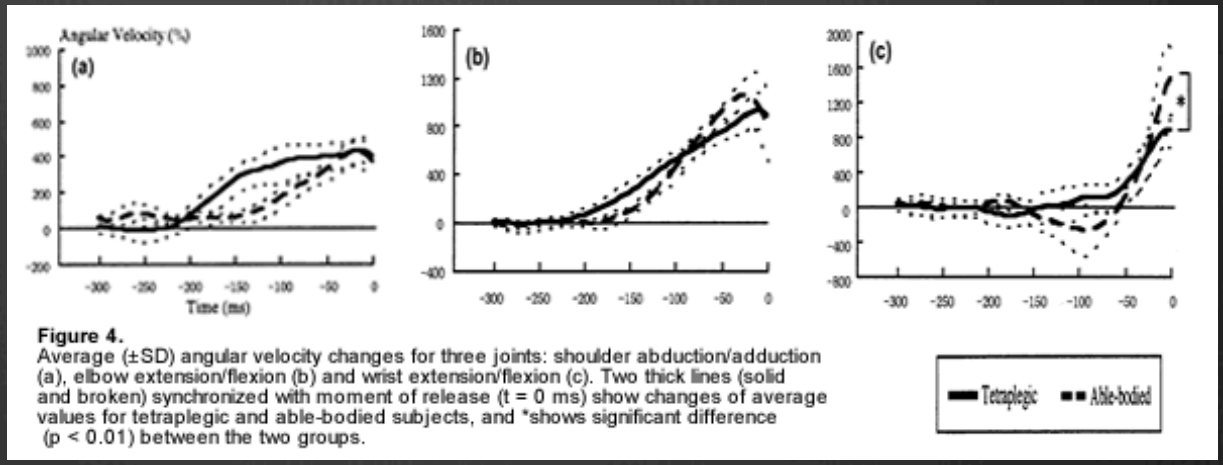


Figure 4.
Average (±SD) angular velocity changes for three joints: shoulder abduction/adduction (a), elbow extension/flexion (b) and wrist extension/flexion (c). Two thick lines (solid and broken) synchronized with moment of release (t = 0 ms) show changes of average values for tetraplegic and able-bodied subjects, and *shows significant difference ($p < 0.01$) between the two groups.

Kinematic Analysis of Volleyball Spiking Maneuver

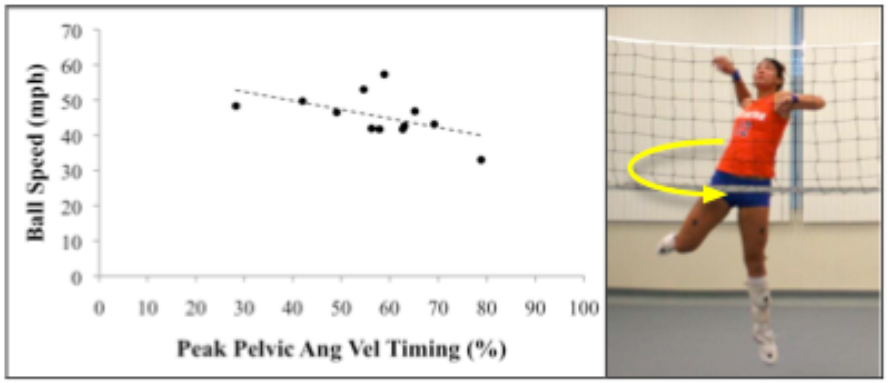


Figure 2: Earlier peak pelvic angular velocity was positively correlated with higher ball speed.

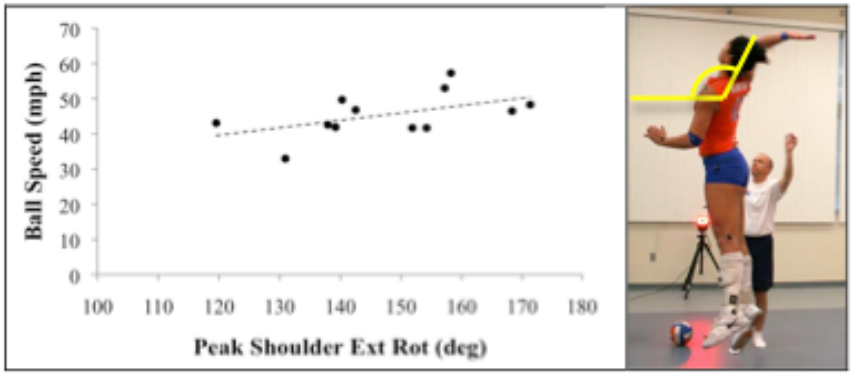
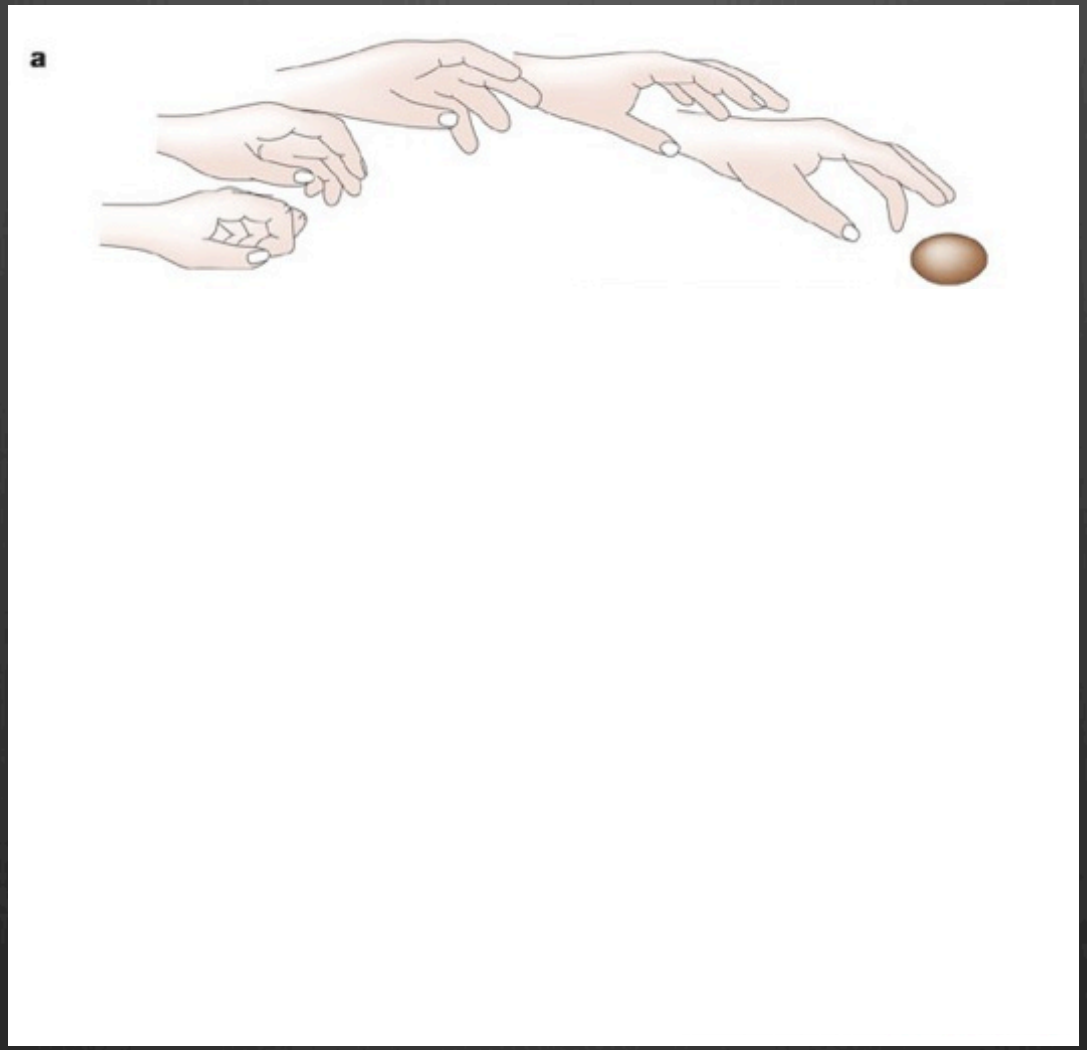
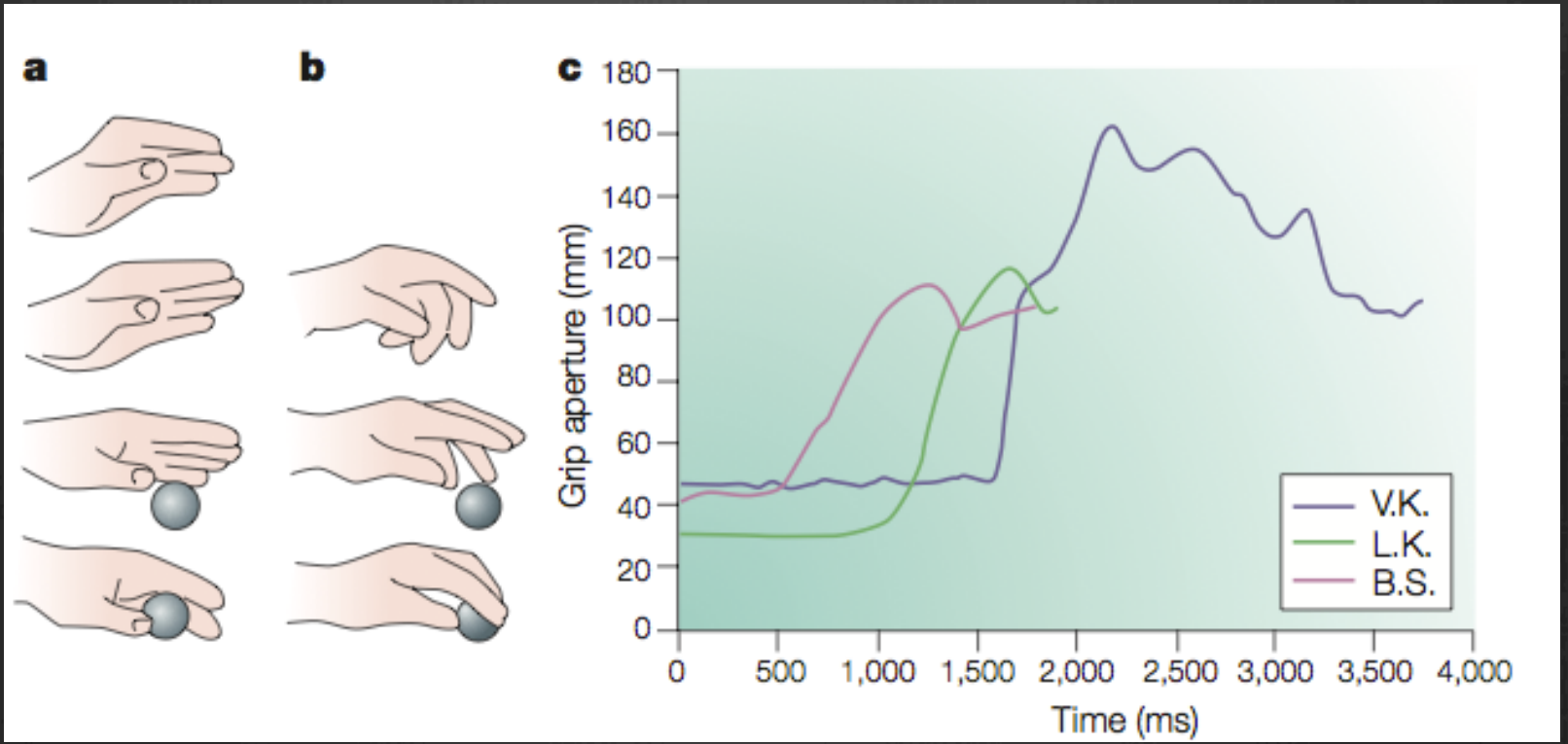


Figure 3: Peak shoulder external rotation was positively correlated with higher ball speed.

Grasping

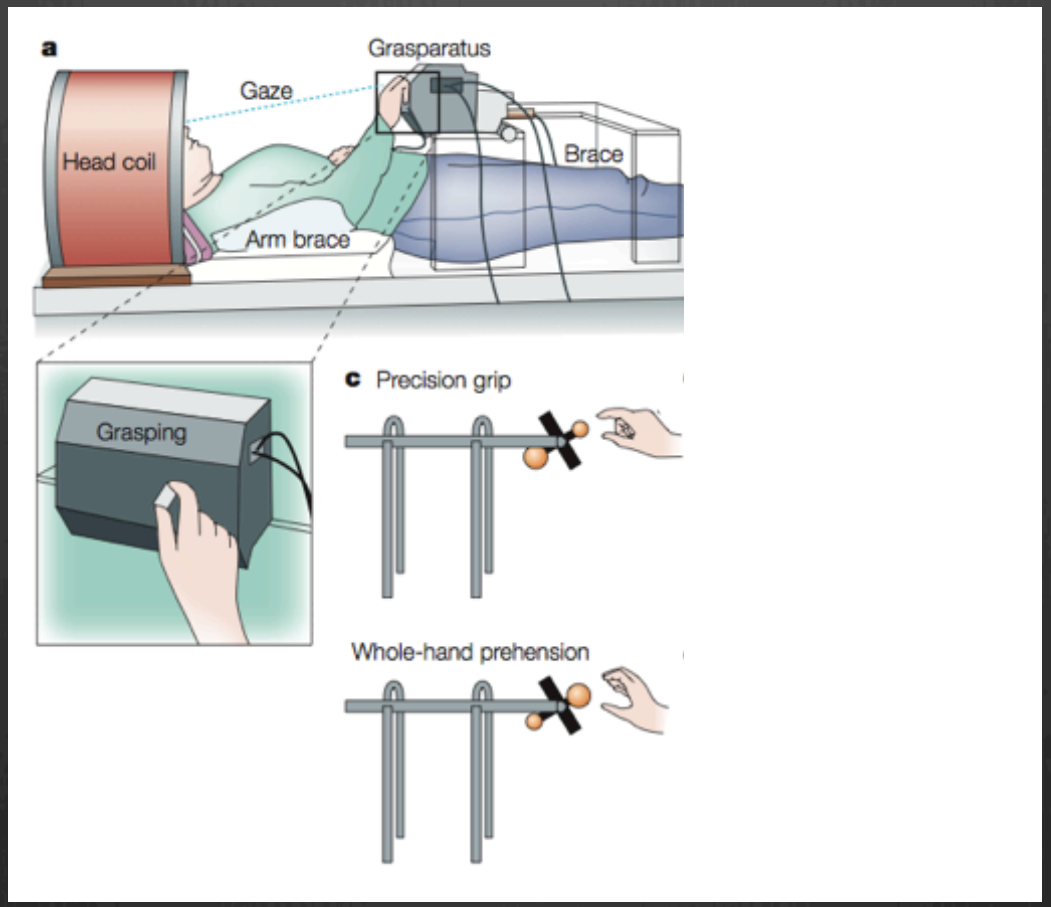


Grasping
patients with brain damage



V.K: patient
L.K. and B.S: healthy participants

Grasping and Brain

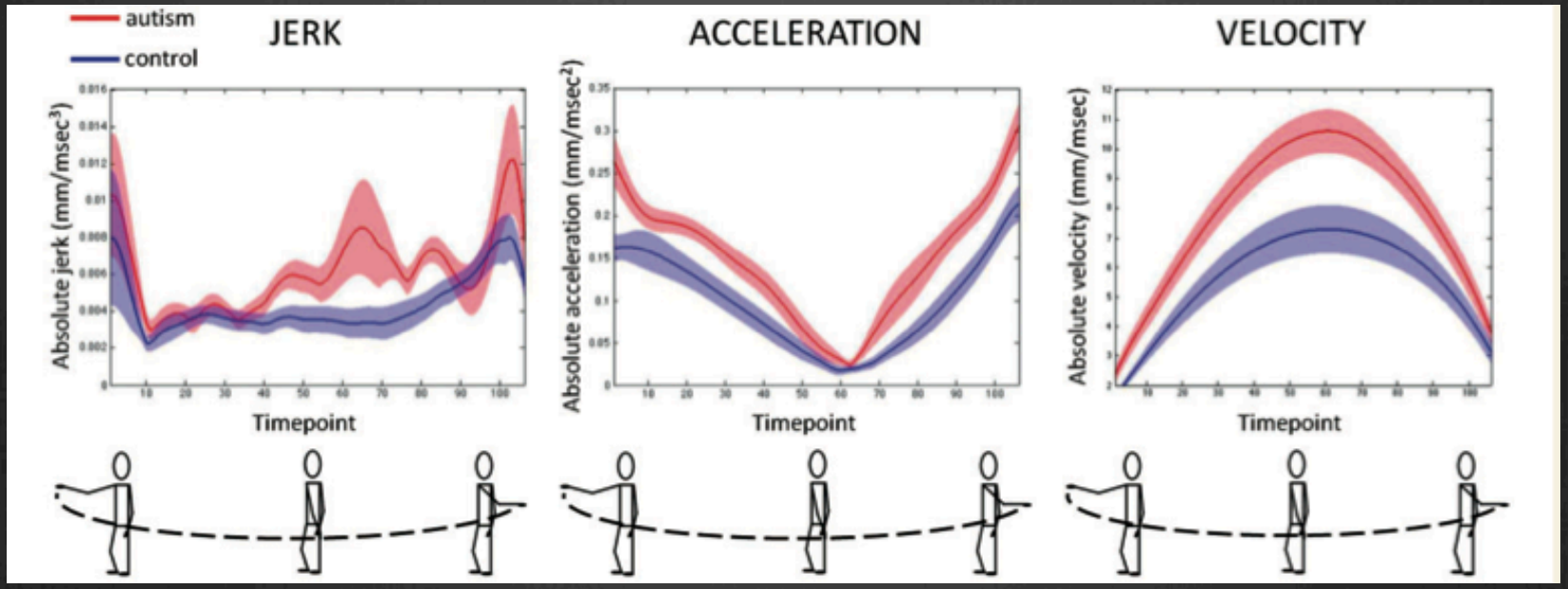


Grasping

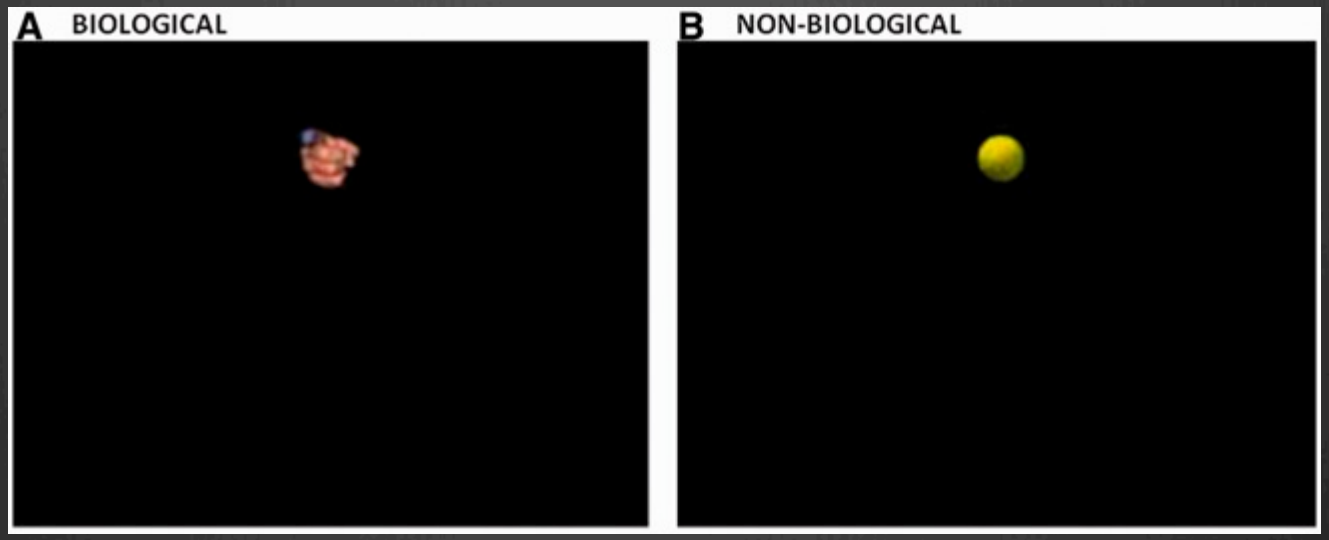
- Heavy and light balls
- Which one needs a larger grip?
- Open eyes and closed eyes?

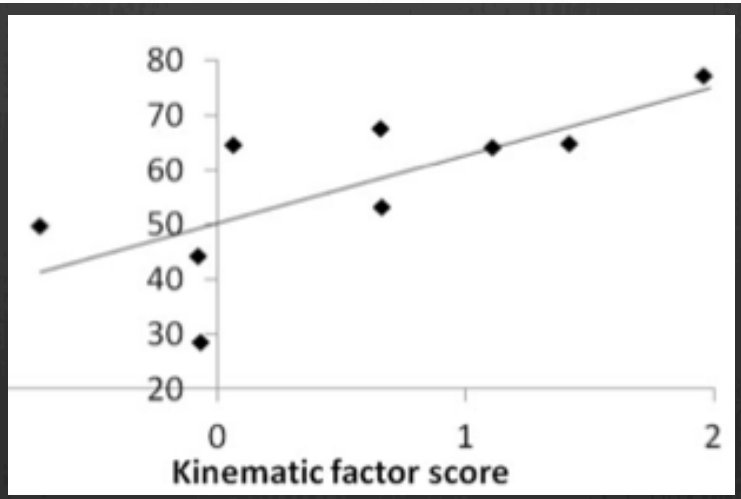
kinematics in autism

kinematics in autism



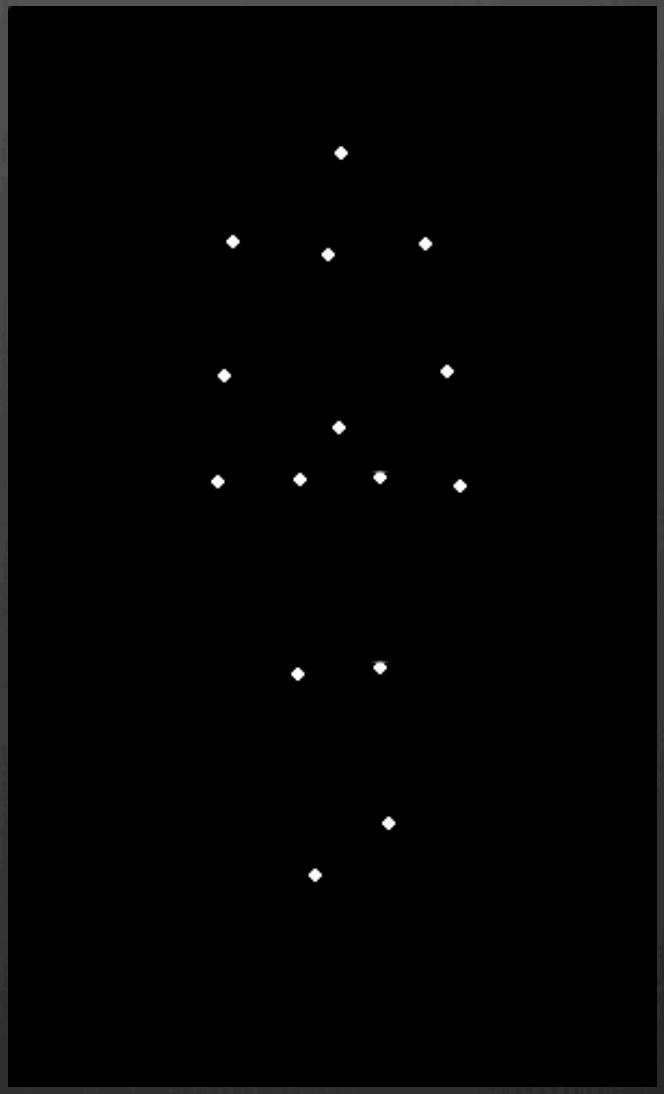
Cognitive perception of the movement



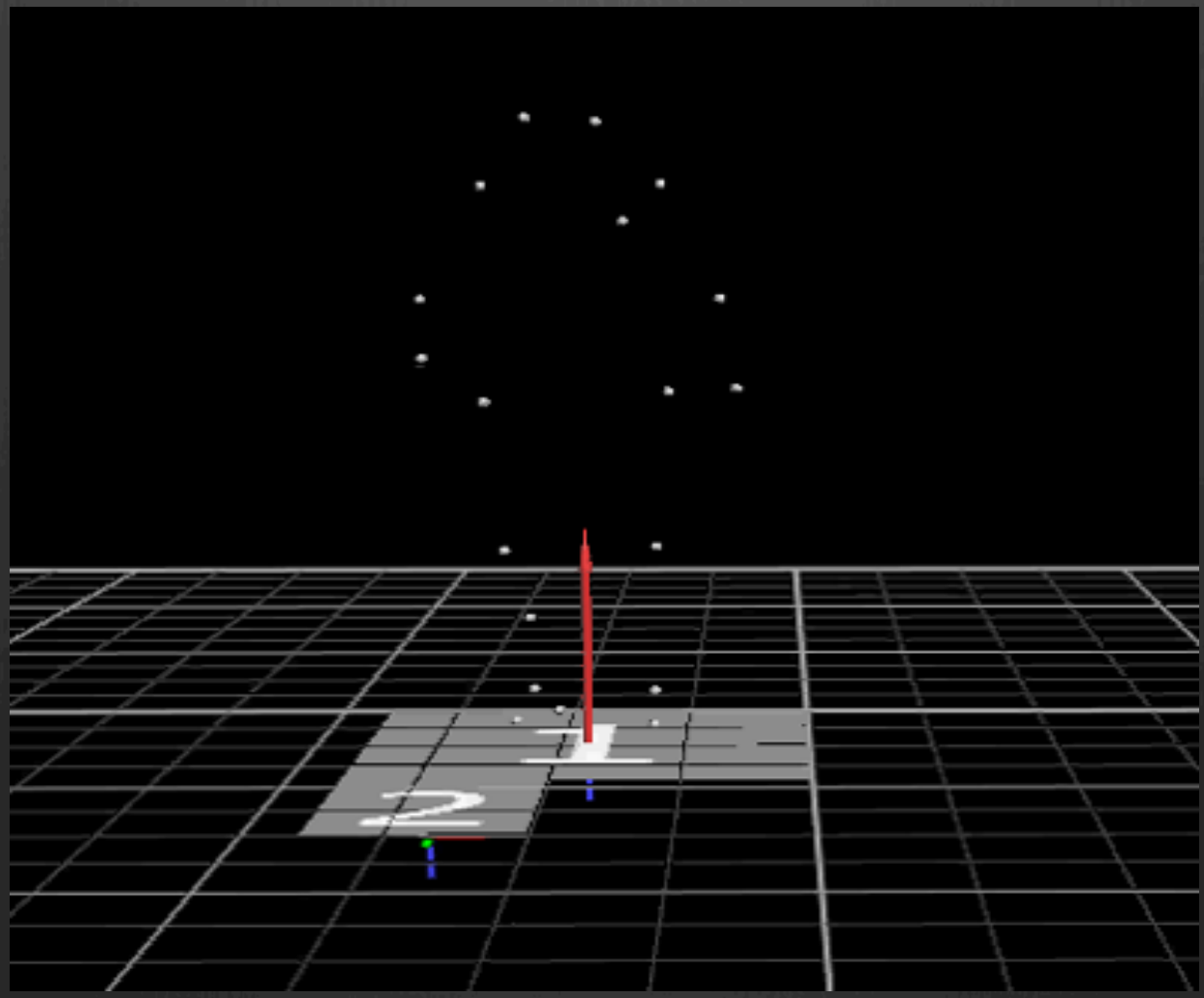


Perception of biological motion

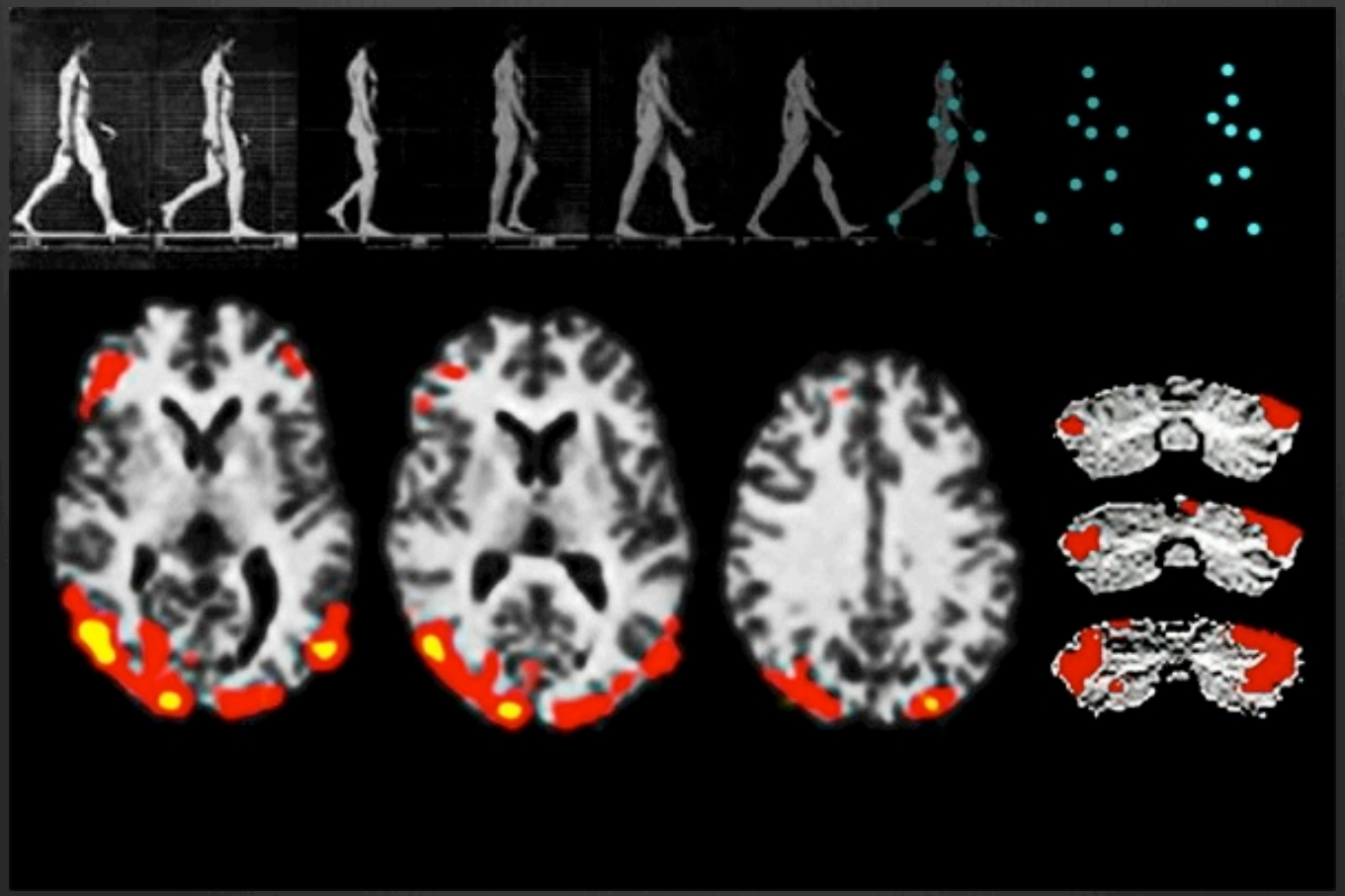
- Click here



chi è e cosa fa ?



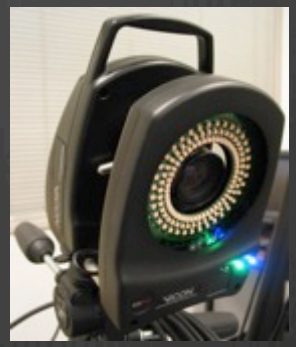
Functional Neuroanatomy of Biological Motion Perception in Humans



VICON components

- Retro-reflective markers

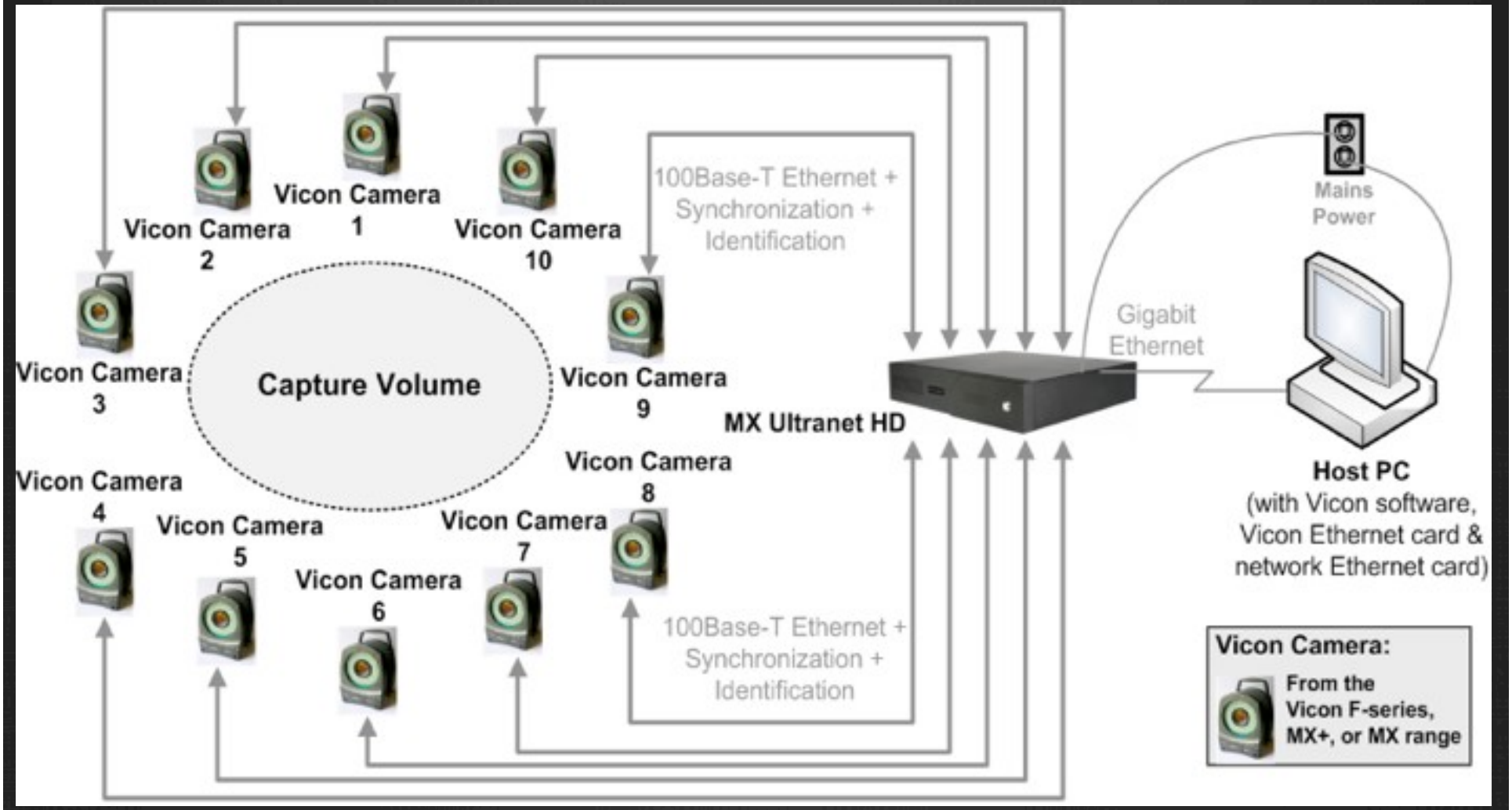
- MX-F40 cameras
  - high resolution (4 Megapixel)
  - high speed (370Hz)
  - tuned for detecting IR light



- MX Ultranet hardware
  - receives raw point information from cameras

- Host computer

VICON Nexus workflow



Nexus 4-steps working process

1. System preparation
   - 1.1 Where? (capturing volume & cameras)
   - 1.2 How? (relationship between them)
2. Subject preparation
   - 2.1 Where? (placement of markers)
   - 2.2 How? (relationship between them)
3. Performing a capture
4. Checking & output the data

1. System preparation

1.1 Where? (capturing volume & cameras)

- Define capturing volume

  - Remove the possible noise (unwanted reflections)

- Optimize the camera position & settings

  - Cover the capturing volume as much as possible

  - Threshold & intensity of each camera

1.2 How? (relationship between them)

- Camera calibration

- Dynamic calibration: define where cameras are in space with respect to each other

- Static calibration: set the origin & direction of 3-axes

2. Subject preparation

2.1 Where?

- Attachment of markers as needed

2.2 How?

- Set subject model
- Subject capture
  - Label markers & define segments + joints
  - Subject calibration

3. Performing a capture

- Click “capture”!

4. Checking & output the data

- Gap filling of the capture
- Output the data for analysis

Camera calibration

- Dynamic: Cameras need to know where they are in space with respect to each other (for optimal 3D-reconstruction)
  - Rain dance in front of all cameras

    Wave the wand making fast 3D figure-eight movements with the wand, covering the whole 3D-volume

- Static: Definition of origin and direction of x, y and z-axes

Subject preparation

- Computer needs information about subject & markers
  - How markers relate to body positions
  - Occlusion

    marker not seen by 2 cameras for certain period
  - Crossover

    system confuses markers with one another

Attachment of Markers

- To capture the movement of the underlying skeleton
- Markers should be placed at specific and easily identified anatomical locations
- Make sure markers are fixed well and stay in position

Subject template & calibration

- Nexus requires a description of the generic relationship between segments-joints-markers (template)
- This information identifies which markers to track and how these markers are connected to the underlying segments
- Subject stands in neutral T-pose or specific pose as the starting position of the movement to be captured

Subject model

- Creating a model

  1. Display a 3D-perspective and view the unlabeled markers on the subject

  2. Labeling markers, creating segments and linking segments

- Using the implemented template

Label/Edit

- Manually labeling

- Gap filling

  - Spline fill

  - Pattern fill

Pipeline

- How to process the capturing
- Outputting the data