

Esther Gokhale

Founder and CEO of the Gokhale Method
esther@gokhalemethod.com

Dr. Björn Krüger

Professor for Distributed Media Applications
and Technologies
bjoern.krueger@th-koeln.de

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

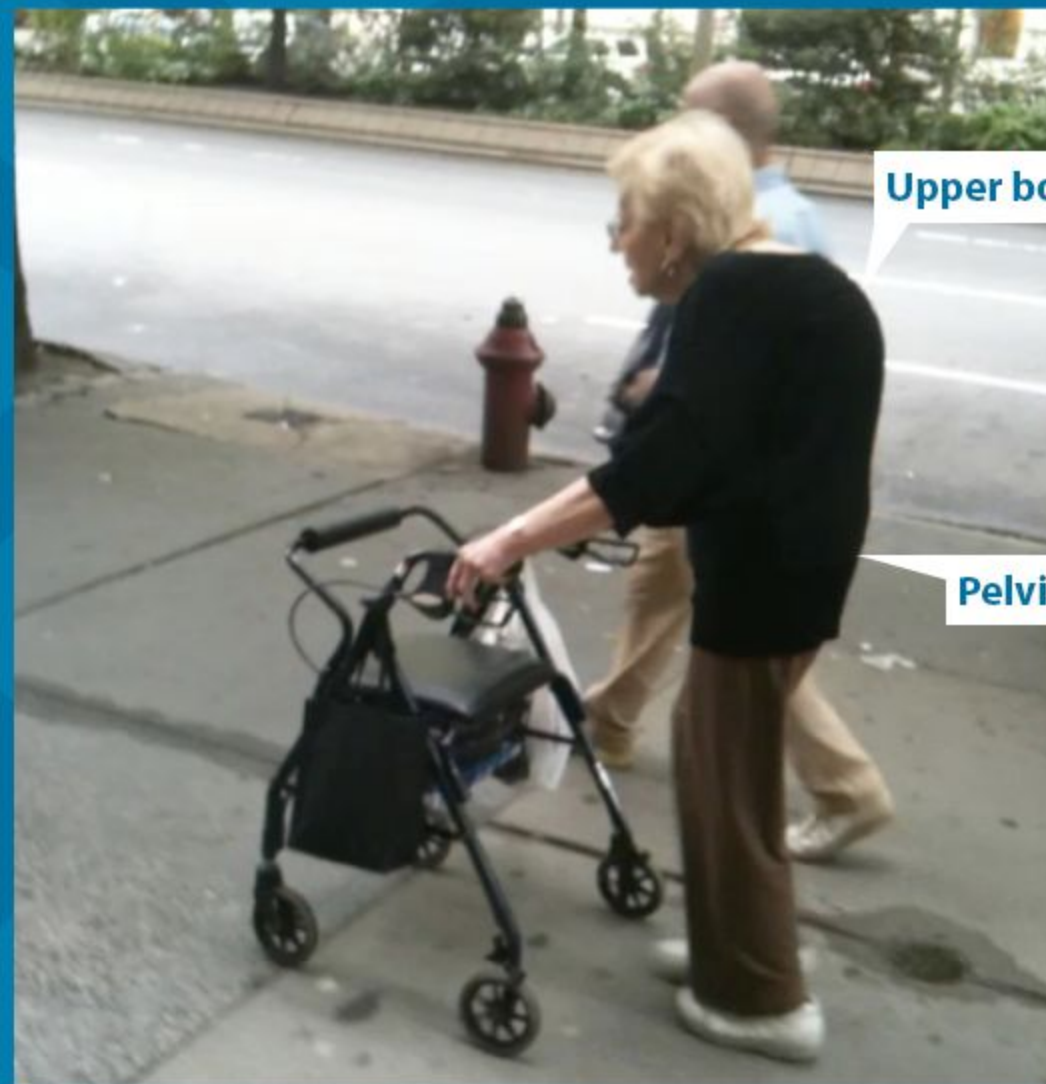
Esther Gokhale

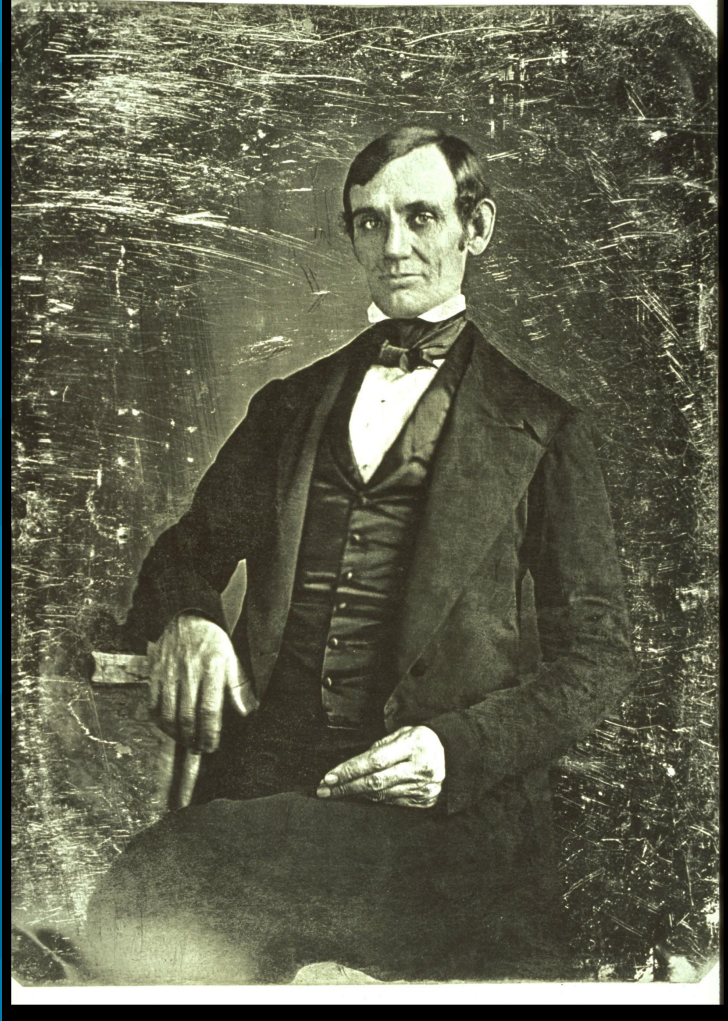
- Drift in posture in recent history
- How does this affect NASA workers?
- Ways to retrieve healthy posture

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







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Behind behind



Behind tucked





1900's train seat

Credit: City Transport

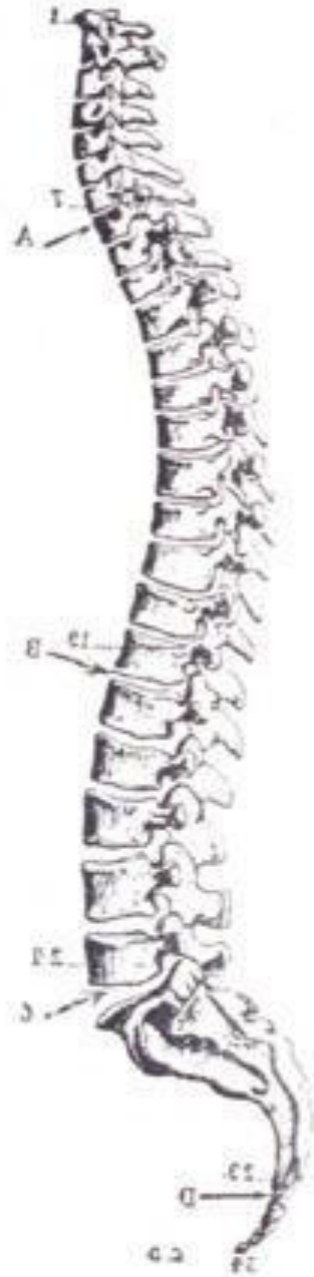


Slat blocking the bottom



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Anatomy text published 1911



Anatomy text published 1990



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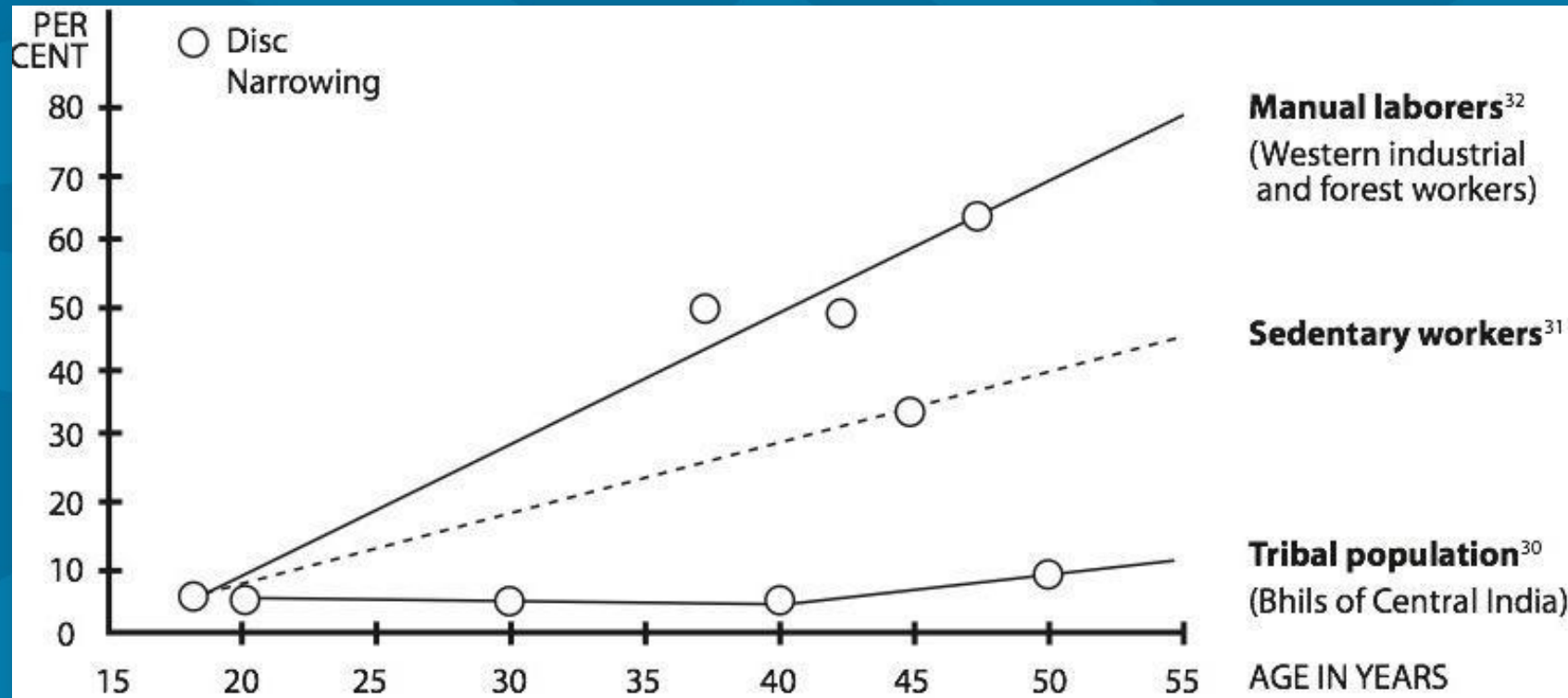


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Disc Narrowing with Age in Three Different Populations



[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 were
Approximately two-thirds
Total lordosis was significantly
Patients tended to stand

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

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 determinant of both standing pelvic rotation and hip extension. It is strongly correlated with segmental and total lordosis in both volunteers and patients.





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



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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



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Astronaut Scott Kelly aboard the International Space Station

Image Credit: Bill Ingalls/NASA/Getty Images

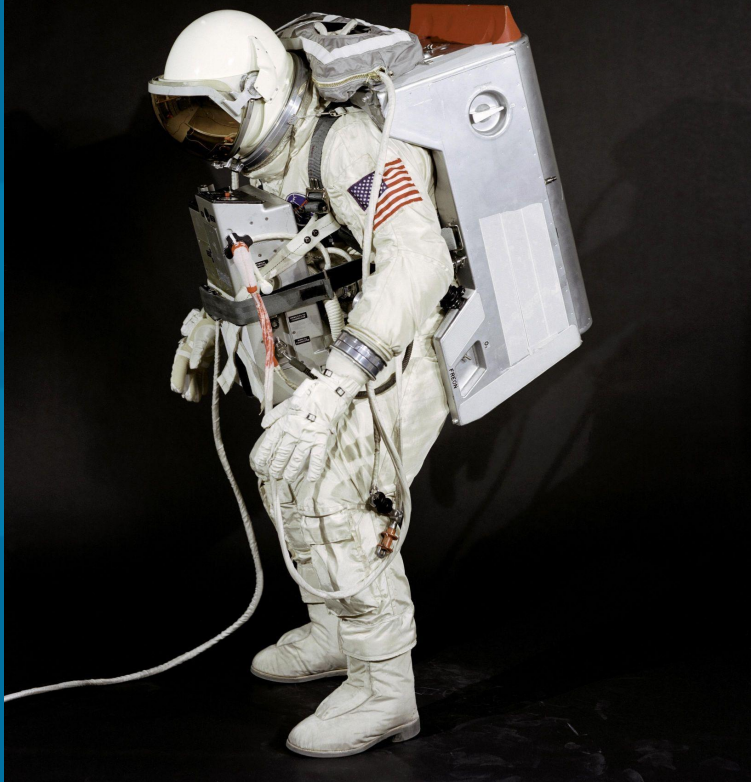


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Testing the Gemini Spacesuit - January 1966



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



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.



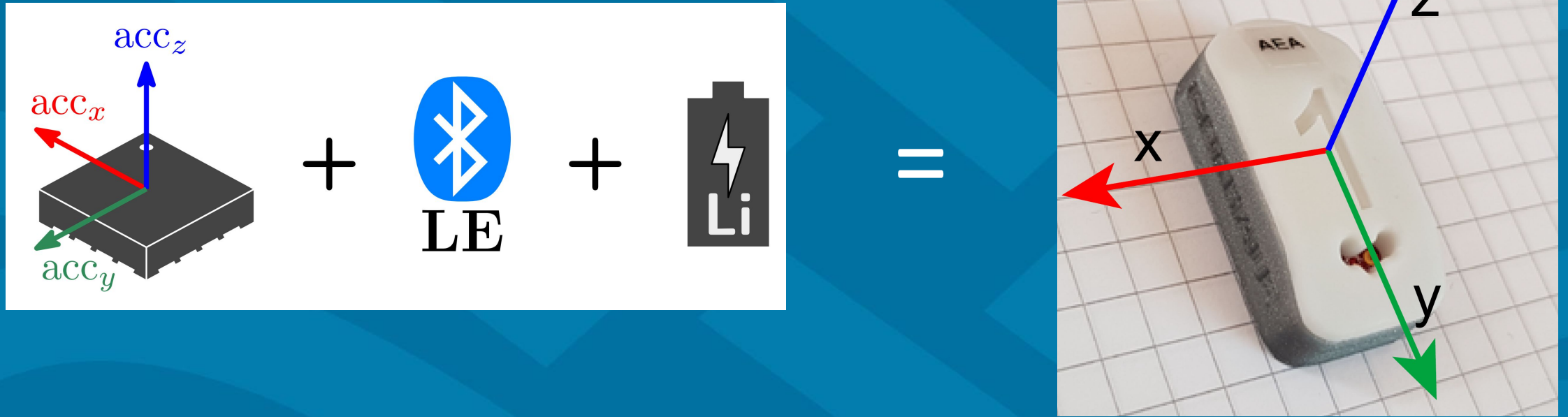
Gokhale, Esther
104
12-08-87
Scan. 05



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The background of the slide features a row of five white, oval-shaped sensors with black wires attached, used for spine tracking. The sensors are arranged horizontally across the top half of the image. The text 'Introduction to SpineTracker™' is overlaid in white, bold font, centered horizontally and positioned below the sensors. A thin white vertical line is located to the left of the text.

Introduction to SpineTracker™



The Sensor



A Sensor Set

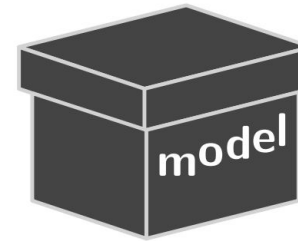
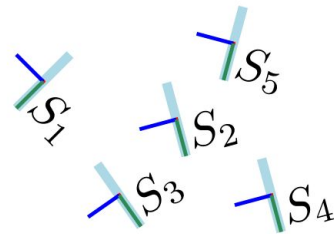
Five identical
sensors



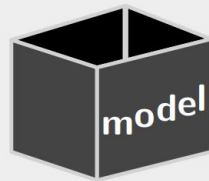
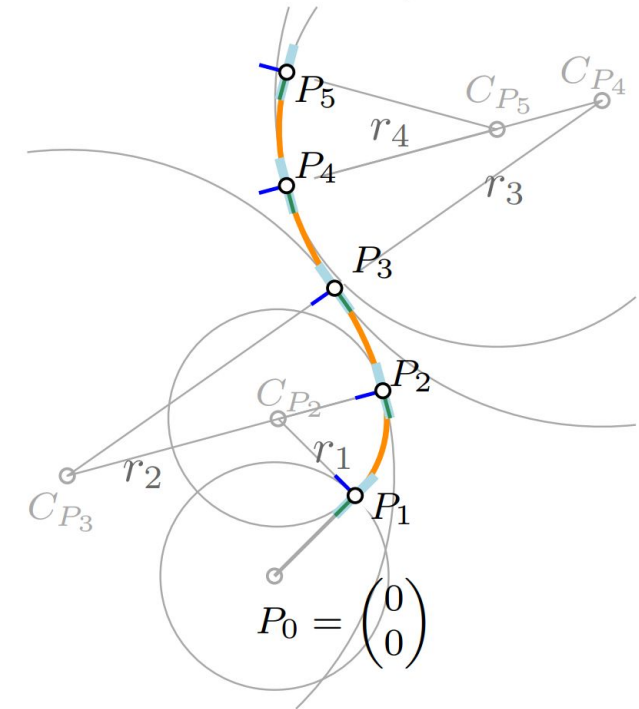
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From Accelerations to Spine Curve

(tilted) sensors



reconstructed pose



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

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

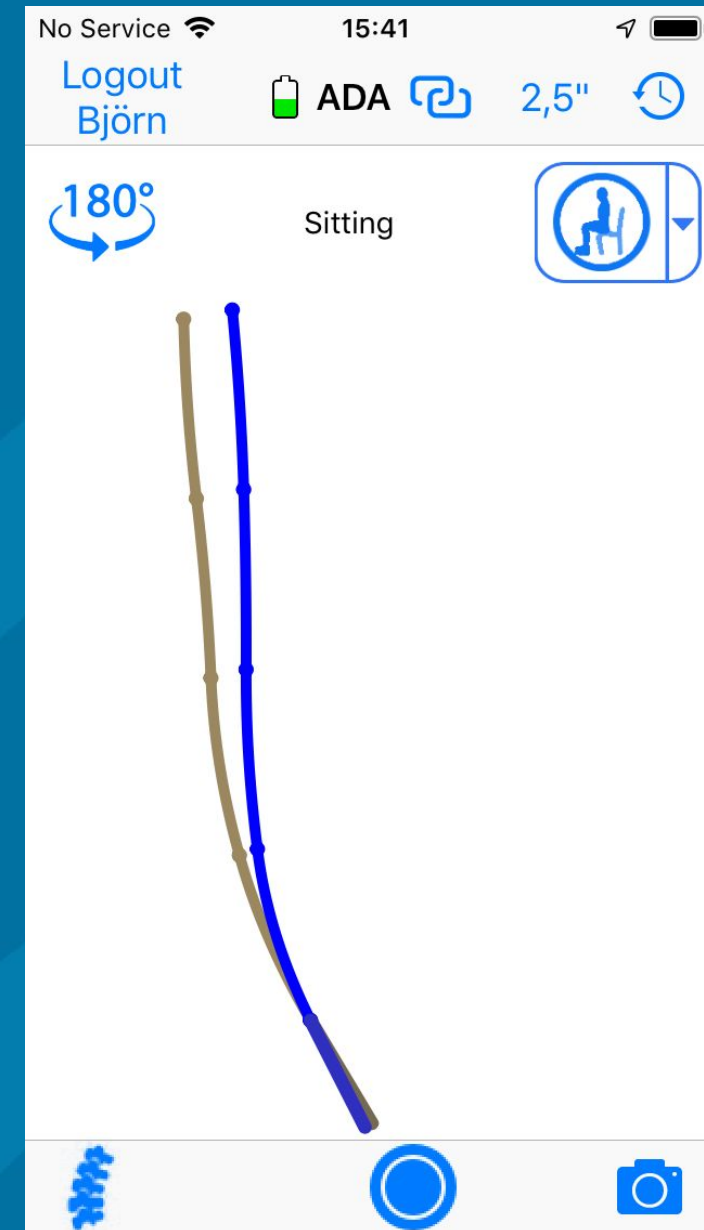
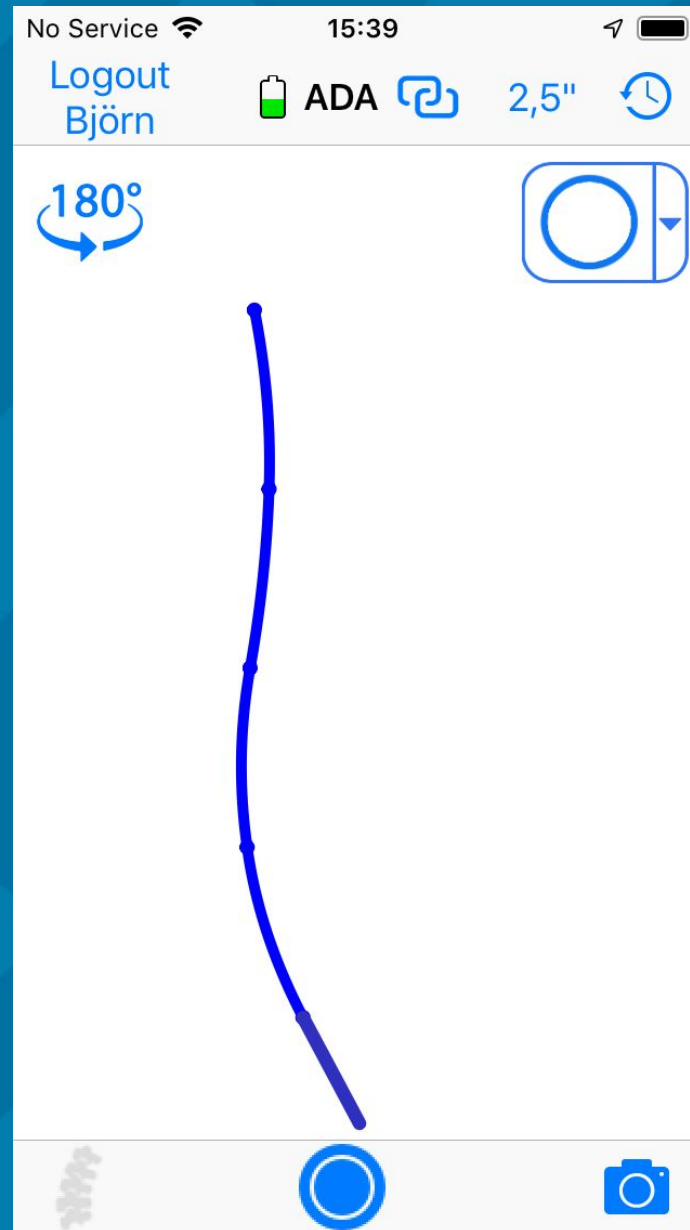
with t_{acc, S_n} forward tilt of sensor S_n ,

r_n radius of the circle around $C_{P_{n+1}}$ to which S_n and S_{n+1} are tangents

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

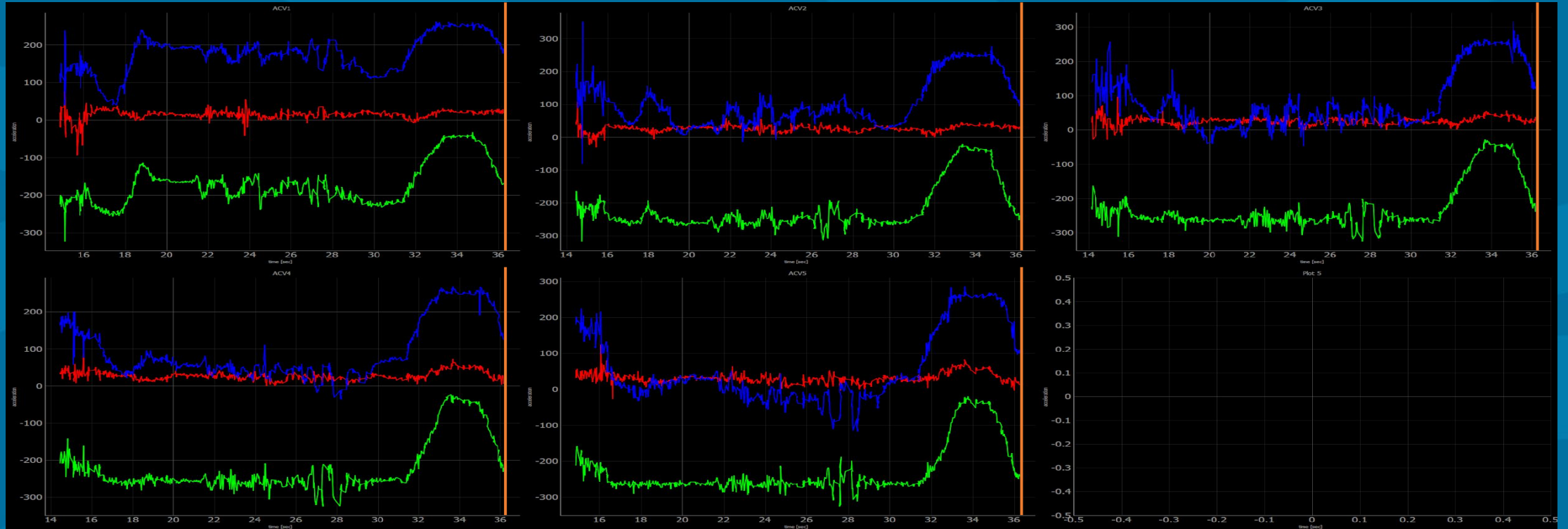
$$\delta_n = t_{\text{acc}, S_n} - t_{\text{acc}, S_{n+1}}$$

SpineTracker App



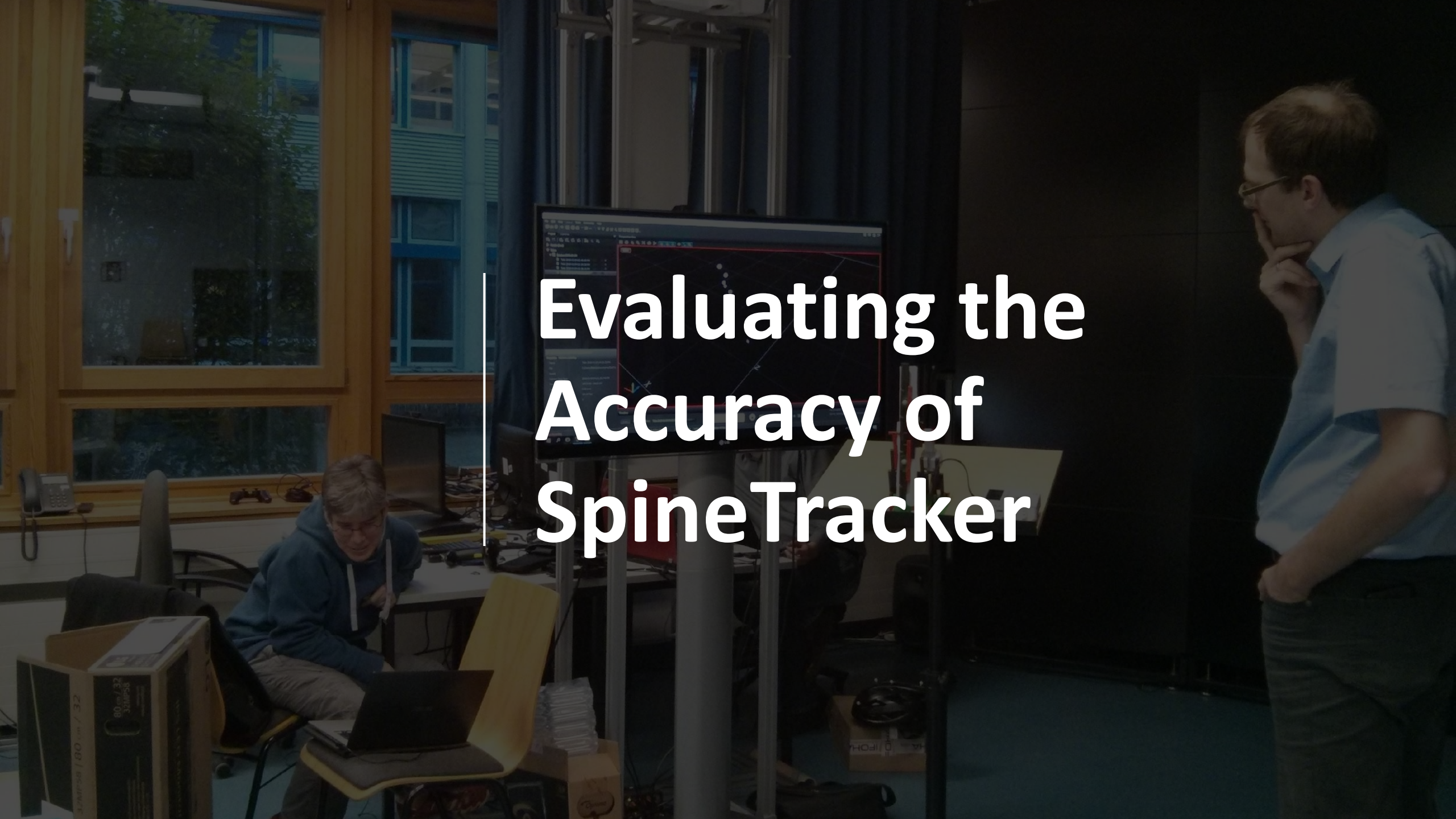
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Time Series Data



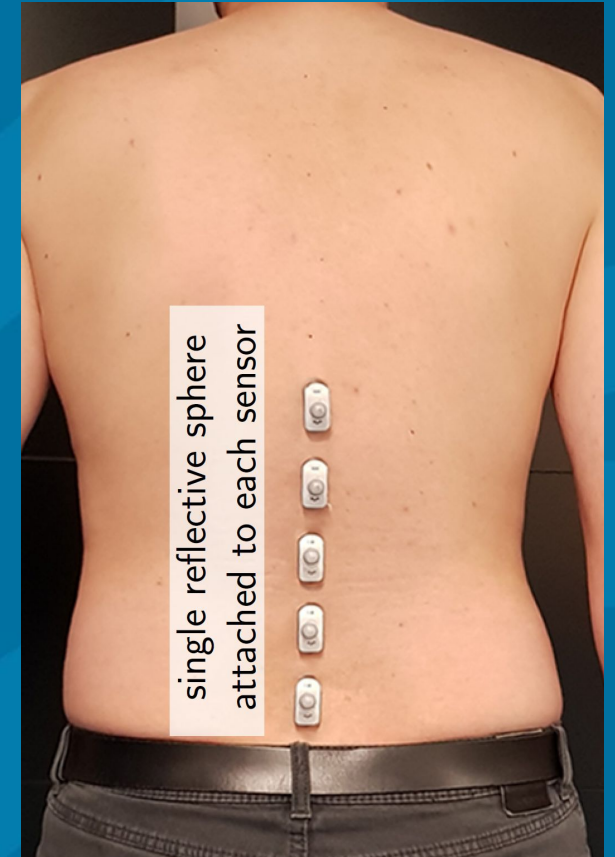
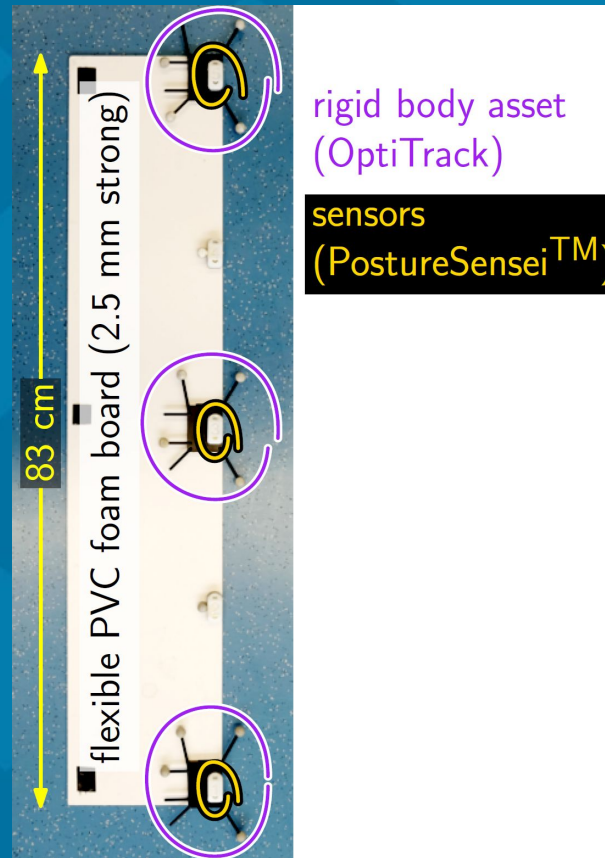
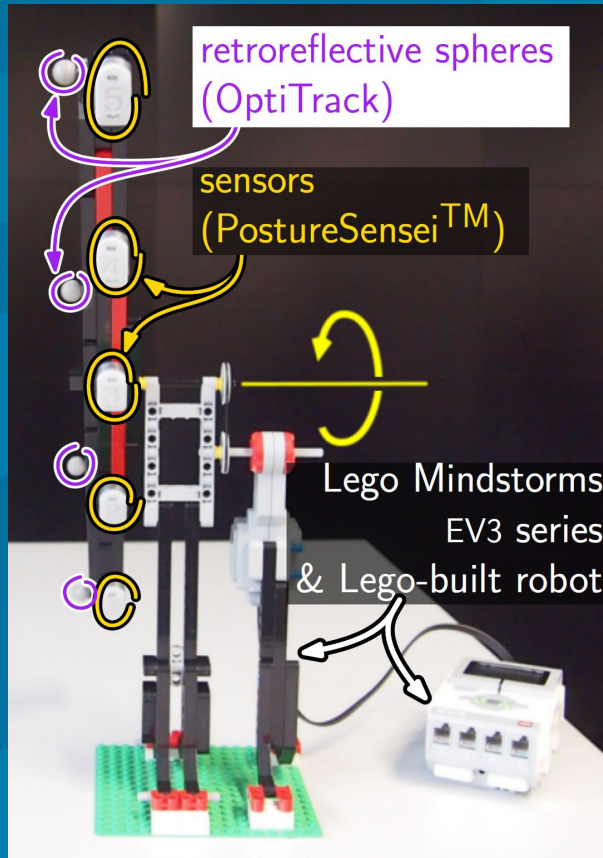
- Accelerations until an „event“ happens
 - Position selection
 - Snapshot taken
 - Leave live view
 - ...



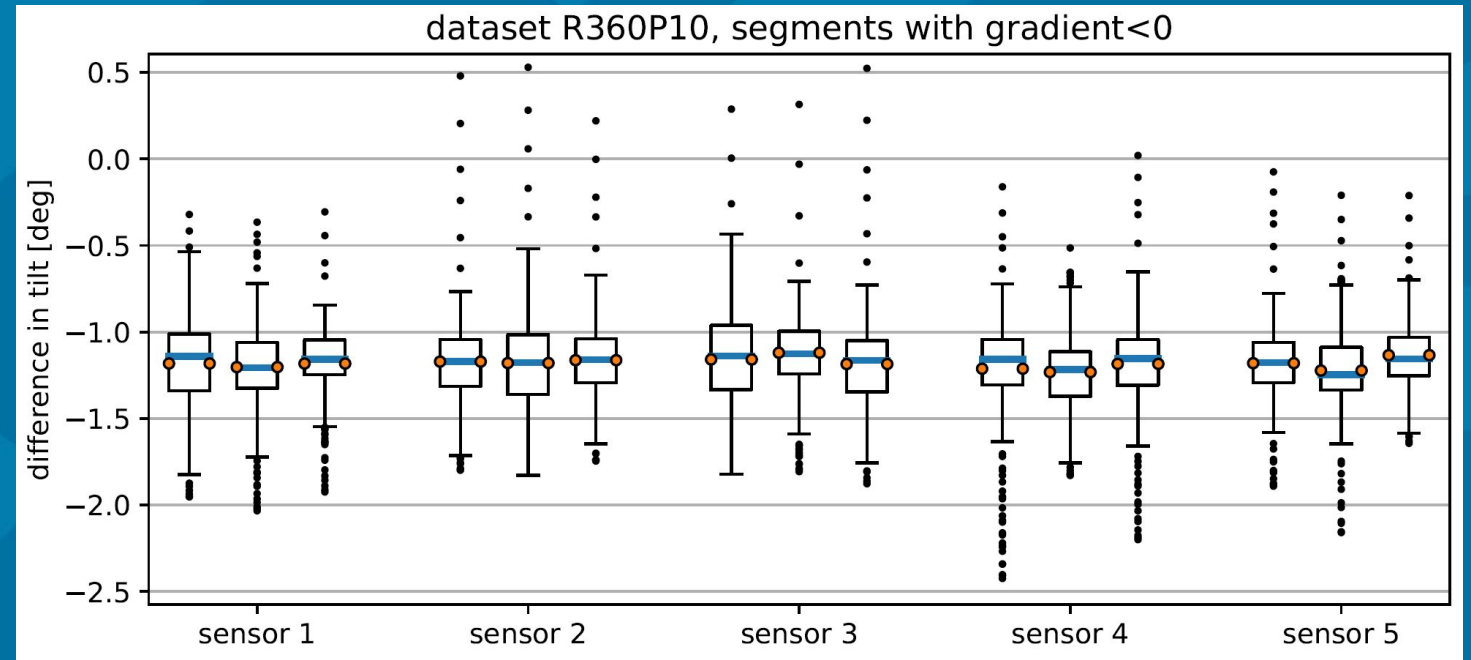
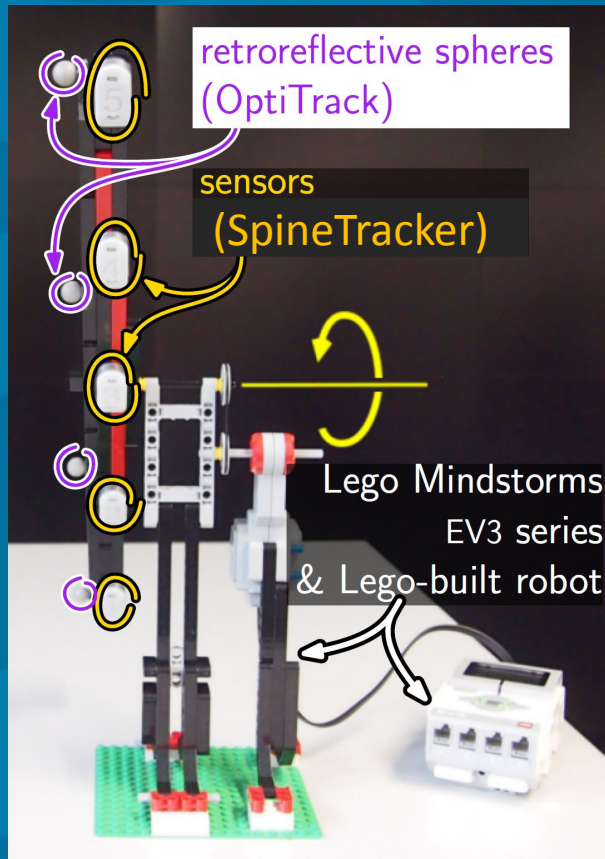
A person in a blue hoodie is sitting at a desk, working on a laptop. In the background, a large monitor displays a graph with a red line and several data points. The setting appears to be a laboratory or office with large windows. Another person is standing on the right side of the frame, looking at the monitor.

Evaluating the Accuracy of SpineTracker

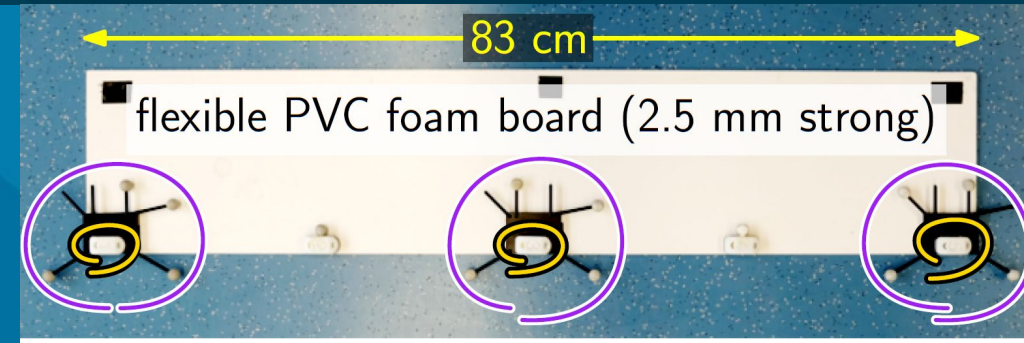
Evaluating an Accelerometer-based System for Spine Shape Monitoring



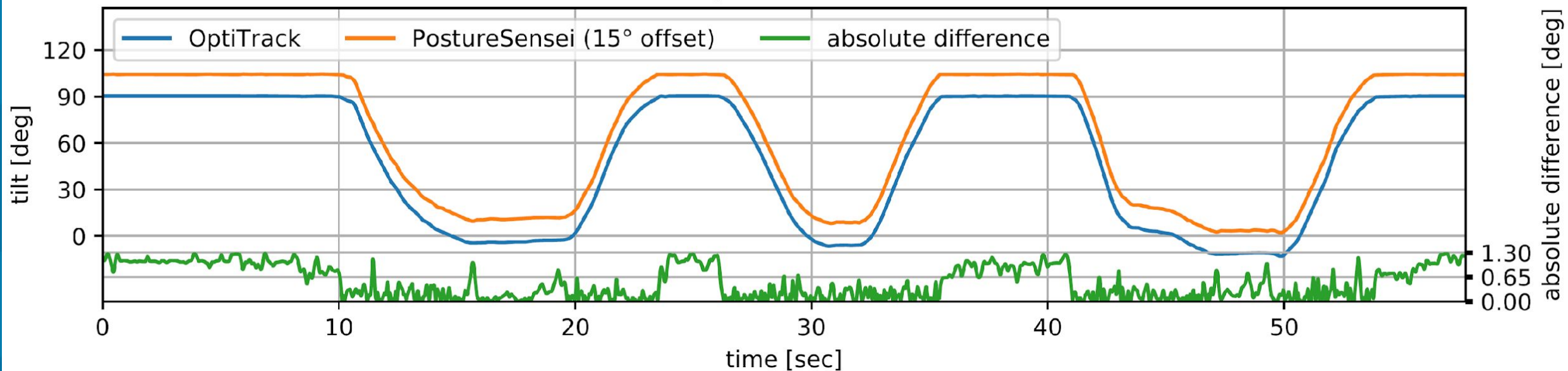
Experiment 1: Robot Arm



Experiment 2: Template

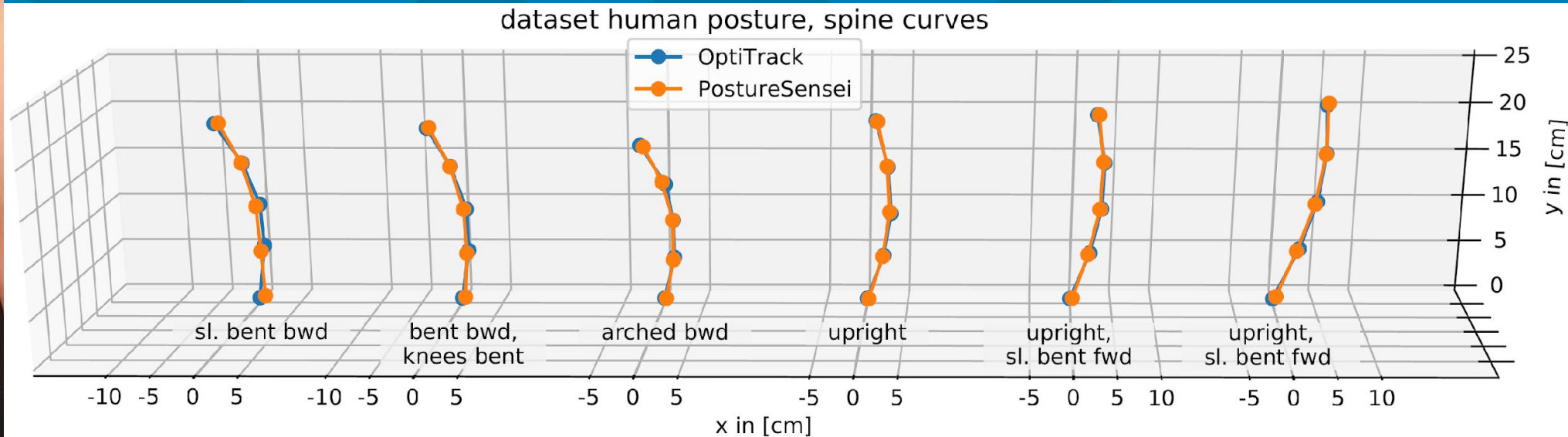



dataset template, take 1, sensor 5



Experiment 3: human back

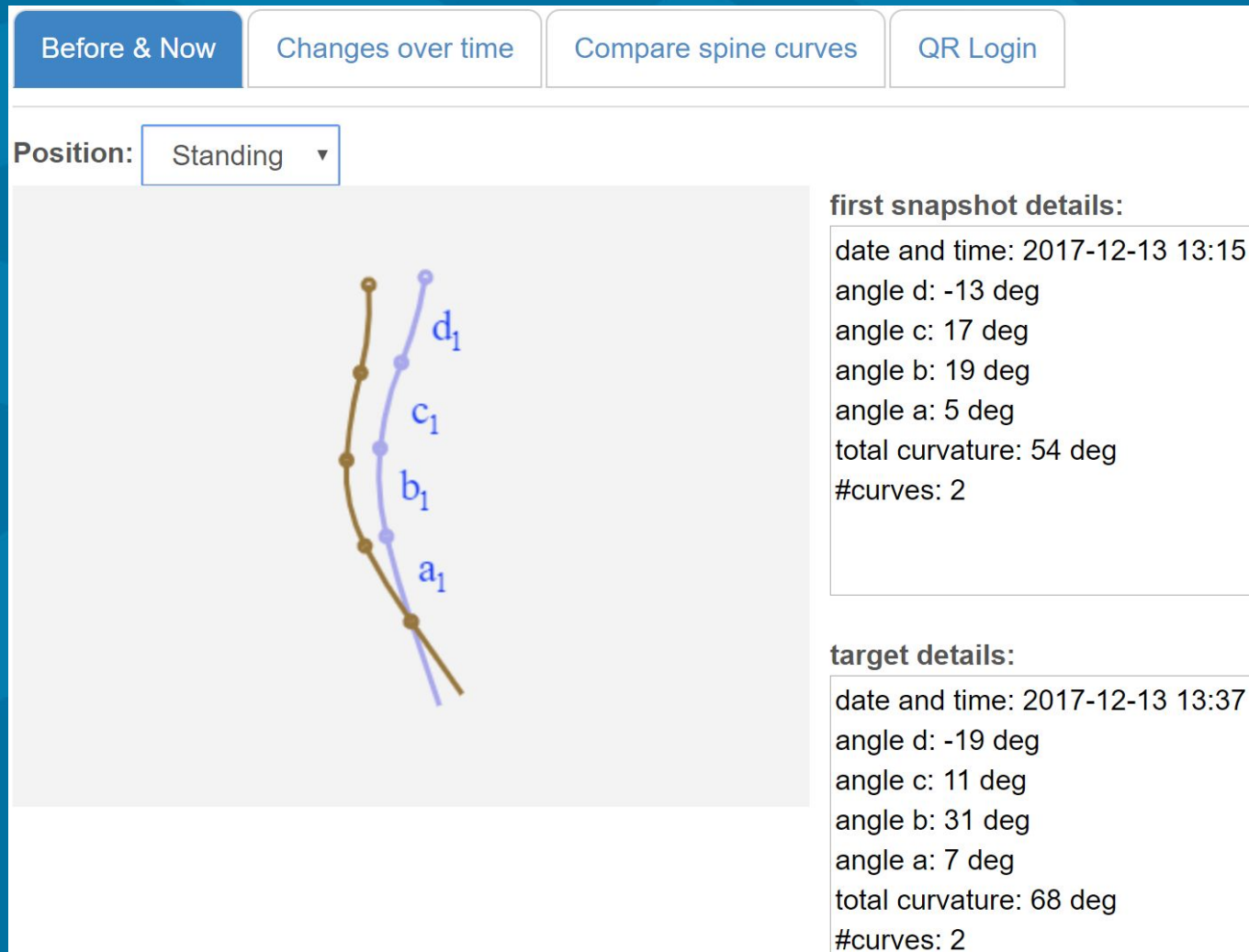
“Thus, we conclude, that SpineTracker™ is capable of capturing the spinal curvature for static poses accurately and provides valuable feedback to the user.”



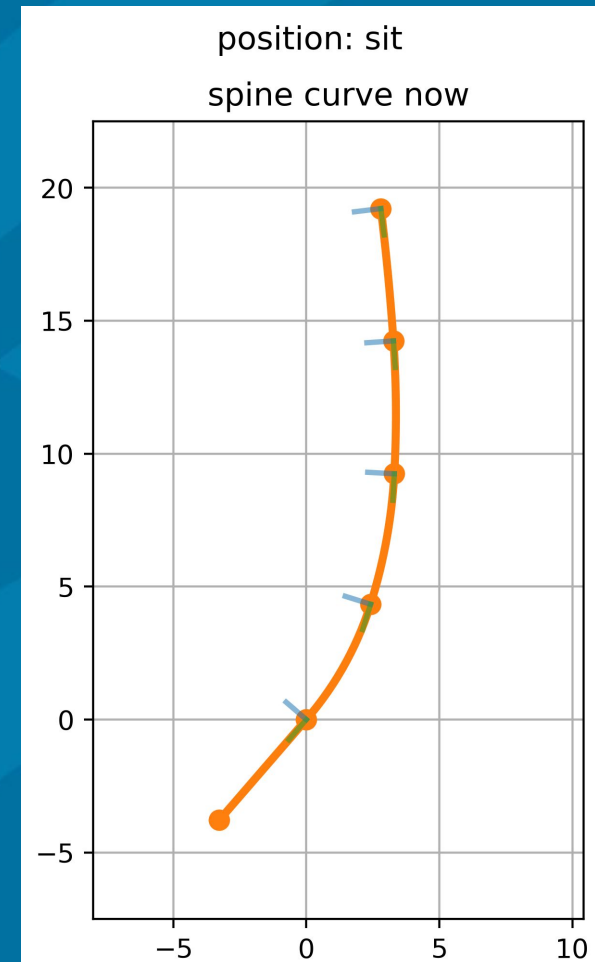
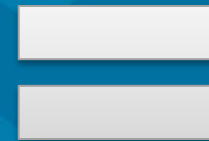
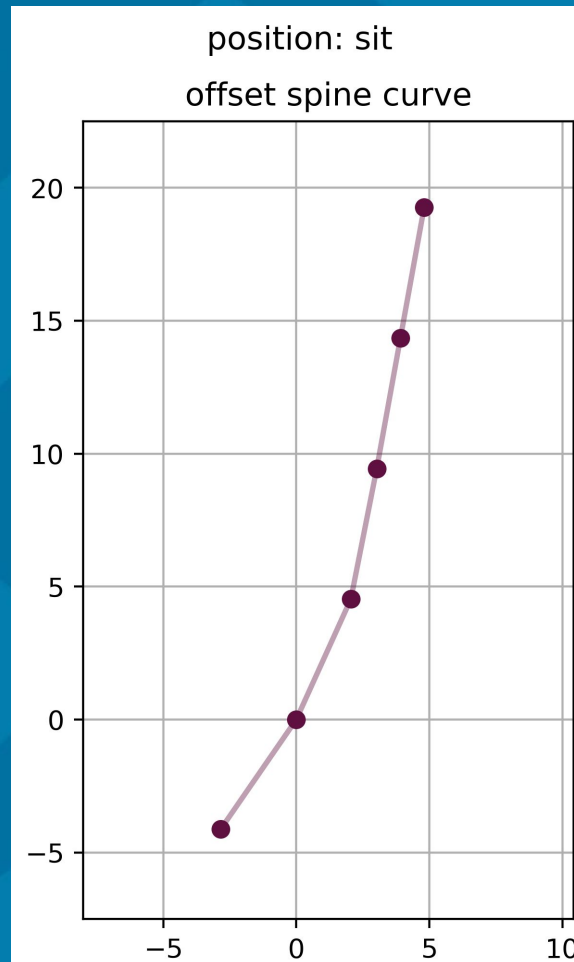
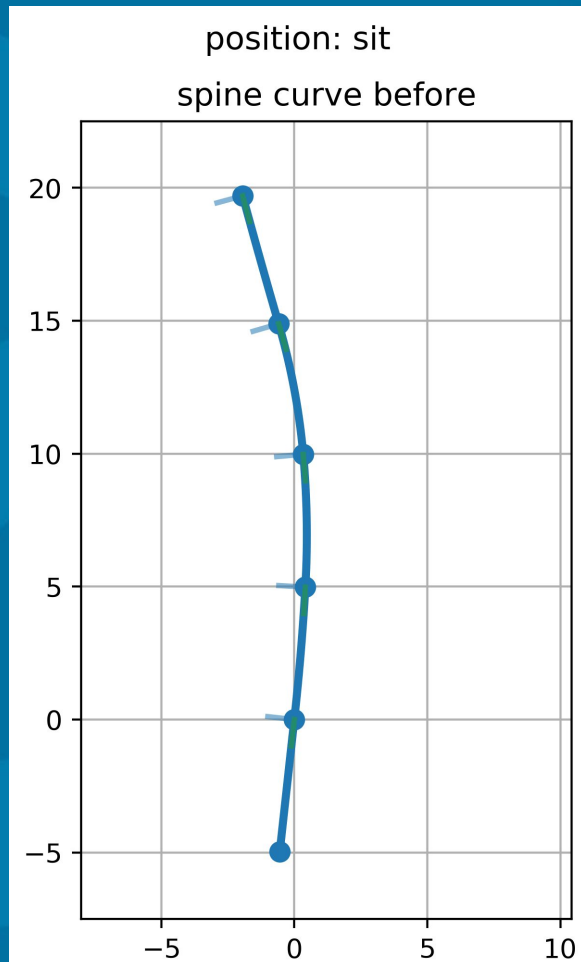
The image is a composite of two side-by-side photographs of a man sitting on a chair, illustrating posture training. The man is wearing a light blue short-sleeved button-down shirt and dark trousers. He is barefoot. In the left image, he is sitting on a simple black folding chair, leaning forward with his back rounded, representing a poor posture. In the right image, he is sitting on a black office chair with a backrest, sitting upright with his back straight, representing a good posture. The background is a simple indoor room with light-colored walls and a wooden floor. A vertical white line separates the two images. Overlaid on the right side of the image is the title text in a large, white, sans-serif font.

Analyzing Spinal Shape Changes during Posture Training using a Wearable Device

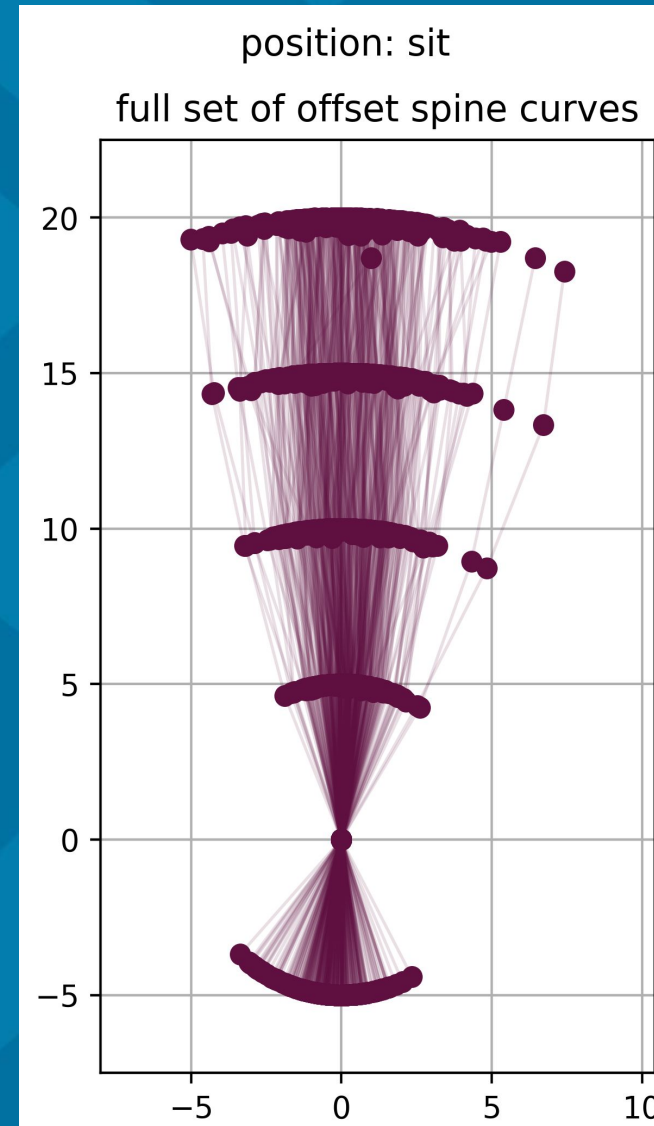
Analyzing Spinal Shape Changes during Posture Training using a Wearable Device



What is analyzed?



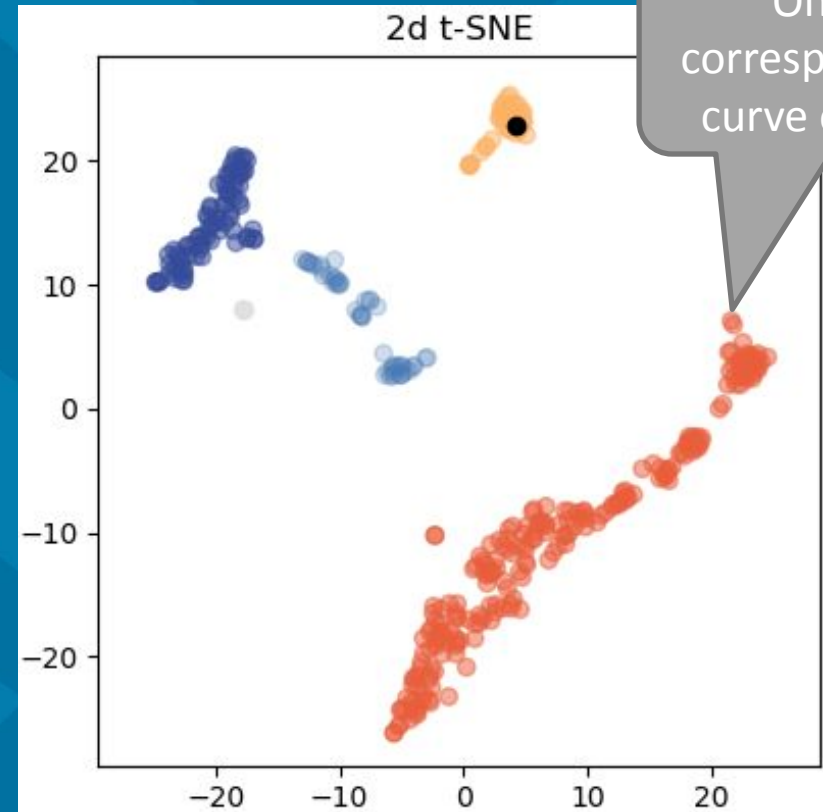
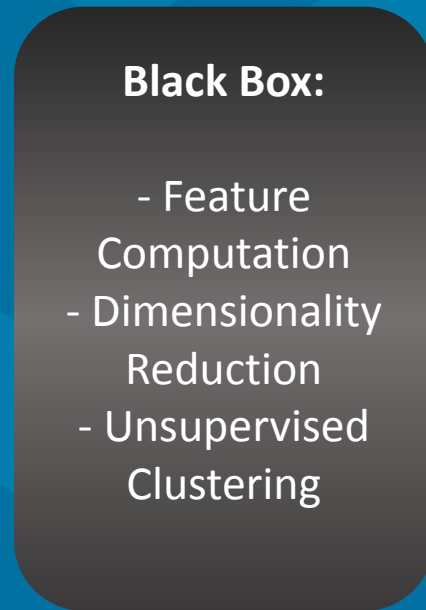
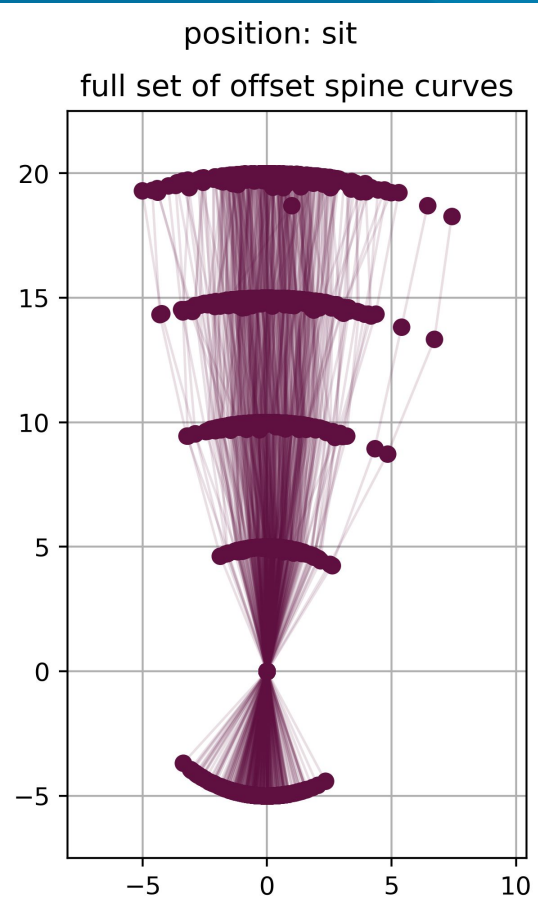
Is there a
structure in
all these
changes?



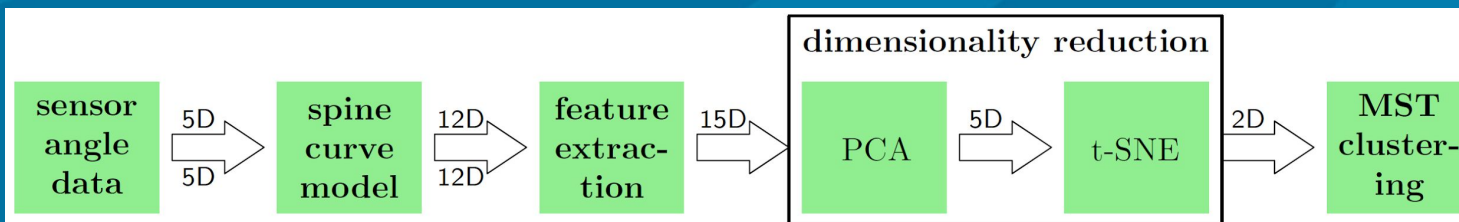
Data from 389
students!



Is there a structure in all these changes?

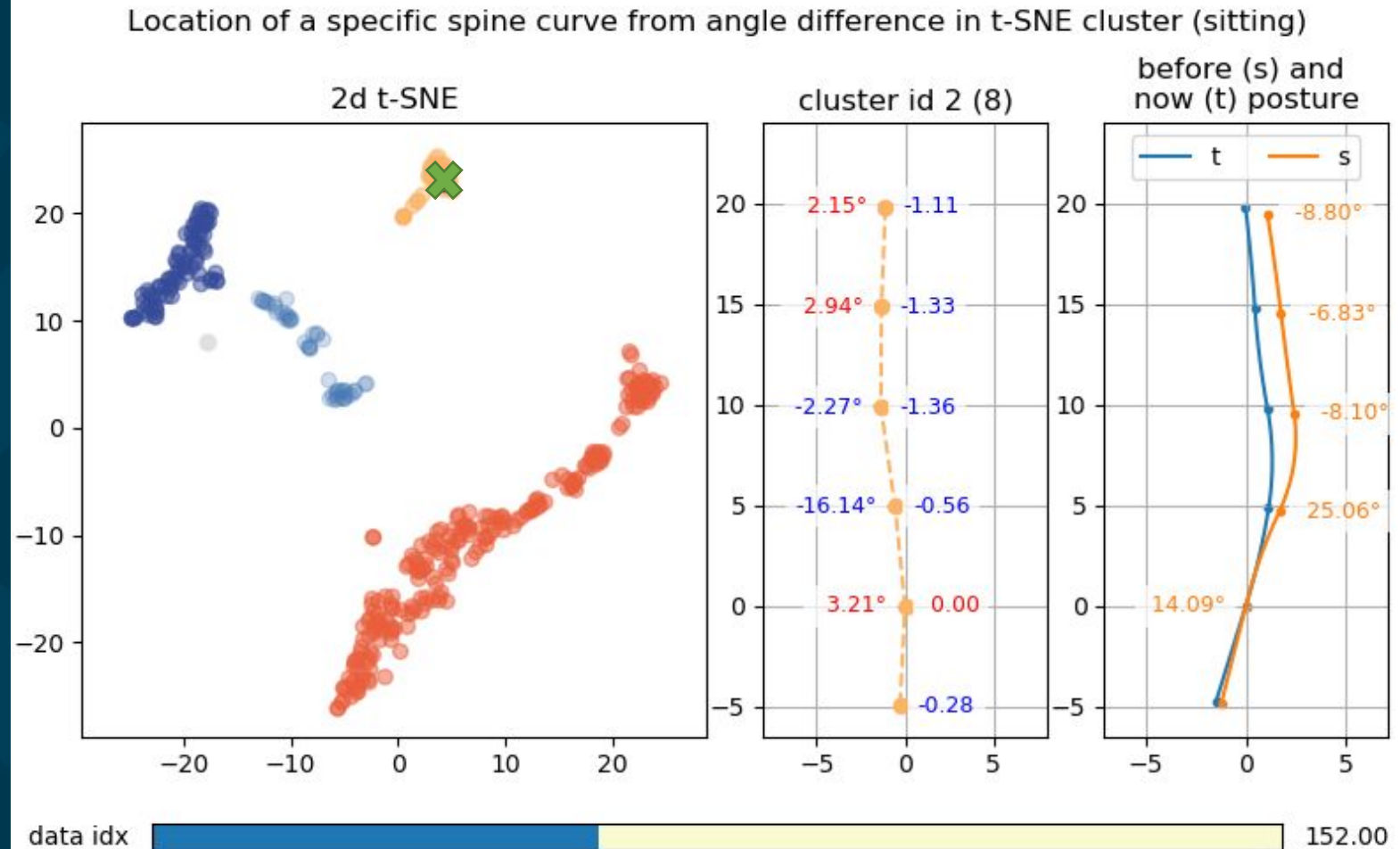


One point corresponds to one curve on the left!



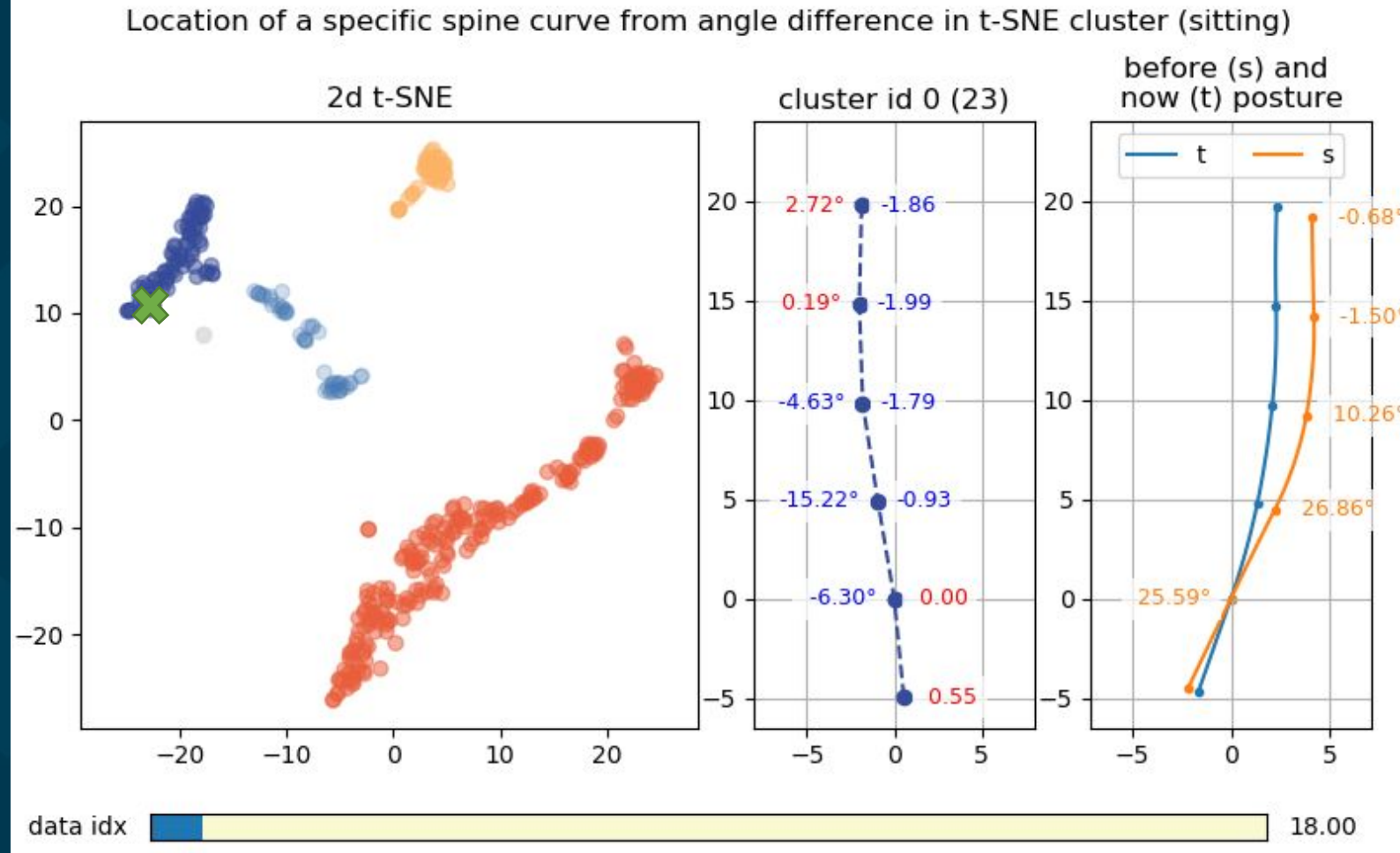
Looking at the clusters

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



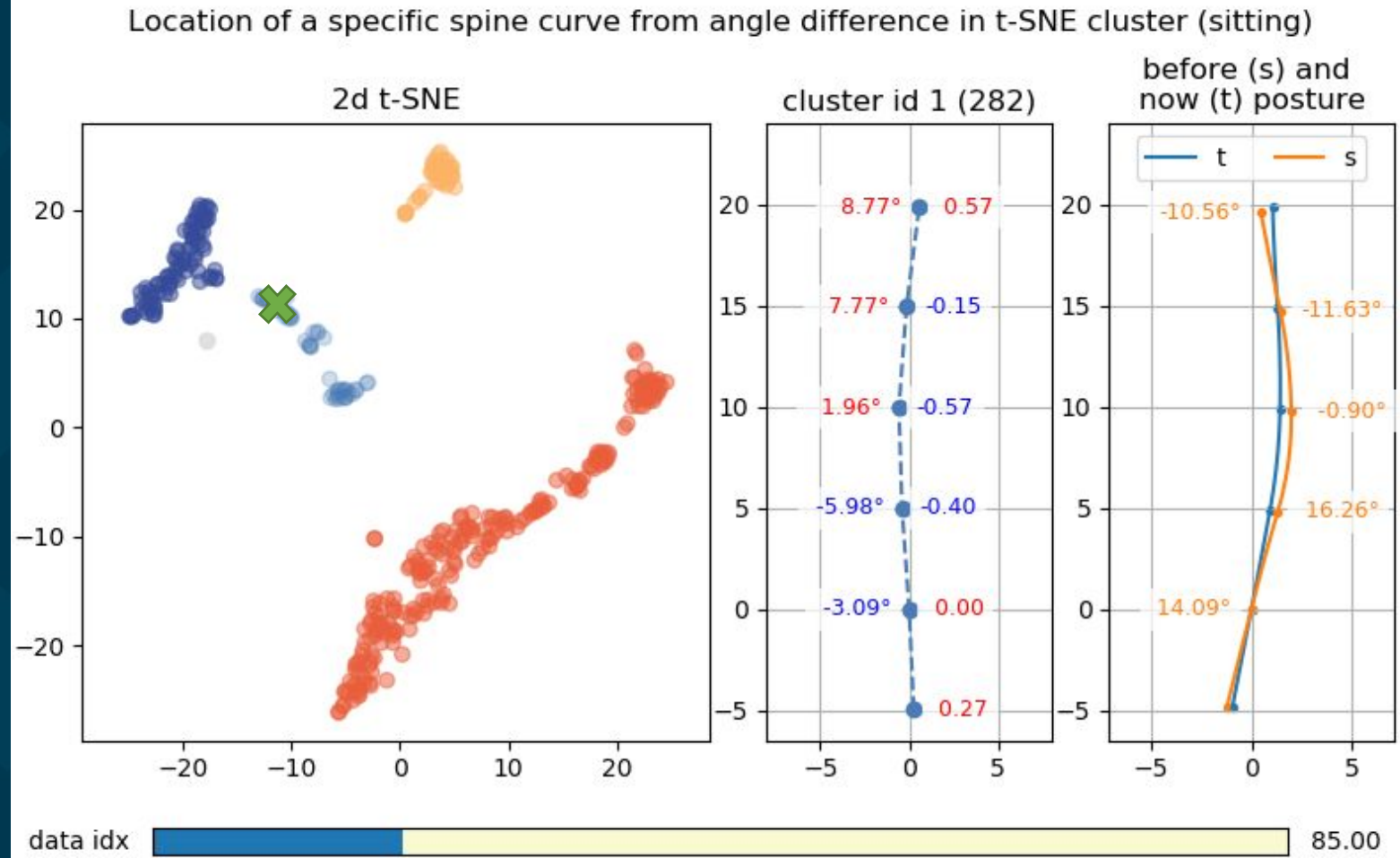
Looking at the clusters

- 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



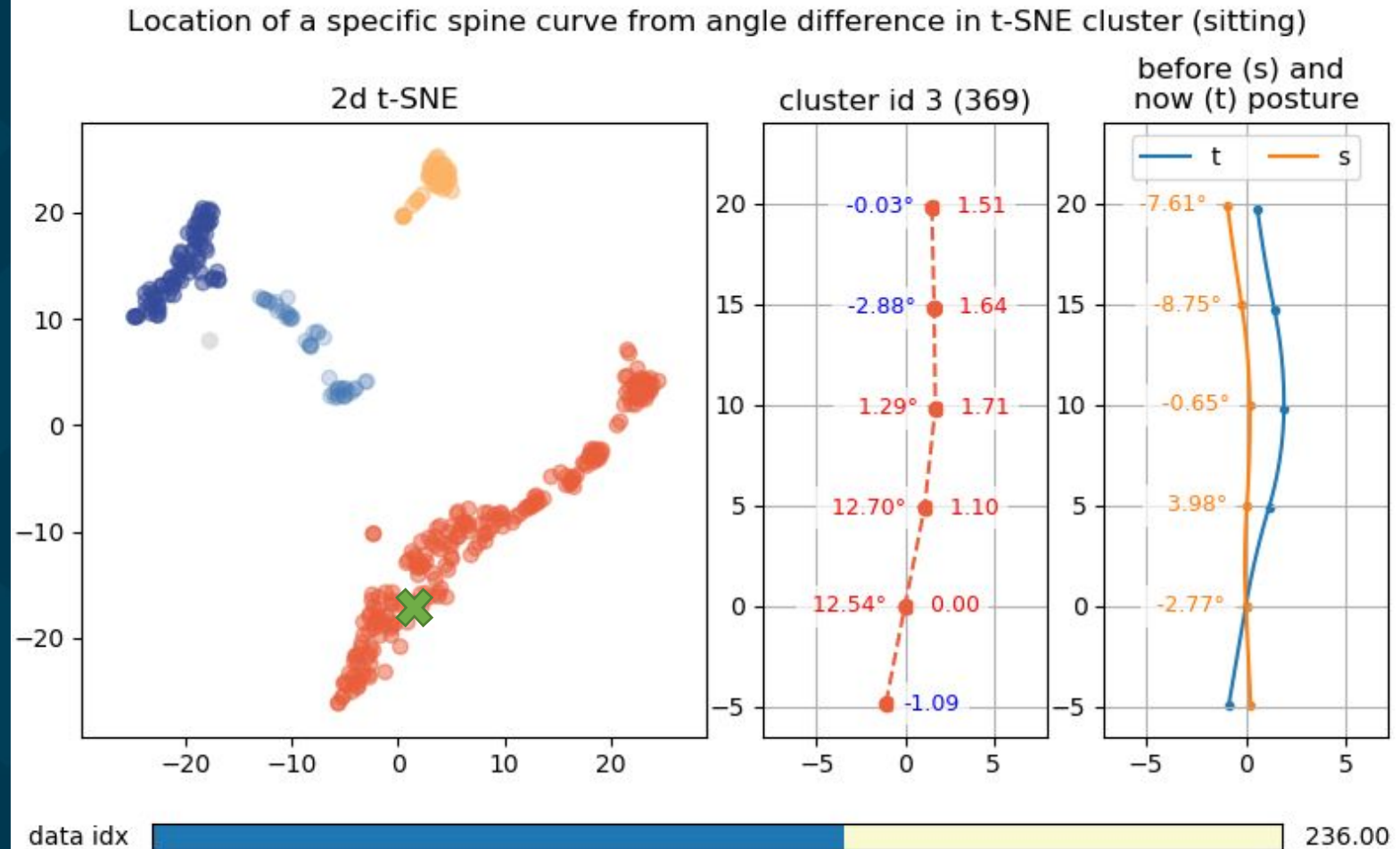
Looking at the clusters

- 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

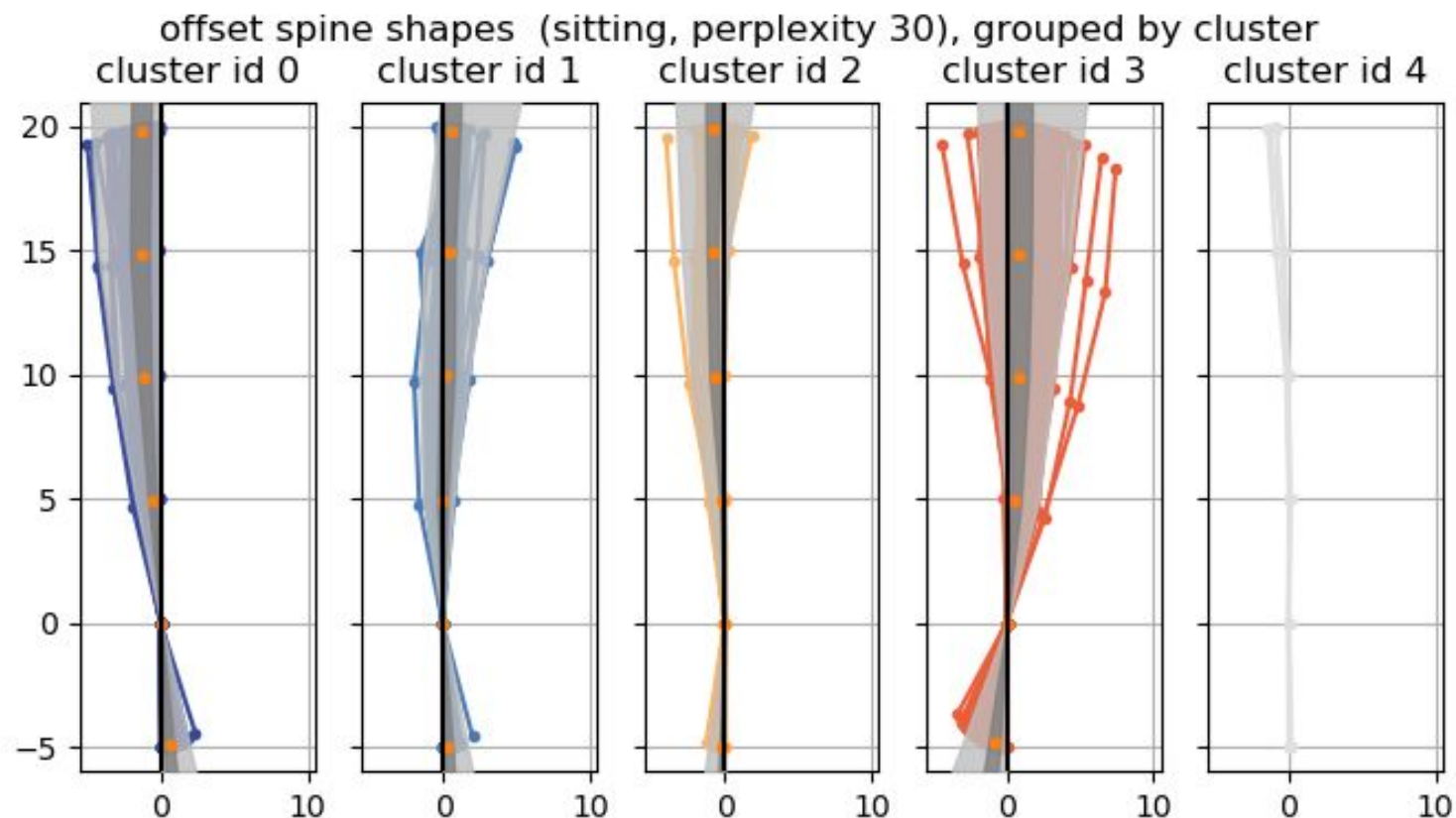
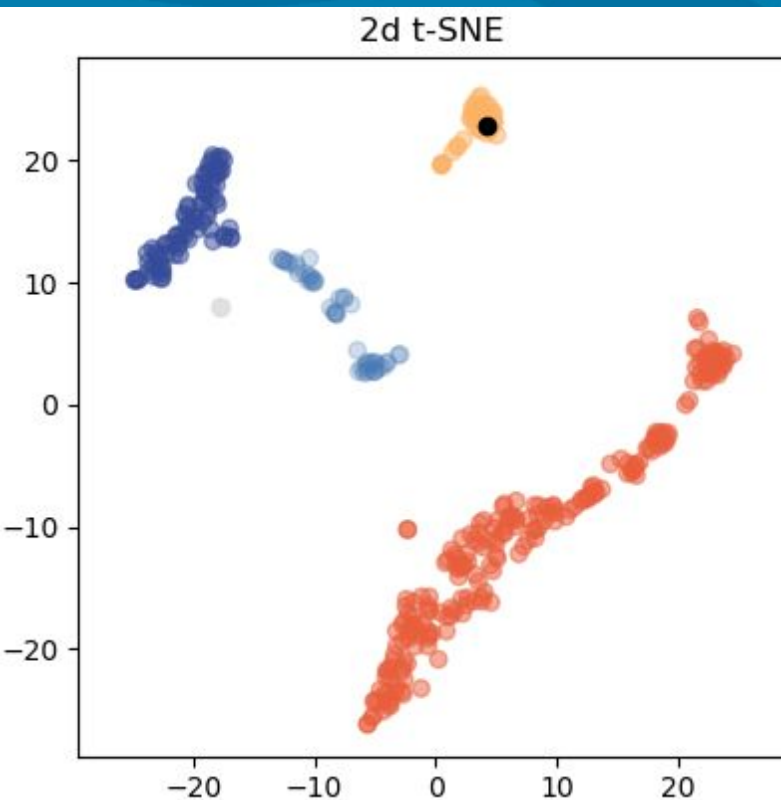



Looking at the clusters

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



What is contained in these groups?



A person is sitting on a bench, wearing a dark-colored motion capture suit with numerous white sensors and markers attached to it. The person's arms are resting on their knees. The background is slightly blurred, showing what appears to be a laboratory or research setting with some equipment and a brick wall. The text is overlaid on the right side of the image.

Comparing Muscle Activity and Spine Shape in Various Sitting Styles

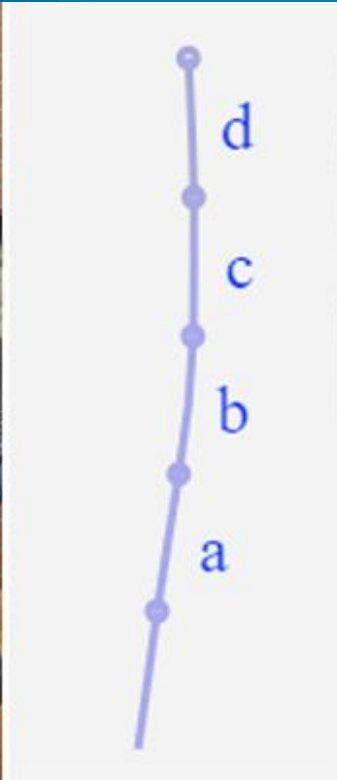
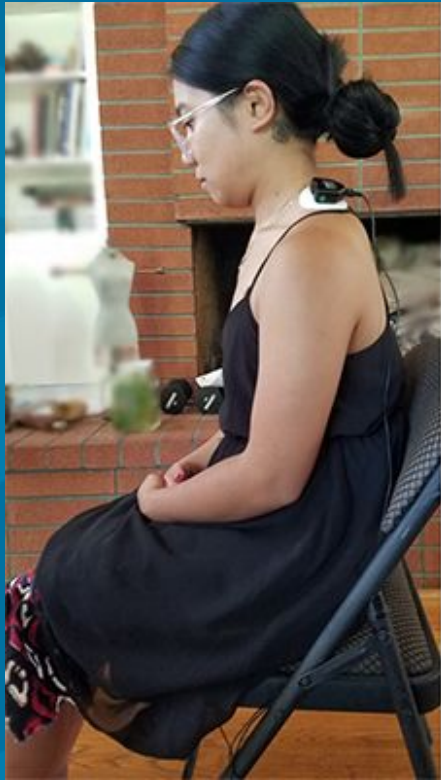
Comparing Muscle Activity and Spine Shape in Various Sitting Styles



- 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



Sitting positions



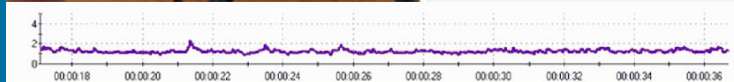
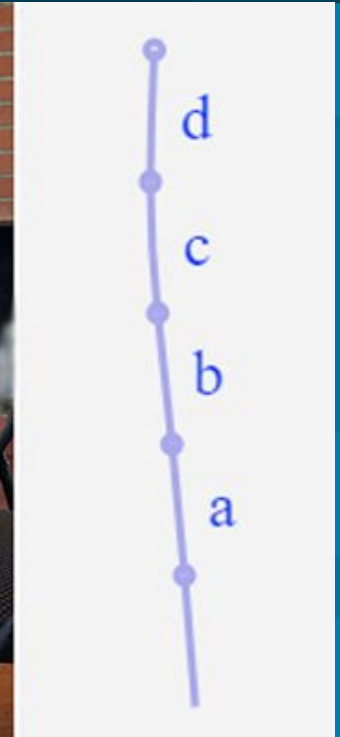
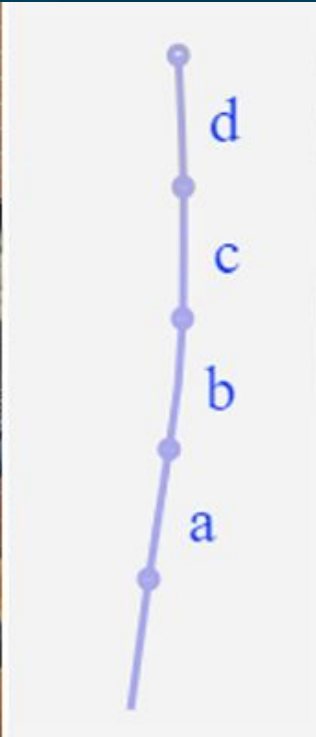
Slouched
(forward bend)

Arched upright

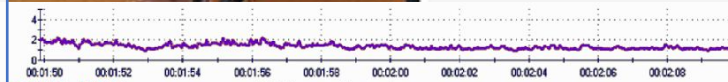
Stacksitting



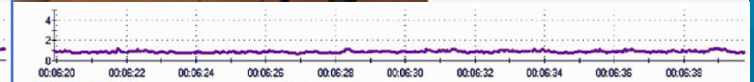
EMG Readings (muscle activity)



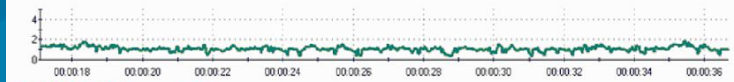
C: EMG (uV RMS) 0.91 Right upper Trapezius



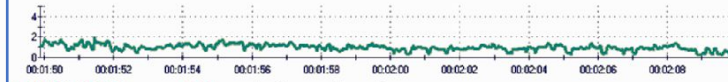
C: EMG (uV RMS) 0.91 Right upper Trapezius



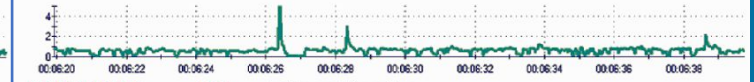
C: EMG (uV RMS) 0.91 Right upper Trapezius



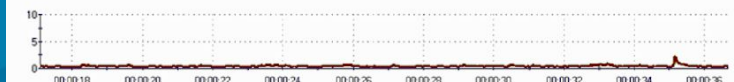
D: EMG (uV RMS) 0.88 Left upper Trapezius



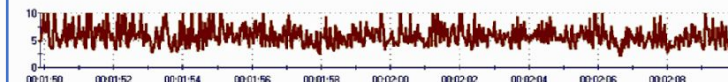
D: EMG (uV RMS) 0.88 Left upper Trapezius



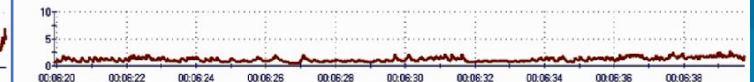
D: EMG (uV RMS) 0.88 Left upper Trapezius



E: EMG (uV) 1.40 Right mid back



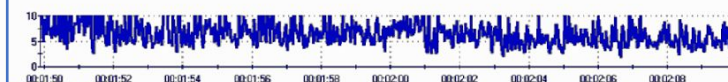
E: EMG (uV) 1.40 Right mid back



E: EMG (uV) 1.40 Right mid back



F: EMG (uV RMS) 0.76 Left mid back

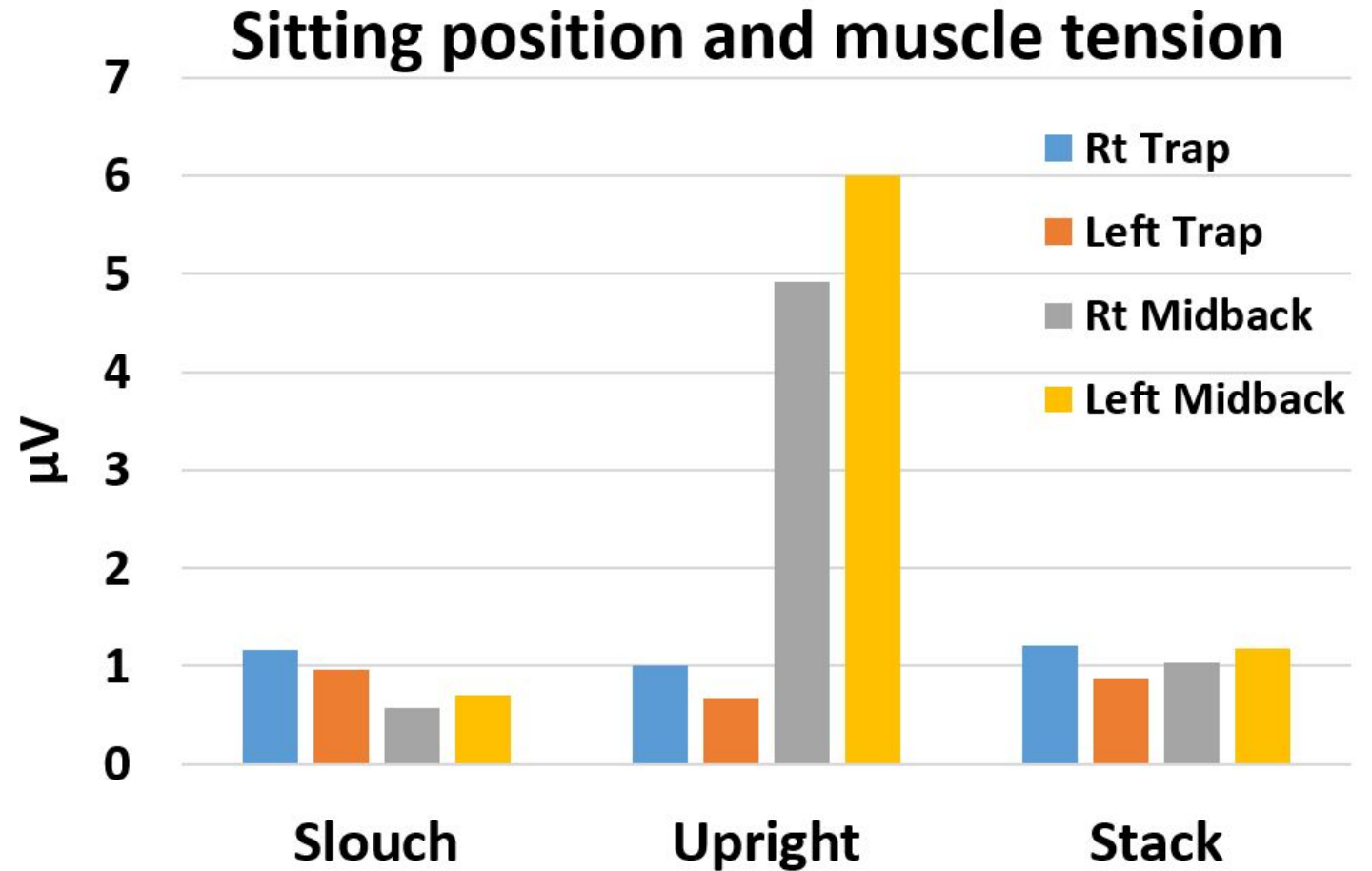


F: EMG (uV RMS) 0.76 Left mid back



F: EMG (uV RMS) 0.76 Left mid back

Summary:
All readings



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

A black computer mouse with five white buttons. One button, located in the lower-left area, is illuminated with a red light. The mouse has a cord extending from the right side. The background is a dark, textured surface.

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)



Esther Gokhale

Founder and CEO of the Gokhale Method
esther@gokhalemethod.com

Dr. Björn Krüger

Professor for Distributed Media Applications
and Technologies
bjoern.krueger@th-koeln.de

NASA Engineering & Safety
Center (NESC) Academy

Webcast - 2022-09-13

A photograph of two women, one in a red shirt and one in a grey shirt, looking at a laptop screen. In the foreground, there is a large, traditional drum. The background is a simple wall. The text 'Thank you for your attention!' is overlaid in large white letters.

Thank you for your attention!