UNIVERSITY OF JYVÄSKYLÄ

Talvilajien luokittelututkimus Suomessa

Vesa Linnamo[1] & Sini Pyy

Lindinger S[2],Rosso V[1,3], Gastaldi L[3], Vanlandewijck Y[4]., Karczewska-Lindinger M[5]., Rapp W[6]

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[6]University of Freiburg, Germany

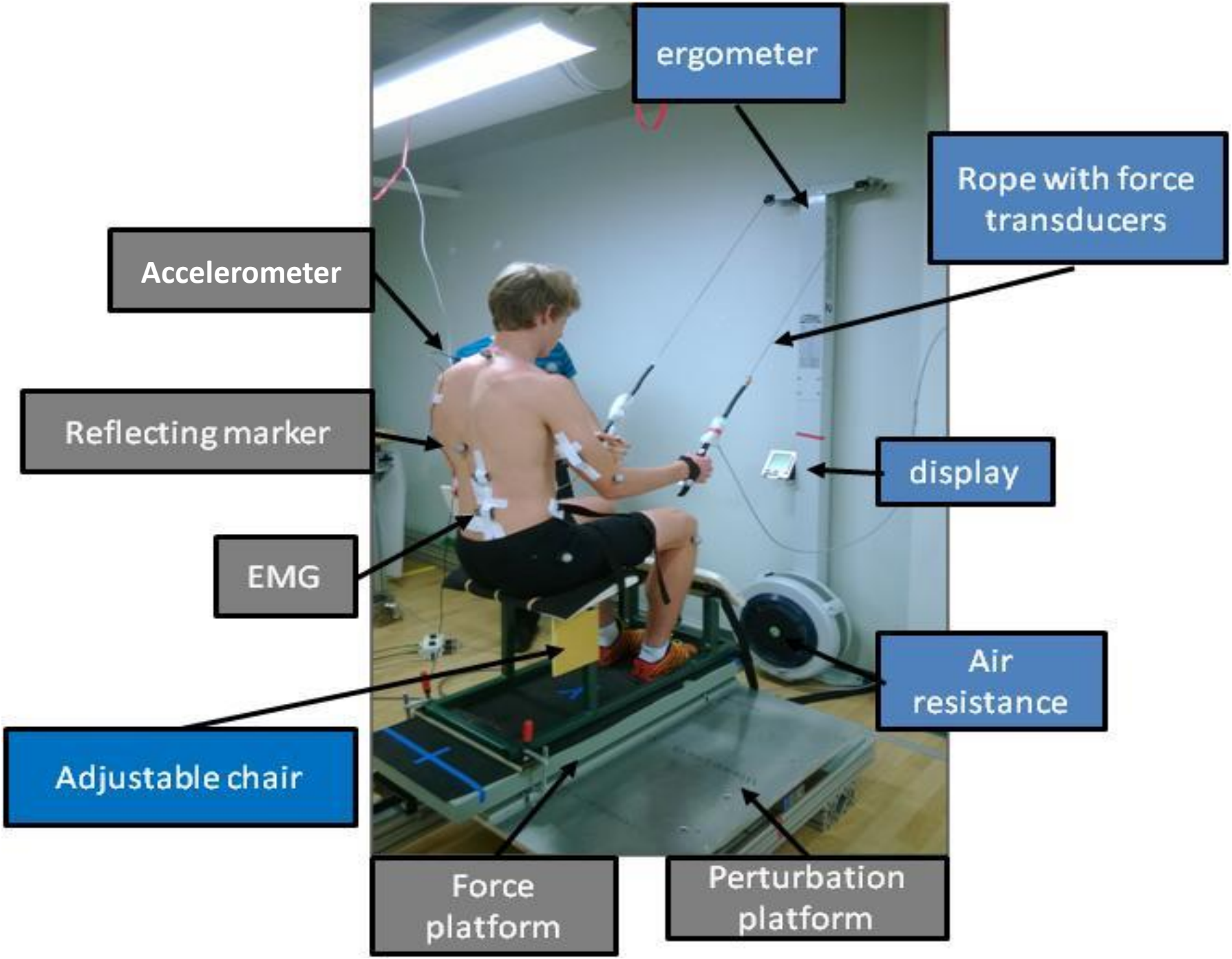
Most common sitting positions

P1
normal

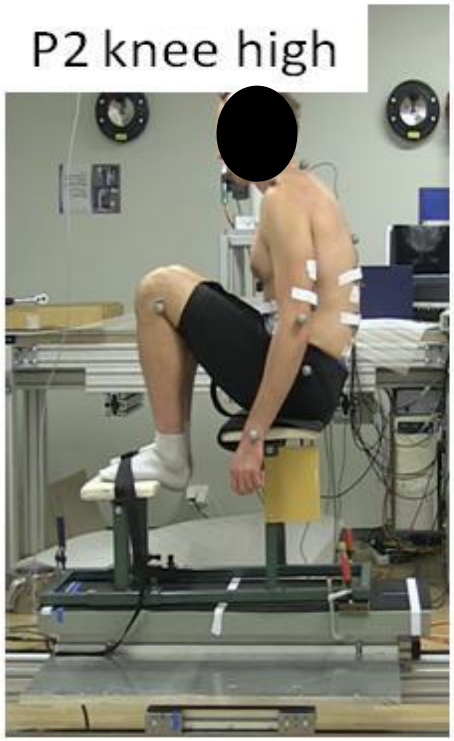
P2
knee high

P3
kneeing

P4
long sit


ergometer
Rope with force transducers
Accelerometer
Reflecting marker
display
EMG
Air resistance
Adjustable chair
Force platform
Perturbation platform

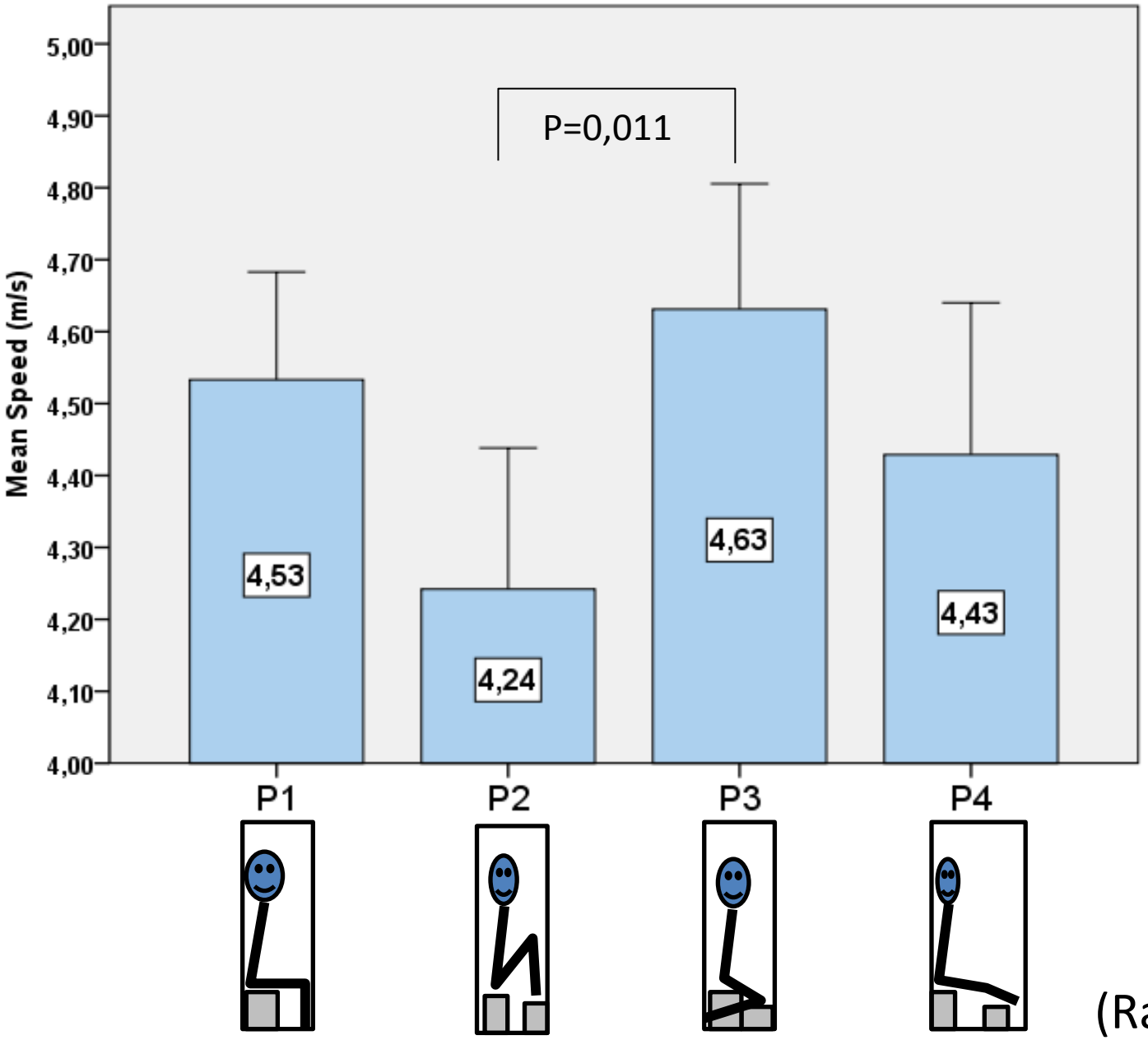

P1 normal


P2 knee high

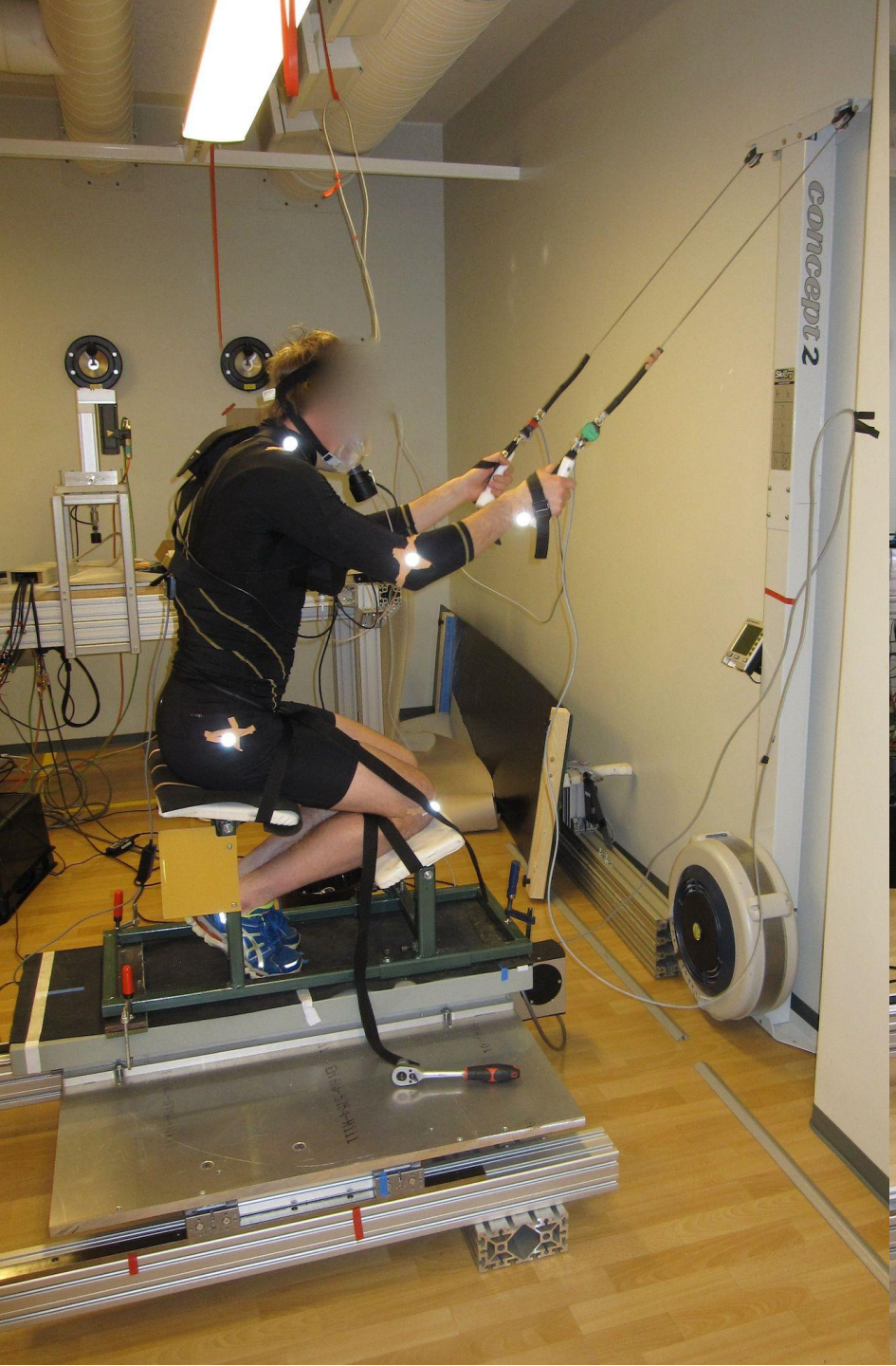

P3 kneeing

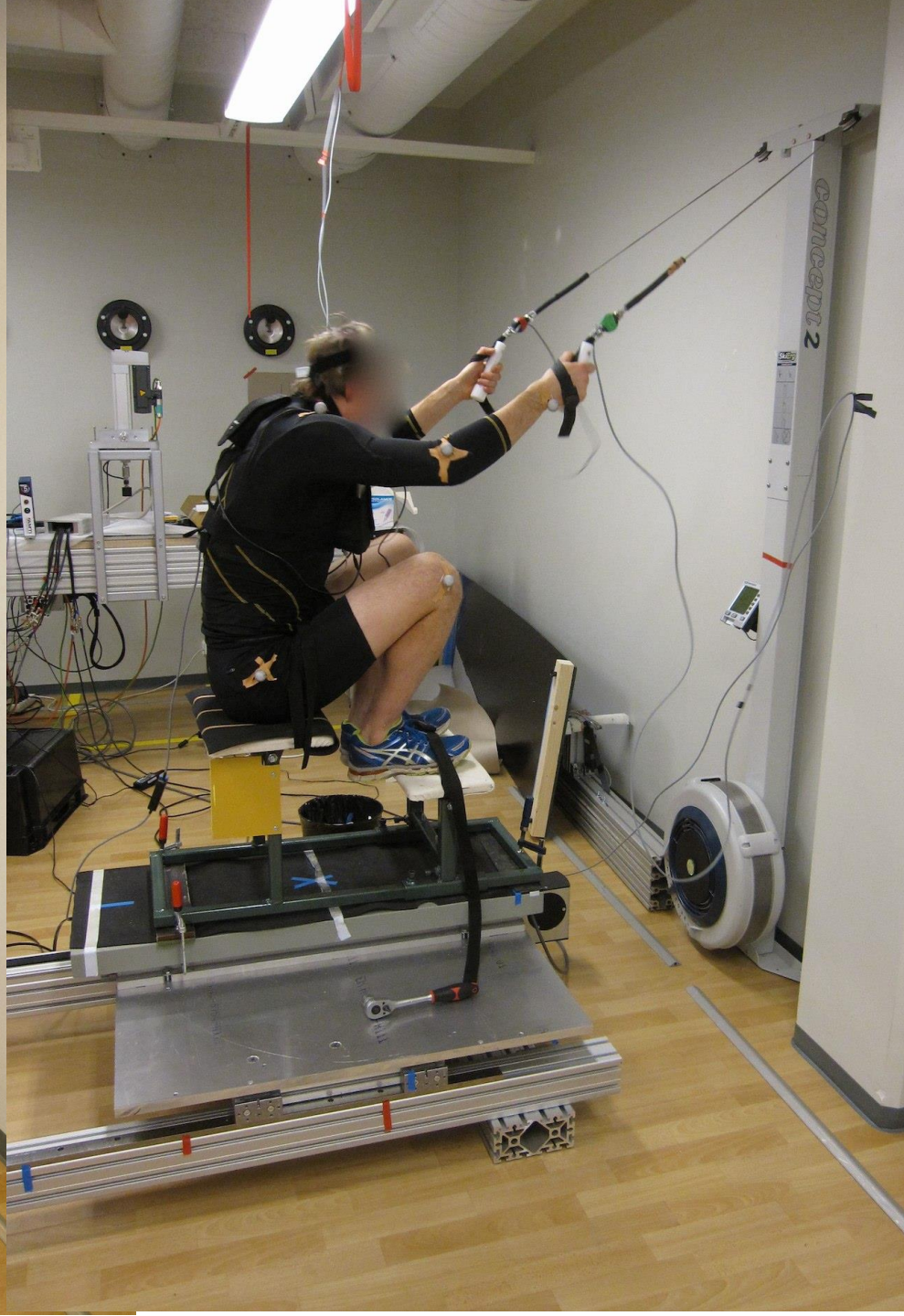

P4 long sit

Maximum velocity at ergometer

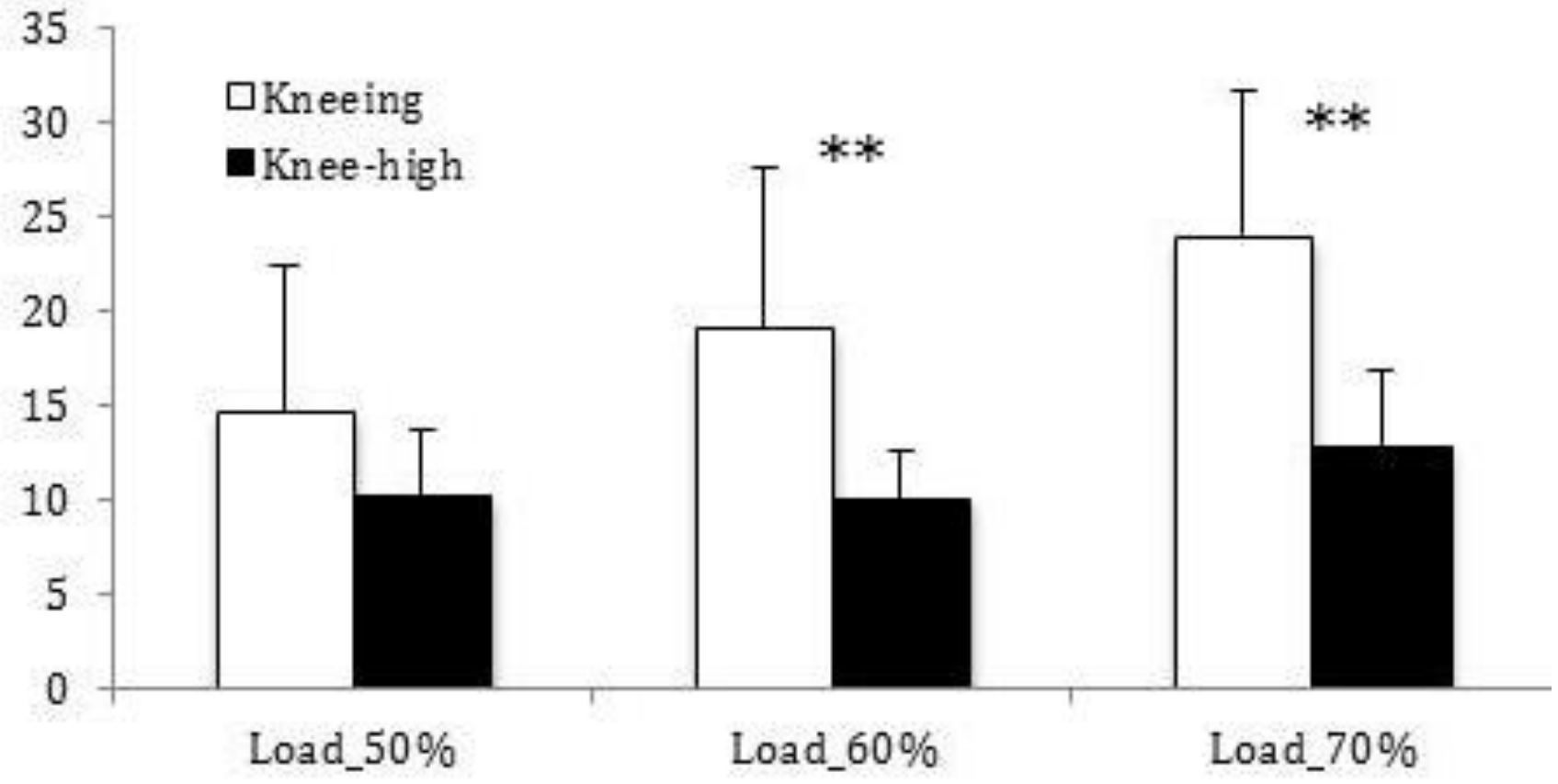


(Rapp et al.2013)


concept 2

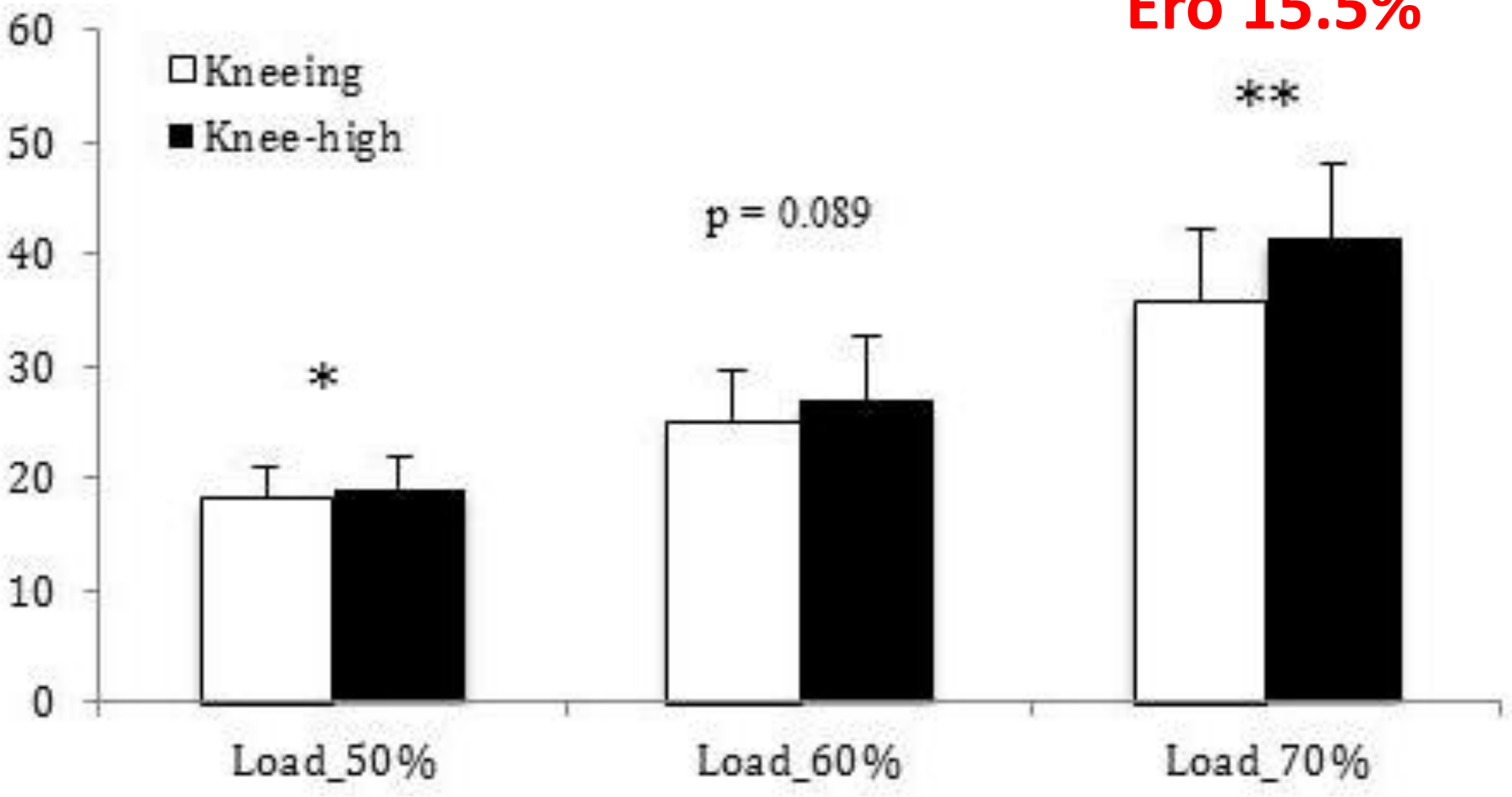

concept 2

Range of hip motion (°)



VO2 (ml/min/kg)

Ero 15.5%



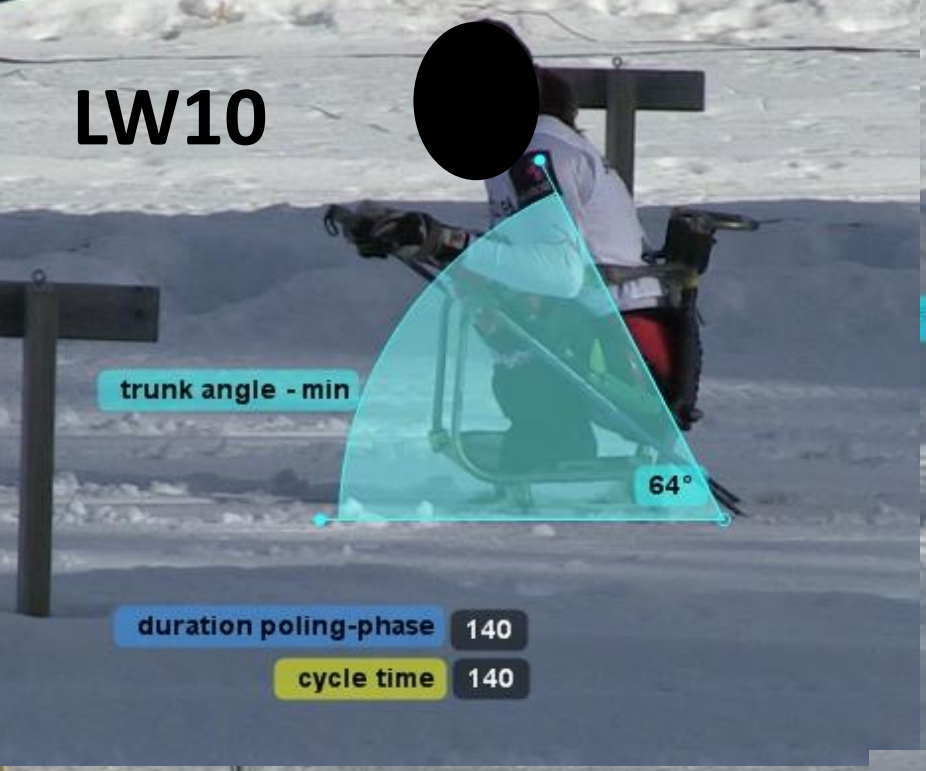
(Lajunen et al.2015)

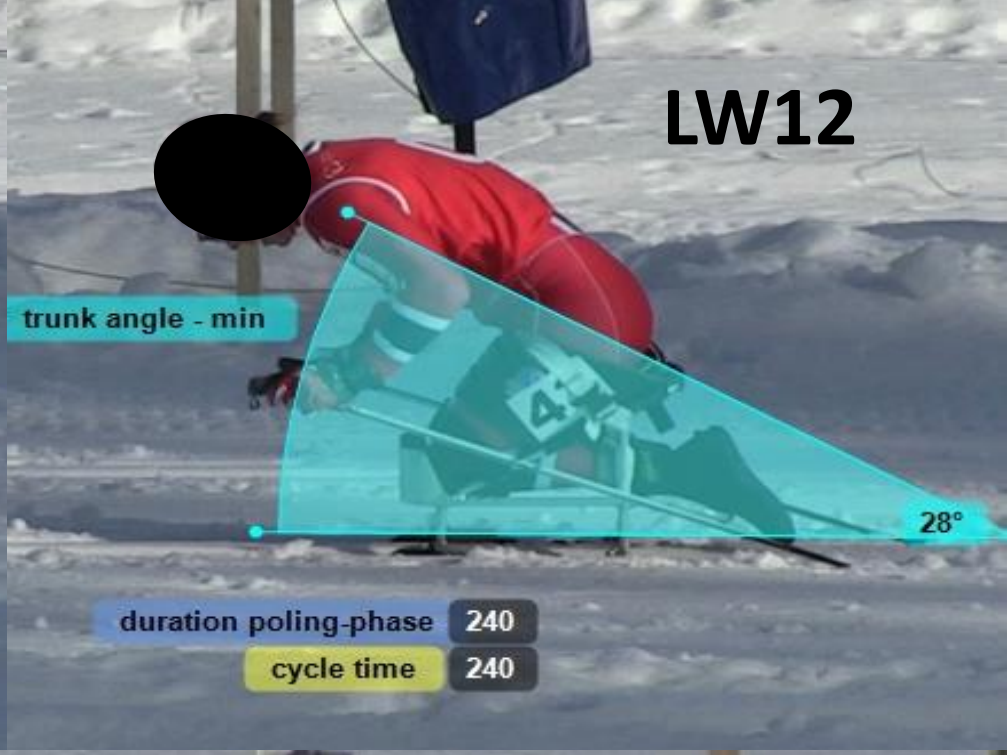
Test- table-test (TTT)

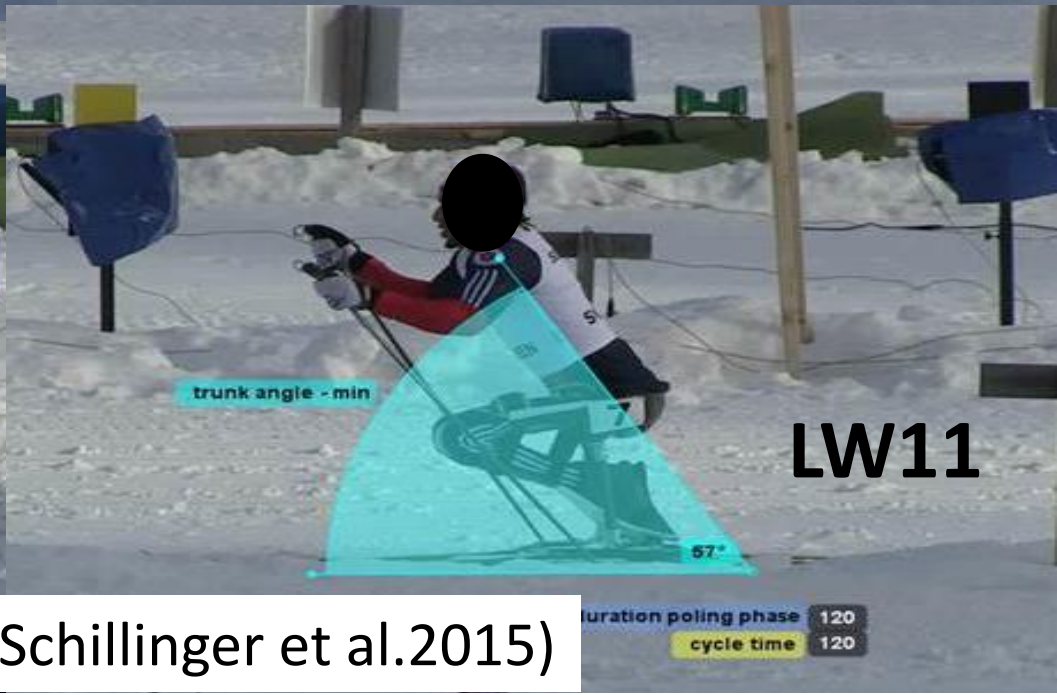
From: Pernot et al. Validity of the test–table–test for Nordic skiing: in: Spinal Cord (2011) 49, 935–941.

class	% race time
LW 10	86
LW 10,5	90
LW 11	94
LW 11,5	96
LW 12	100

class	Impairment	Muscle activity (ASIA classification*)	TTT
LW 10	Lower limb and trunk	**Unable to sit** without strapping	**0-2**
LW 10,5	Lower limb and trunk	**sit statically** without arm support	**3-6**
LW 11	Lower limb and trunk	**Retained** abdominal muscles and trunk extensor	**7-10**
LW 11,5	Lower **limb (s)** and trunk	Near to **normal** trunk muscles activation	**11**
LW 12	Lower **limb (s)**	**Normal** trunk function	**12**





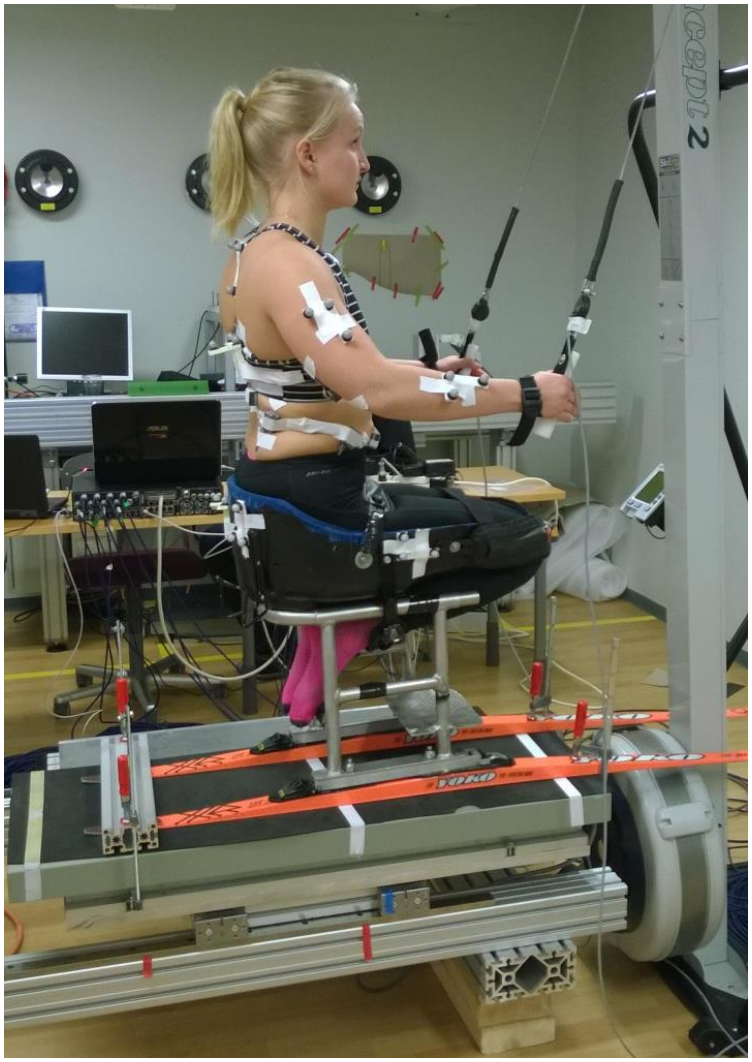


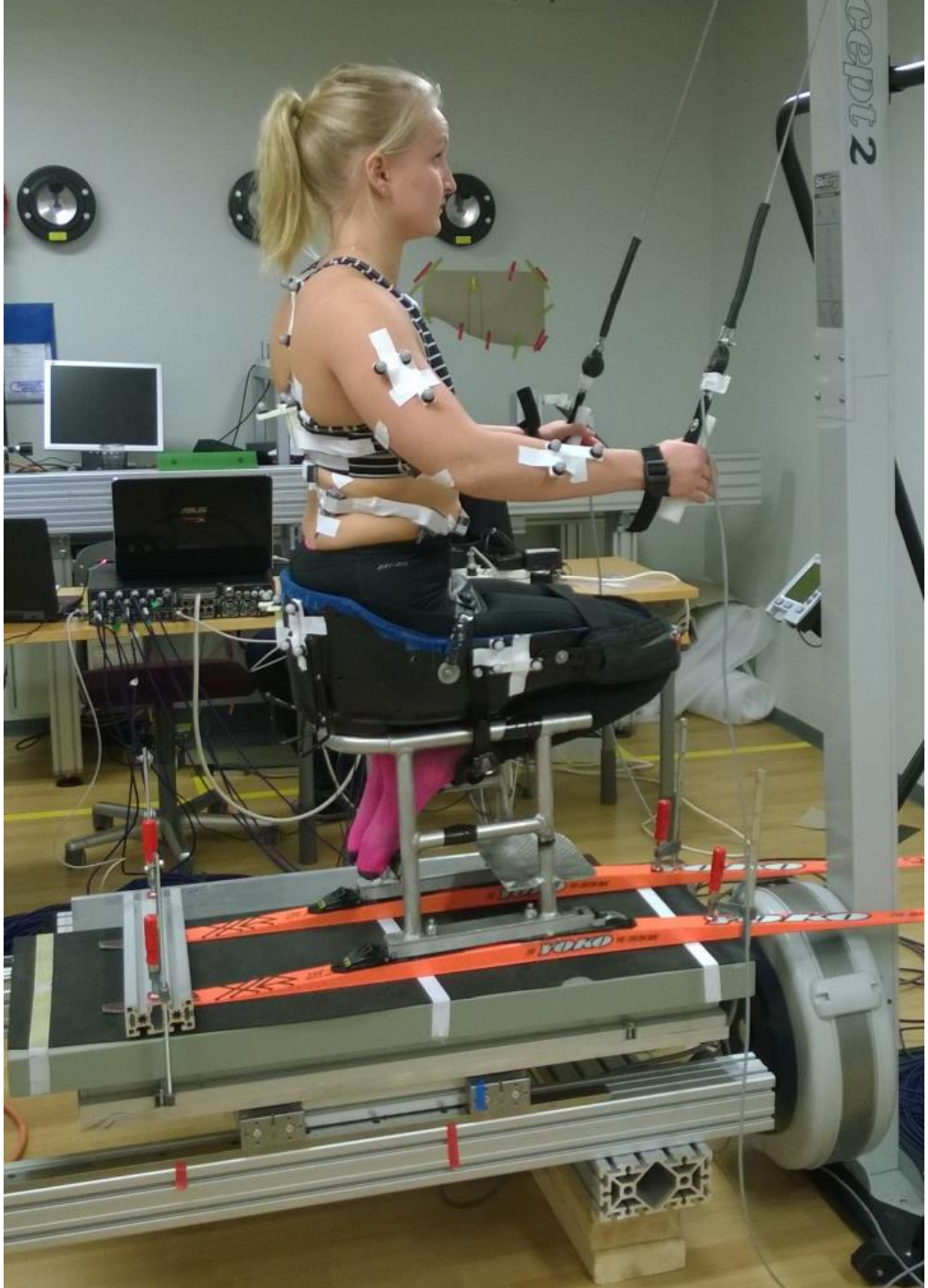
(Schillinger et al.2015)

Data pool of analysed video files (classifiers & coaches)

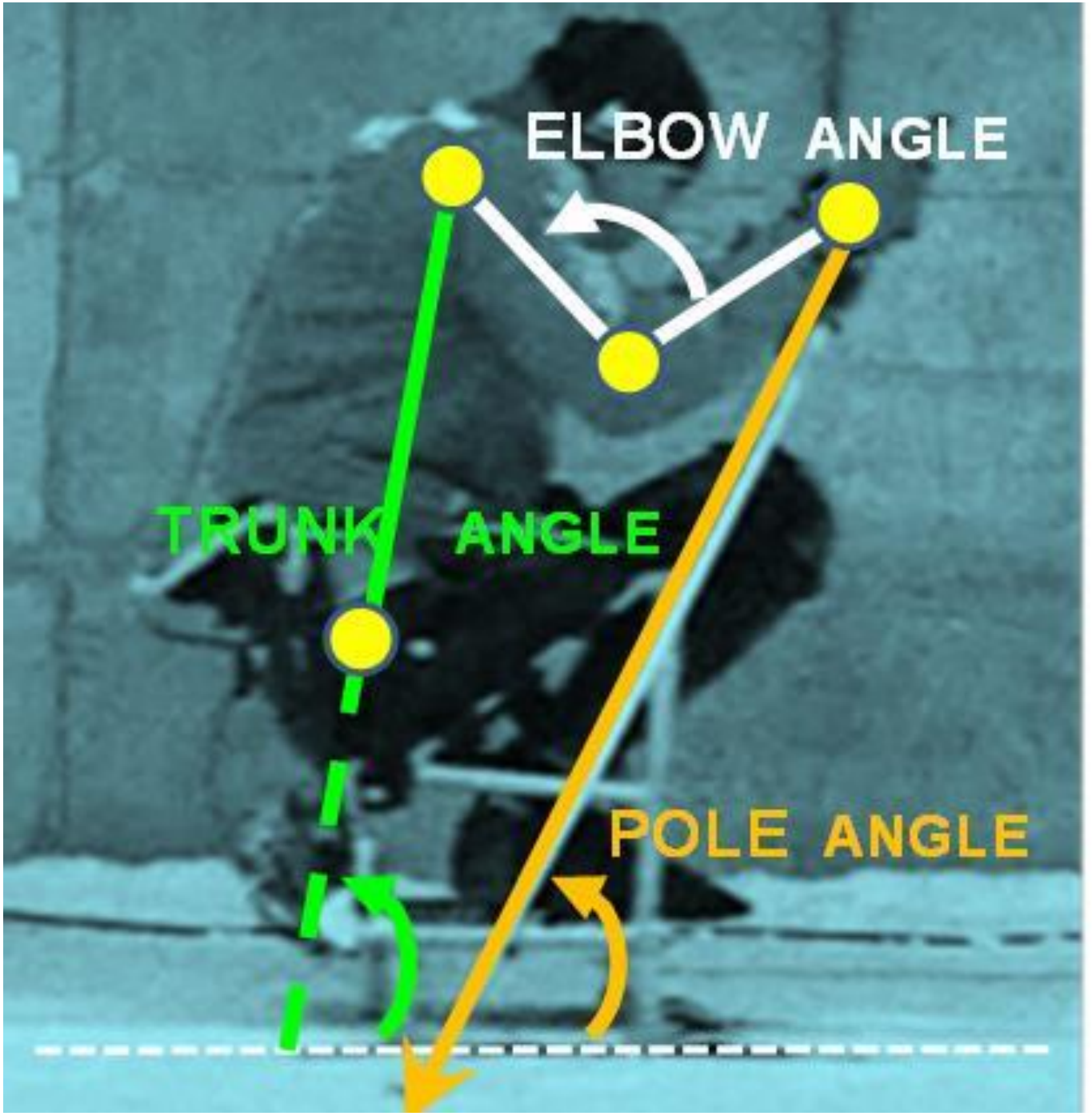
flat men	flat women	uphill men	uphill women	curve men	curve women
LW10 	LW10 	LW10 	LW10 	LW10 	LW10 
LW10.5 	LW10.5 	LW10.5 	LW10.5 	LW10.5 	LW10.5 
LW11 	LW11 	LW11 	LW11 	LW11 	LW11 
LW11.5 	LW11.5 	LW11.5 	LW11.5 	LW11.5 	LW11.5 
LW12 	LW12 	LW12 	LW12 	LW12 	LW12 

Simulated vs. natural skiing

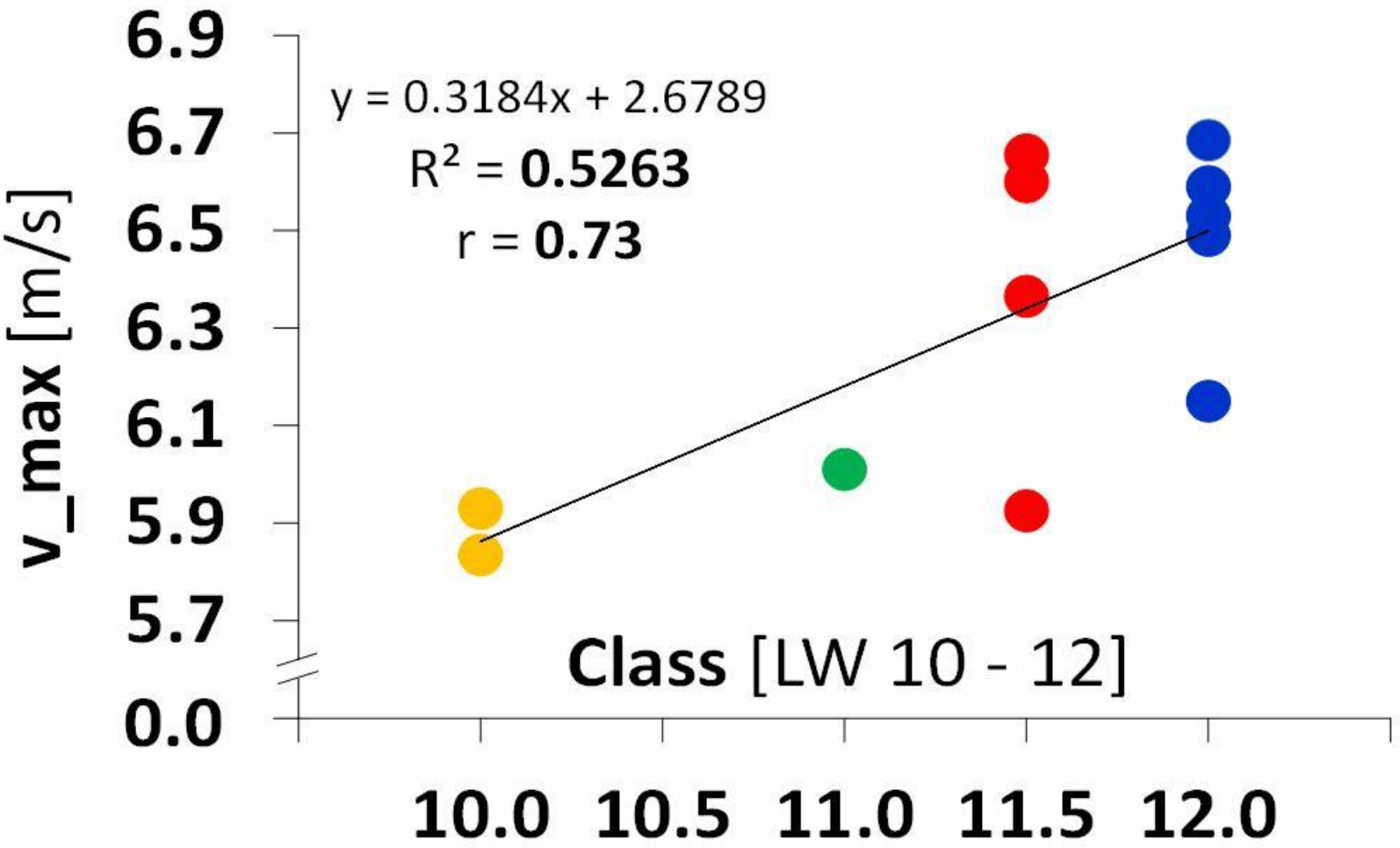



VOKO
VOKO


Concept 2

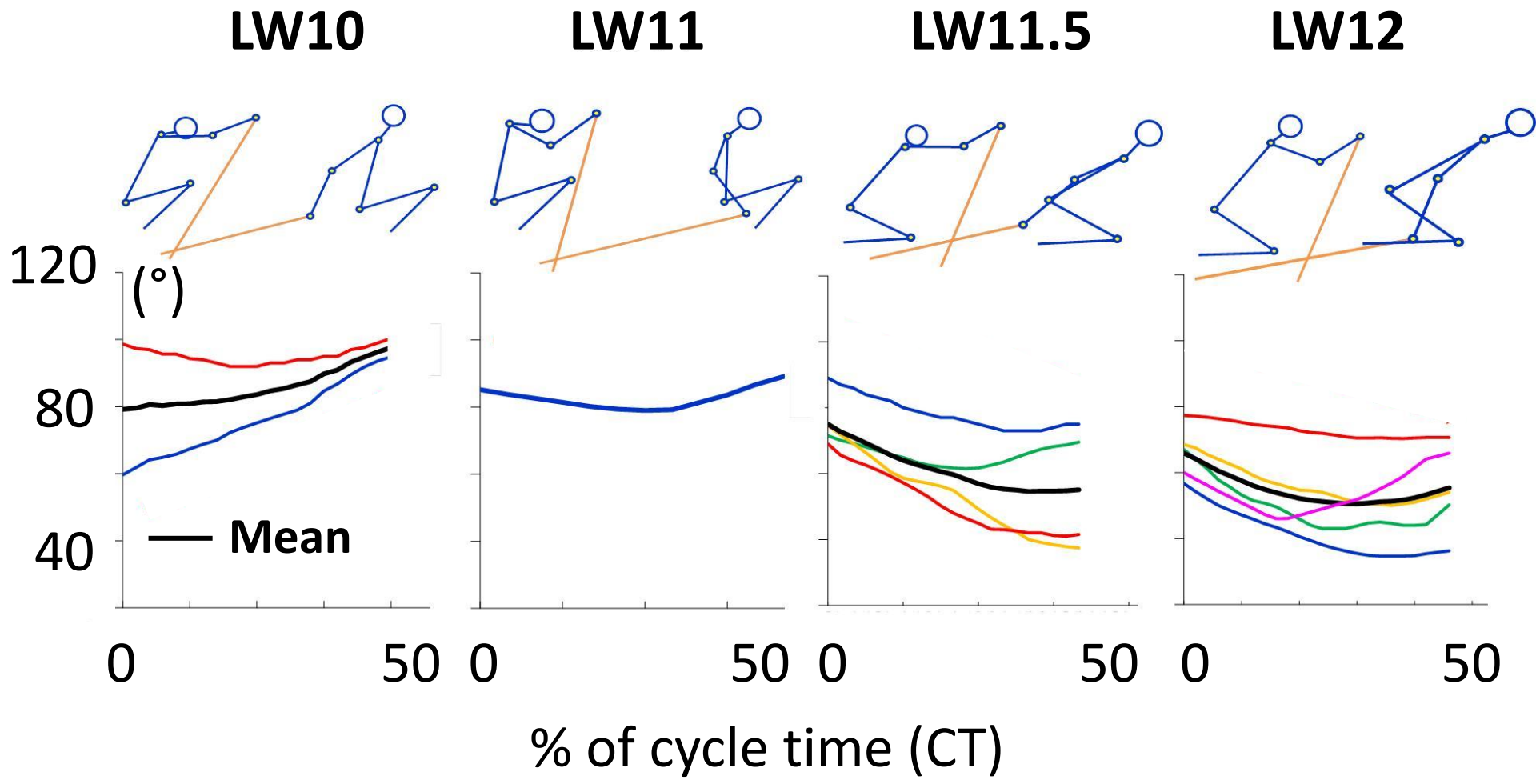

ELBOW ANGLE
TRUNK ANGLE
POLE ANGLE

12 male skiers on flat terrain

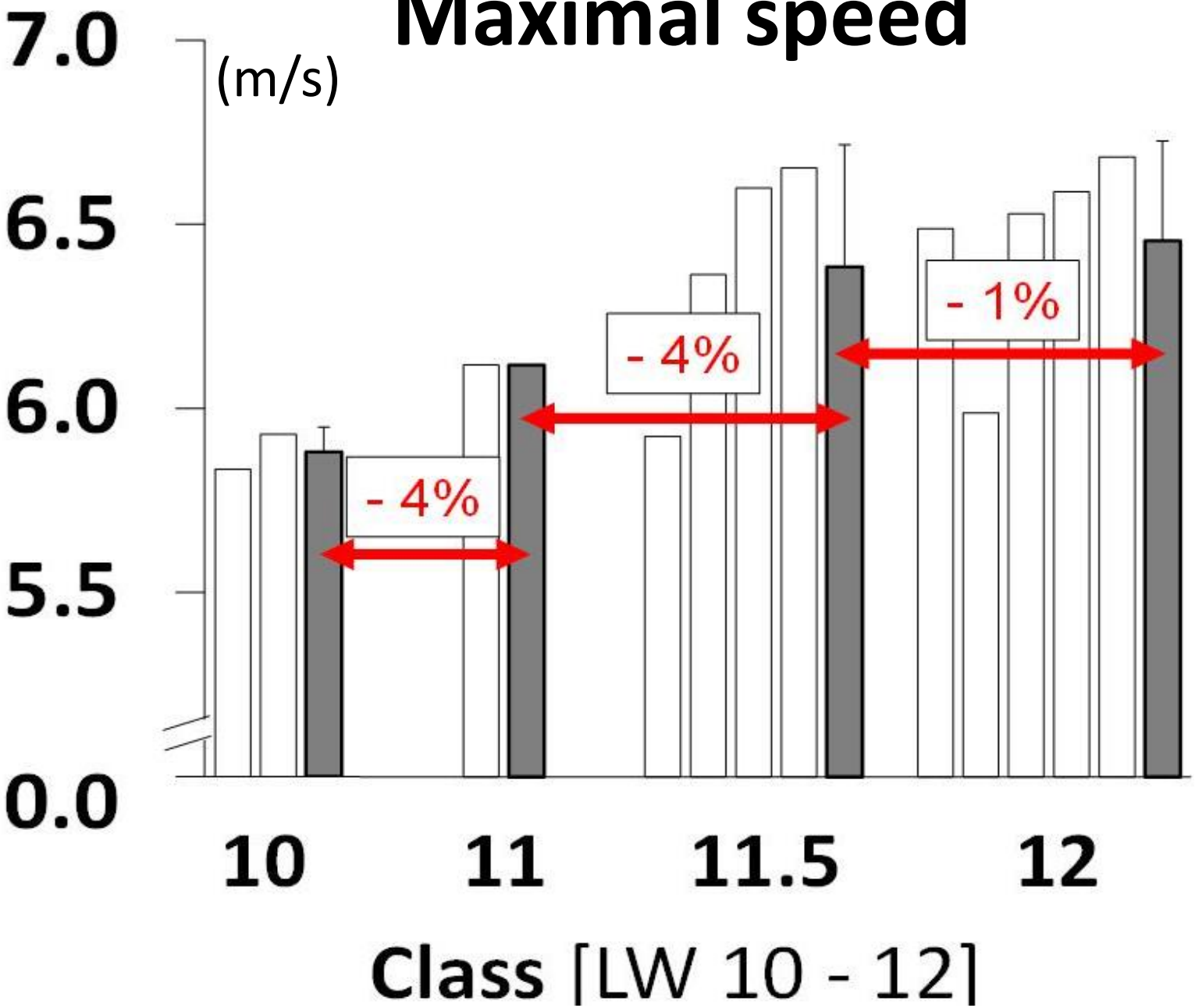


(Karczewska-Lindinger et al. 2016)

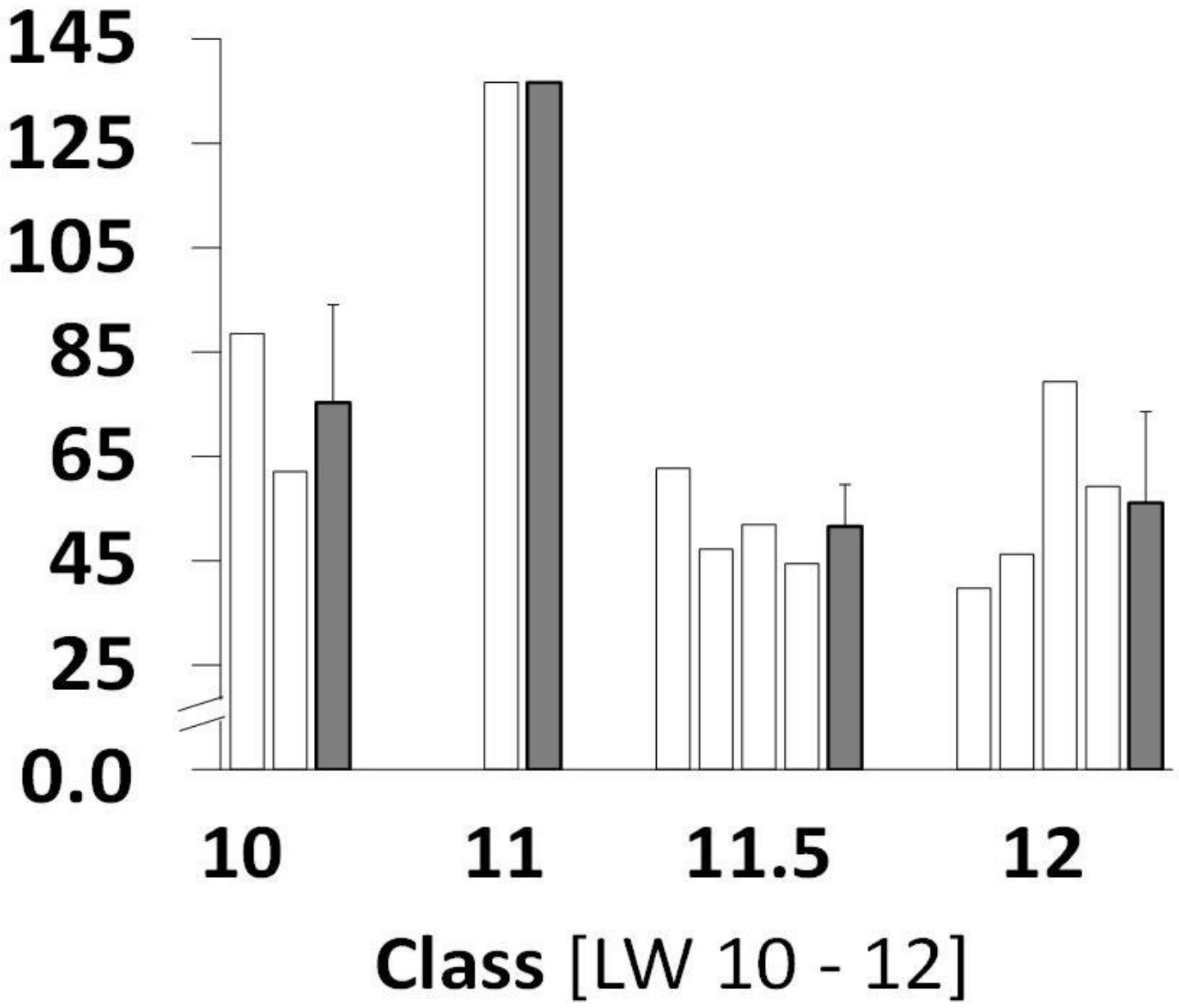
Trunk angle during poling phase



Maximal speed



Poling frequency /min



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Biomechanics of simulated versus natural cross-country sit skiing

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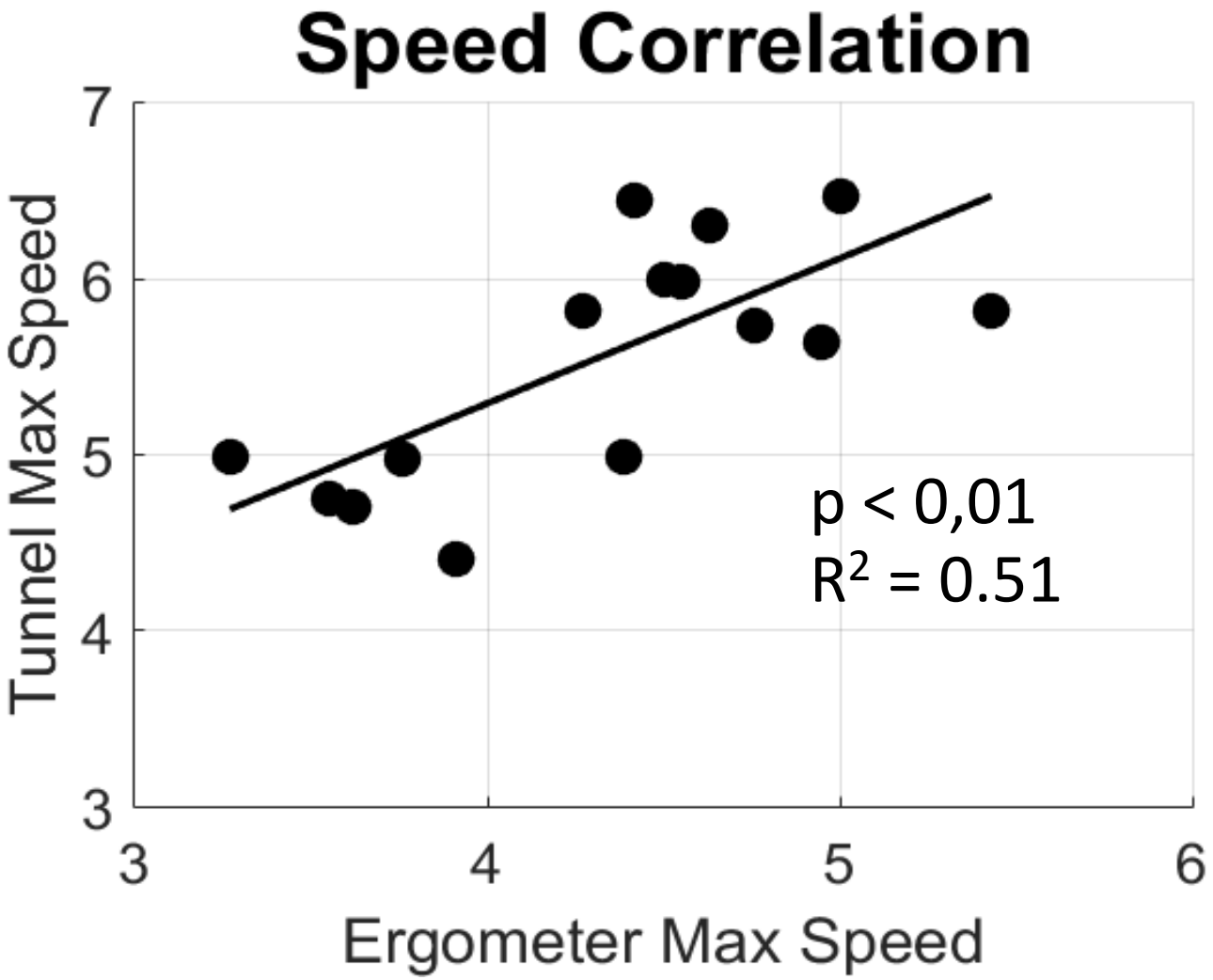
[d] Department of Sport Science and Kinesiology, University of Salzburg, Austria
[e] Department of Rehabilitation Sciences, KU Leuven, Belgium

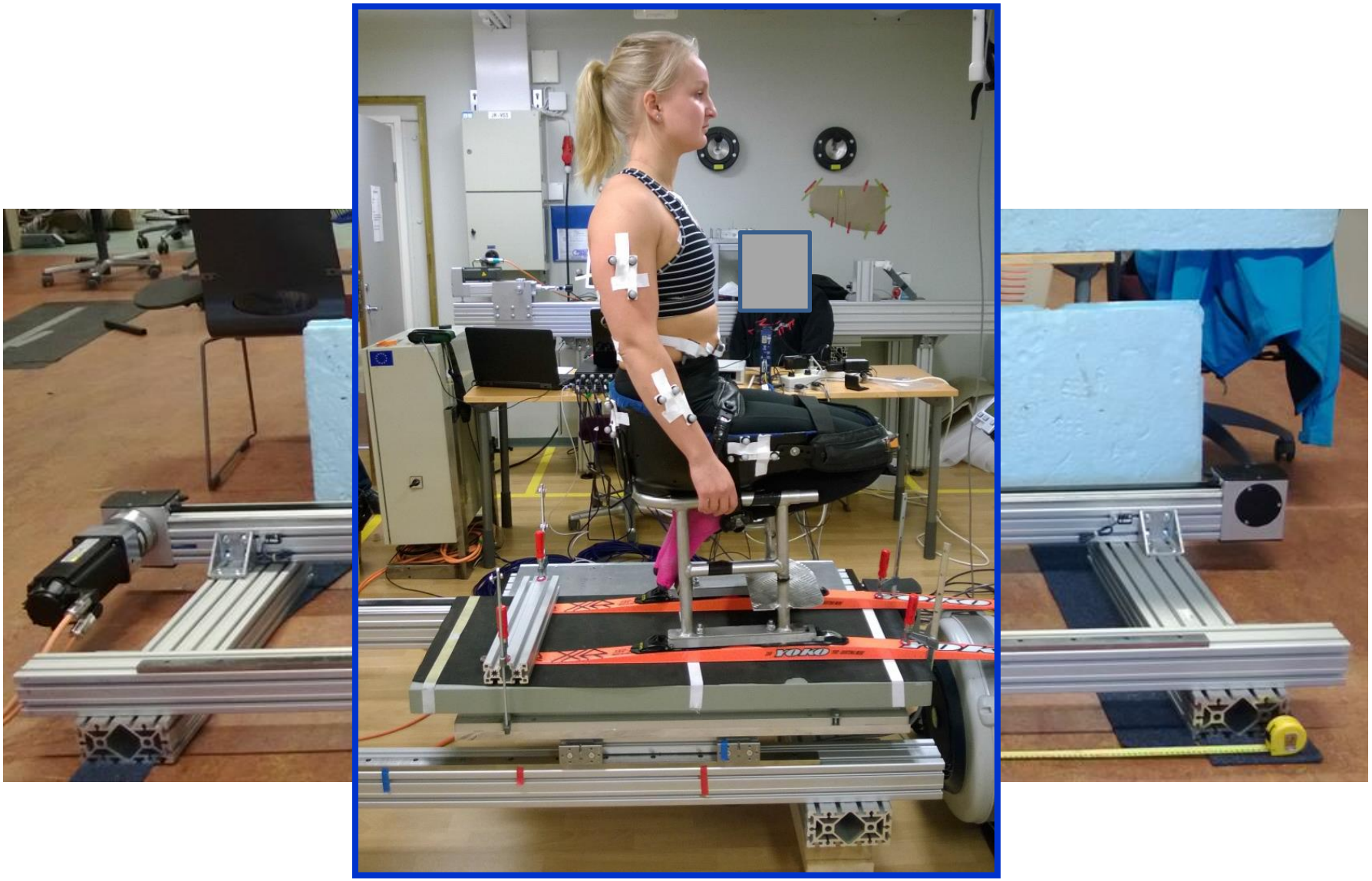
- 5 females and 8 males
- LW10 N=1, LW10.5 N=1, LW11 N=3, LW11.5 N=4, LW12 N=4
- 16m of 2.5° incline in ski tunnel

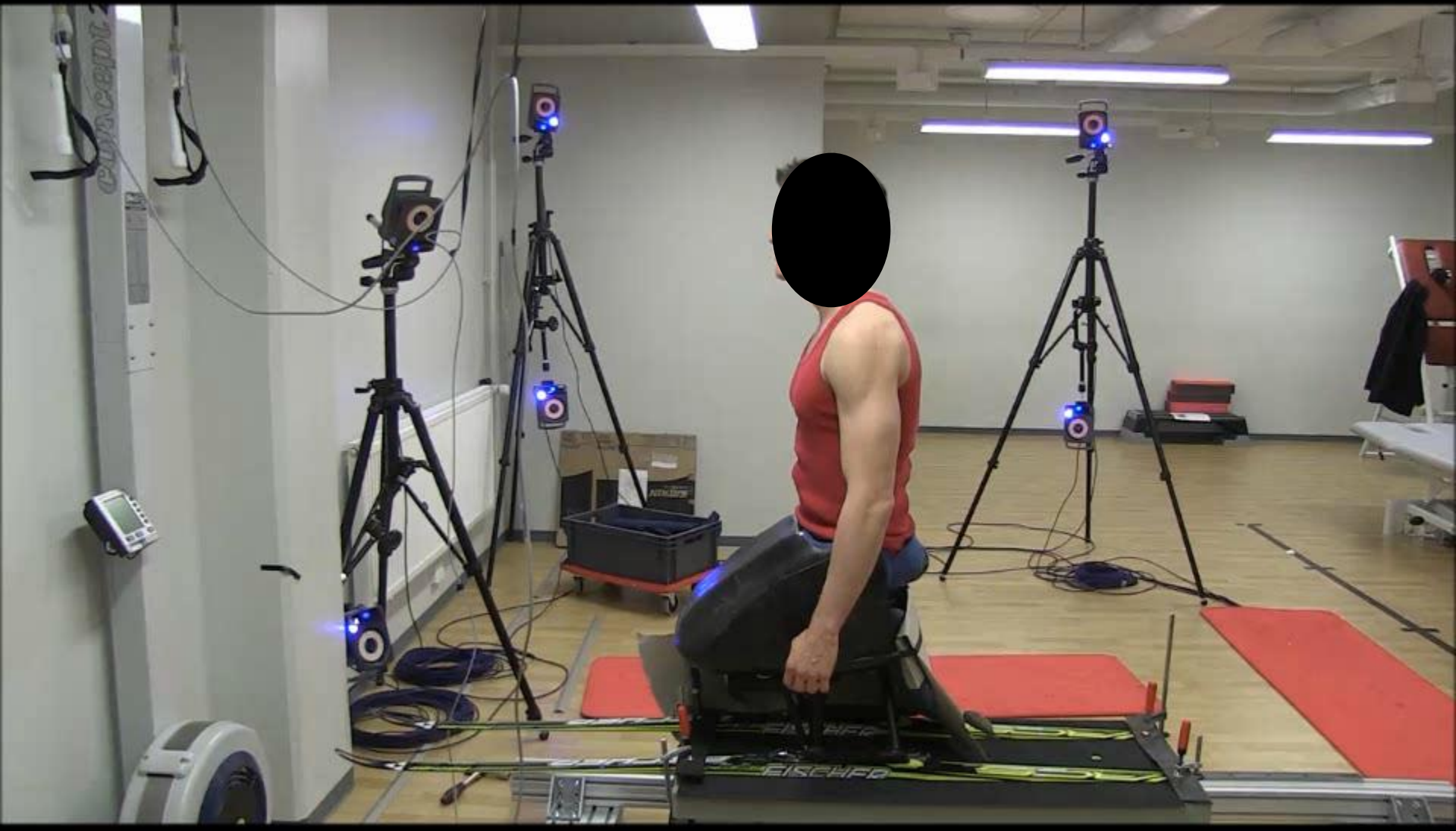
Maximal speed

- Ergo 4.3 ± 0.6m/s
- Tunnel 4.6 ± 0.7 m/s (P<0,05)



Balance perturbations as a measurement tool for trunk impairment in cross-country sit skiing





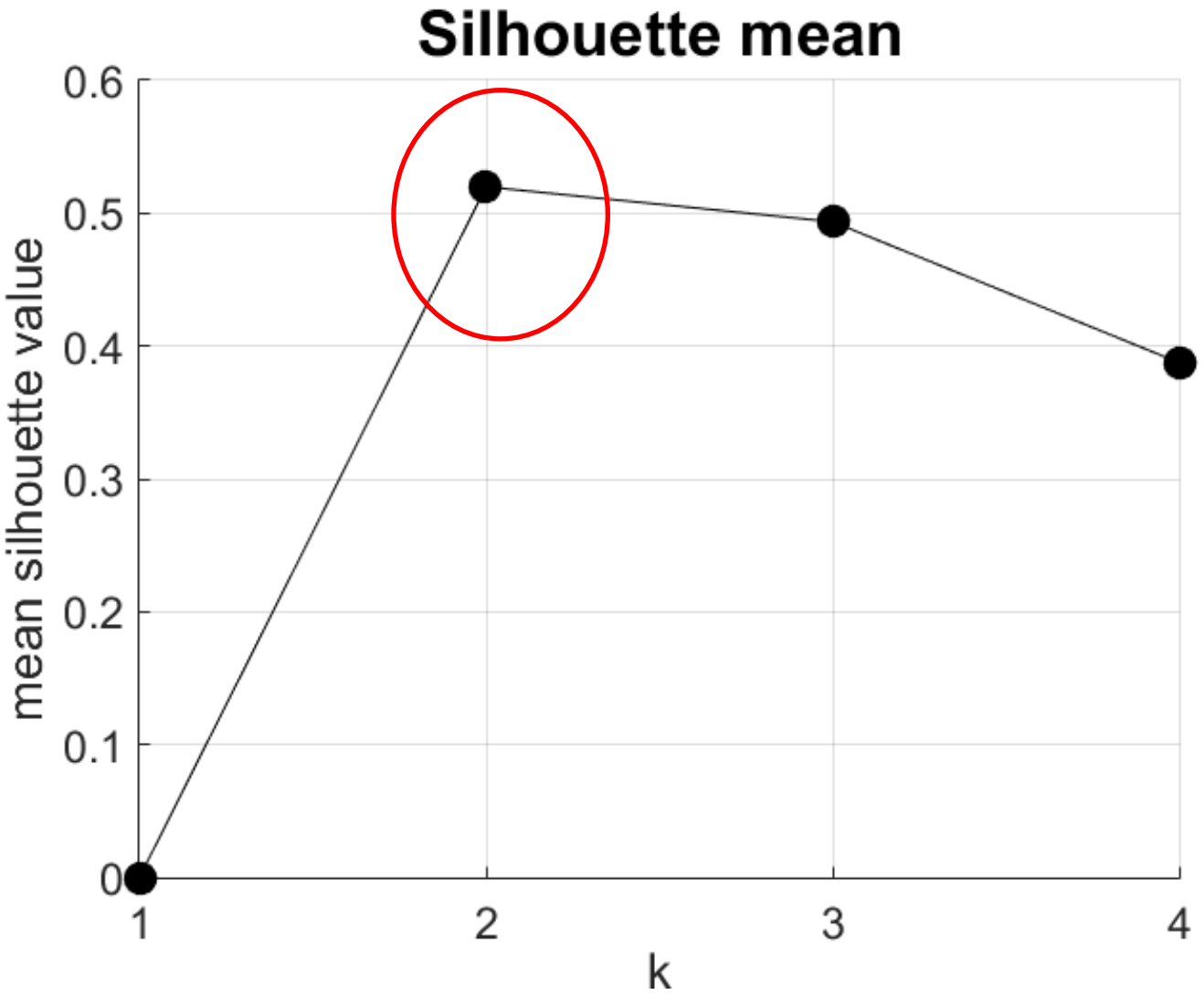
15 athletes (10 male and 5 female)

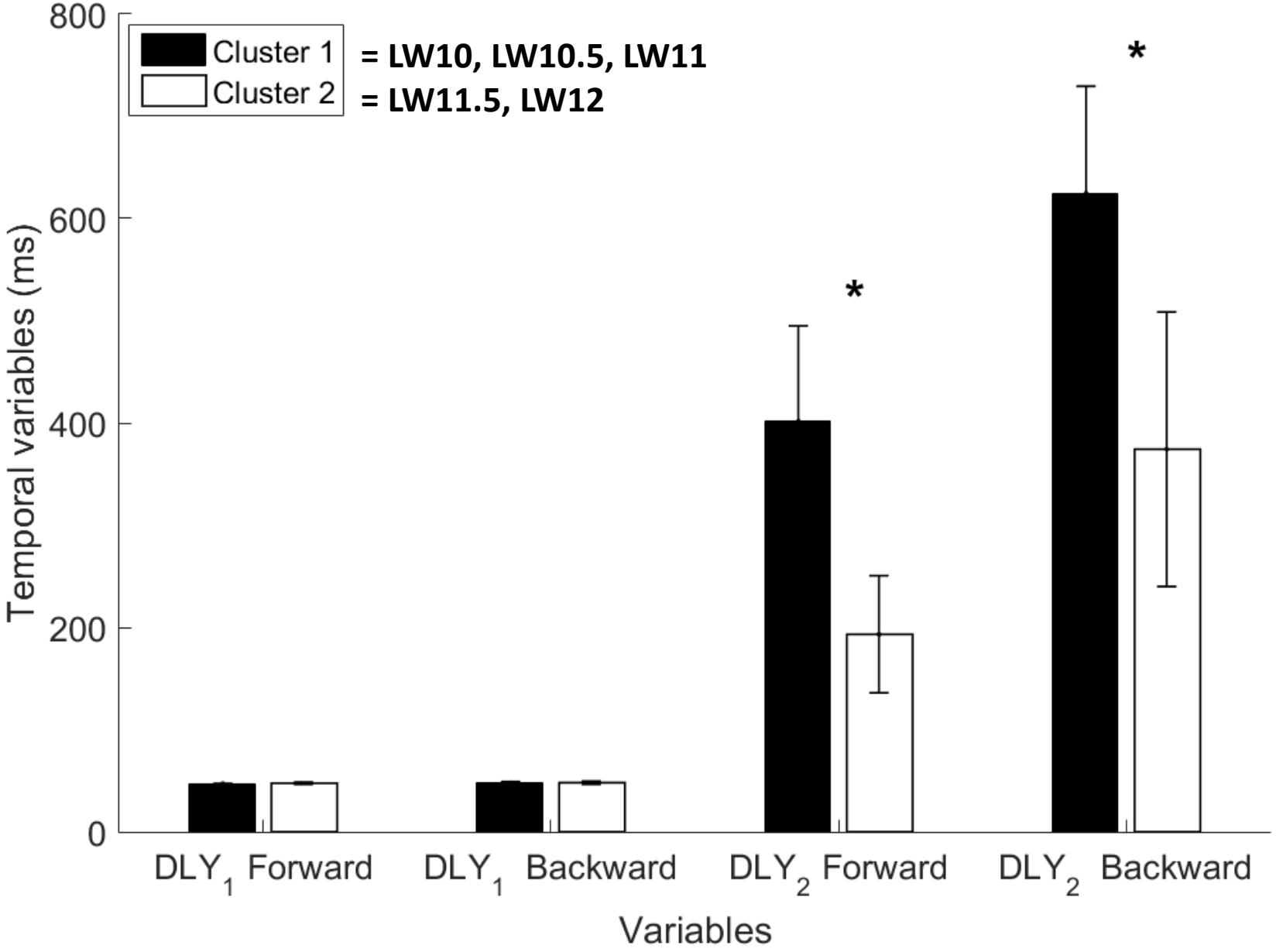
- spinal cord injury n=8, spina bifida n=2, amputee n=5
- LW10 = 2, LW10.5 = 1, LW11 = 3, LW11.5 = 4, LW12 = 5

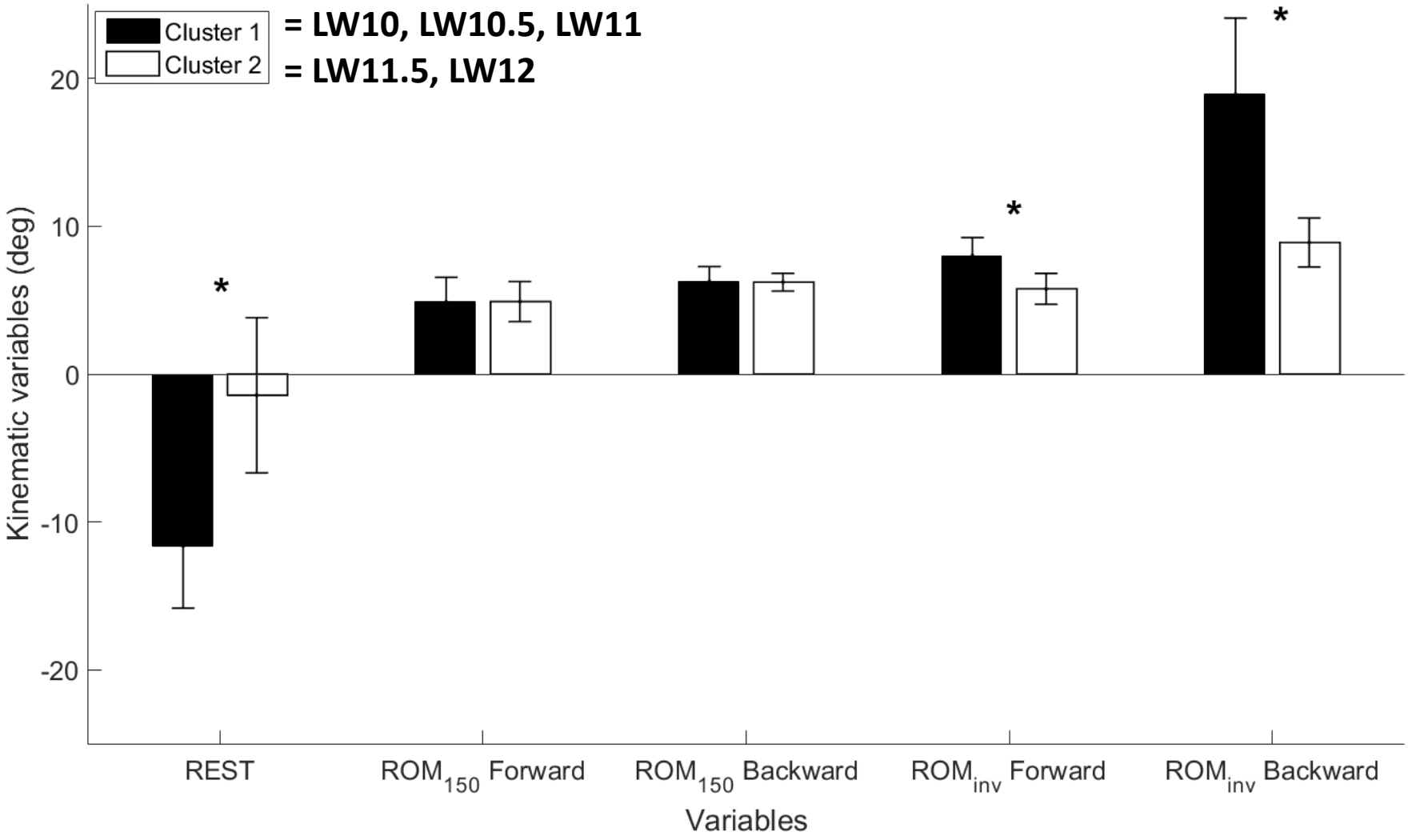
- **DLY_1** = delay between the onset of the sledge acceleration and the onset of the shoulder acceleration
- **DLY_2** = delay between the onset of the shoulder acceleration and the time when the trunk inverted the motion
- **REST** = The trunk angle with respect to the vertical at rest
- **ROM_{150}** = the trunk range of motion 150 ms after the shoulder acceleration
- **ROM_{inv}** = trunk range of motion when the trunk inverted the motion

Cluster method

- the k-means using the squared Euclidean distance

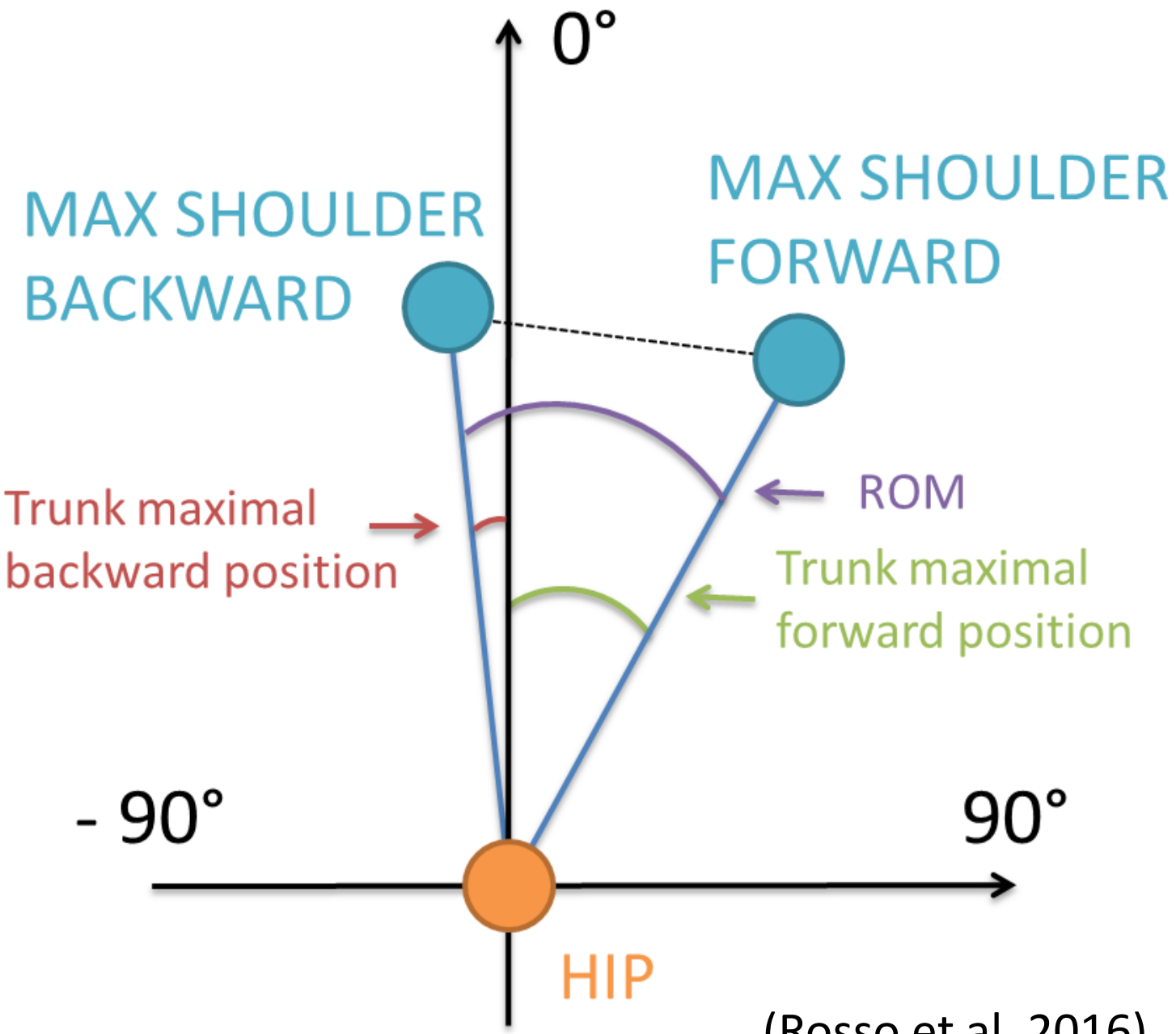



800
600
400
200
0
Temporal variables (ms)
Cluster 1
Cluster 2
= LW10, LW10.5, LW11
= LW11.5, LW12
*
*
DLY1 Forward
DLY1 Backward
DLY2 Forward
DLY2 Backward
Variables


Cluster 1
Cluster 2
= LW10, LW10.5, LW11
= LW11.5, LW12
Kinematic variables (deg)
20
10
0
-10
-20
*
*
*
REST
ROM150 Forward
ROM150 Backward
ROMinv Forward
ROMinv Backward
Variables

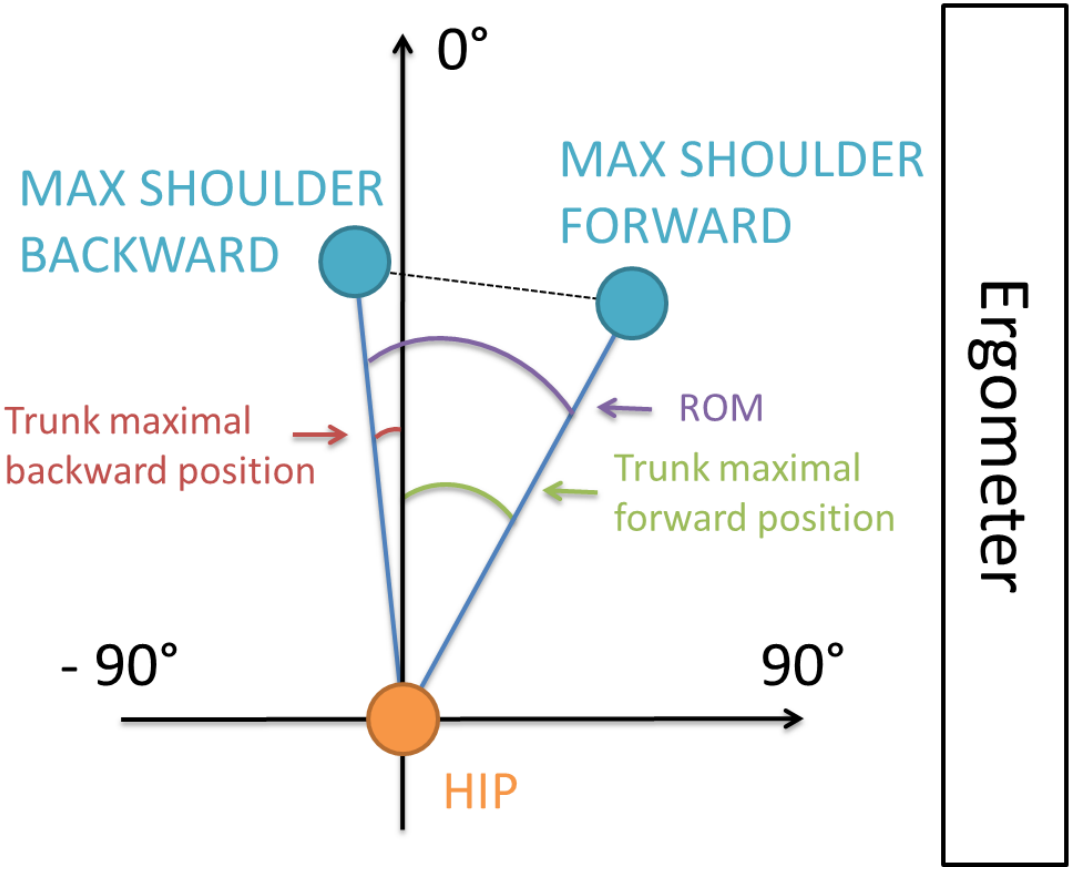
Simulated skiing as a measurement tool for performance in cross-country sit skiing, *submitted*

- LW10 = 1, LW10.5 = 1, LW11 = 3, LW11.5 = 4, LW12 = 4 performed at the ski ergometer seven poling cycles at their maximal speed, while sitting on their sit-ski strapped as in competitive events.
- On the basis of maximal speed, generated force, cycle characteristics, and trunk kinematic variables, the cluster analysis (k-means) divided athletes into **three** groups

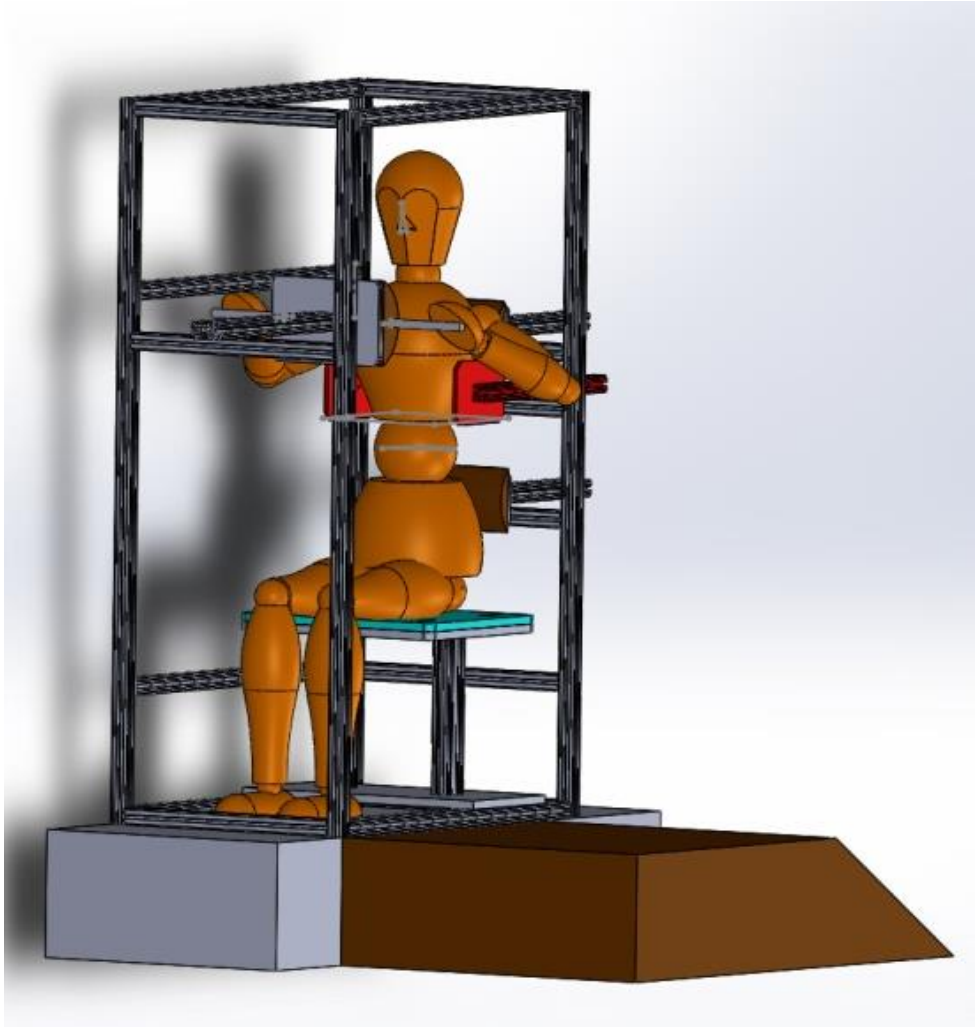


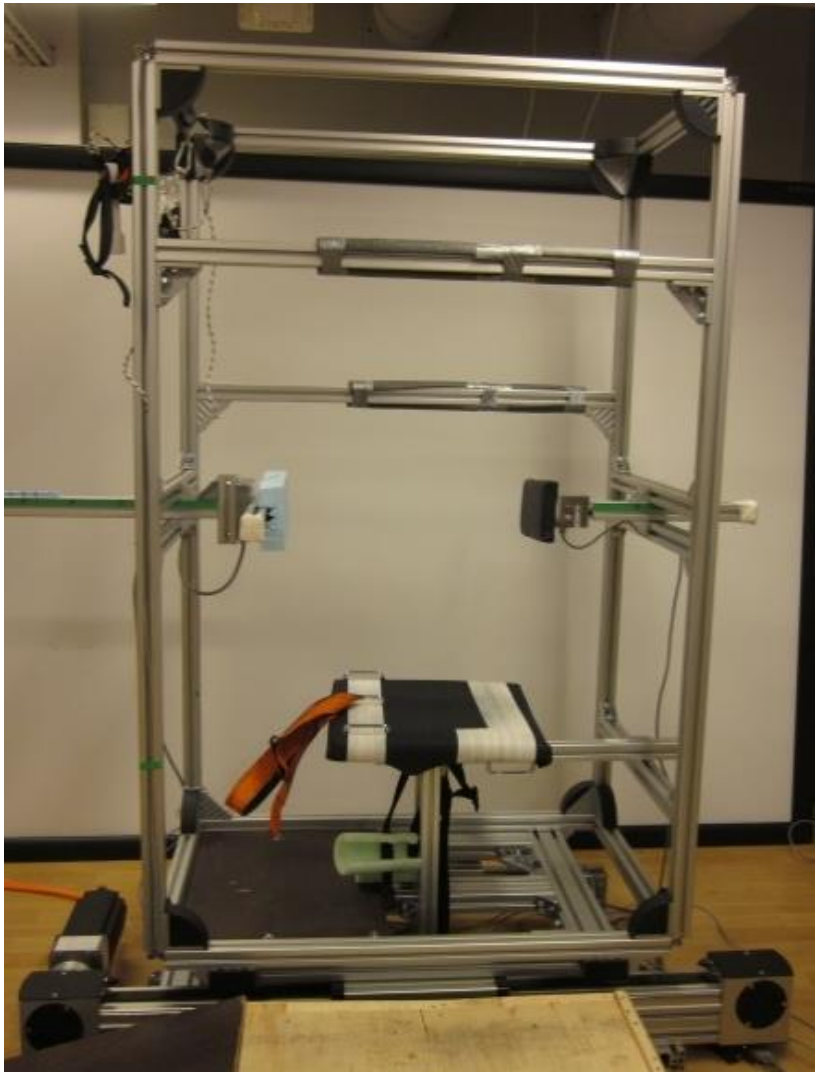
(Rosso et al. 2016)

Ergometer

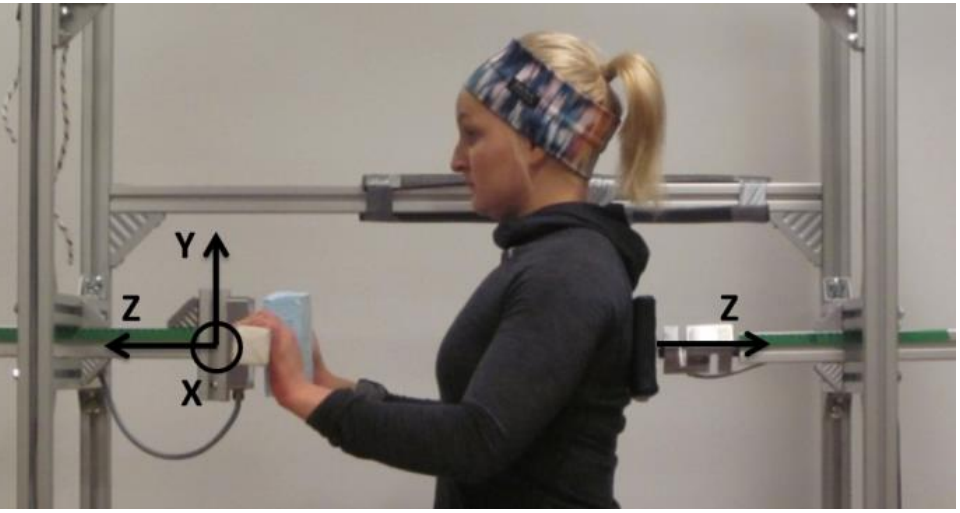


Group (6 females, 10 males)	LW10, 10.5 **(N=3)**	LW 11, 11.5 **(N=7)**	LW12 **(N=6)**
Max backward [°]	-4.6 ± 4.4	7.9 ± 6.4	14.4 ± 11.6
Max forward [°]	17.8 ± 6.0	40.2 ± 15.0	52.5 ± 8.2
ROM [°]	22.4 ± 8.9	32.3 ± 13.9	38.1 ± 14.2

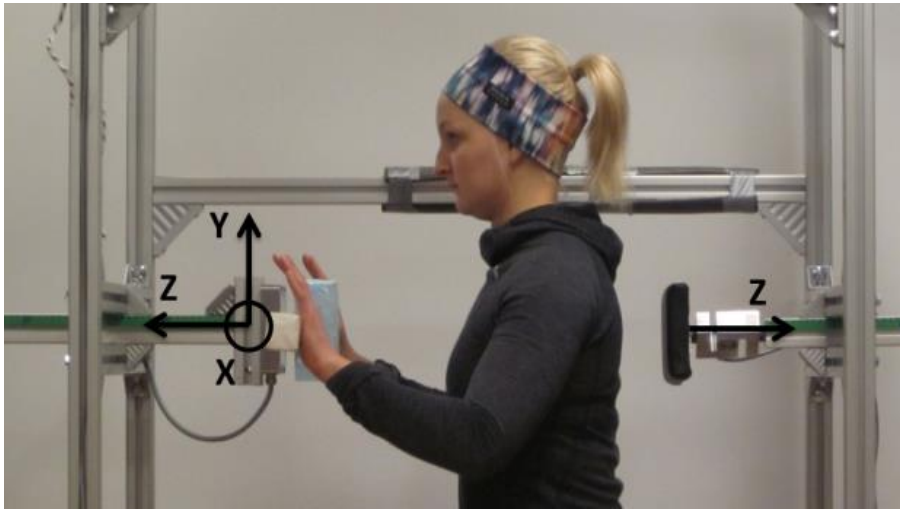




FORCE PRODUCTION

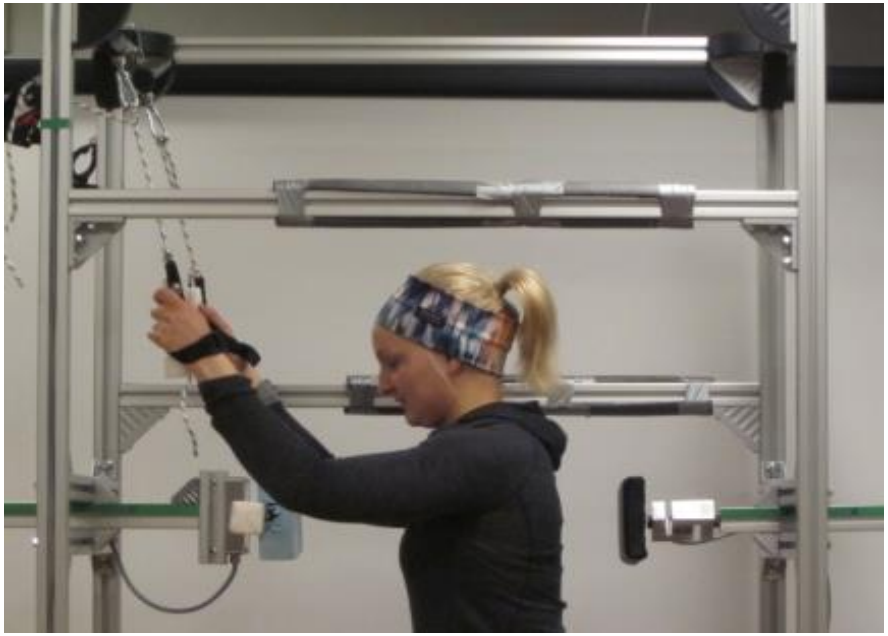


Simulated bench press by pushing with back support



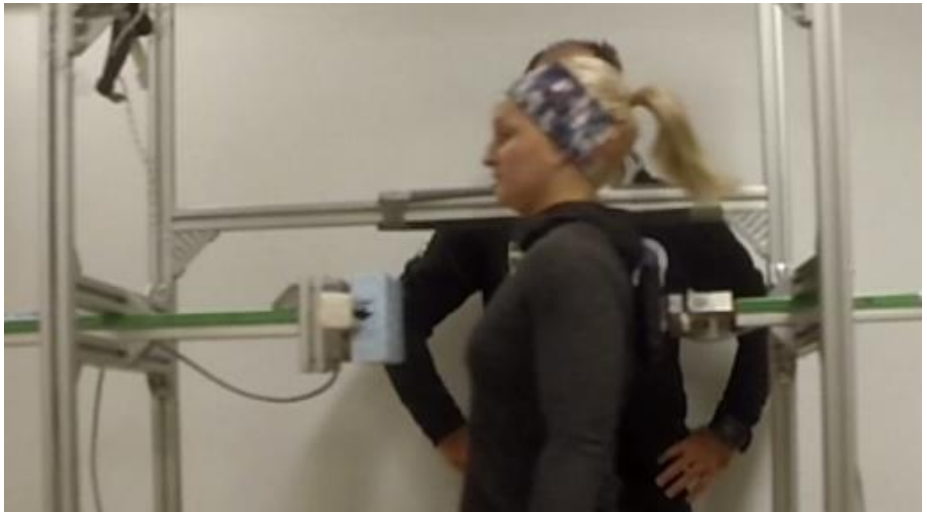
Simulated bench press by pushing without back support

FORCE PRODUCTION



Simulated poling by pulling couple of ropes

TRUNK CONTROL



Unpredictable forward and backward stimuli

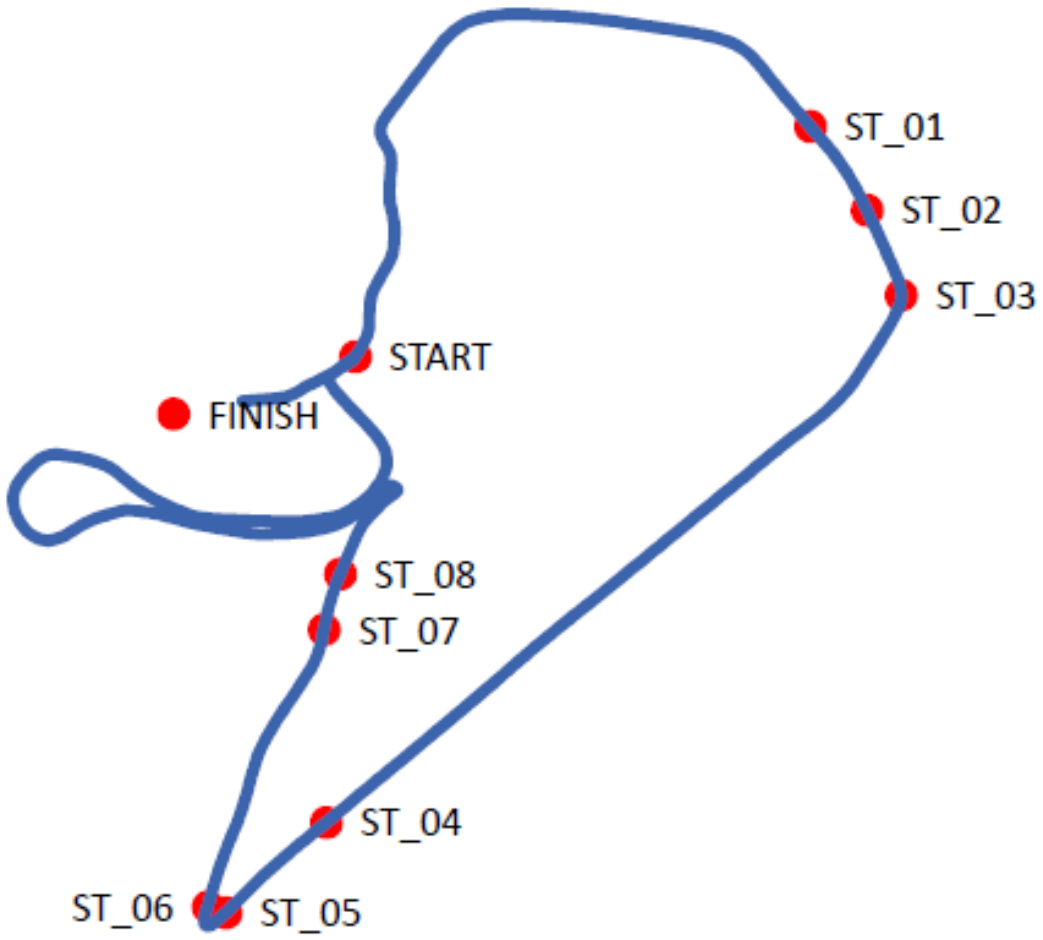
Towards evidence-based classification in cross-country sit skiing: measures of impairment of strength and trunk range of motion, *manuscript*

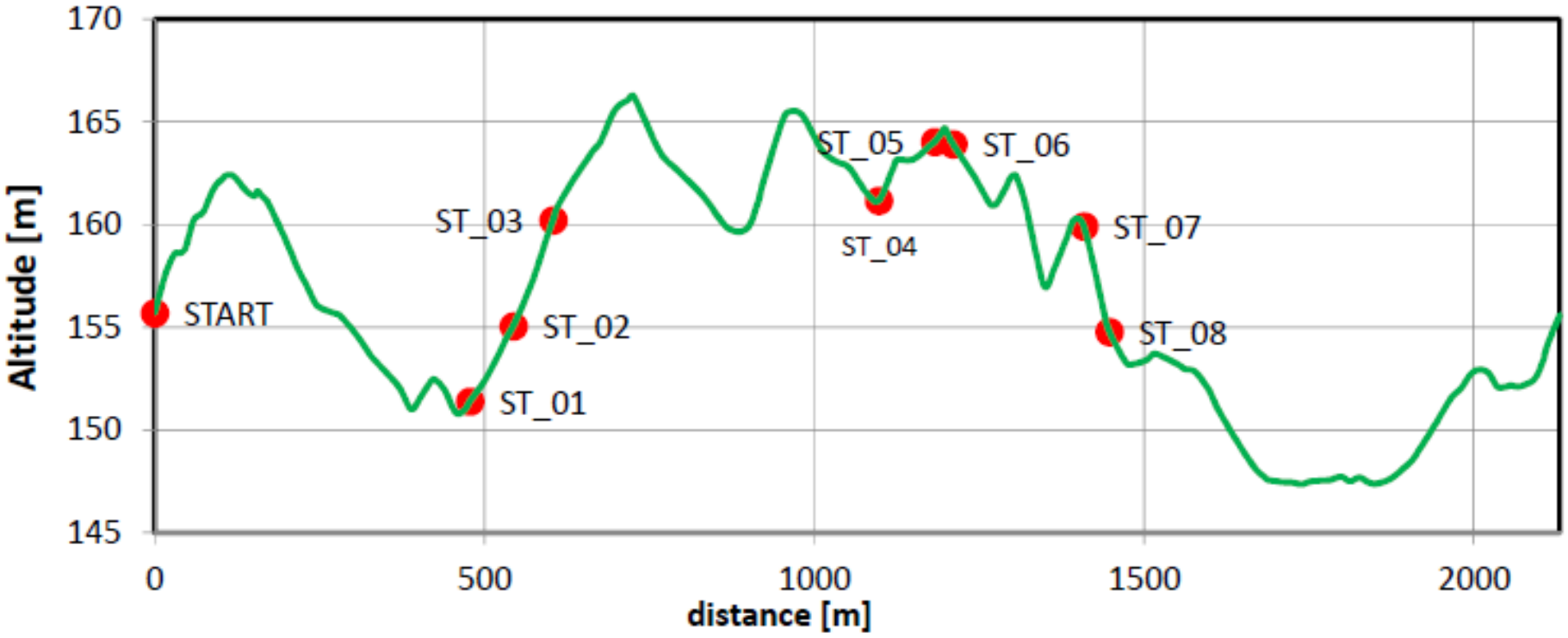
- LW10.5=1, LW11=2, LW11.5=3, LW12=8
- Results showed a very high reliability for bench press (0.71<ICC<0.98) and balance control tests (0.83<ICC<0.99) and a very good correlation (-0.76<r<-0.53) between the two impairment measurements.
- Cluster analysis identified **three** clusters with a high precision and sensitivity on the basis of trunk generated force and trunk range of motion.

IPC WORLD CUP VUOKATTI
BIATHLON SPRINT

03-feb-18

Lastname	Class
Athlete	LW 0




170
165
160
155
150
145
Altitude [m]
0
500
1000
1500
2000
distance [m]
START
ST_01
ST_02
ST_03
ST_04
ST_05
ST_06
ST_07
ST_08

lap 01

	start Time	ST_01	ST_02	ST_03	ST_04	ST_05
Athlete	**0:00:00**	**0:00:00**	**0:00:00**	**0:00:00**	**0:00:00**	**0:00:00**
average athletes LW 10, 10.5, 11		0:02:04	0:02:22	0:02:47	0:04:57	0:05:18
average athletes LW 11.5, 12		0:01:46	0:02:01	0:02:21	0:04:07	0:04:25

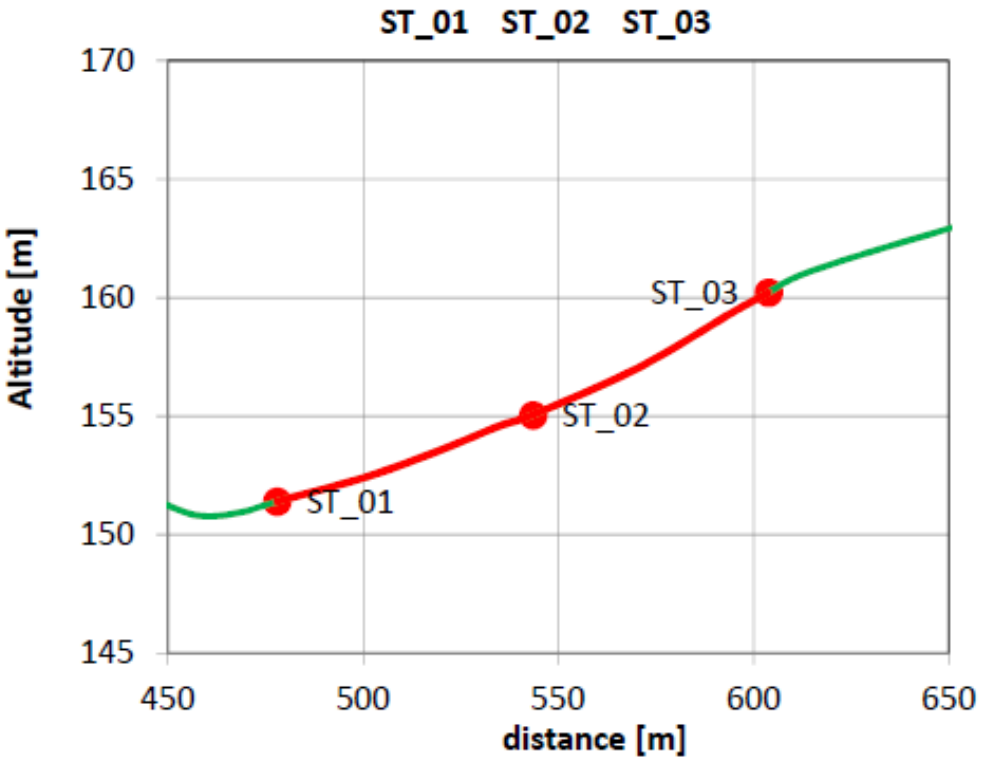
lap 02

	ST_01	ST_02	ST_03	ST_04	ST_05
Athlete	**0:00:00**	**0:00:00**	**0:00:00**	**0:00:00**	**0:00:00**
average athletes LW 10, 10.5, 11	0:13:24	0:13:42	0:14:10	0:16:25	0:16:47
average athletes LW 11.5, 12	0:11:51	0:12:09	0:12:33	0:14:34	0:14:56

Section ST_01-ST_02-ST_03

ST_01-ST_02
Medium uphill straight, part of longer uphill
(distance= 65,5 m; elevation angle 5,5%)

ST_02-ST_03
Medium to steeper uphill, part of longer upl
(distance= 60,5 m; elevation angle 8,2%)

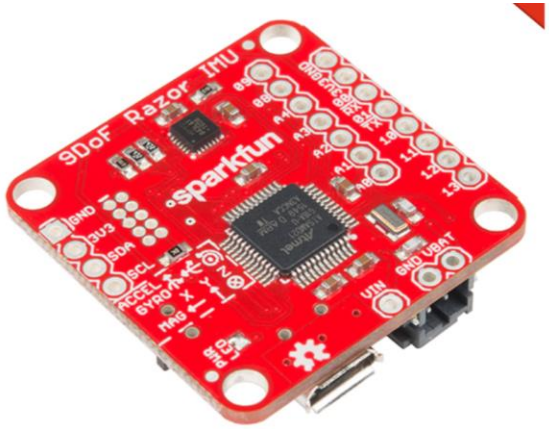


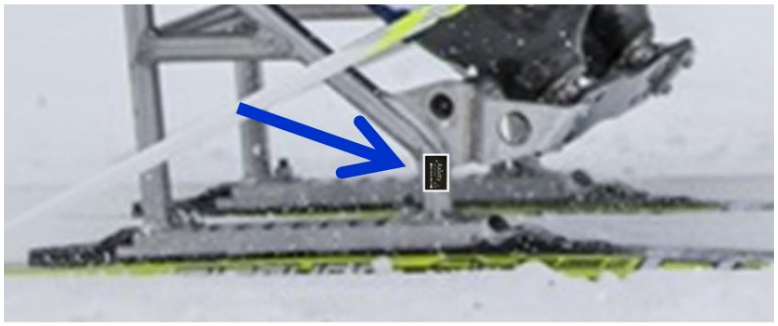
TECHNOLOGY:

MINI-MAGNETO-SENSORS (RECEIVER) + MAGNETS (SENDER) IN SNOW

SparkFun 9DoF Razor IMU M0

SEN-14001

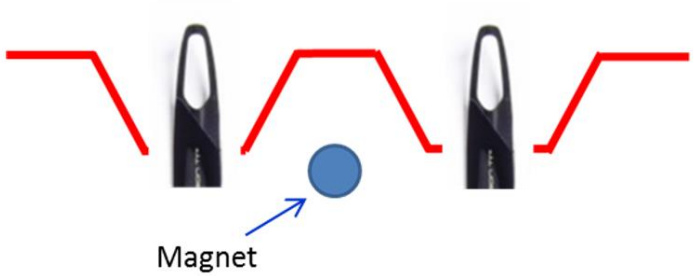




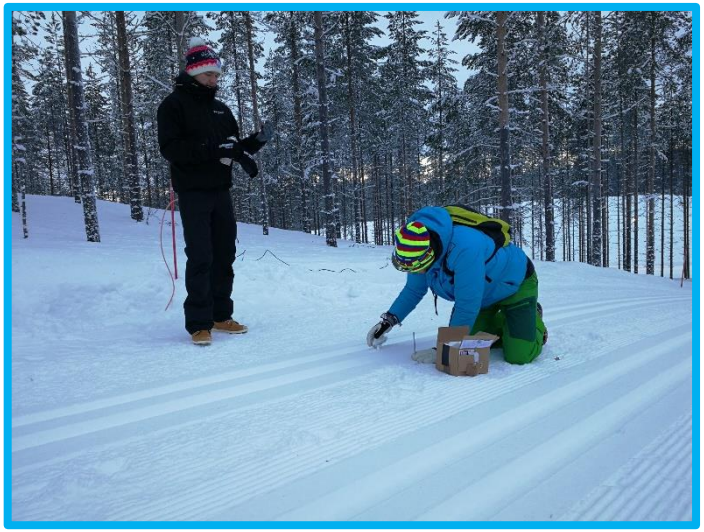
*„No“ weight (15g)
*Small
*Easy to mount

(plastic band fixed)

*„No“ interference with athlete
*100 Hz



EARLY MORNING MAGNET INSTALLATIONS

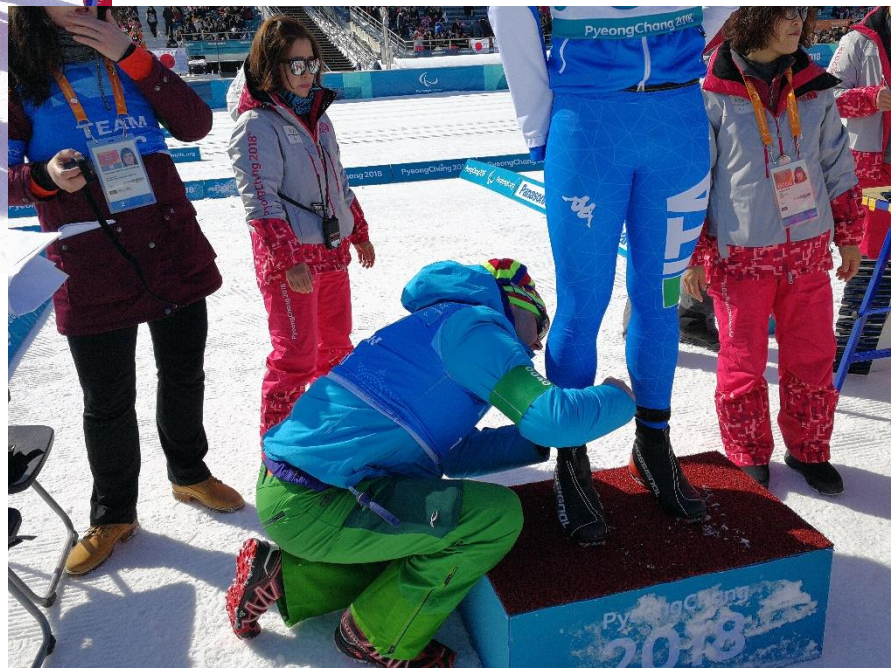


TECHNOLOGY:

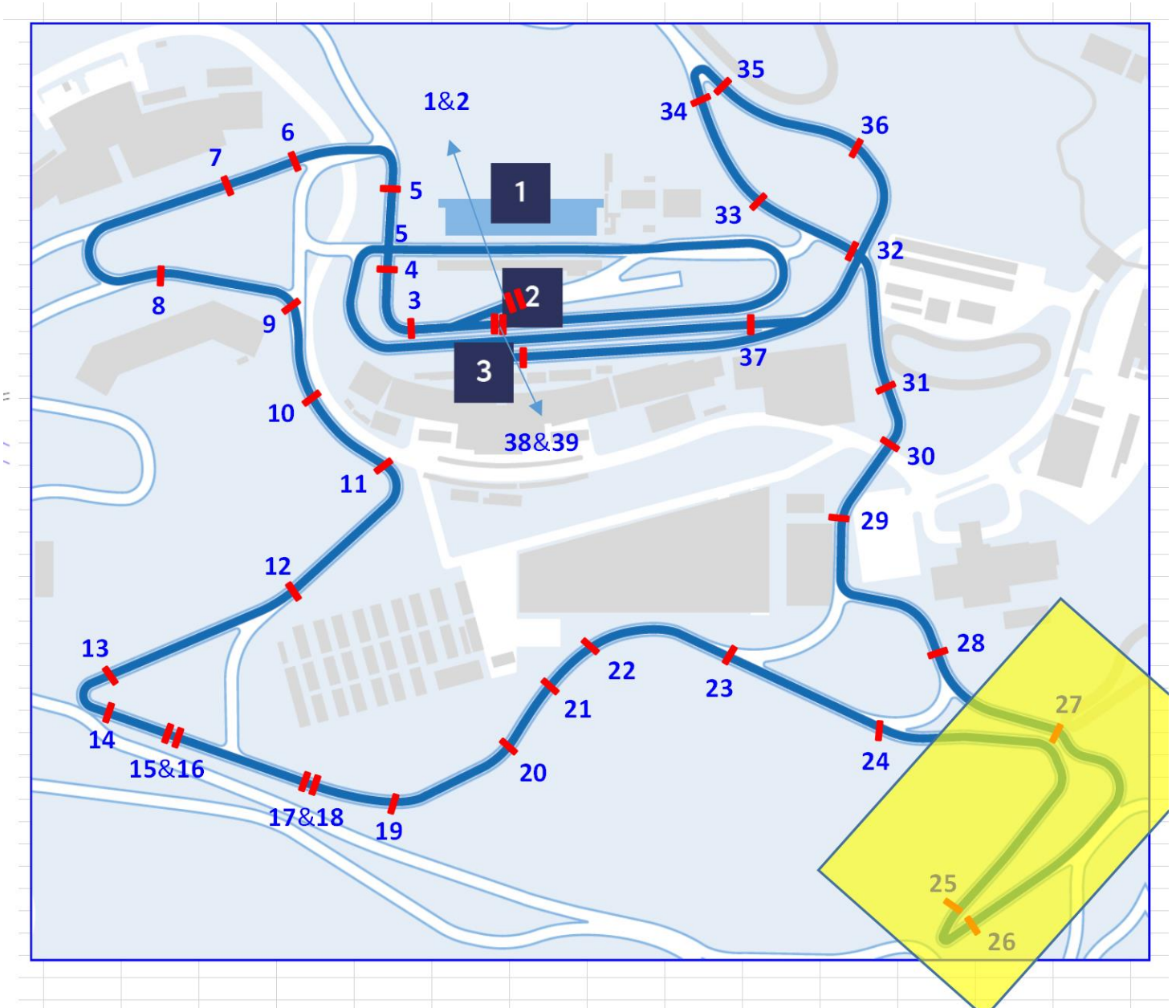
MOUNTING OF SENSORS

TECHNOLOGY:

MOUNTING OF SENSORS



Sit-ski men 7.5km



Articles and book chapters:

1. Rapp W., Lappi T., Lindinger S., Ohtonen O., Linnamo V (2015). Force production, balance control and muscle activation in different sitting positions – pilot study for disabled sit sledge cross-country skiers. In Book: Science and Skiing VI. Eds. Müller E., Kröll J.,Lindinger S., Pfusterschmied J., Stöggl T. ISBN 978-1-78255-066-2, p. 453-464.
2. Rapp W., Rosso V., Ohtonen O., Gastaldi L., Vanlandewijck Y., Lindinger S., Linnamo V (2016) Role of muscle activation in the sit-skiing performance and classification process. In Book: Science and Nordic Skiing III. Eds. Hakkarainen A., Linnamo V., Lindinger S. ISBN: 978-951-39-6430-6, p. 165-172.
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Yhteenveto

- Uusi laite ja analysointimenetelmät antaisivat uutta tieteellistä pohjaa luokitteluprosessiin
- Ehdottomasti tarve testata enemmän urheilijoita
- Muut lajit?
- Väliaika-analyysi pitää saada valmiiksi

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CYCLE:			FORCE (/kg):			
CT [s]	Push / Swing [%]	CL [m]	ø PPF [N]	ø CF [N]	ø IMP [N]	diff (L/R) [%]
1.1	43.4/56.6	3.8	141 /127.5	62 /60.5	47.3 /36.8	66 /39.2

Cameras: side | rear

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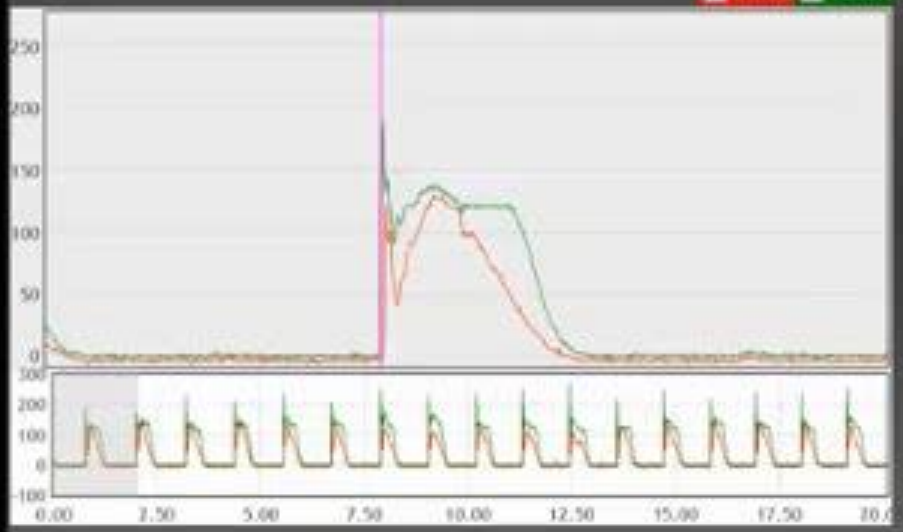

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CYCLE:			FORCE (/kg):			
CT [s]	Push / Swing [%]	CL [m]	ø PPF [N]	ø CF [N]	ø IMP [N]	diff (L/R) [%]
1.32	39.4/60.6	4.3	131 /123.2	56 /62.6	39.7 /51.7	43.7 /51.1

Cameras: side | rear

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