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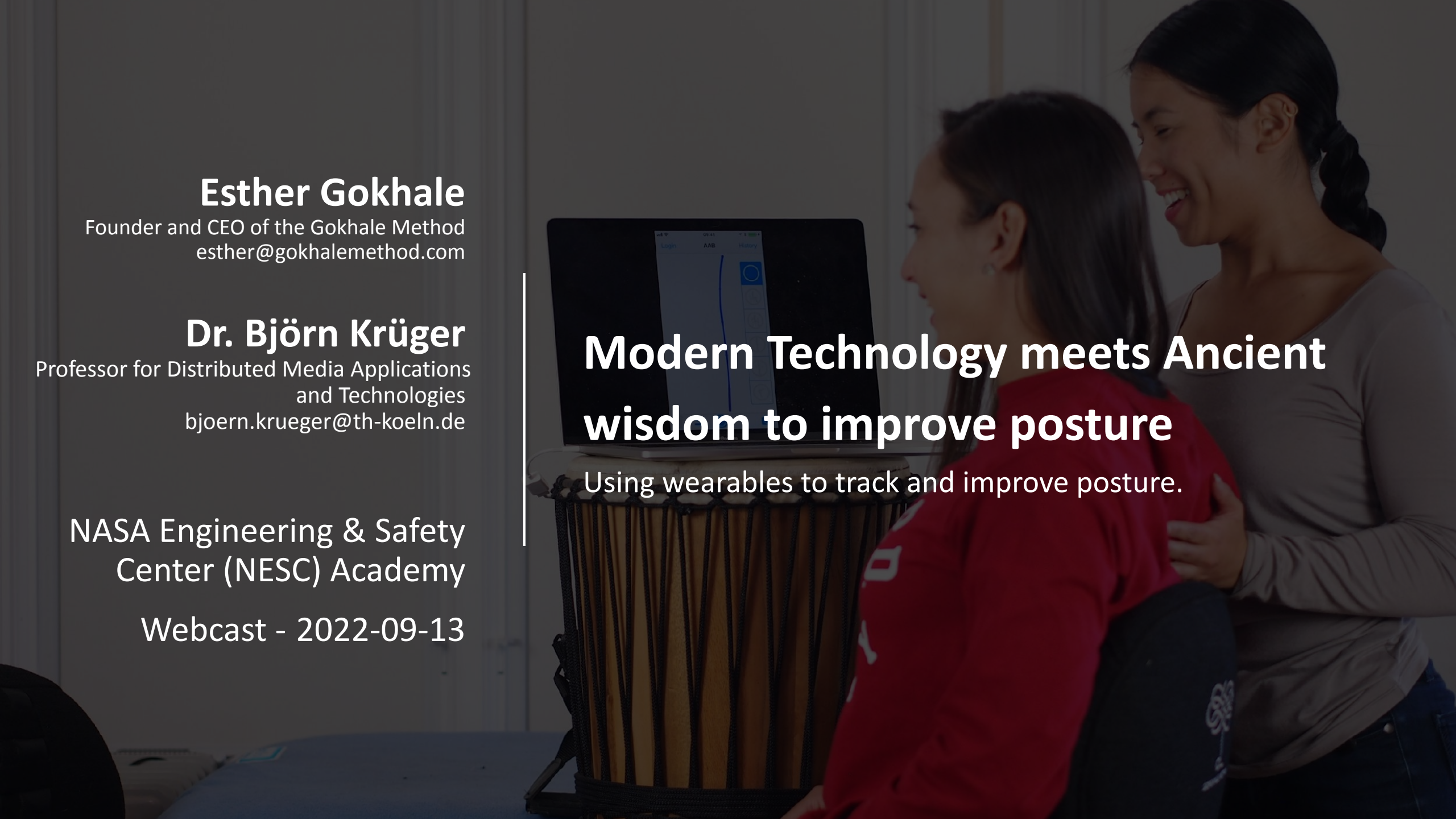
NASA Engineering & Safety Center (NESC) Academy

Webcast - 2022-09-13



Modern Technology meets Ancient wisdom to improve posture

Using wearables to track and improve posture.

Outline

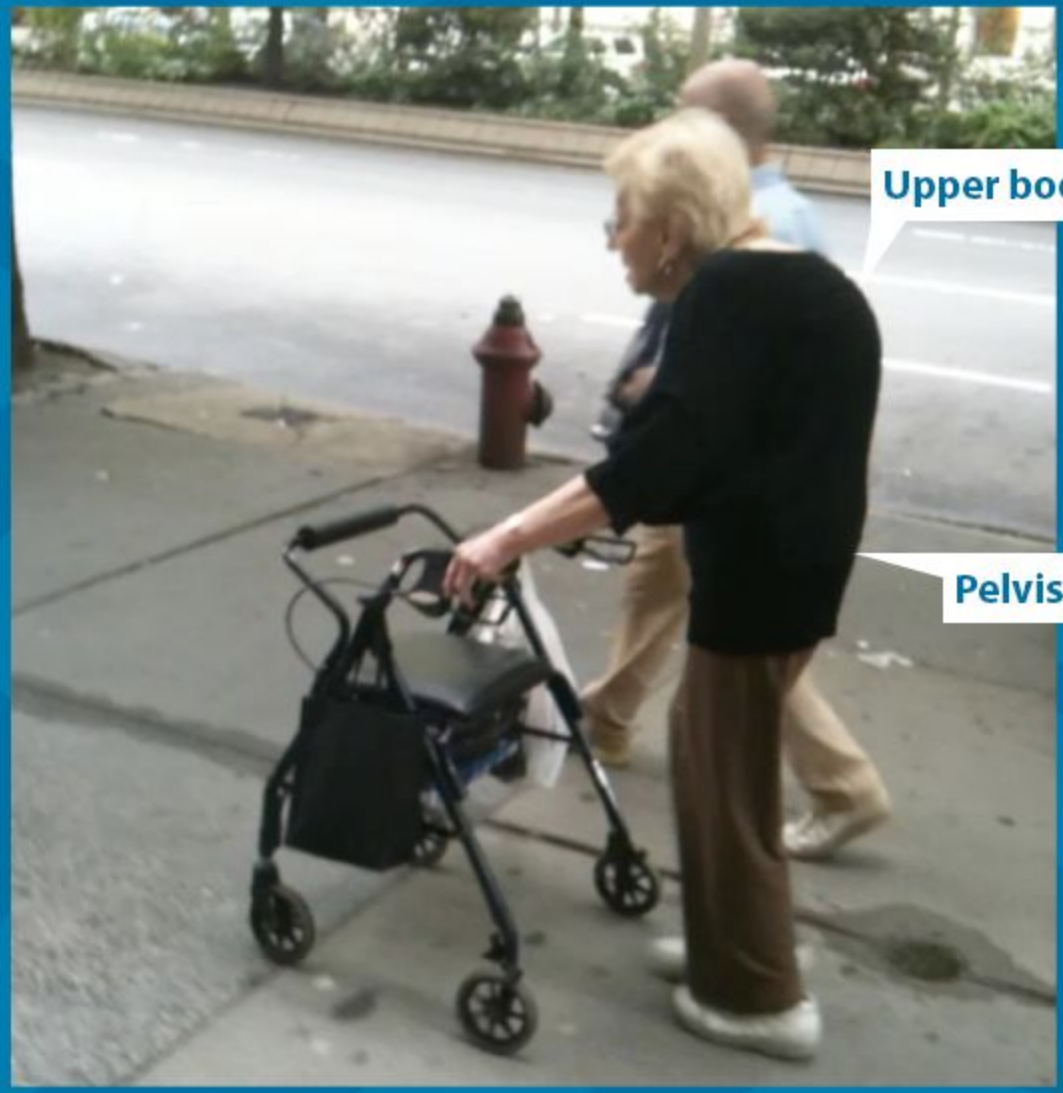
Esther Gokhale

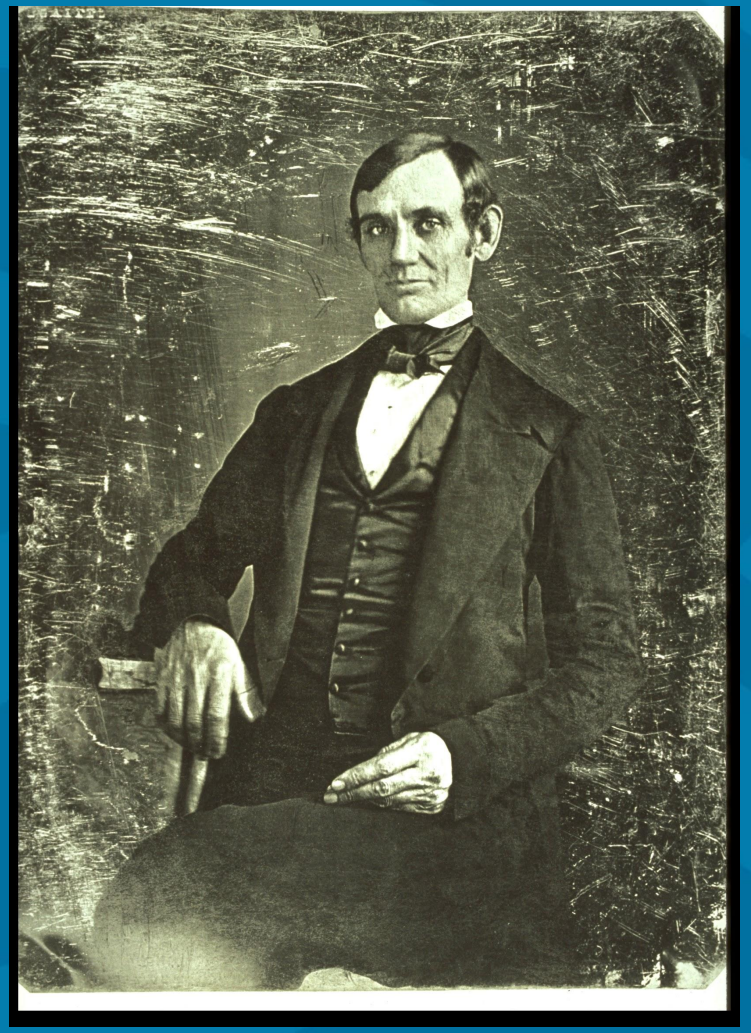
- Drift in posture in recent history
- How does this affect NASA workers?
- Ways to retrieve healthy posture

Dr. Björn Krüger

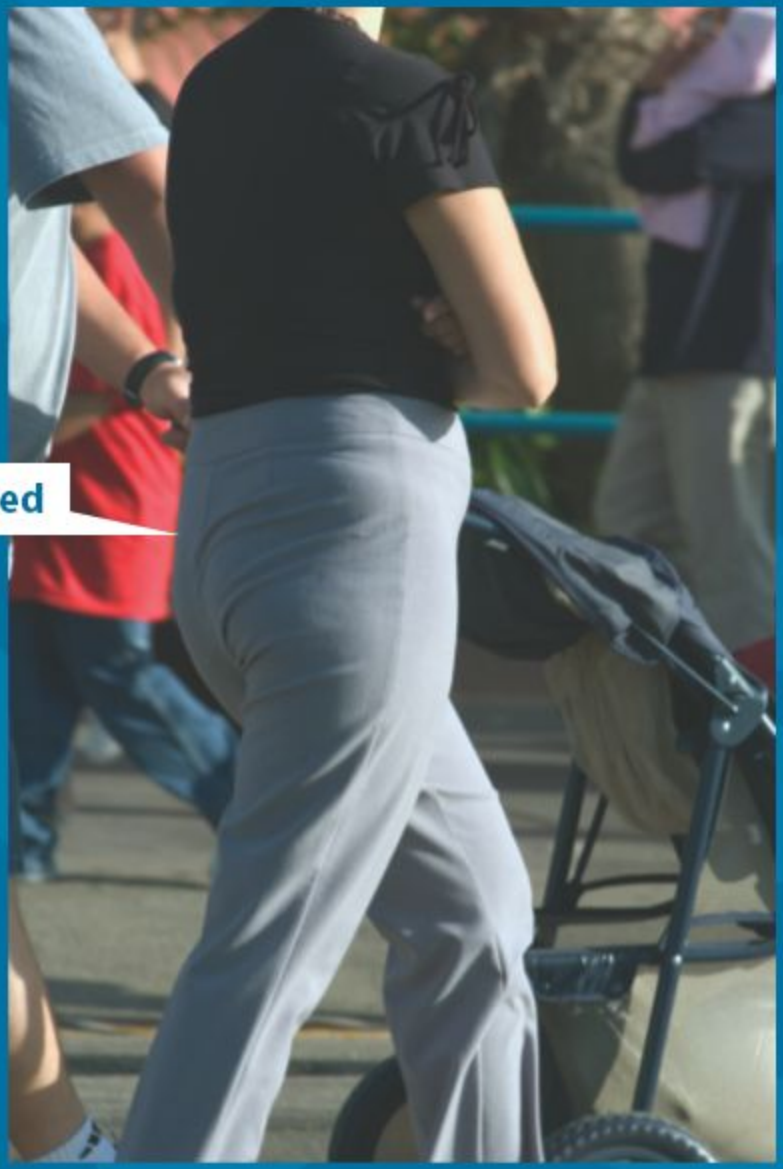
- Introduction to SpineTracker
- Accuracy of SpineTracker
  - Evaluating the accuracy of SpineTracker
- Looking at changes we teach our students
  - Shape changes
  - Muscle Activity


Upper body open
Pelvis anteverted


Upper body rounded
Pelvis tucked



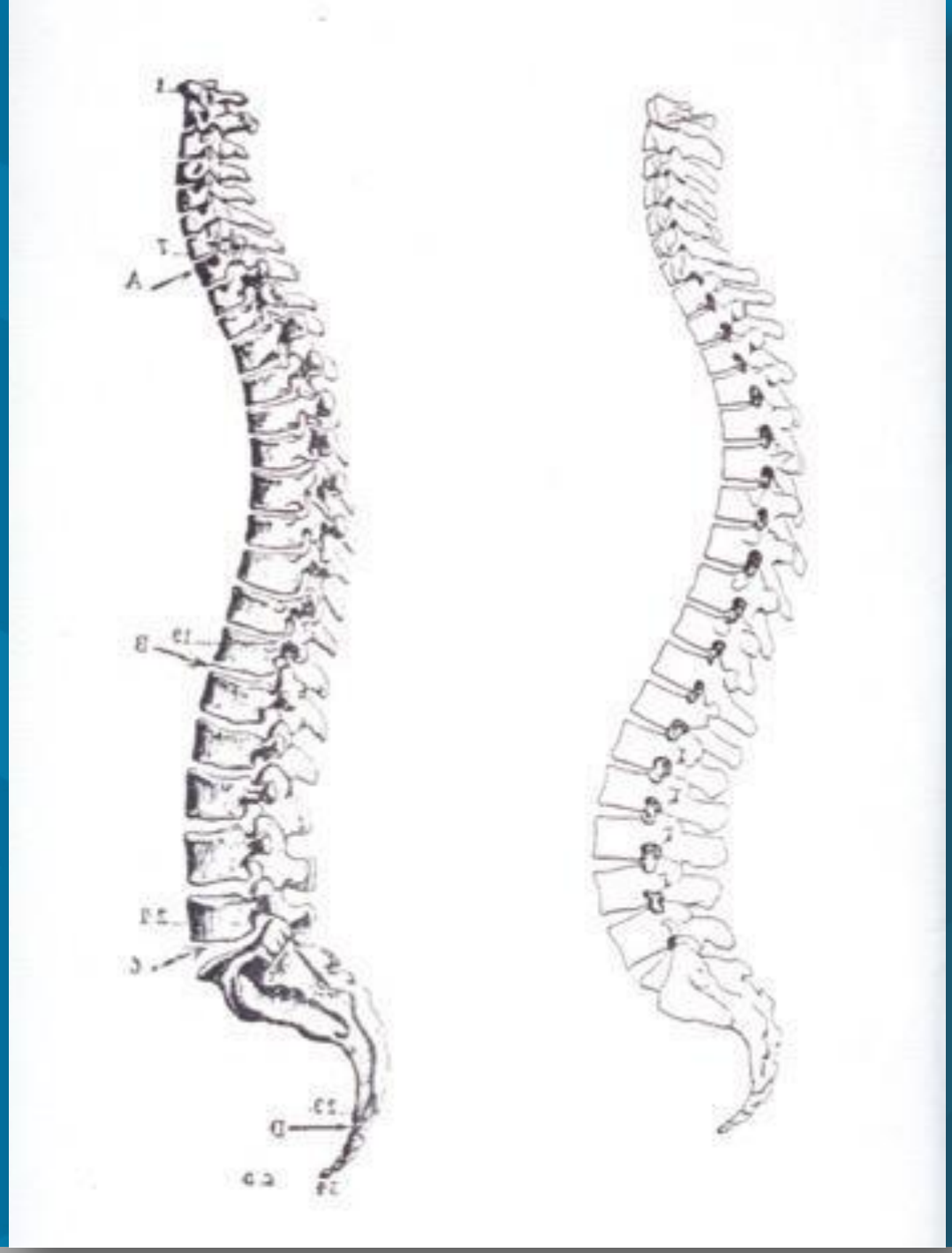

Behind behind


Behind tucked

1900's train seat

Credit: City Transport

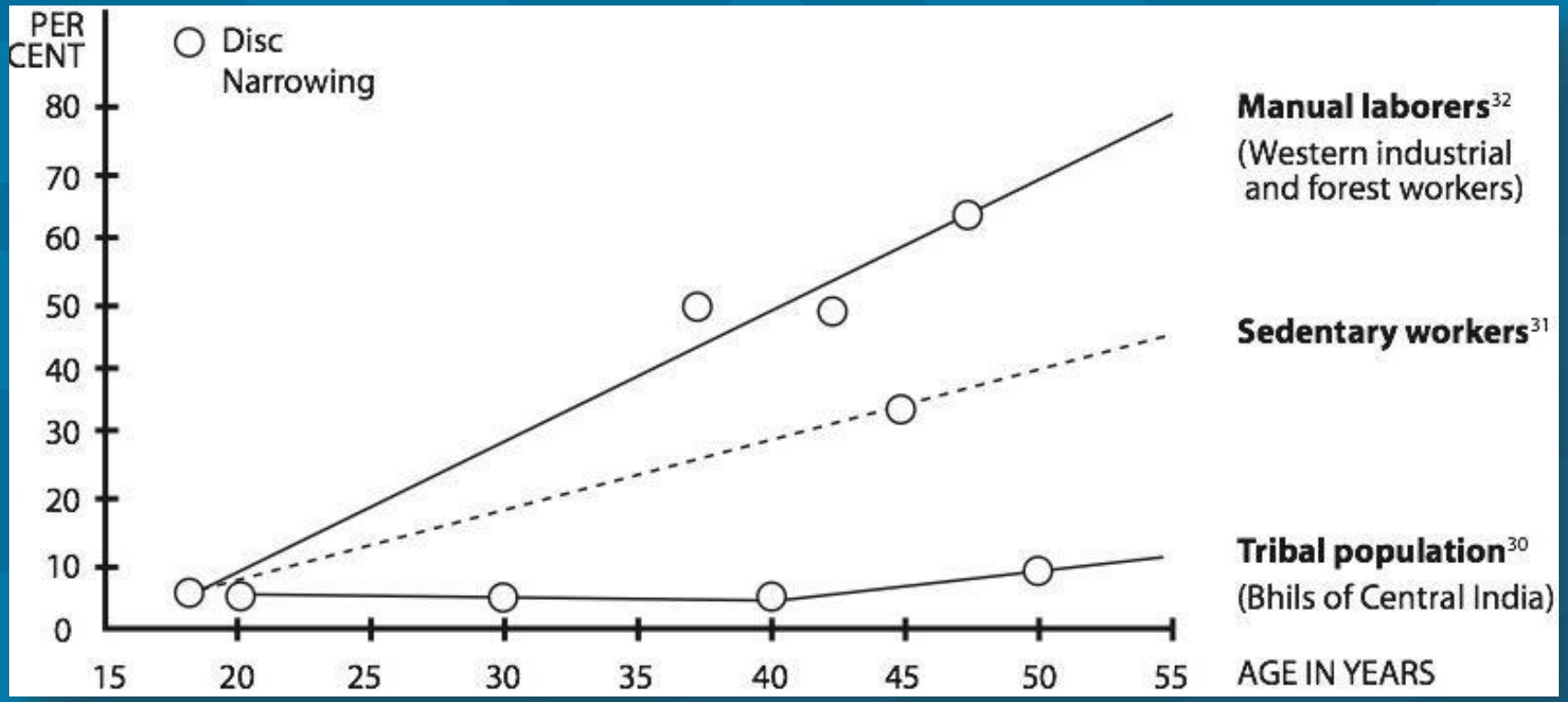
Anatomy text published 1911



Anatomy text published 1990

GOKHALE METHOD®

Disc Narrowing with Age in Three Different Populations



[30] Fahrni, W. Harry and Trueman, Gordon E. (1965): Comparative Radiological Study of the Spines of a Primitive Population with North Americans and Northern Europeans, The Journal of Bone and Joint Surgery, 47-B (3): 552.
[31] Fullenlove, T.M., and Williams, A.J. (1957): Comparative Roentgen Findings in Symptomatic and Asymptomatic Back. Radiology, 68, 572.
[32] Hult, L. (1954): The Munkfors Investigation. A study of the Frequency and Causes of the Stiff Neck-Brachialgia and Lumbago-Sciatica Syndromes. Acta Orthopaedica Scandinavica, Supplementum No. 16.

Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low back pain matched for age, sex, and size. A prospective controlled clinical study.
Jackson RP, McManus AC.Spine (Phila Pa 1976). 1994 Jul 15;19(14):1611-8.

STUDY DESIGN:
A global and segmental study on standing lateral radiographs of 100 volunteers and 100 patients who had low back pain was undertaken to further define sagittal plane alignment and balance. The volunteer control group and the patient group were matched for age, sex, and size.

RESULTS:
Segmental lordoses w
Approximately two-th
Total lordosis was sig
Patients tended to sta
more vertical sacrum and, therefore, more hip extension. This may be related to compensation as C7 sagittal plumb lines were comparable in both groups. Both groups had similar thoracic kyphosis. A much higher percentage of smokers was found in the low back pain patient population studied. Because of the significant amount of angulation in the lower lumbar spine, measurement of lordosis should include the L5-S1 motion segment and be done standing to better assess balance. Sacral inclination is a determinate of both standing pelvic rotation and hip extension. It is strongly correlated with segmental and total lordosis in both volunteers and patients.

"Patients tended to stand with less distal segmental lordosis, but more proximal lumbar lordosis, a more vertical sacrum and, therefore, more hip extension."

Computer at her work with microscope and the Friden calculating machine.

Credits: NASA

Flight director Richard Jones was the first Hispanic to lead space shuttle teams.

Credits: NASA

Sir Richard Branson provides a thumbs up from a seat in the course of the unveiling of a scale model of Virgin Galactic's SpaceShip2 at a news conference.

Credit: DON EMMERT/AFP by way of Getty Visuals

Astronaut Scott Kelly aboard the International Space Station

Image Credit: Bill Ingalls/NASA/Getty Images

Test subject Fred Spross, Crew Systems Division, wears the spacesuit and extravehicular equipment planned for use by Gemini VIII astronaut David R. Scott. The helmet is equipped with a gold-plated visor to shield the astronaut's face from unfiltered sun rays. The system is composed of a life-support pack worn on the chest and a support pack worn on the back. *Image Credit: NASA*

Exploration EMU (xEMU) Development Unit. Computer-aided design (CAD) graphic rendering side view. The xEMU is an improved design for increased mobility necessary for the Artemis program. The xEMU project patch which will eventually be replaced with the EVA patch.

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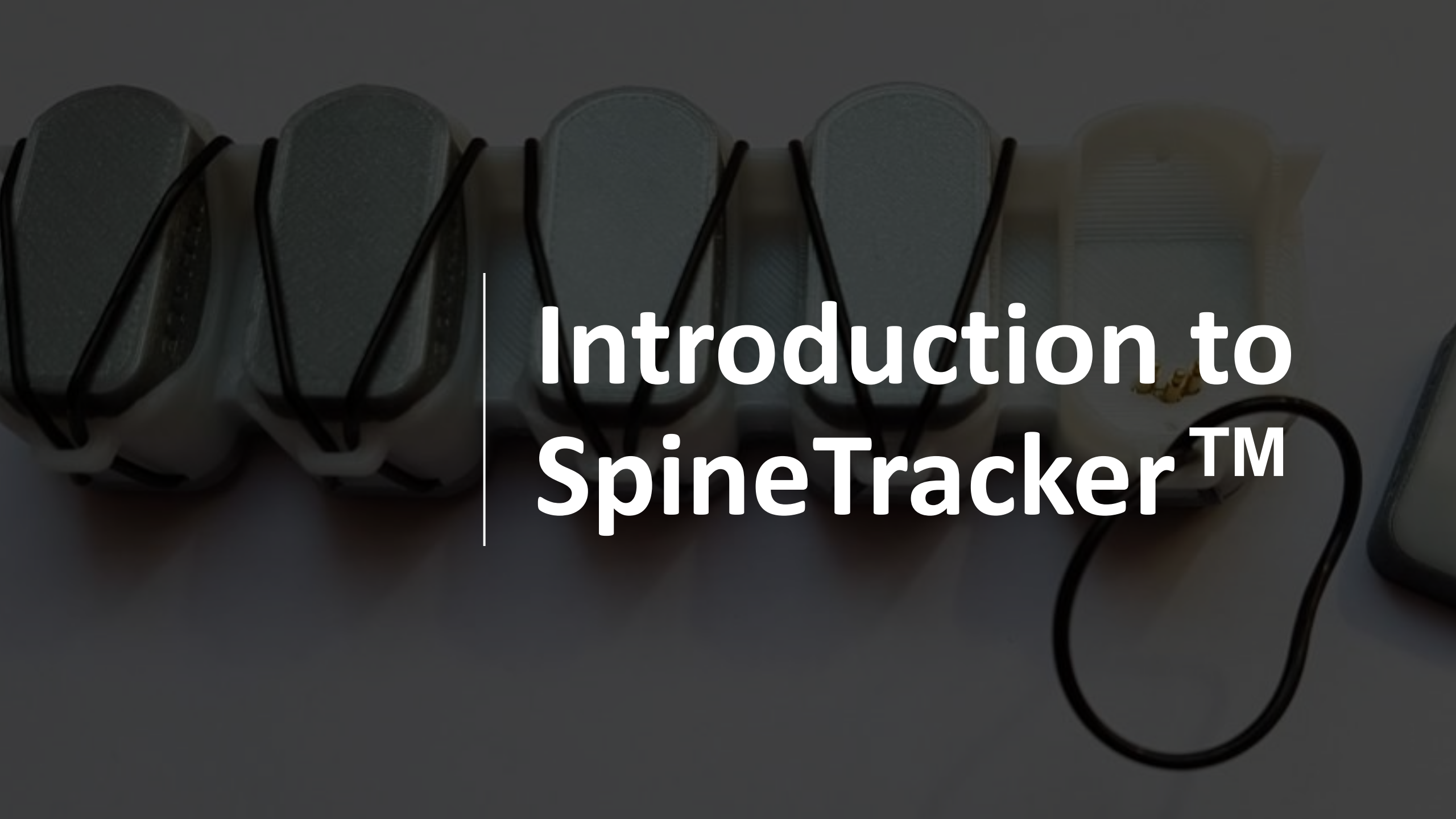
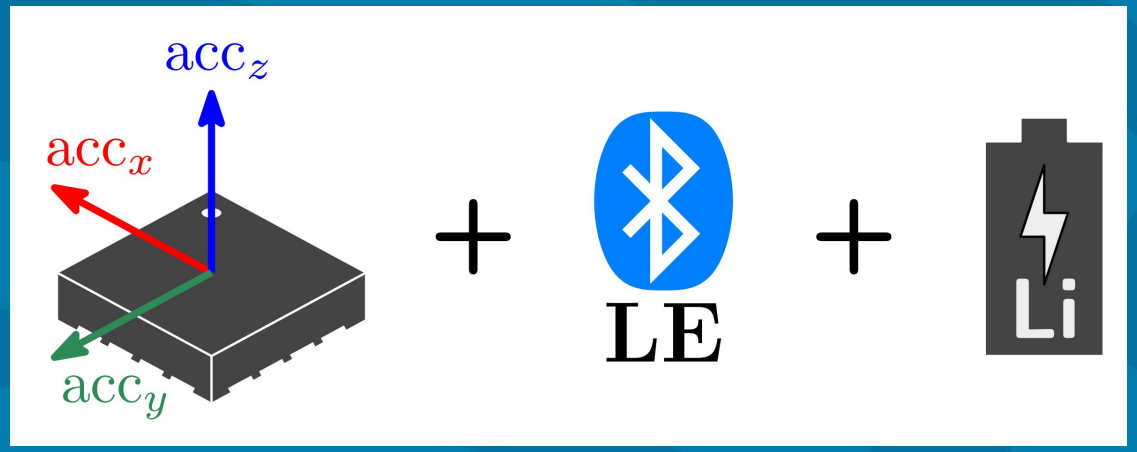
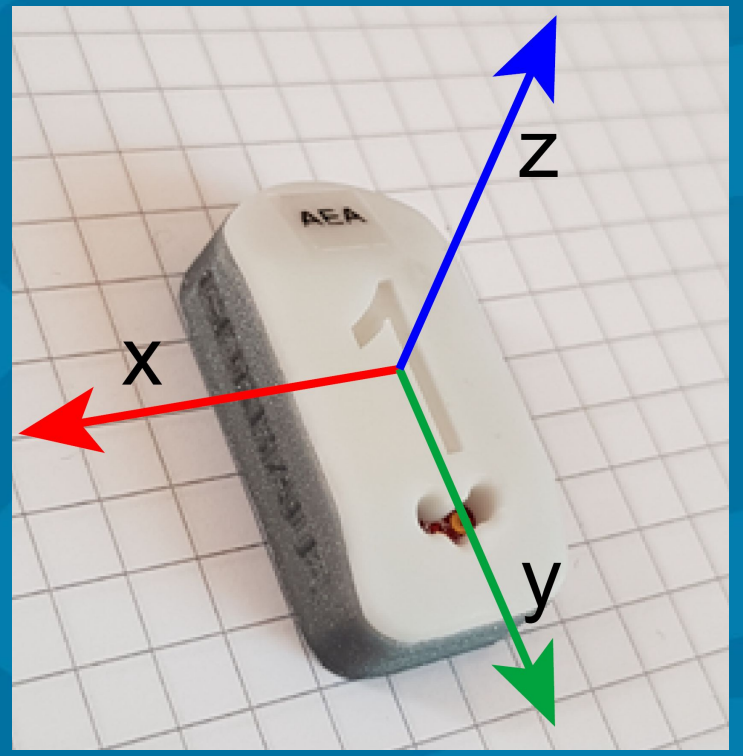


Introduction to SpineTracker™





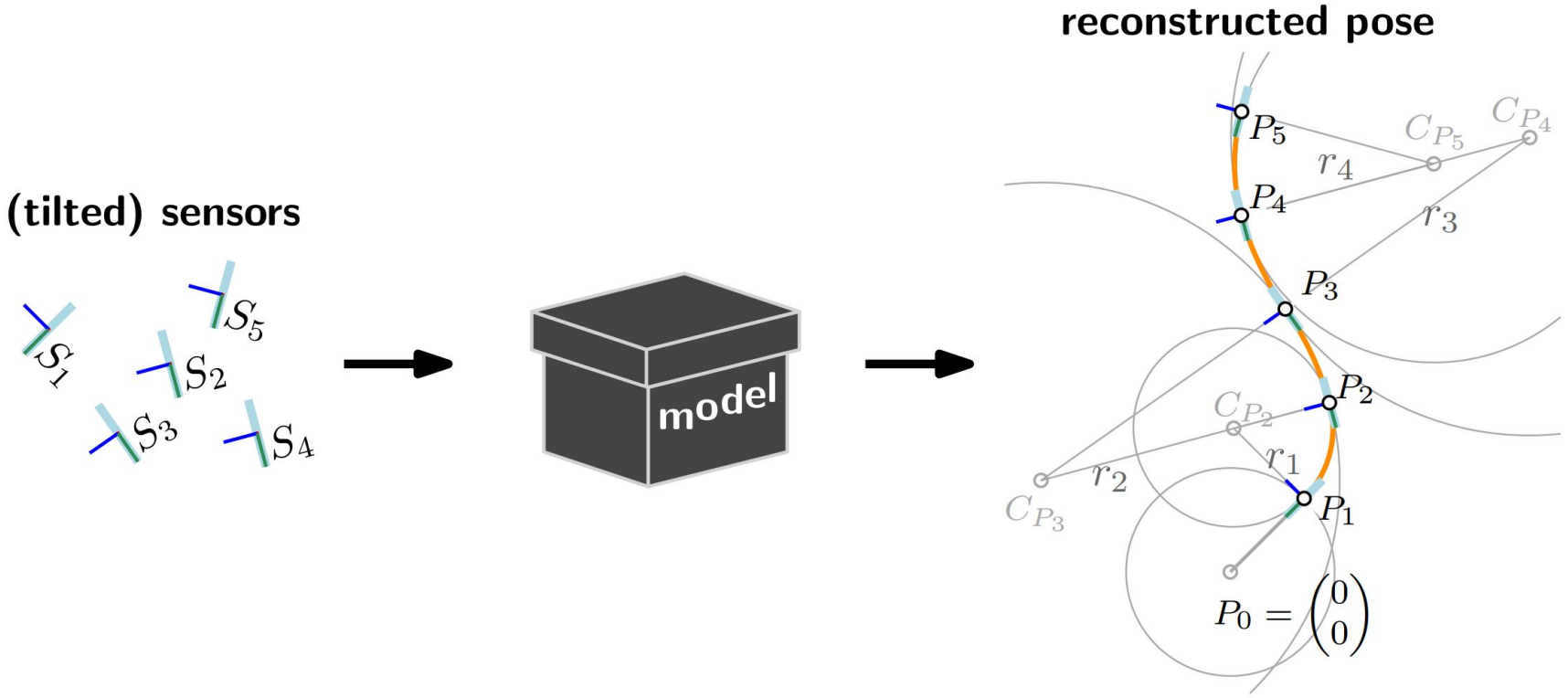
The Sensor

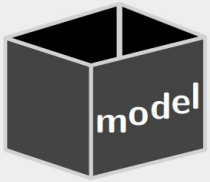
A Sensor Set

Five identical sensors

GOKHALE METHOD®

From Accelerations to Spine Curve





$$C_{P_{n+1}} = P_n - r_n \begin{pmatrix} \cos(-t_{\text{acc},S_n}) \\ \sin(-t_{\text{acc},S_n}) \end{pmatrix}$$

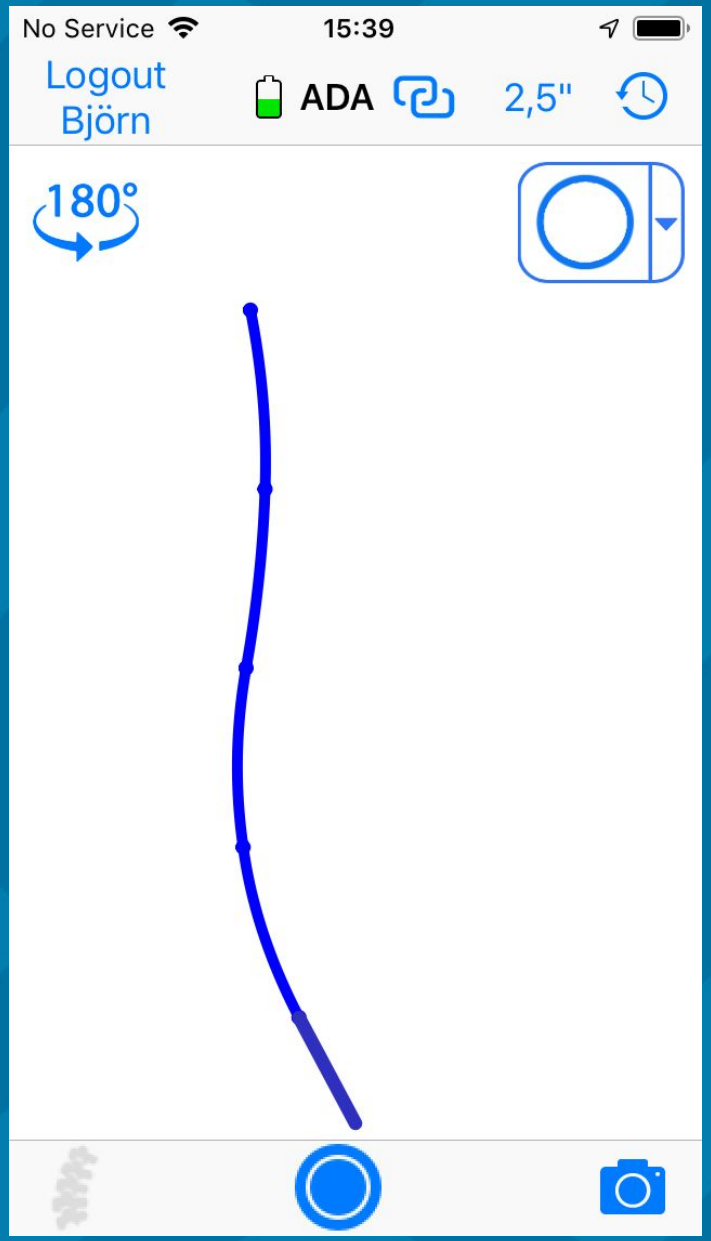
$$P_{n+1} = C_{P_{n+1}} + r_n \begin{pmatrix} \cos(-t_{\text{acc},S_{n+1}}) \\ \sin(-t_{\text{acc},S_{n+1}}) \end{pmatrix}$$

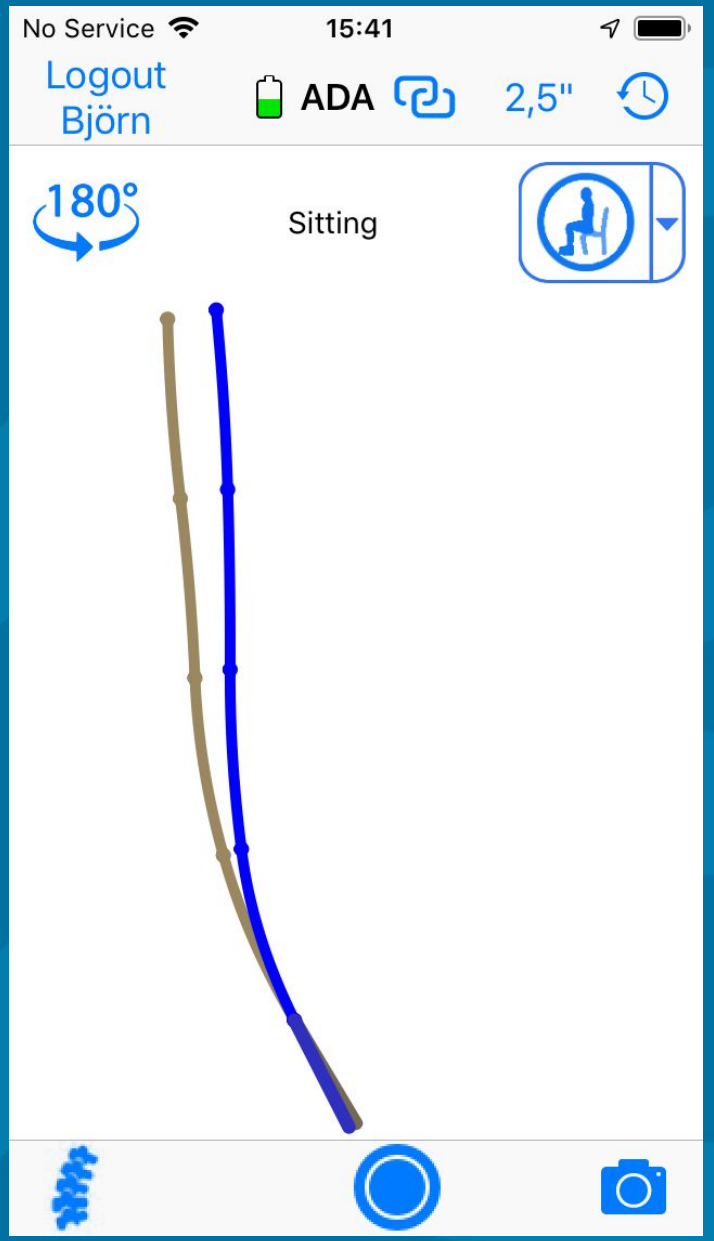
$$r_n = \frac{c}{|\delta_n|}, \quad c \text{ constant}$$

$$\delta_n = t_{\text{acc},S_n} - t_{\text{acc},S_{n+1}}$$

with t_{acc,S_n} forward tilt of sensor S_n,
r_n radius of the circle around $C_{P_{n+1}}$ to which S_n and S_{n+1} are tangents

SpineTracker App





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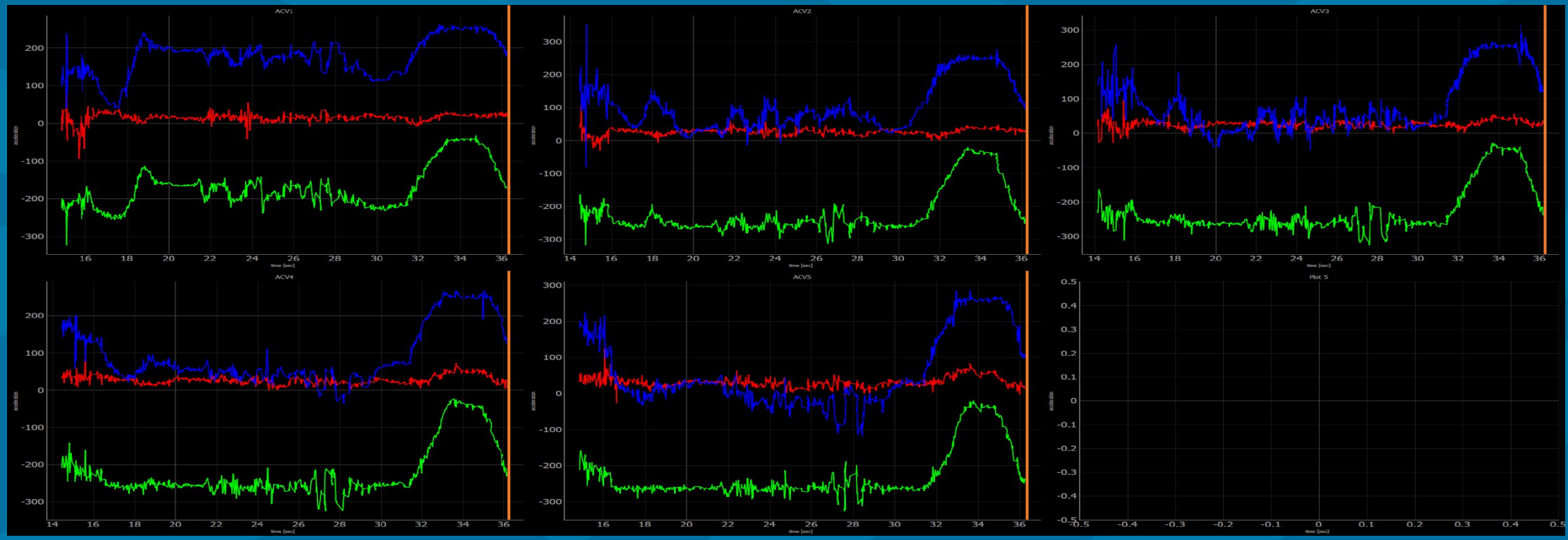
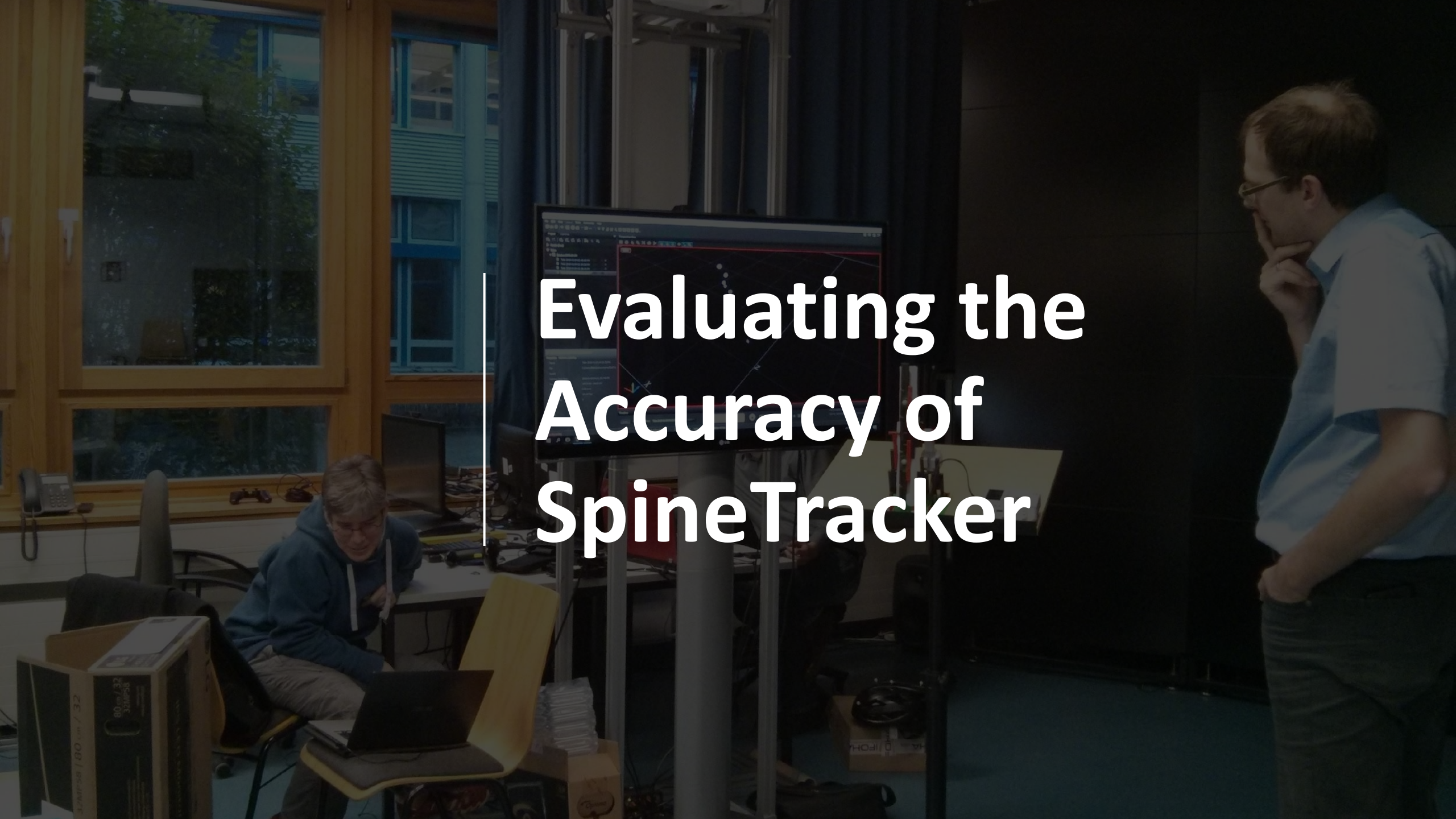
Time Series Data

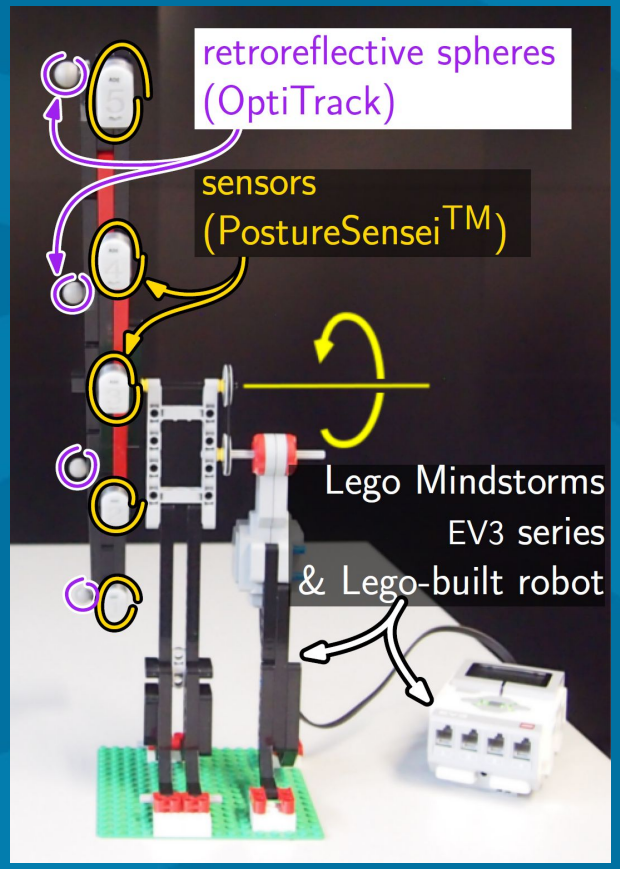


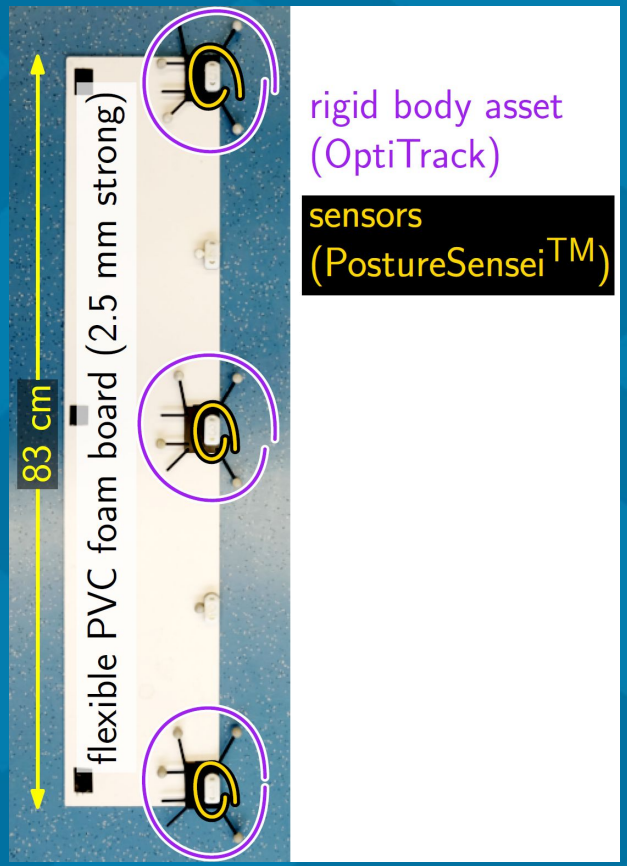
- Accelerations until an „event“ happens
  - Position selection
  - Snapshot taken
  - Leave live view
  - …



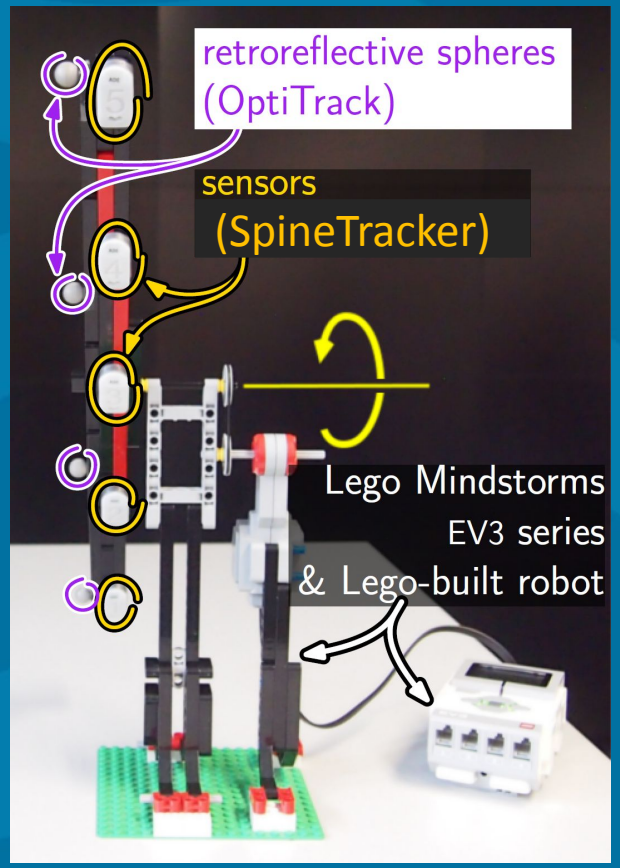
Evaluating the Accuracy of SpineTracker

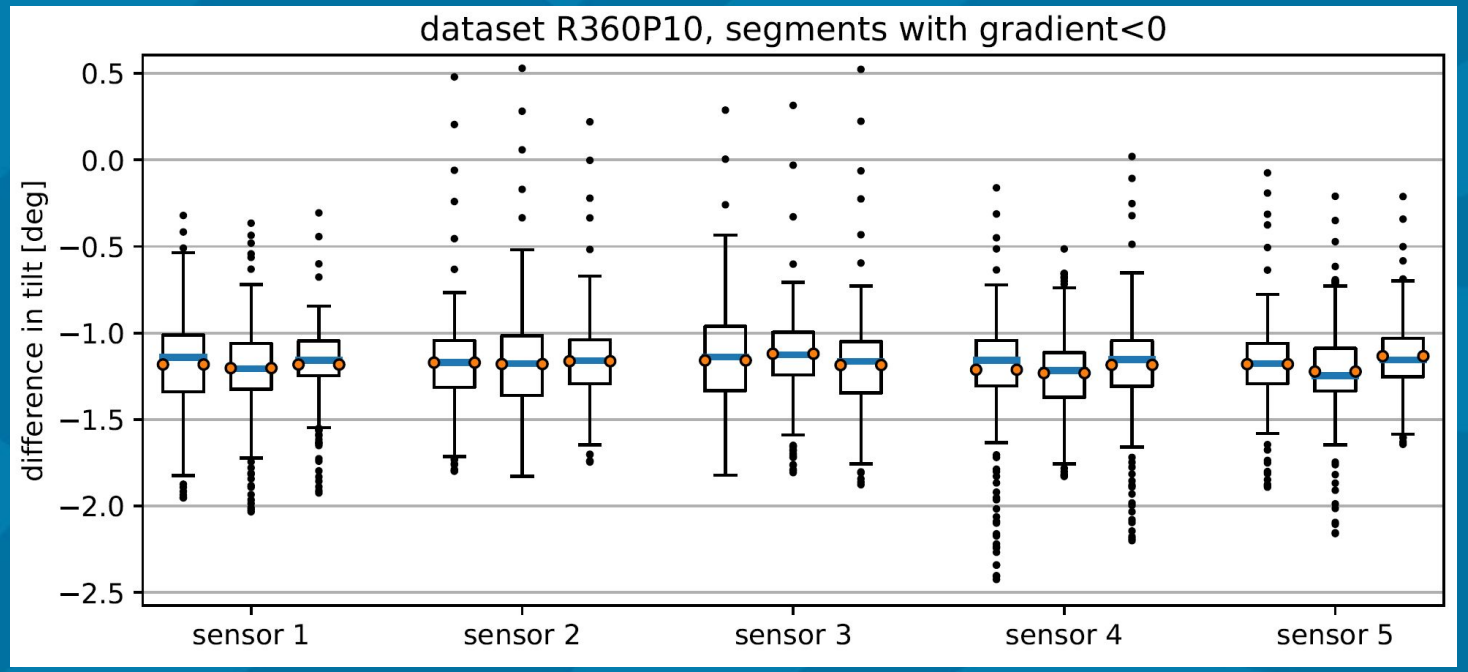
Evaluating an Accelerometer-based System for Spine Shape Monitoring



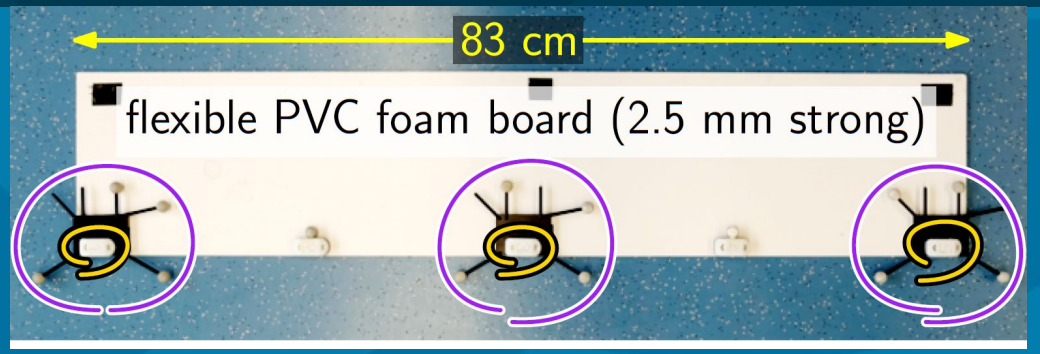


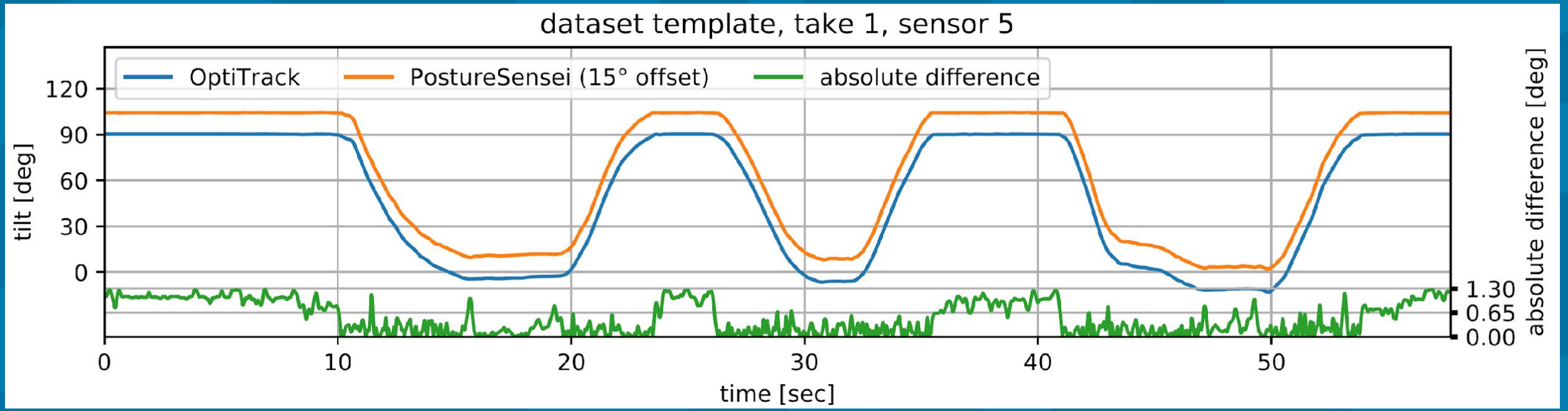
Experiment 1: Robot Arm





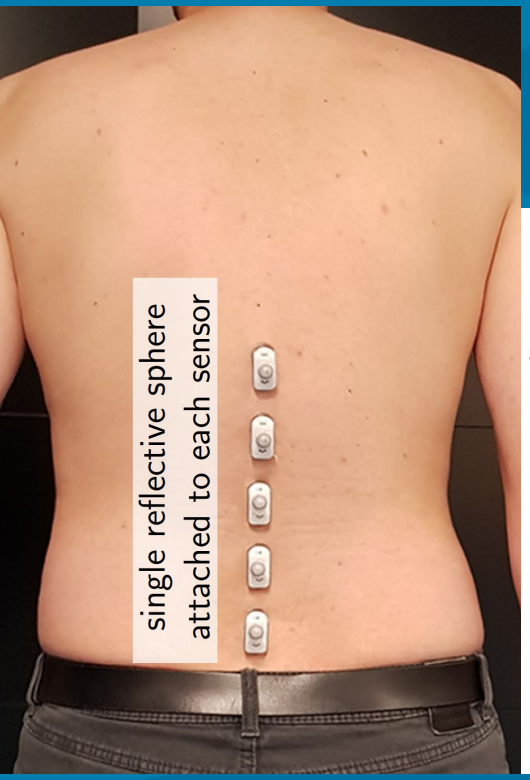
Experiment 2: Template

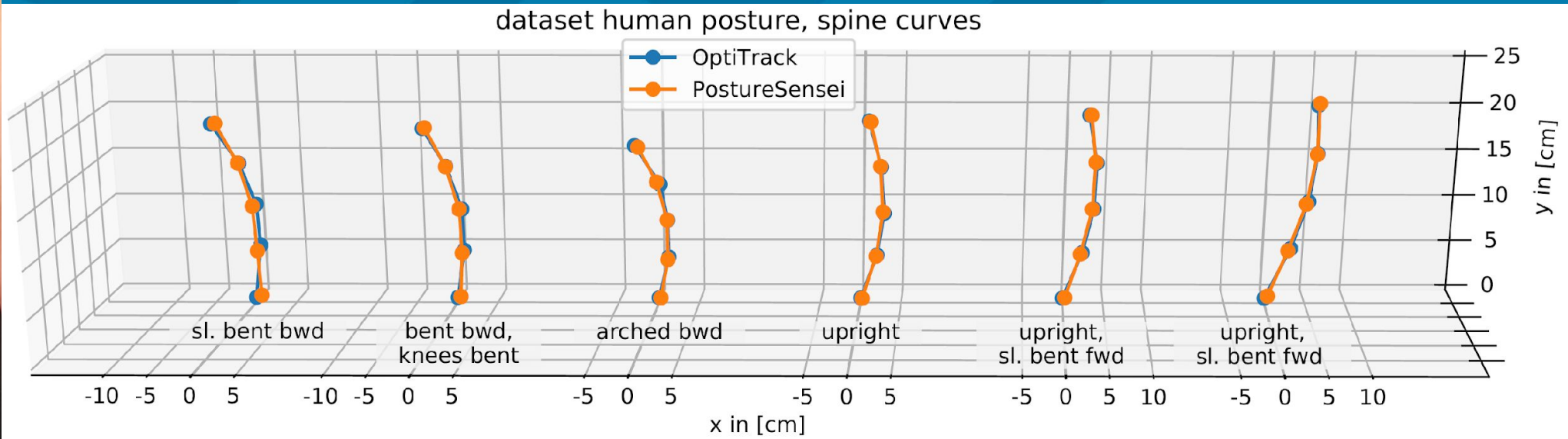




Experiment 3: human back

"Thus, we conclude, that SpineTracker™ is capable of capturing the spinal curvature for static poses accurately and provides valuable feedback to the user."





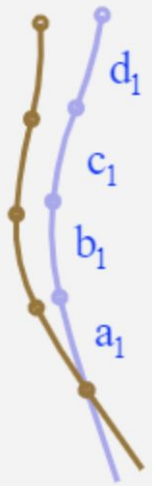
GOKHALE METHOD®

Analyzing Spinal Shape Changes during Posture Training using a Wearable Device

Analyzing Spinal Shape Changes during Posture Training using a Wearable Device

Before & Now | Changes over time | Compare spine curves | QR Login

Position: Standing



first snapshot details:

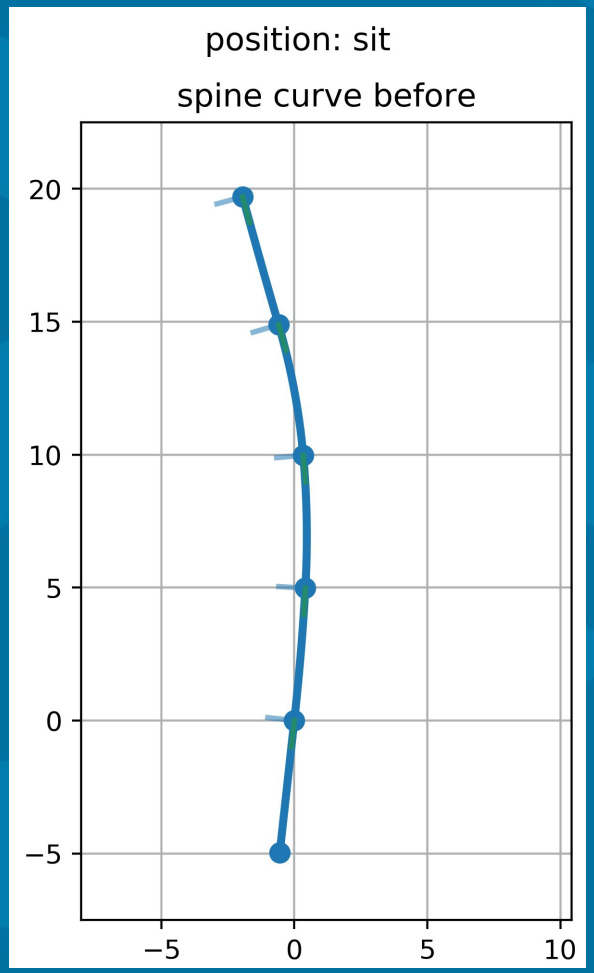
date and time: 2017-12-13 13:15
angle d: -13 deg
angle c: 17 deg
angle b: 19 deg
angle a: 5 deg
total curvature: 54 deg
#curves: 2

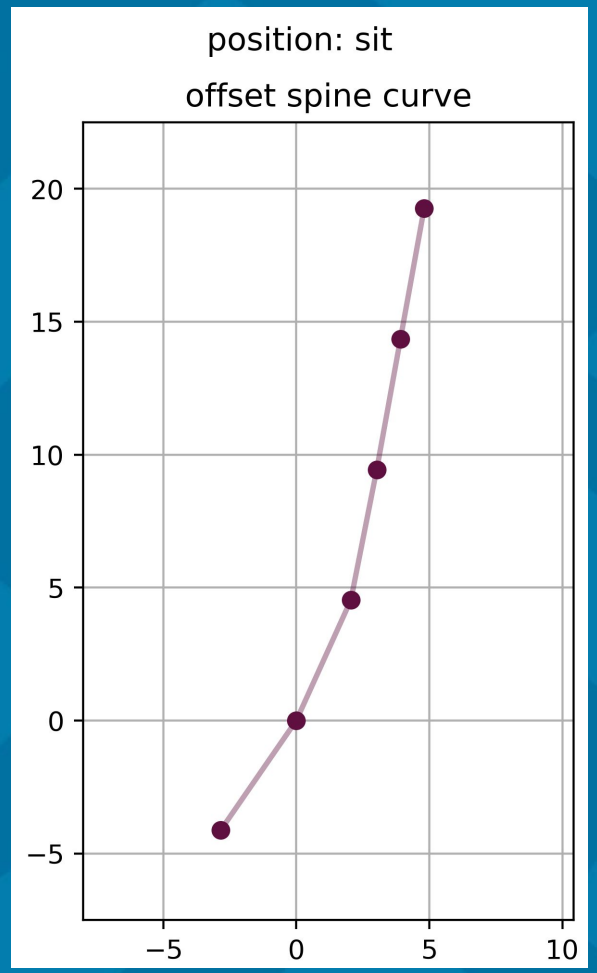
target details:

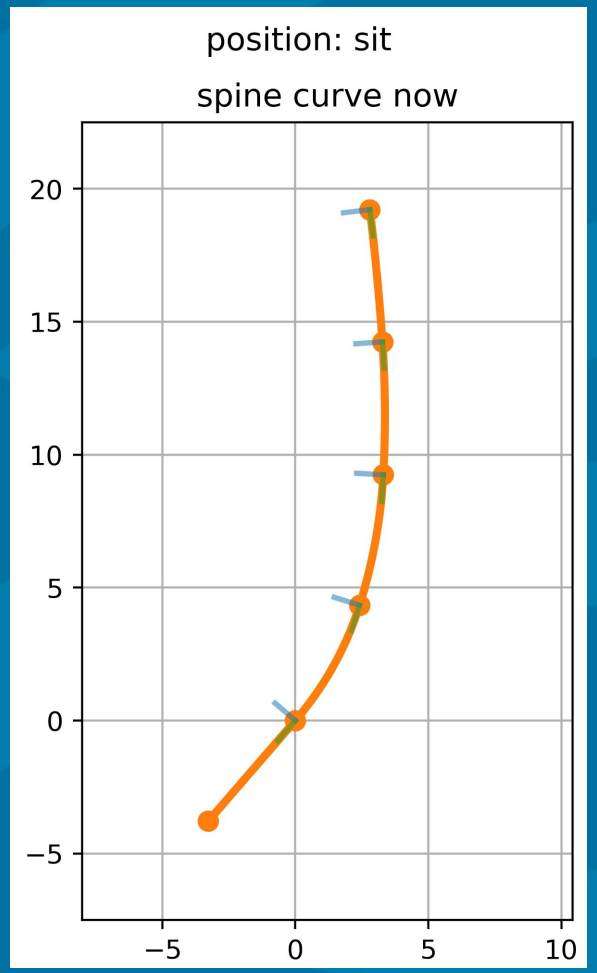
date and time: 2017-12-13 13:37
angle d: -19 deg
angle c: 11 deg
angle b: 31 deg
angle a: 7 deg
total curvature: 68 deg
#curves: 2

GOKHALE METHOD®

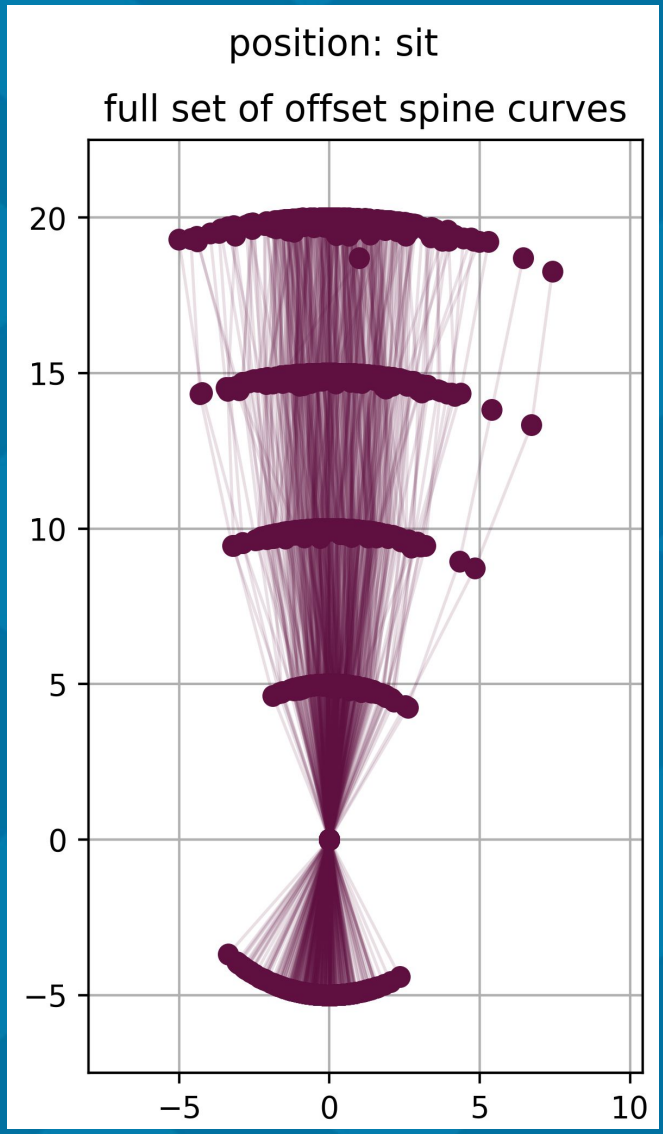
What is analyzed?





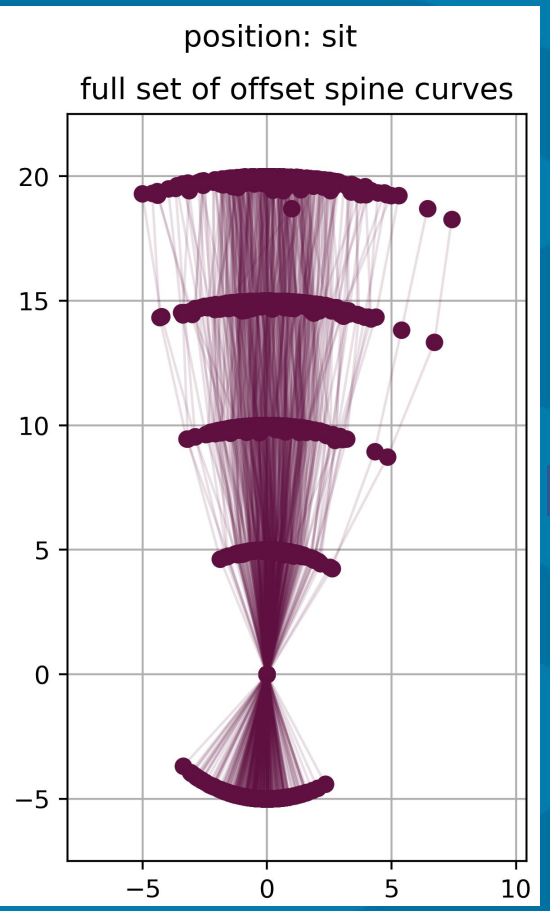


Is there a structure in all these changes?



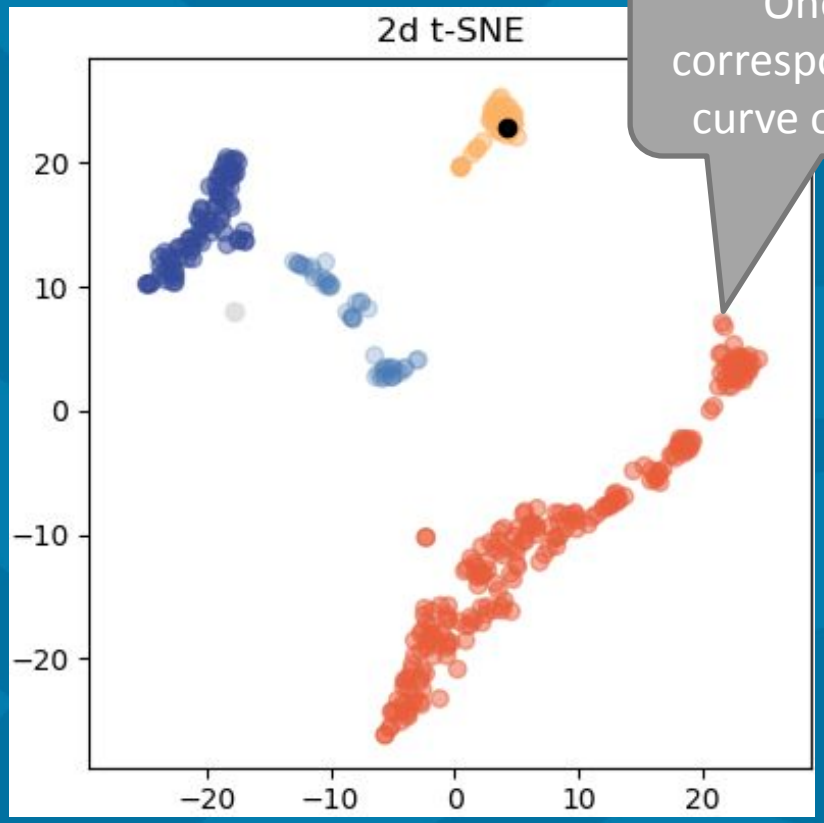
Data from 389 students!

Is there a structure in all these changes?

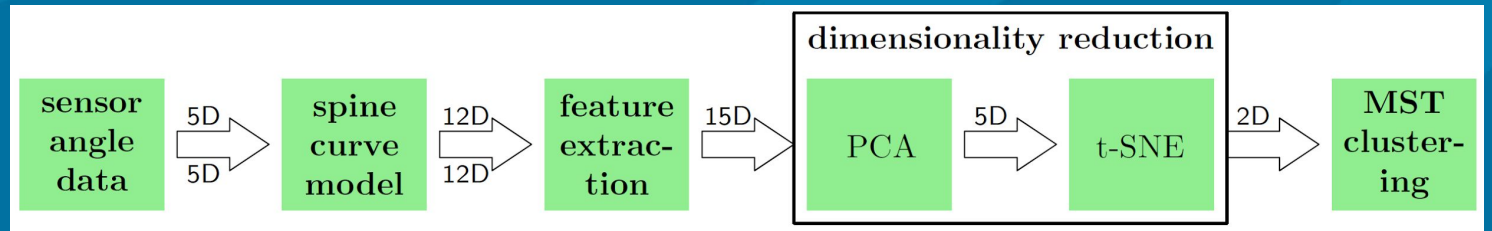


Black Box:

- Feature Computation
- Dimensionality Reduction
- Unsupervised Clustering



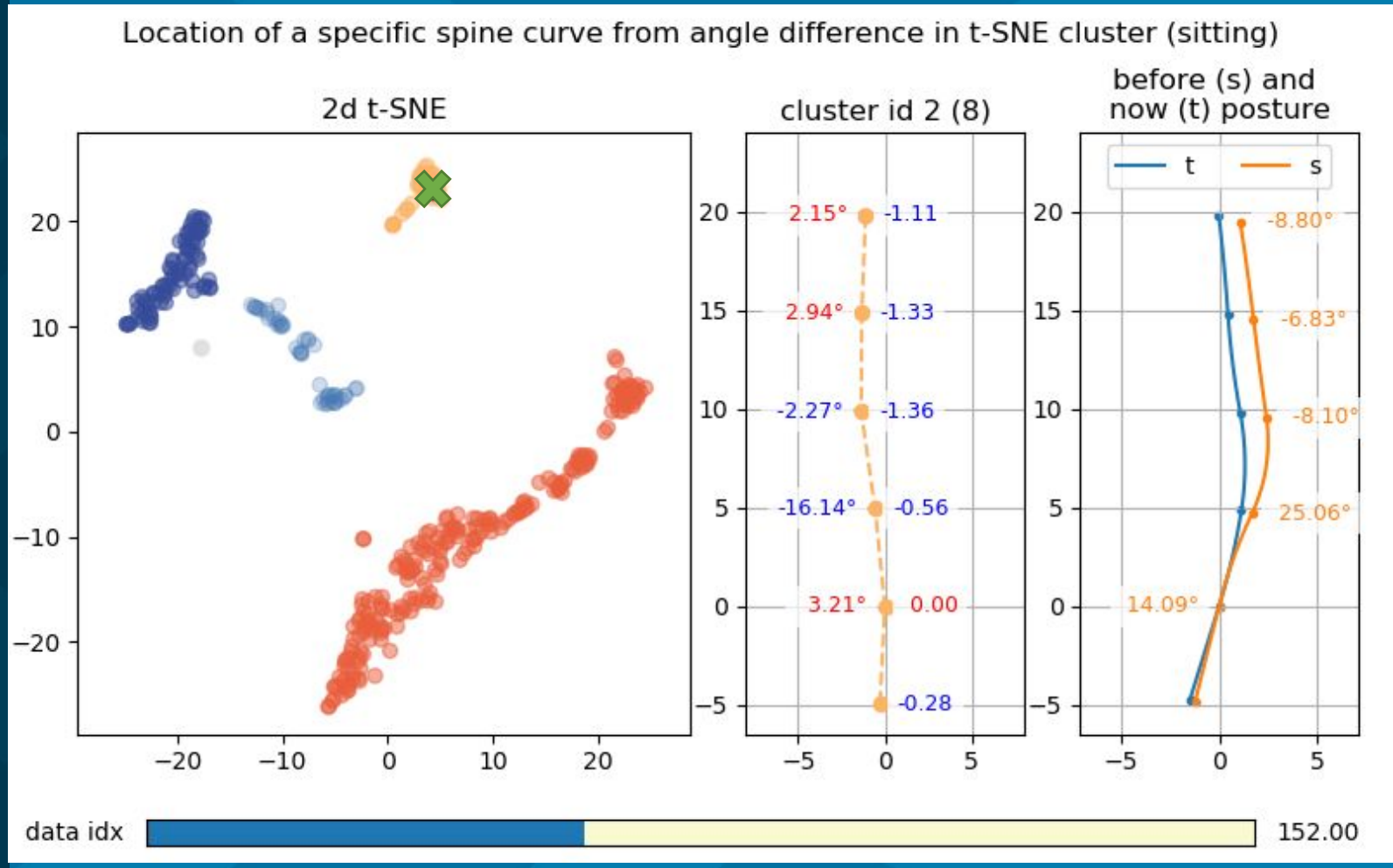
One point corresponds to one curve on the left!



GOKHALE METHOD®

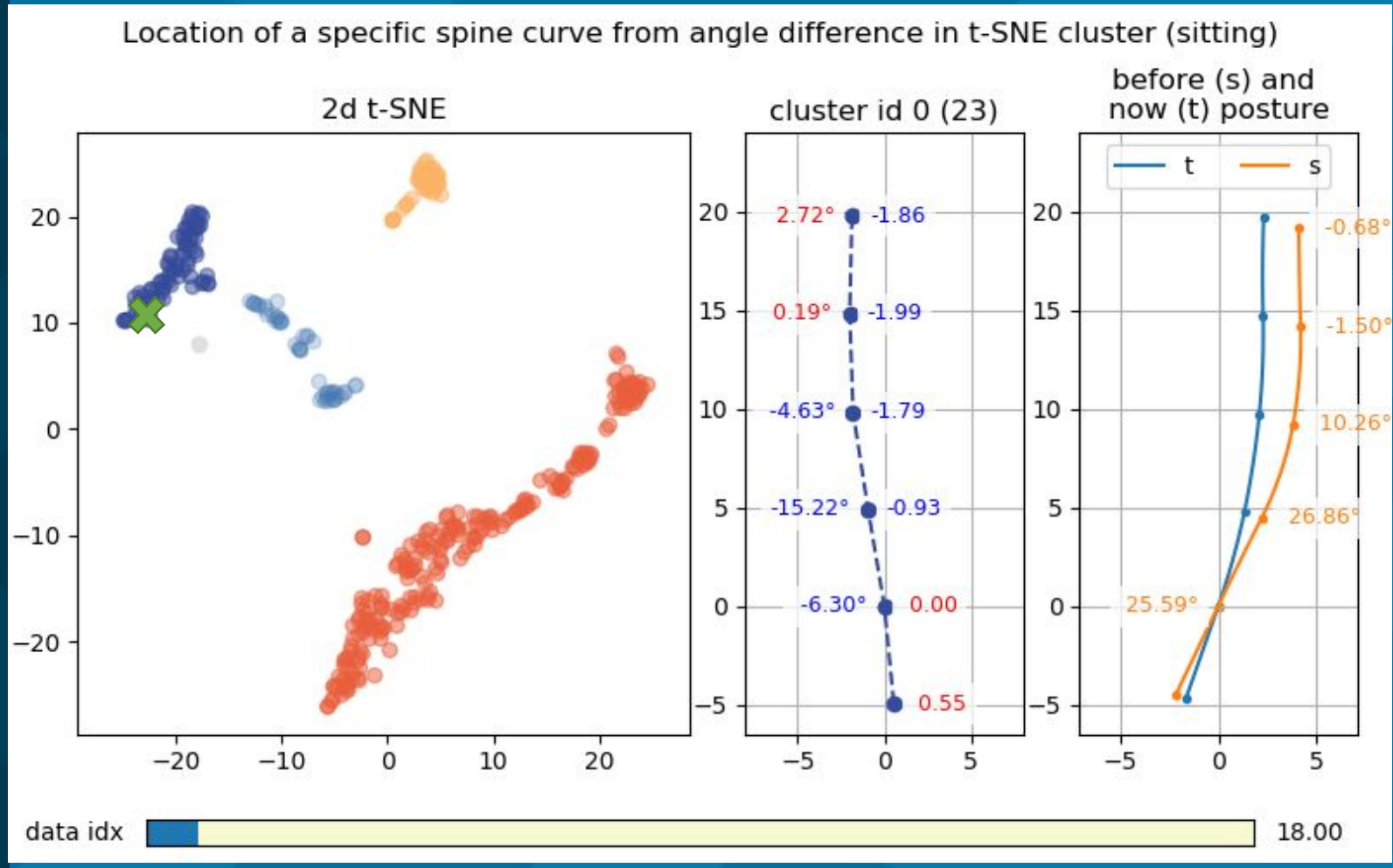
Looking at the clusters

- Orange cluster
- Green marking localizes the example
- Students in this group show:
  - reduced sway
  - increased pelvic anteversion



Looking at the clusters

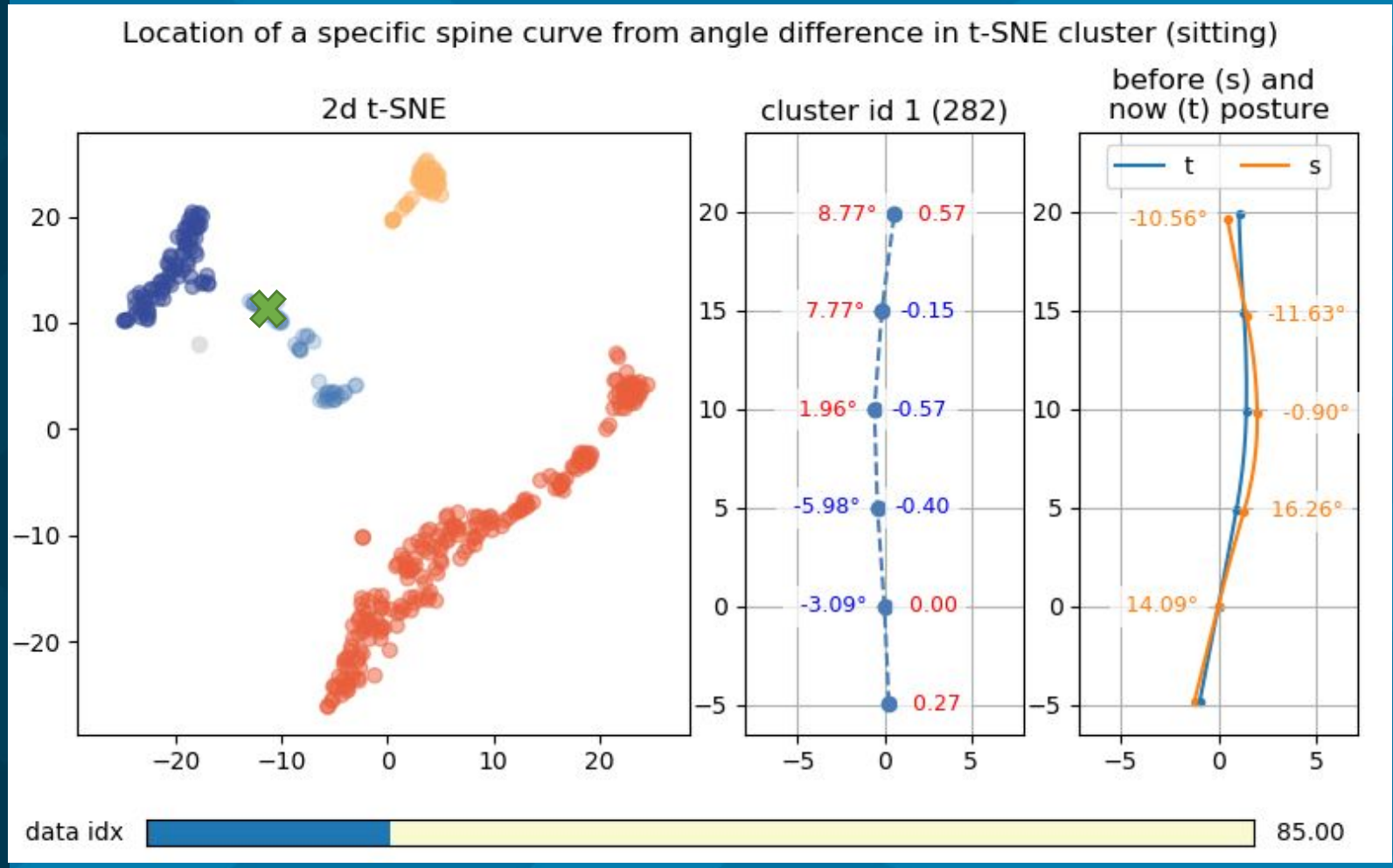
- Dark blue cluster
- Green marking localizes the example
- Students in this group show:
  - increased sway (possibly due to (partial?) stiffness in L5/S1 joint)
  - increased pelvic anteversion



GOKHALE METHOD®

Looking at the clusters

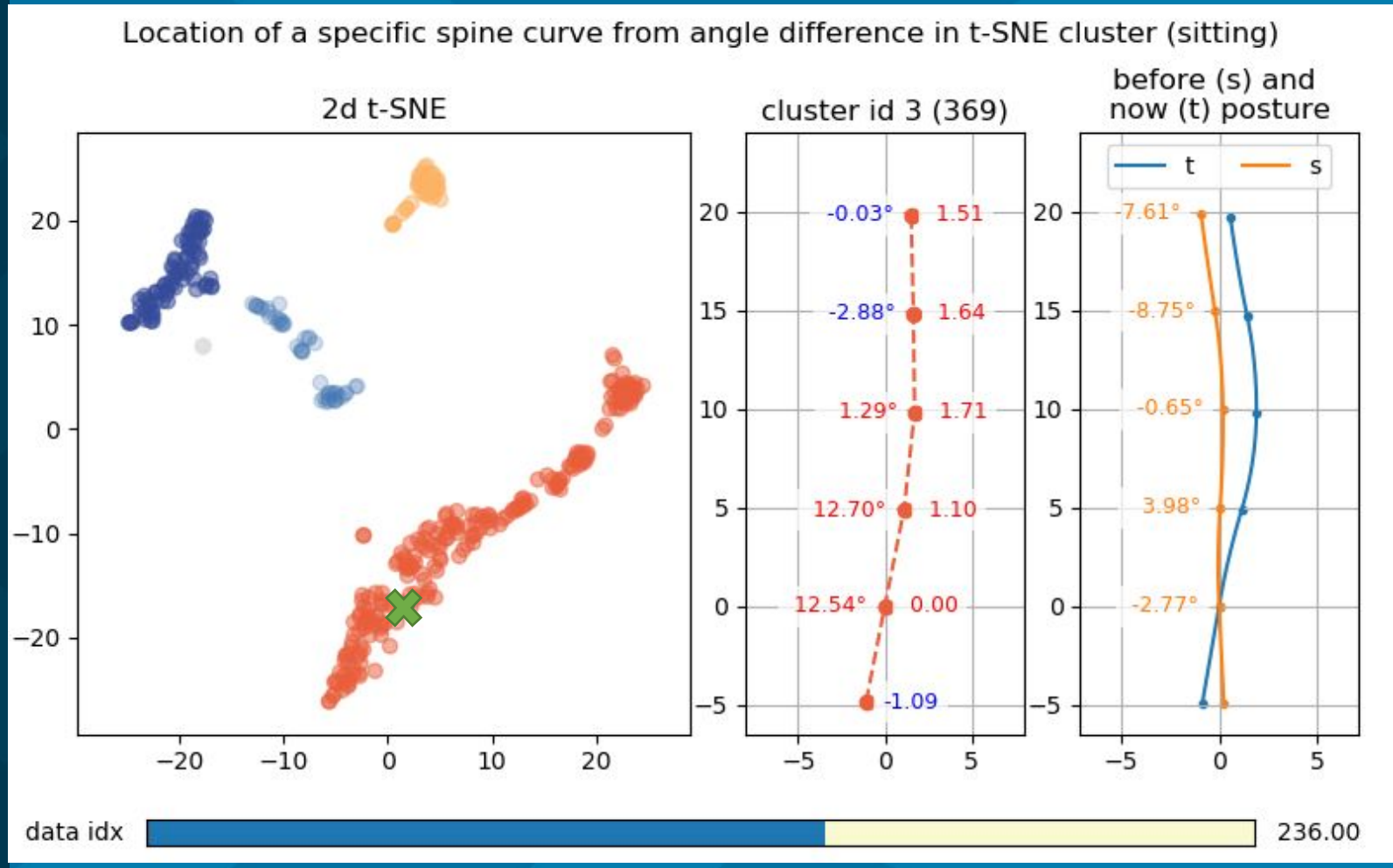
- Light blue cluster
- Green marking localizes the example
- Students in this group show:
  - reduced sway (straightened out upper lumbar curve)
  - slight reduction of pelvic anteversion



GOKHALE METHOD®

Looking at the clusters

- Dark orange cluster
- Green marking localizes the example
- Students in this group show:
  - increased pelvic anteversion
  - No clear pattern for other properties



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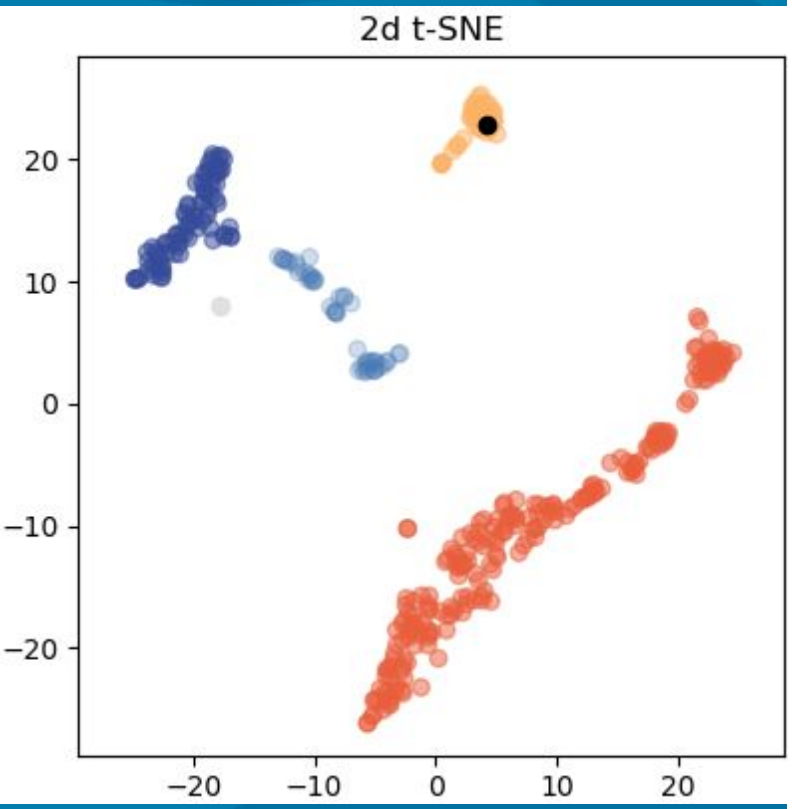
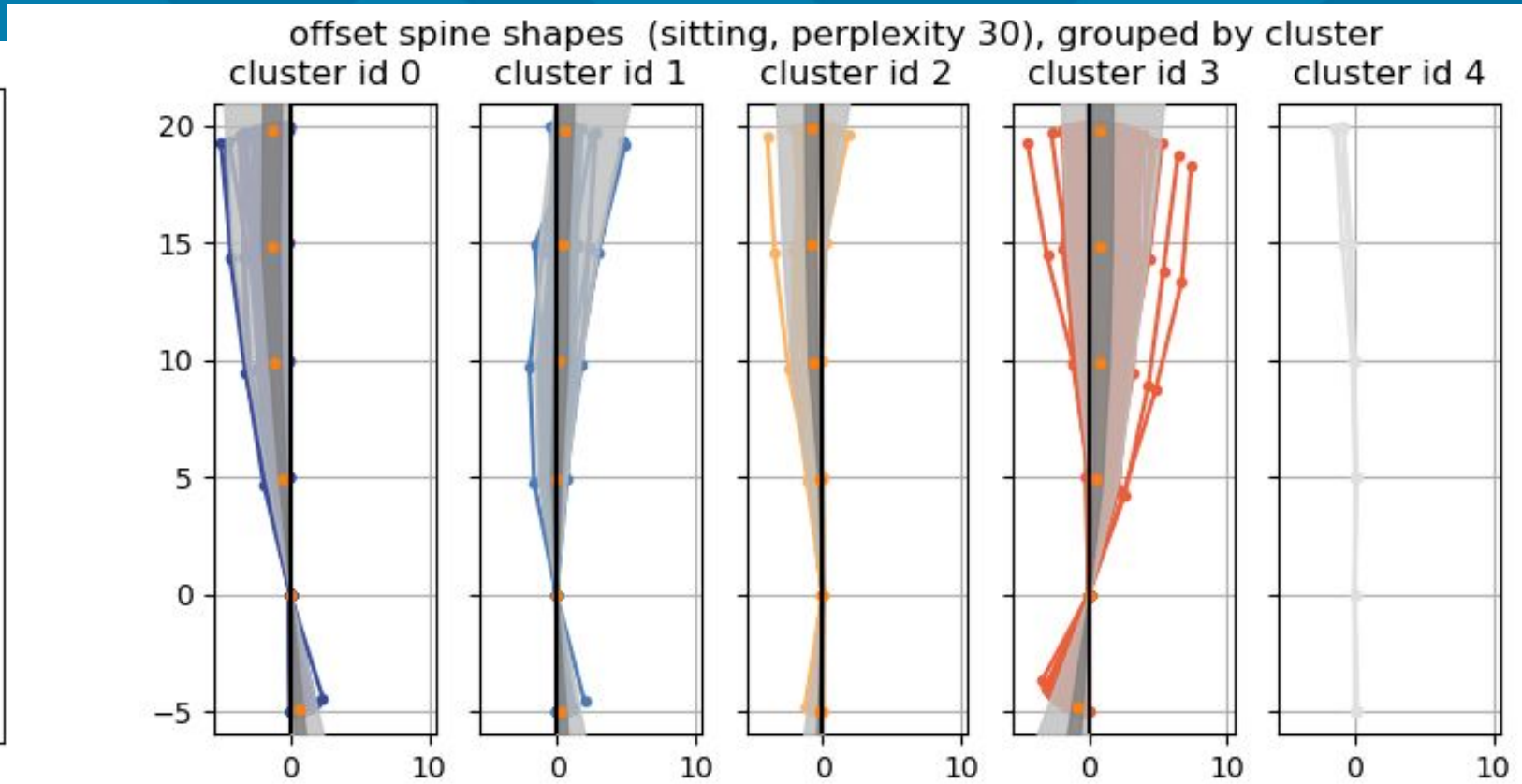
What is contained in these groups?





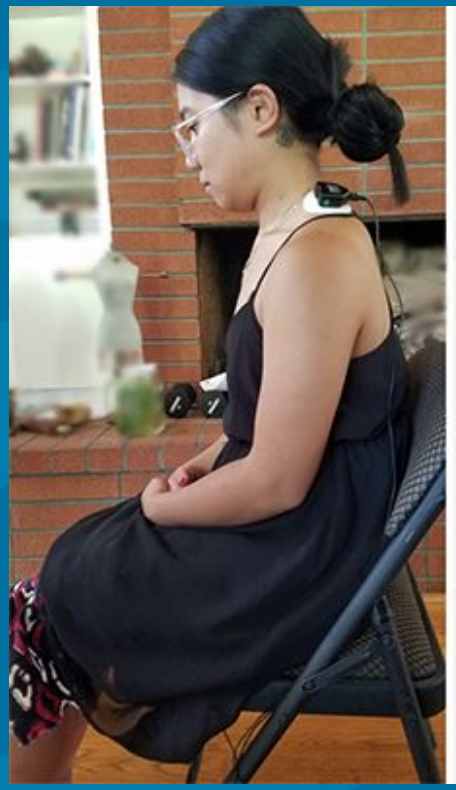
Comparing Muscle Activity and Spine Shape in Various Sitting Styles

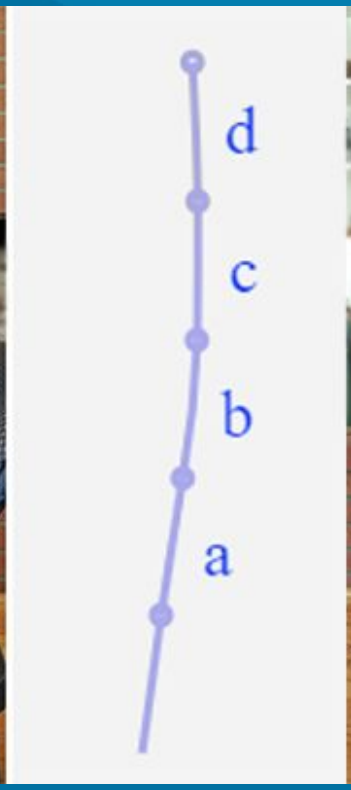
Comparing Muscle Activity and Spine Shape in Various Sitting Styles

- We equipped two subjects with our SpineTracker and EMG sensors
- SpineTracker captures the shape of the lumbar spine
- EMG sensors capture muscle activity of
  - right and left upper trapezius muscle
  - midback over the erector spinae muscles

GOKHALE METHOD®

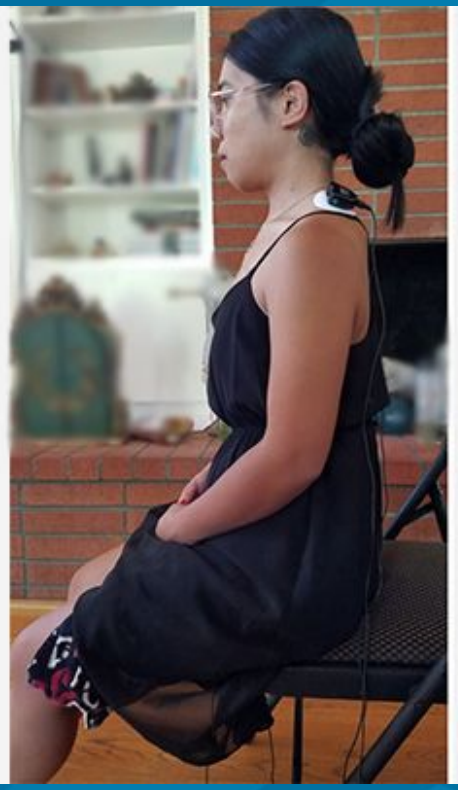
Sitting positions

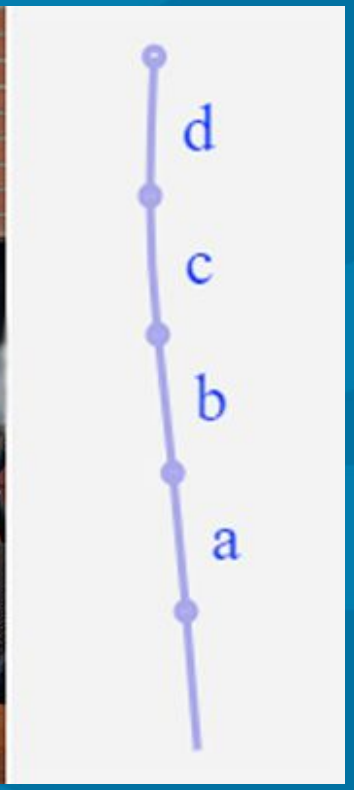




Slouched
(forward bend)

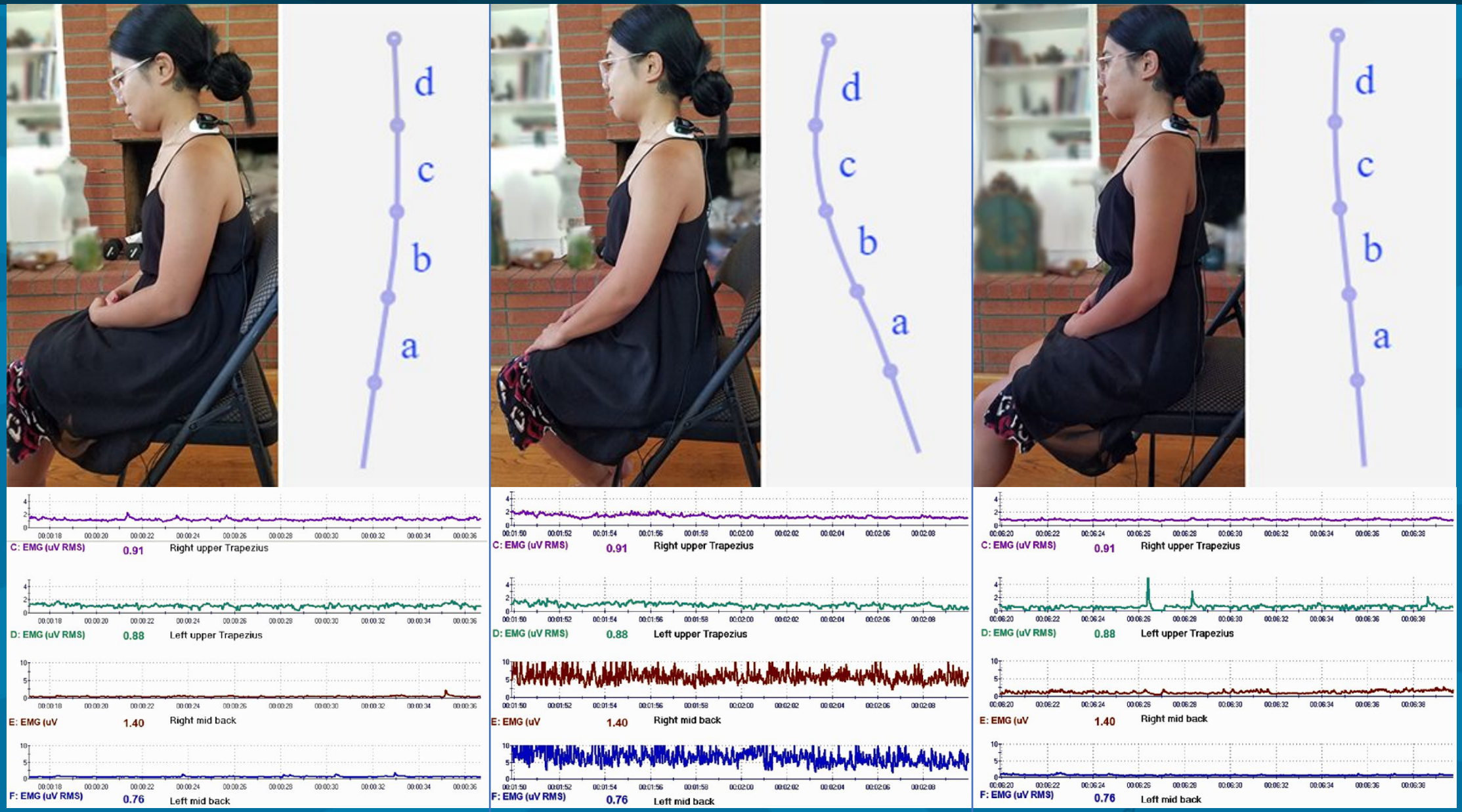
Arched upright



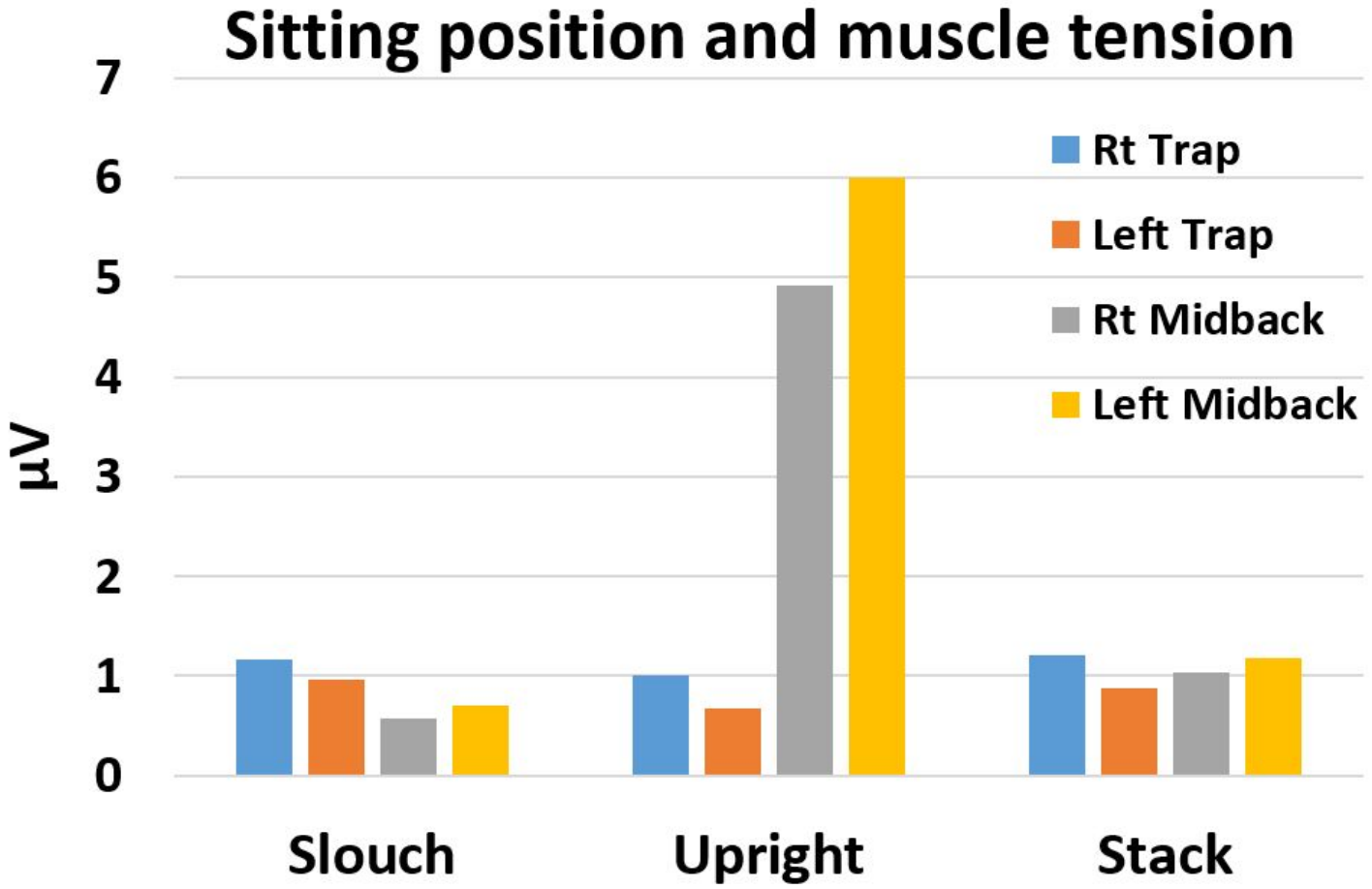


Stacksitting

EMG Readings (muscle activity)



Summary: All readings



Position	Slouch	Upright (arched)	Stack
angle d	-3 deg	12 deg	4 deg
angle c	-2 deg	19 deg	6 deg
angle b	-9 deg	10 deg	0 deg
angle a	2 deg	-7 deg	-1 deg
total curvature	16 deg	47 deg	11 deg

Future Directions

Future Directions

- Next generation hardware is ready
  - 9D sensor data
  - Wireless charging
  - Waterproof design
- Gokhale PostureTracker
  - Two sensor device that can go home with the student
  - Supports our online classes
- We are searching for collaborations!
  - Study the effectiveness of Gokhale Method
  - All projects where spine shape is of interest
  - All projects where multiple sensors are used for pose capturing
  - Further development of pose estimation

Technology
Arts Sciences
TH Köln

GOKHALE METHOD®

References

- Evaluating an Accelerometer-based System for Spine Shape Monitoring;
  Katharina Stollenwerk, Johannes Müllers, Jonas Müller, André Hinkenjann, and Björn Krüger;
  In proceedings of Computational Science and Its Applications - ICCSA 2018
- Posture Classification based on a Spine Shape Monitoring System;
  Icxa Khandelwal, Katharina Stollenwerk,Björn Krüger, and Andreas Weber;
  In proceedings of Computational Science and Its Applications - ICCSA 2019
- Analyzing Spinal Shape Changes during Posture Training using a Wearable Device;
  Katharina Stollenwerk, Jonas Müller, André Hinkenjann and Björn Krüger;
  In Sensors (2019)
- Comparing Muscle Activity and Spine Shape in Various Sitting Styles;
  Erik Peper, Björn Krüger, Esther Gokhale, and Richard Harvey;
  In Biofeedback (2020)

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Thank you for your attention!

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