



How medical doctors and developers
collaborate to develop educational XR
applications

Physical Therapy solution development

April 20, 2023

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VIDZEME UNIVERSITY
OF APPLIED SCIENCES





Virtual Reality and Smart Technologies lab activities

Since 2010

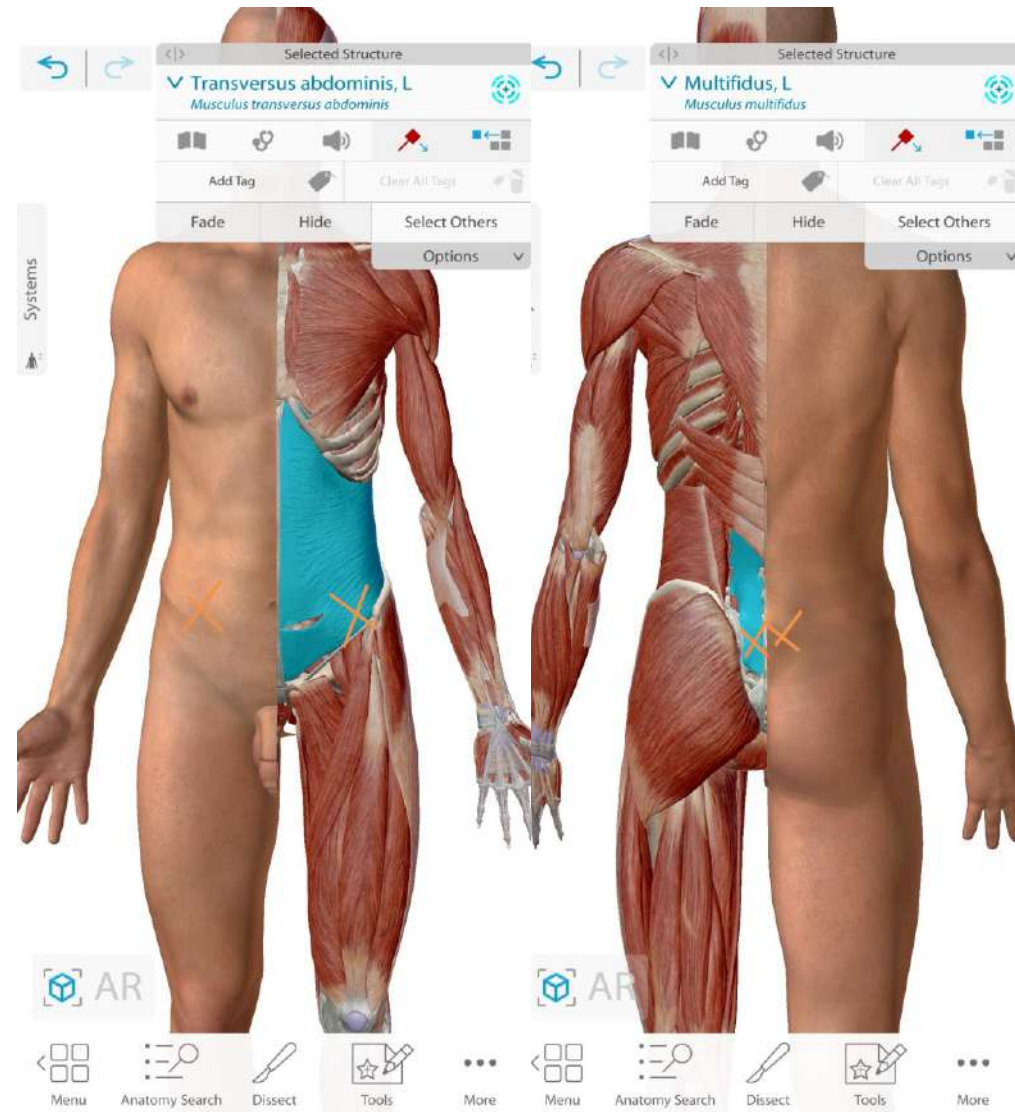
- ❑ Multi-player, team collaborations
- ❑ Safety
- ❑ Security
- ❑ Education
- ❑ Cognitive effort – efficiency evaluation
- ❑ Data driven experiences - IoT
- ❑ Change VR environment based on data – IoT
- ❑ Mental experiences
- ❑ Rehabilitation
- ❑ Real-time feedback



We make rehabilitation faster, individual & effective

Deep core muscles

- ✓ Hard detect
- ✓ Hard to measure
- ✓ Core muscles!
- ✓ Engaged prior to any movement
- ✓ Endurance



**Deep core muscle activation
&
Deep breathing training**

Guided in Mixed Reality

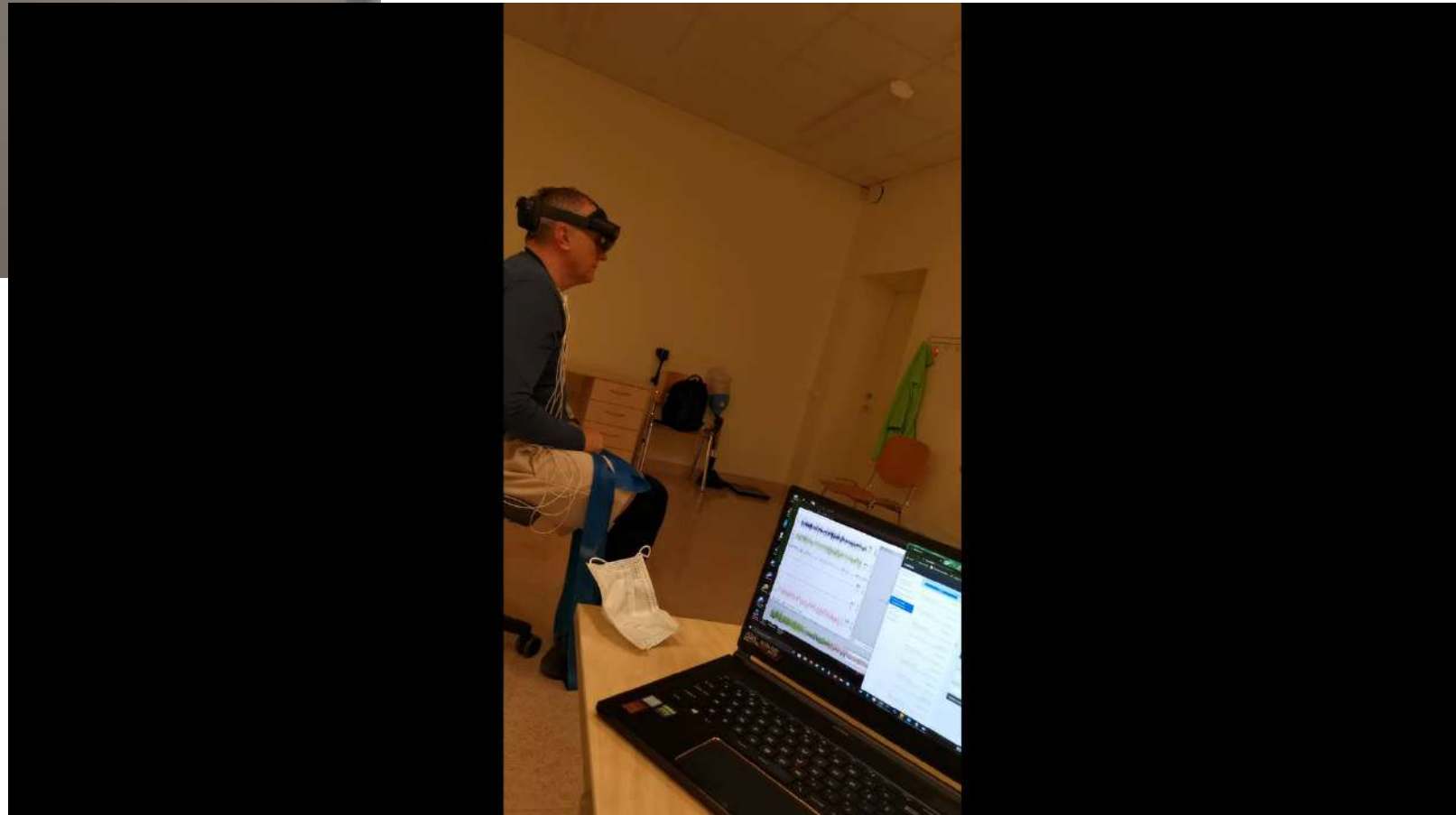
Raising self-awareness

**Increasing movement quality
&
Endurance**

- ❑ Muscle Activity – surface electromyography
 - ❑ ECG – electrocardiography
 - ❑ Oxygen Saturation



When ready - say 'Start' / Kad esi gatavs - saki 'Start'



Evidence based

Amputees

Physical therapists in private and governmental institutions

9 institutions involved in the validation

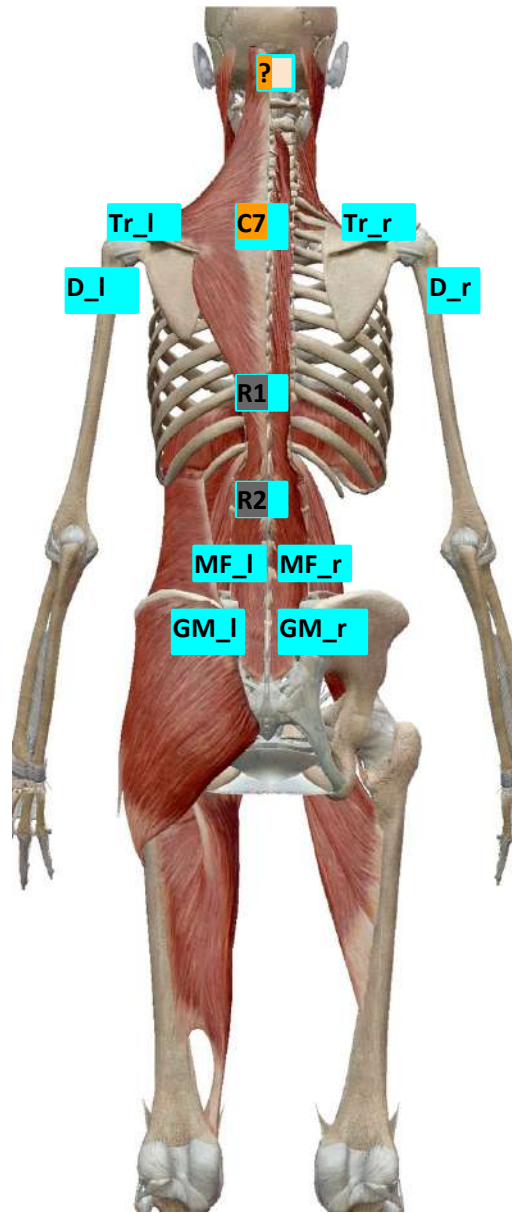
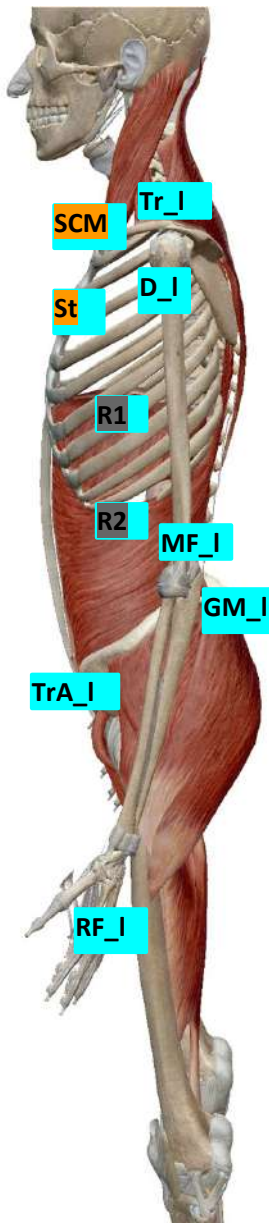
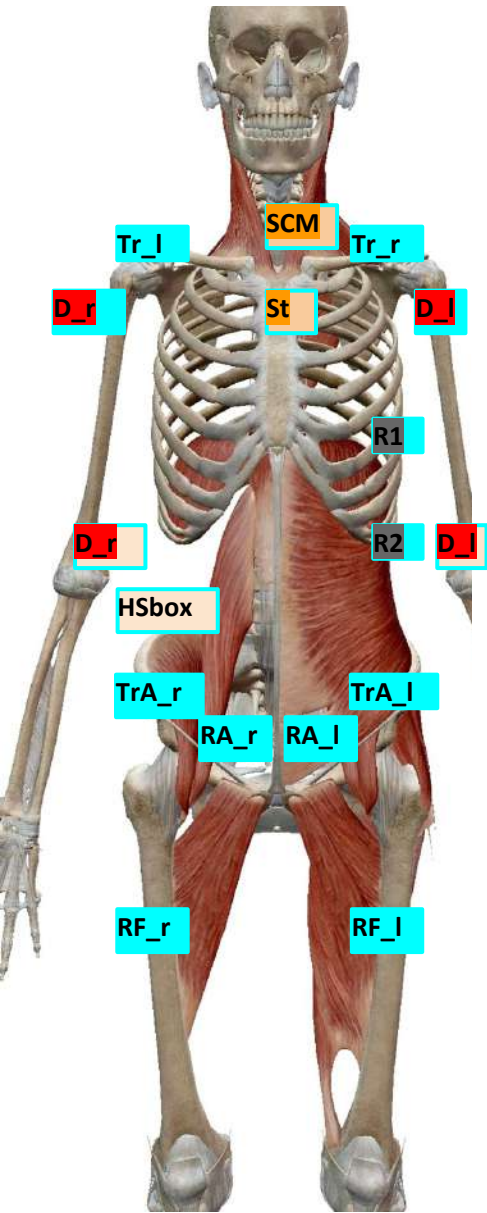
3 Human studies

4 Scientific publications



The Road



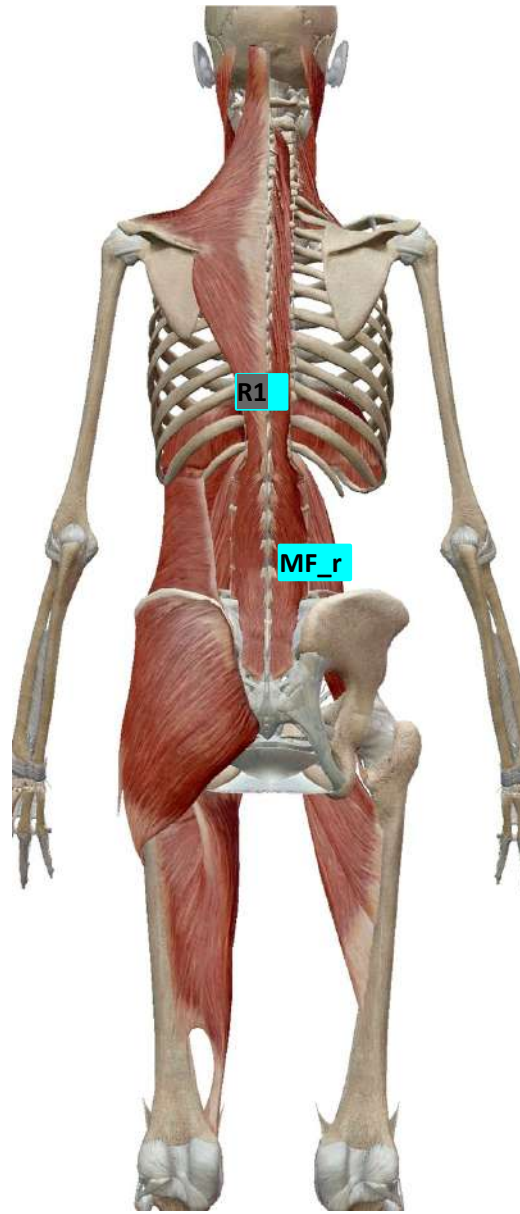
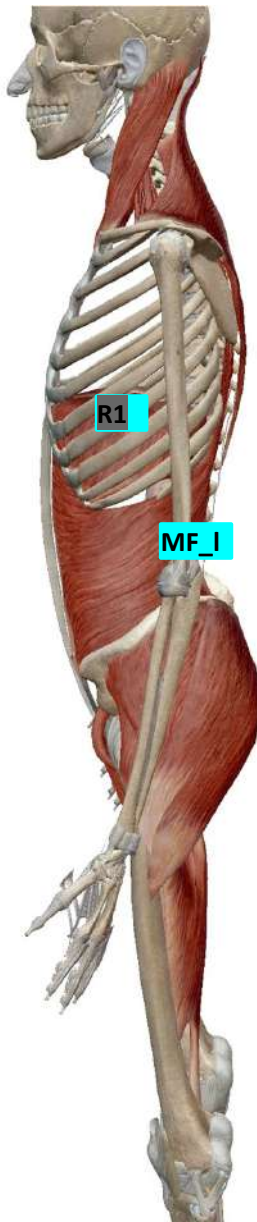
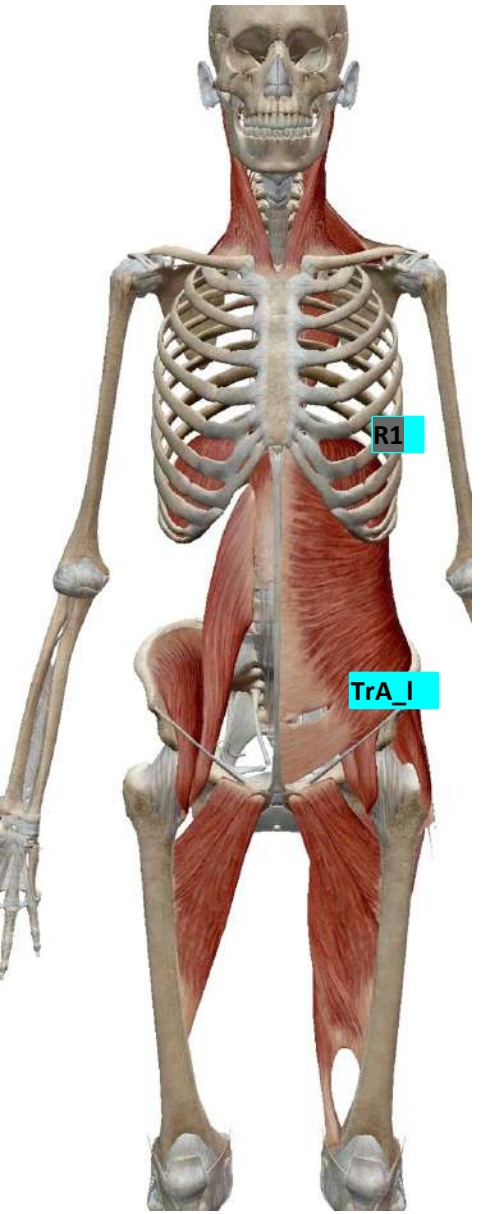


Healthy group:

- 1.No of reps & time & progression level
- 2.Trankinator - center of mass, jerkiness, velocity vs ES, MF, TrA recruitment delay - Trunk control
- 3.LBP - ODI
- 4.McGill - Muscle fatigue and recruitment, %MVC
- 5.Core vs compensatory m. after weakening - Kendall, %MVC - additional sensors
- 6.Core vs periphery - SmO2
- 5.Postural angles
6. 7.One leg stance - eye o/c, time, %MVC
- 8.Posture, anatomical landmarks, muscle disbalance
- 9.Faulty posture vs HR, BP
- 10.Inspiratory strength -> chest mobility -> spine mobility -> proprioception ^ -> LBP v

Amputee group:

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- 6.Core vs periphery - SmO2
- 7.Postural angles
- 8.Posture, anatomical landmarks, muscle disbalance
- 9.Lower rib excursion, amplitude - erector spinae, multifidus, TrA %MVC
- 10.Lower rib excursion, amplitude, all direction comparison DURING exercises
- 11.SmO2 - CO, HR



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- 5.One leg stance - eye o/c, time, %MVC
- 6.Inspiratory strength

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FINAL SOLUTION WORKFLOW

PATIENT
DATA

CALIBRATION
/ TESTING

DEEP
BREATHING
LEARNING

TrA
ACTIVATION

DEEP CORE
EXERCISES

Hexoskin

ECG (1 channel, 256Hz)
Heart Rate: 30-220 BPM, 1Hz
QRS event detection: 4ms resolution
RR intervals: 4ms resolution
HRV analysis
Breathing (2 channels, 128Hz)
Breathing Rate: 3-80 BPM, 1Hz
Tidal Volume (last inspiration), 80mL-10L, 1Hz
Minute Ventilation, 2-150 L/min, 1Hz
Inspiration and Expiration Events, 8ms resolution



Notch

Gyroscope range
 $\pm 250, \pm 500, \pm 1000, \pm 2000, \pm 4000$ dps

Accelerometer range
 $\pm 2, \pm 4, \pm 8, \pm 16, \pm 32$ g

Magnetometer range
 $\pm 4 / \pm 8 / \pm 12 / \pm 16$ gauss

Sampling frequency
5Hz, 10Hz, 20Hz, 40Hz, 50Hz
100Hz, 125Hz, 200Hz, 333Hz, 500Hz

Delsys



Hololens



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Hololens



ECG



Breathing

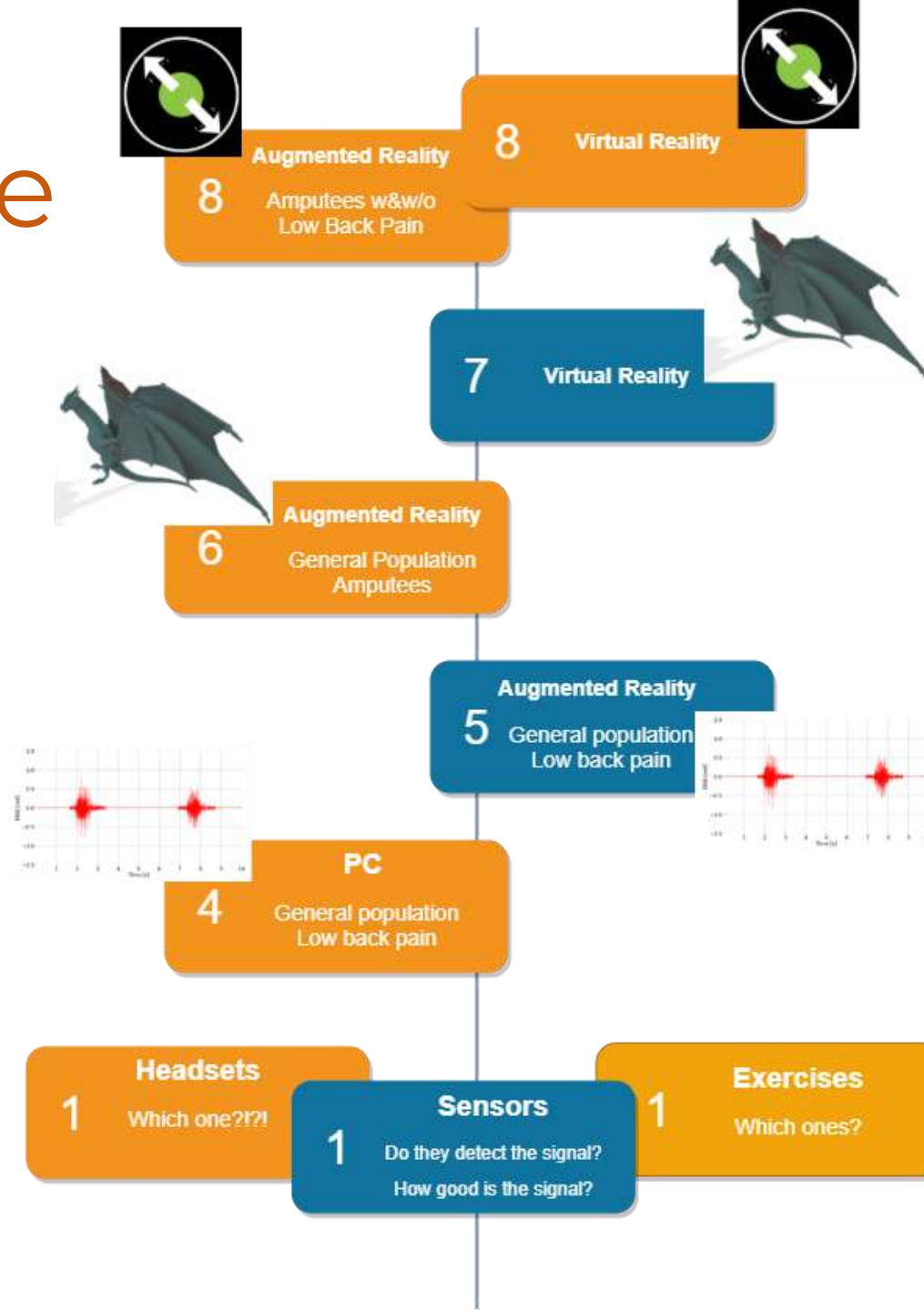


Accelerometer



Devices tested

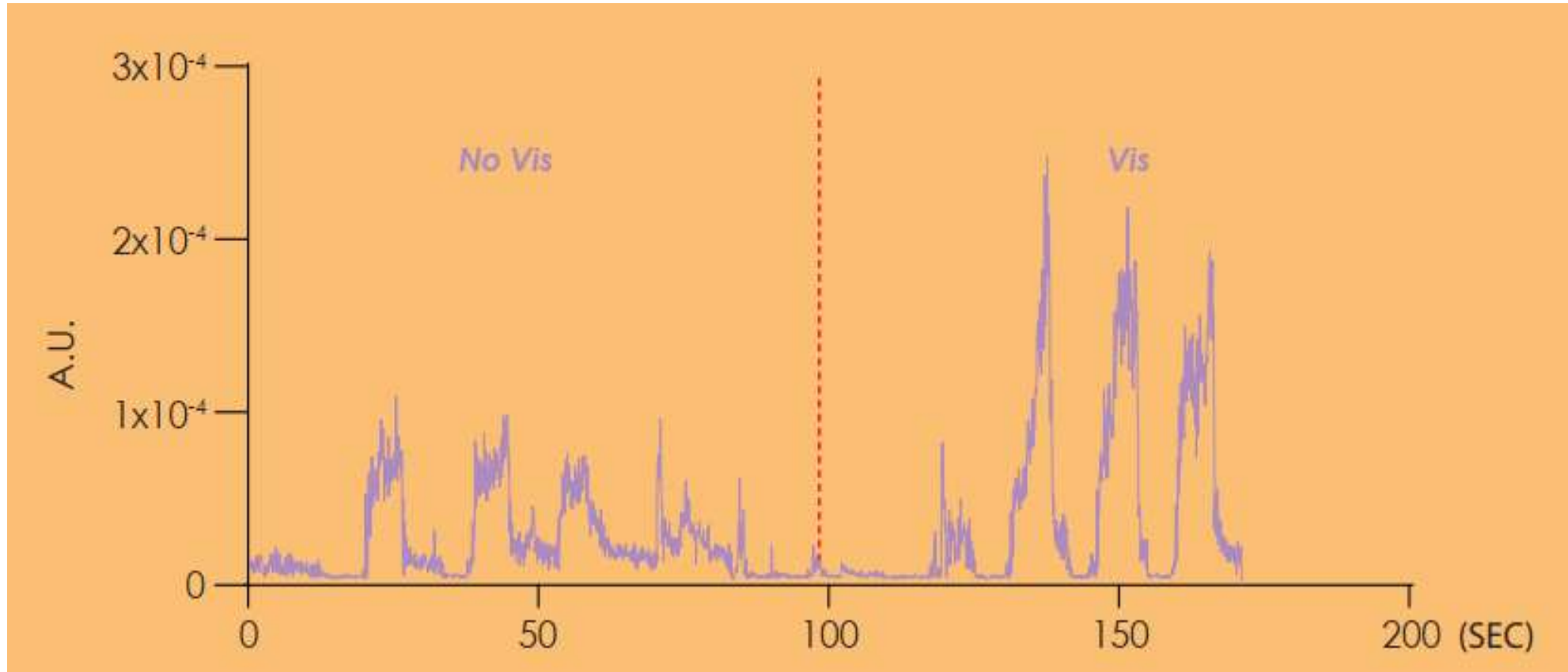
The Timeline



5 exercises
2 muscles
sEMG data

11 exercises
8 muscles
sEMG data

Use of real-time visual feedback to facilitate core muscle activation in individuals with low back pain



PT survey

82% would use periodically, or on everyday basis

80% patient's motivation would increase

50% patient's self-awareness would increase

80% instructions aligned with the actions demonstrated in the AR

1 wouldn't save the Physical Therapist's time

21% visual information was hard to process

5-? min user introduction time

14% afraid the headset would fall during the activities

!!!! the previous experience with technologies

!!!! adjustability of the system

!!!! necessity for a complex real-time visual feedback providing systems

E³UDRES² European University Alliance



*joining E³UDRES² from Autumn 2023

Virtual Gym

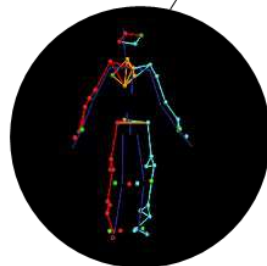


Real-Time Biofeedback | Exergaming

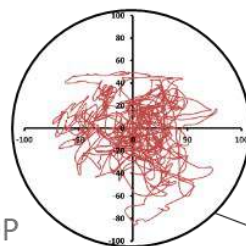
A head-mounted-display provides the fully immersive Virtual Reality



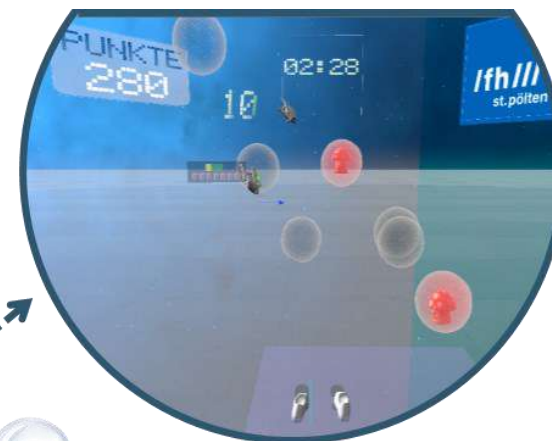
unity



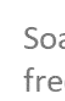
A full-body or minimal marker set can be used to track pelvis, hands, and feet in real-time.



Medio-lateral COP excursion is tracked with a force plate



Soap bubbles need to be popped with fingers



Soap bubbles spawn more frequently on the "forced side", which is the side of the prosthesis

Physical inactivity is the fourth leading risk factor for global mortality.

6% of deaths globally

22% of heart disease

22% of colon cancer

12% diabetes and hypertension

Physical inactivity is linked to higher risks for

Mental disorders

Depression

Dementia

Alzheimer's disease

- Shortage of medical personnel
- Limited service availability
- Long covid
- Socialization issues

**A virtual reality platform for people with sedentary lifestyle –
to increase socialization and to adapt the physical activity to each individual**

The effects of virtual reality physical activity application on

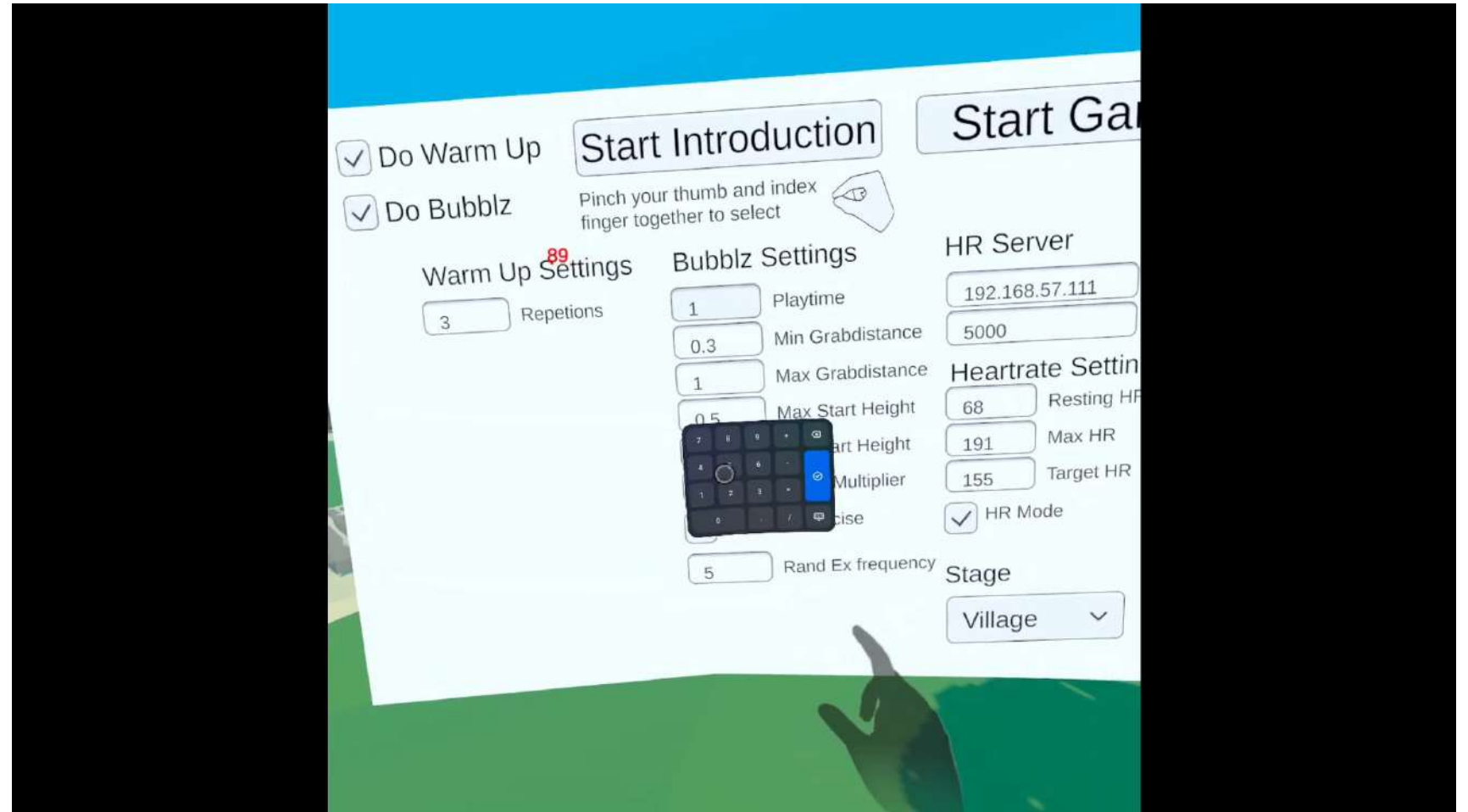
- physical activity level and vital parameters in the population with sedentary lifestyle
 - metabolic stress/energy expenditure for sedentary population
 - heart rate variability
 - PA recommendations
- socialization level in the population with sedentary lifestyle (the effect of VR)

Fun and Motivating
game

Workplace/ Home



- ❑ Based on physical activity WHO guidelines
- ❑ VR activities include warm-up, strength and cardio training
- ❑ Real-time feedback
- ❑ VR environment adapts to the player's capabilities (data from the heart rate sensor changes VR activity speed and other parameters)
- ❑ Multi-player functionality – socialization



Requirements

- User-centered
- User journey/ service design
- Data-driven – sensors for feedback and guidance
- Evidence-based
- Duration/ load
- 18 – 65 age range/ perception/ cognitive load/ audio
- Exciting
 - For winners
 - For enjoyers



Requirements

- ❑ Warm-up
 - ❑ Strength – reps/time
 - ❑ Squat
 - ❑ Deadlift with no weights
 - ❑ Lunges to front one step and back/ Lunges to sides
-
- ❑ Aerobic
 - ❑ Jumping Jacks
 - ❑ Boxing imitation
 - ❑ Diagonal movement from left to right from down to up
 - ❑ Stepping over objects in knee height/ kicking with legs





Dumbbell Front Squat



Bent Over Dumbbell Row



Dumbbell Lunge



Dumbbell Standing Shoulder Press



Dumbbell Romanian Deadlift

High to Low & Twist



Squat & Press



Front Lunge & Twist



Back Lunge & Twist



Slams



Side Throw



Sit-Up & Throw



V-Sits with a Twist



1



Flutter Kicks x 70

2



Heel Touch x 50

3



Jumping Jacks x 50

4



Scissor Kicks x 70

5



Toe Tap Leg Lifts x 60

6



Russian Twist x 50



Motion sickness questionnaire – SSQ

Scores 0 - 78

Fatigue

Reduced/ increased

Eyestrain

Reduced

Sweating

Increased

Nausea

Reduced

Difficulty concentrating

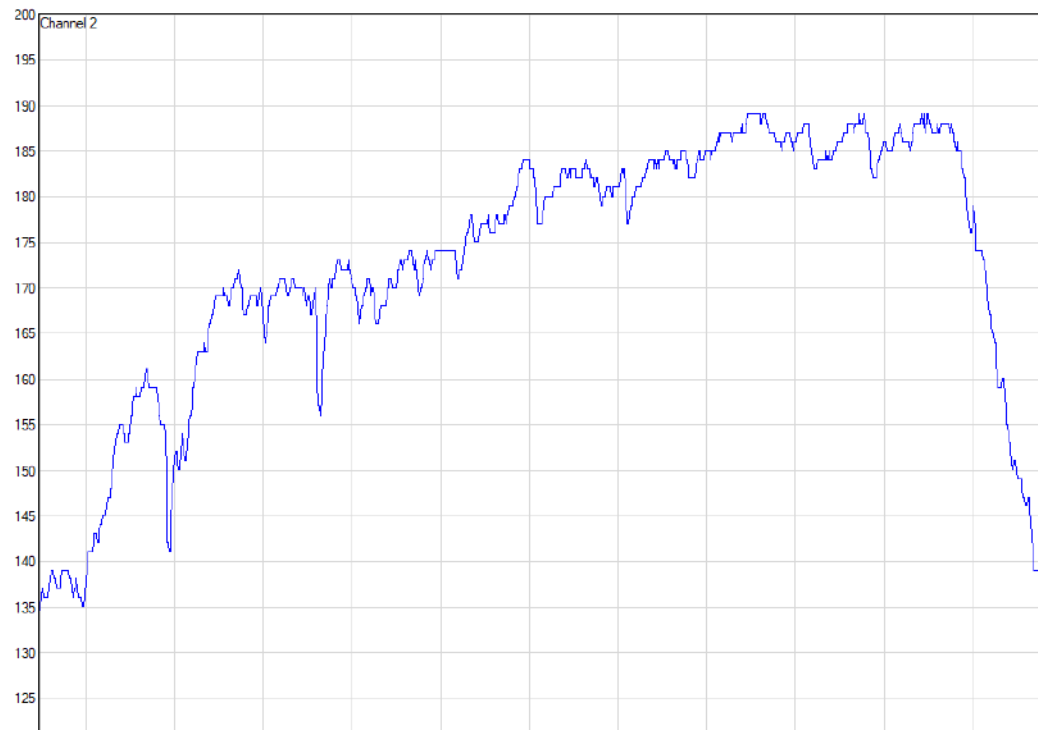
Reduced

Vertigo

Reduced

Heart Rate

- The target of intensity – 59% of HRmax by Karvonen formula
- Target intensity from 125 to 159
- In the age range 21 – 57 years
- The heart rate alteration:



Start, HR	95	103	70	71	83
Max, HR	167	189	96	98	115
%	43	46	27	28	28

Conclusions

- The mental state of a person is crucial when performing physical activity
- The guidelines of physical activities can be implemented in VR/ MR ... with imagination and caution
- Socialisation needs to be individualized
- Initial assessment to ensure relevant experience and success
- Sensors/data as pre-requisite for success

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