מדידות קינמטיות להערכת תנועות הושטה ואחיזה

פרופ' ג'ייסון פרידמן
החוג לפיזיותרפיה
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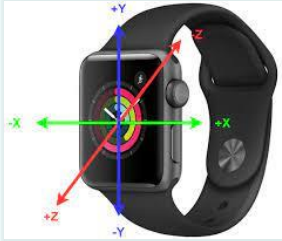
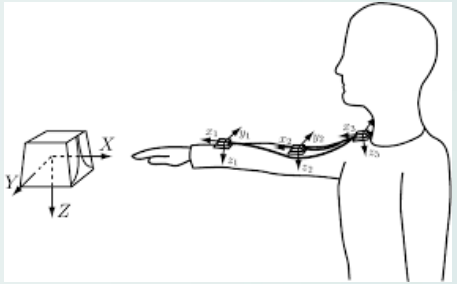
Why measures kinematics?

- Standard tests (e.g., Fugl-Meyer, ARAT) can have difficulty differentiating between recovery and compensatory movements
- These tests can also lack sensitivity to small improvements
- Kinematic data can be very rich – it is possible to extract many informative features from performing simple tasks
- It has the potential to provide more fine-grained assessments, as well as therapeutic uses (e.g. in biofeedback)

How can we measure kinematics?



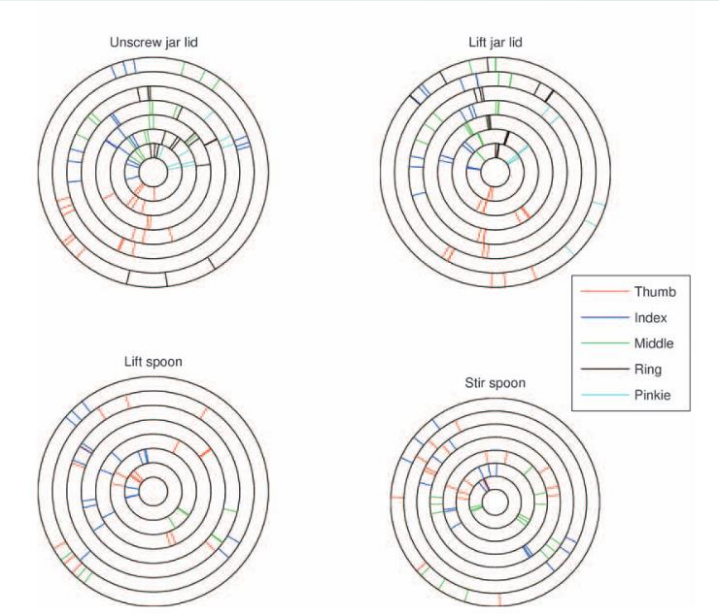


- There are many devices available for measuring kinematics with varying quality, e.g.
  - Manipulandum (e.g., Kinarm)
  - Graphics tablets
  - Motion capture systems (visual / magnetic)
  - Smartphones / smartwatches
  - Markerless motion capture

- Most of these systems require the arm to be supported for many stroke patients
- Prices range from 500 NIS to 500,000 NIS

What is the problem with measuring reaching & grasping?

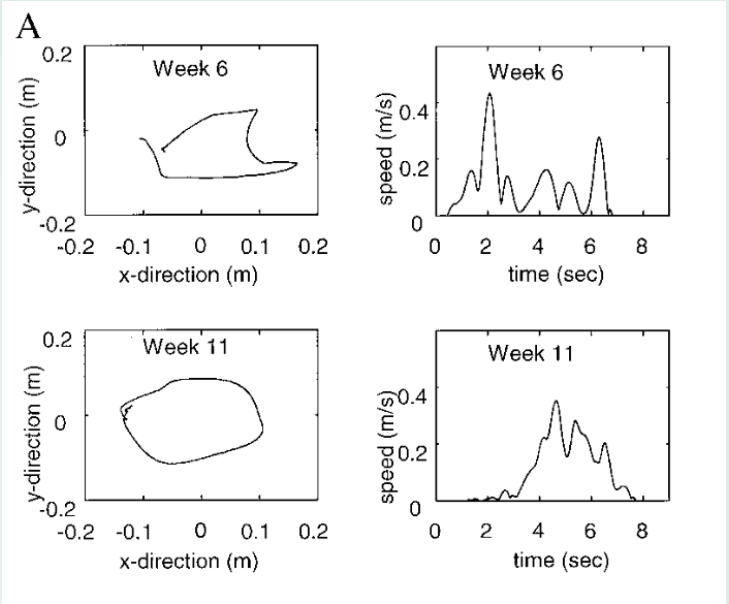
- Even if we only look at the kinematics, there are a huge number of degrees of freedom when studying arm and hand movements
- There is no “standard” quantity to measure
- In addition, even among healthy participants, there is a huge amount of variability in the way tasks are performed



Friedman & Flash, 2007

Reaching

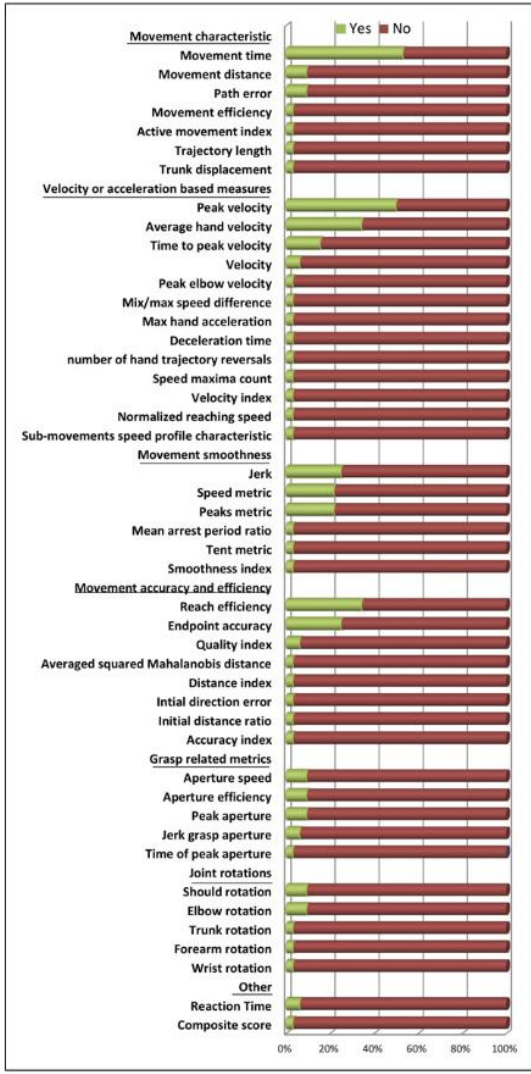
- Often smoothness-based measures are used because smooth movements are a feature of healthy movements
- Movements become smoother with recovery
- There are some issues with selecting which smoothness measure to use (e.g., Balasubramanian et al., 2015)



Krebs et al., 1999

Reaching

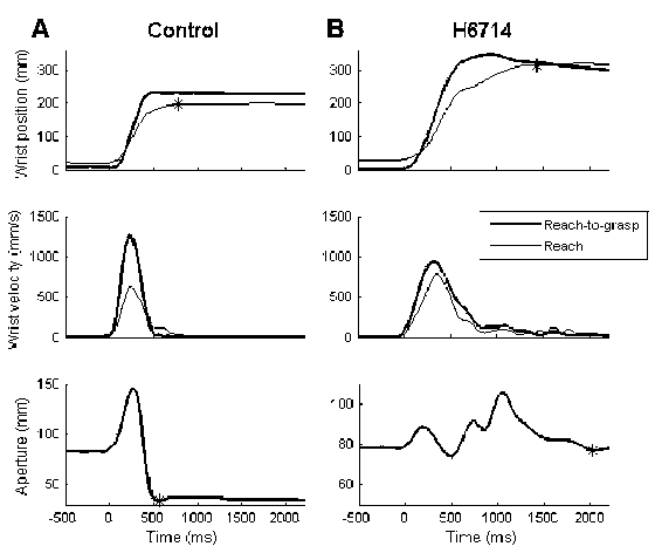
- Many measures have been used to quantify arm movements, including:
  - Reaction time
  - Movement time
  - Movement distance
  - Movement efficiency
  - Average hand velocity
  - Peak hand velocity
  - Time to peak velocity
  - Jerk
  - Number submovements
  - Endpoint accuracy
  - Initial direction error

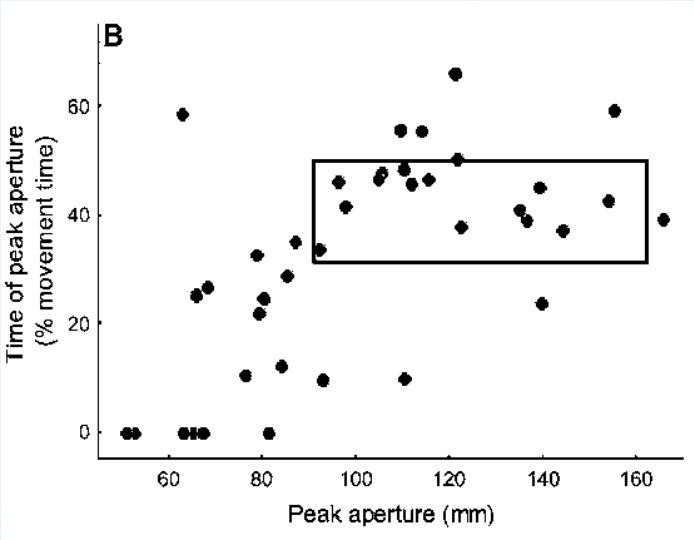


Saes et al., 2022

Grasping

- Reach to grasp can be studied in terms of kinematics or forces
- In terms of *kinematics* – we observe coordination between wrist movement and aperture in healthy subjects, and a lack of coordination in stroke patients



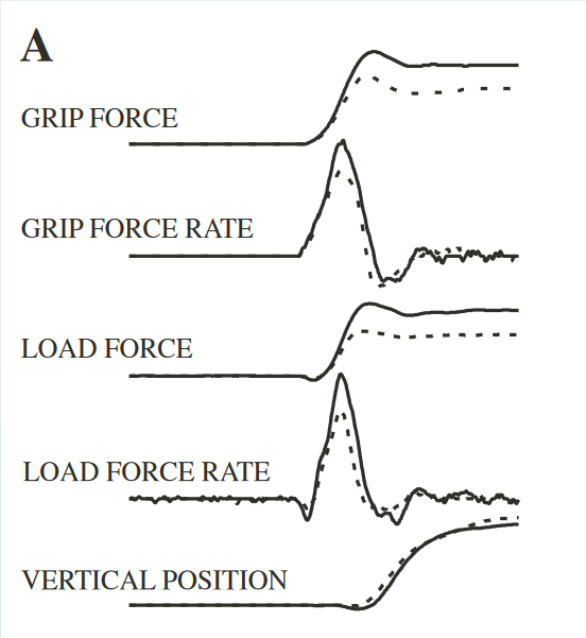


Lang et al., 2005

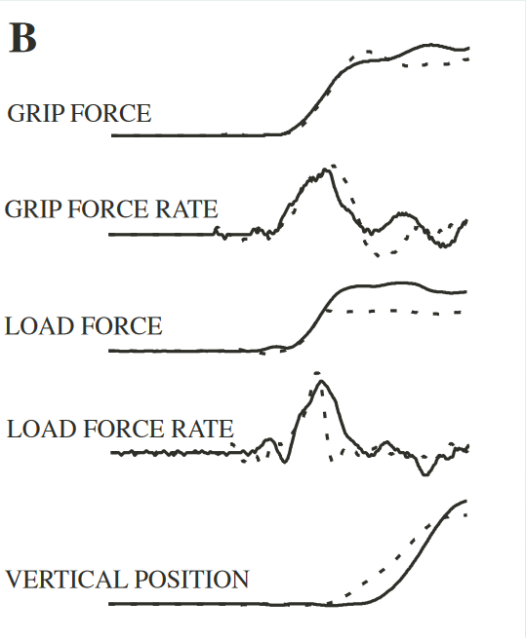
Grasping

- In terms of forces – we can compare grip force and load force, and see how well grip force is selected

Control subject

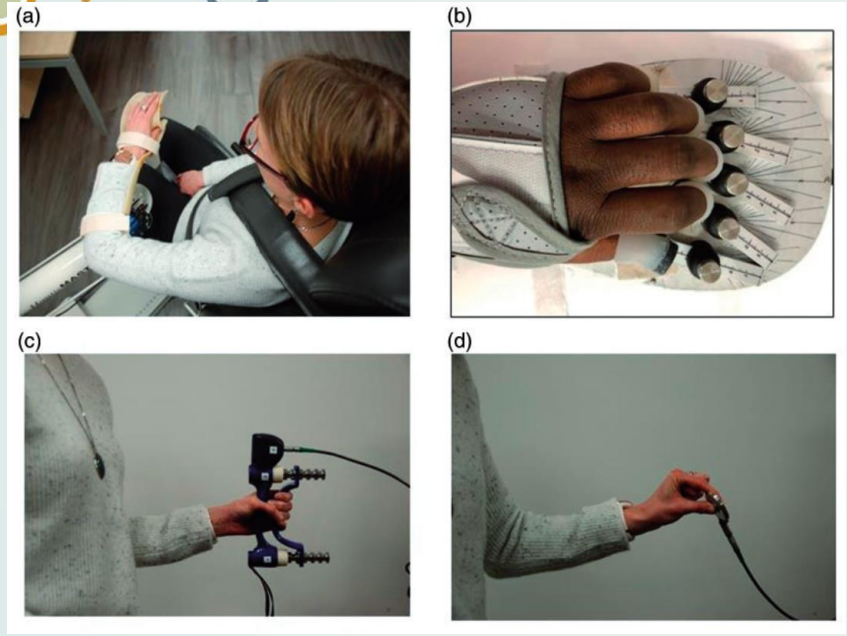


Stroke patient

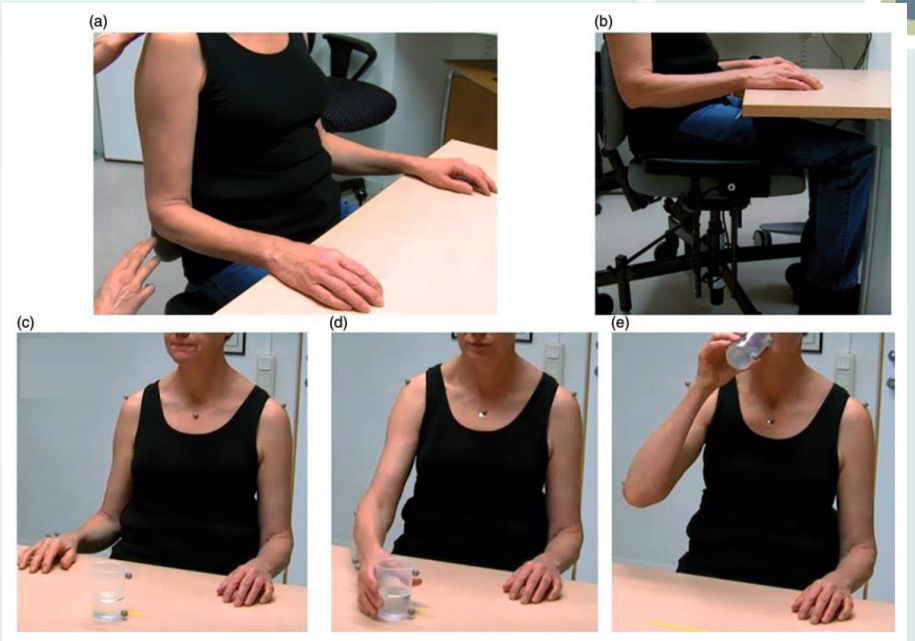


SSRRR recommendations

Second Stroke Recovery and Rehabilitation Roundtable



(a) Planar reaching to 9 targets
(b) Finger individuation (with force sensors)
(c) Grip strength
(d) Precision grip strength



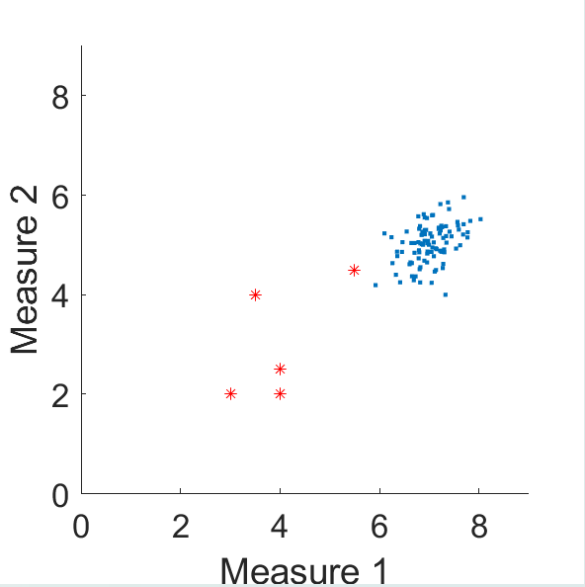
3D task – lifting a cup to drink

Kwakkel et al., 2019

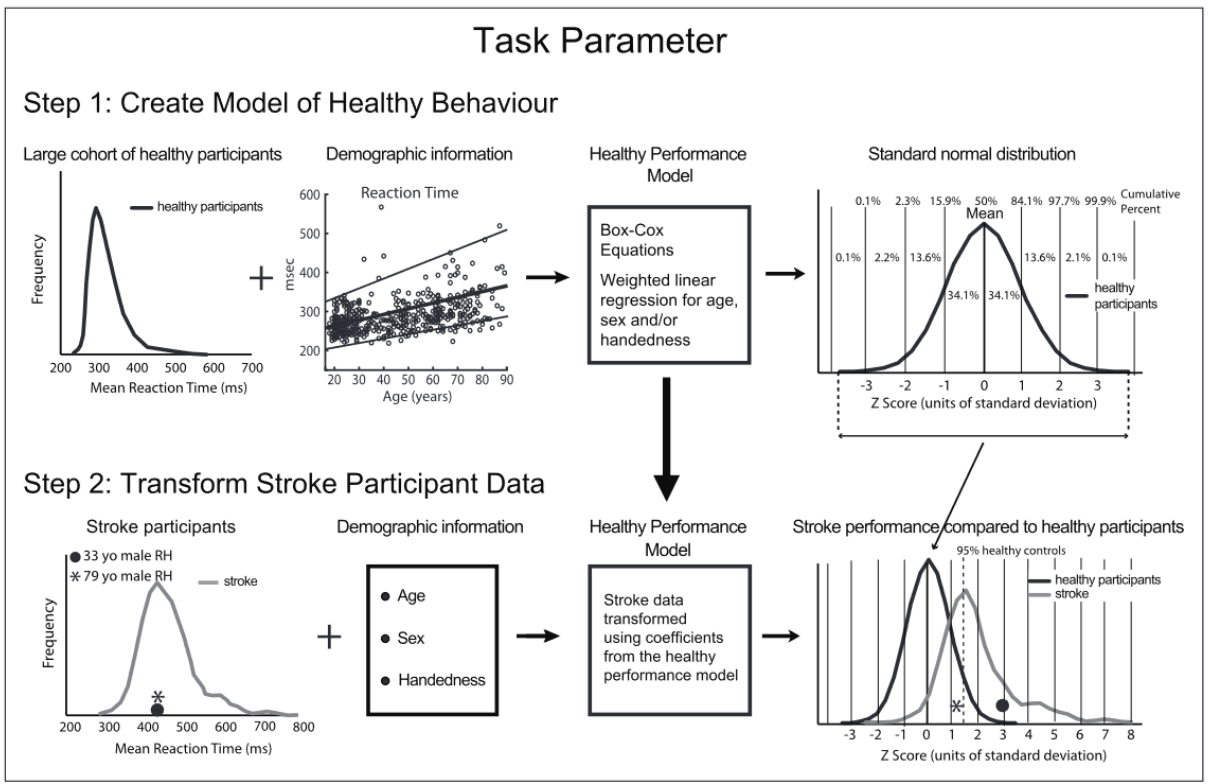
What is the solution for too many measures?

Dimensionality reduction

- In general, we are interested in how far the movements of patients are from “normal”
- We can record “normal” movements, in an appropriate control group, and then measure how far away a patient is from “normal” (which itself is a distribution, not a point)



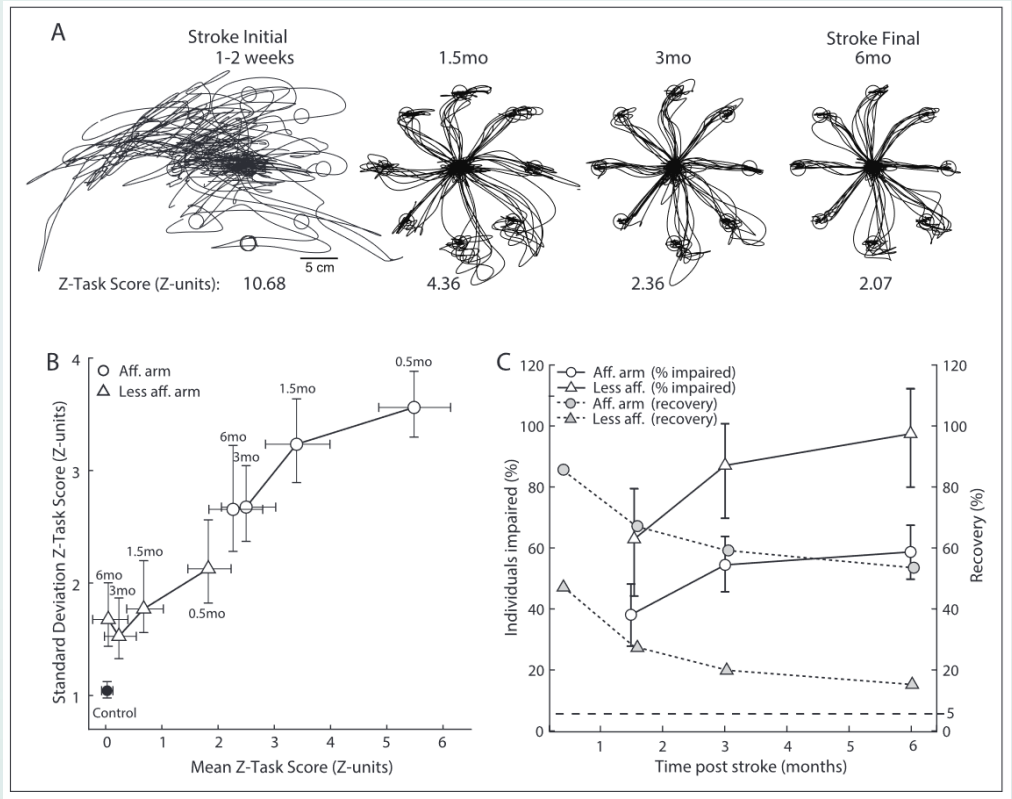
Dimensionality reduction



- The z scores of all the parameters are then combined into a single score

Scott et al., 2022

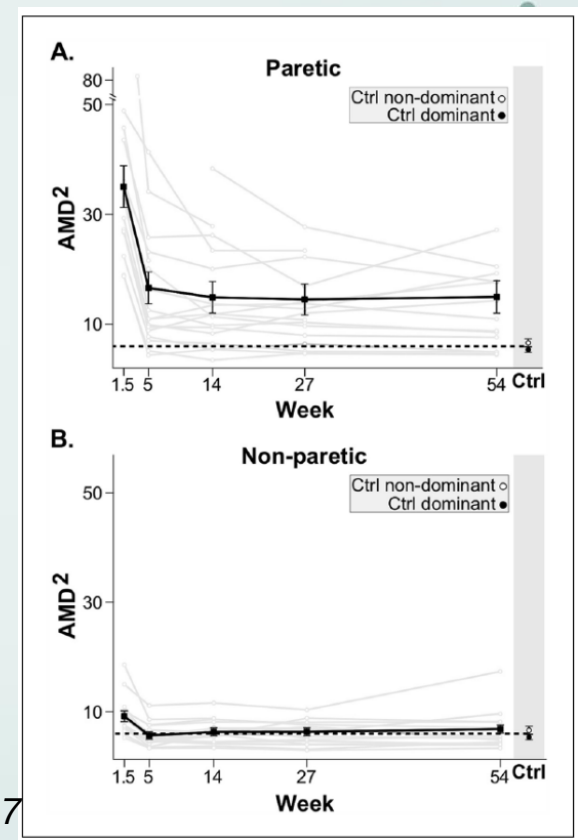
Dimensionality reduction



Scott et al., 2022

Dimensionality reduction

- Other studies have used functional principal component analysis to try to compare trajectories without selecting parameters (e.g., Kitago et al., 2015)
- 3 functional principal components are enough to explain most of the variance in the kinematic data
- From this, a distance measure is calculated



Cortes et al., 2017

Recommendations

- Simple devices (e.g., tablets) are often sufficient to collect rich kinematic data
- Arm support is often an issue, but external supports are an option
- The current trend is a move to global measures which are compared to variation in healthy controls
- Use of these techniques requires standardization of setups and measures, collection of large data sets from healthy controls, and significant computational analyses

QUESTIONS?

Do you have any questions?

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