Testing elite XC skiers with use of wearable sensor technology

Thomas Losnegard, PhD

Department of physical performance
Norwegian School of Sport Sciences, Oslo, Norway

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Outline

Using wearable sensor technology in elite XC skiers - with focus on GPS systems

- Valid GPS-systems for XC skiing?
- Examples from studies
  - "Influence of pole lengths on performance tested on snow"
  - "Exercise intensity in distance XC skiing race"
- Comments / questions

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Valid GPS systems for XC skiing?

Reference systems

"Gold standard"
Accuracy <5cm
(**590 gram**)

Catapult S5
(**10Hz, 67gram**)

ZXY-GO
(**10 Hz, 63 gram**)

Garmin Forerunner 920XT
(**1 Hz, 61 gram**)

Gløersen, Kochbach, Gilgien, under revision

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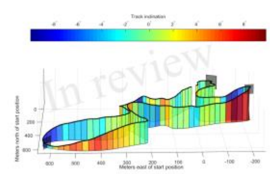
Valid GPS systems for XC skiing?



Gløersen, Kochbach, Gilgien, under revision

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Conclusion

ZXY-GO and Catapult S5 (10HZ);
- *Perform substantlially better than the wrist-worn Garmin-920XT (1HZ)*

Speed errors suggest that ZXY and Catapult (10HZ) can detect typical speed differences in XC skiing, while the 920XT can not.

Gløersen, Kochbach, Gilgien, under revision

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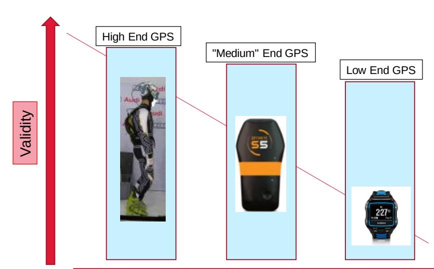

Modified from Myklebust 2016

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Influence of pole lengths on performance tested on snow

-Catapult S5 GPS (10hz)

Erik Trøen 2017

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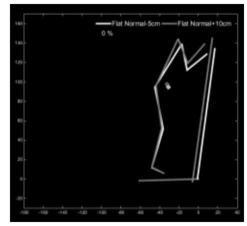
Flat (1.7°)



Carlsen et al 2018, Losnegard et al 2017

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Purpose and methods

Investigate influence pole lengths on Double poling performance

- 21 (7♀, 14 ♂) XC skiers
- Pole length; 84 and 90 % of body-height (counter balanced)
- 700-m course, 2 x with 20 min break,
- Track consisted of flat/uphill/downhill

Erik Trøen 2017, master thesis

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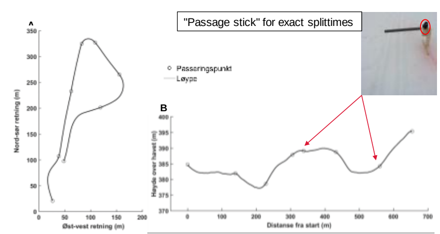

Erik Trøen 2017

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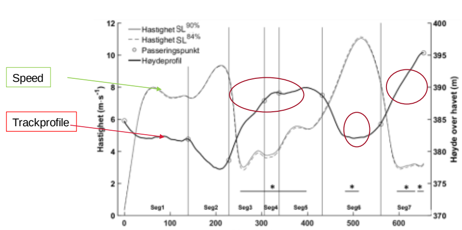

Erik Trøen 2017

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Conclusion

Using GPS-systems (Catapult) on snow we have shown that:

- Longer poles (90%) superior in uphills (low speeds) for both sex.
- At high speeds (>8 m/s) shorter poles (here 84%) seems better.
- Results confirm our lab-based testing (Losnegard et al 2017, Carlsen et al 2018)

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ORIGINAL RESEARCH ARTICLE

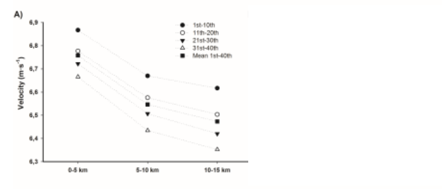
Front. Physiol. | doi: 10.3389/fphys.2018.00846

Exercise intensity during cross-country skiing described by oxygen demands in flat and uphill terrain

Øyvind Karlsson[1*], Matthias Gilgien[1, 2], Øyvind N. Gløersen[1, 3], Bjarne Rud[1] and Thomas Losnegard[1]

[1]Department of Physical Performance, Norwegian School of Sport Sciences, Norway
[2]Alpine Skiing, Norwegian Ski Federation, Norway
[3]Department of Physics, University of Oslo, Norway

Pacing pattern in XC skiing World Cup



Losnegard, Kjeldsen, Skattebo, *JSCR* (2016)

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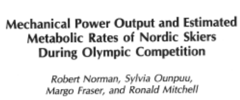
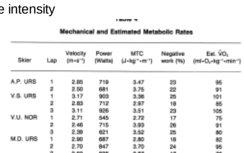
Exercise intensity in distance XC skiing?

Specificity of training is perhaps the most significant principle used in athlete preparation

- Few studies have investigated exercise intensity - in distance skiing
- From a practical point; HR is used to evaluate intensity


Mechanical Power Output and Estimated Metabolic Rates of Nordic Skiers During Olympic Competition

Robert Norman, Sylvia Ounpuu, Margo Fraser, and Ronald Mitchell


Mechanical and Estimated Metabolic Rates

Skier	Lap	Velocity (m·s⁻¹)	Power (Watts)	MTC (J·kg⁻¹·m⁻¹)	Negative work (%)	Est. $\dot{V}O_2$ (ml·O_2·kg⁻¹·min⁻¹)
A.P. URS	1	2.85	719	3.47	23	95
	2	2.50	681	3.75	22	91
V.S. URS	1	3.17	903	3.36	25	101
	2	2.83	712	2.97	18	85
	3	3.11	926	3.51	23	105
V.U. NOR	1	2.71	545	2.72	17	75
	2	2.46	715	3.93	26	91
	3	2.39	621	3.52	25	80
M.D. URS	1	2.90	687	2.80	18	82
	2	2.70	847	3.70	24	95
	3	2.62	638	2.87	17	76

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Purpose

Investigated pacing patterns in a 13.5 km self-paced time trial (TT) by describing exercise intensities in flat and uphill terrain

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Methods

8 ♂ highly trianed/ elite XC skiers (23±5 yrs, 77±6 kg)

Test 1: 13,5 km **outdoors**

Test 2: Submaximal and maximal tests **indoor**

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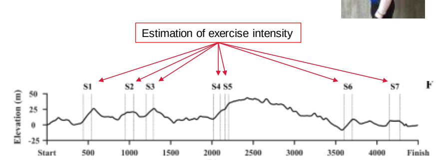
Outdoors

"15 km" **rollerski skate in Holmenkollen**

- 3 x 4.6 km



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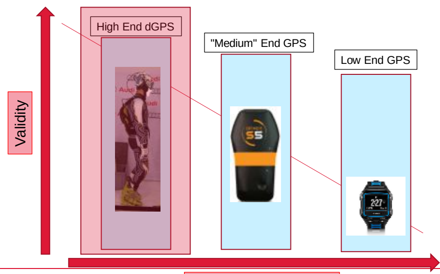
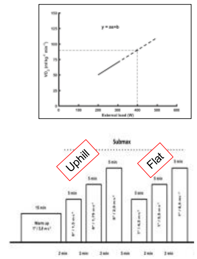


Modified from Myklebust 2016

Indoors



Karlsson et al., (2018)

Maximal tests

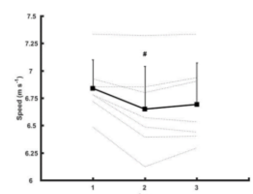
Table 1

	1°		8°		
Variable	Mean ± SD	Range	Mean ± SD	Range	p
Average speed (m·s⁻¹)	8.04 ± 0.36	7.58 - 8.62	2.92 ± 0.28	2.57 - 3.37	< 0.001
VO_{2peak} (mL·kg⁻¹·min⁻¹)	72.7 ± 5.3	64.9 - 81.5	72.3 ± 6.2	64.2 - 82.7	0.411
ΣO_2-deficit (L)	4.6 ± 0.5	3.8 – 5.3	6.2 ± 0.6	5.3-7.0	0.001
HR_{peak} (b·min⁻¹)[a]	182 ± 5	174 - 188	183 ± 6	173 - 190	0.365
[La⁻] (mmol·L)[b]	7.6 ± 1.0	6.1 - 8.9	6.9 ± 1.6	4.9 - 9.6	0.138
VE (L·min⁻¹)	200.5 ± 10.8	175.1 - 210.7	188.6 ± 14.1	169.0 - 211.3	0.037
RPE (0-10)	9 ± 1	8 – 10	9 ± 1	7 -10	0.504

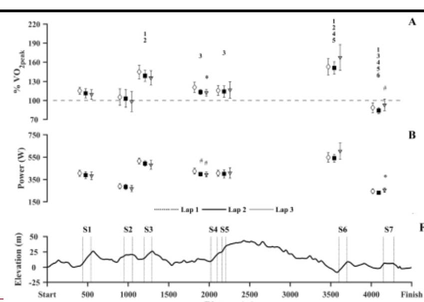
n = 8, [a]: n =6, [b]: n = 7

Karlsson et al., (2018)

Positive Pacing – lap-to-lap basis

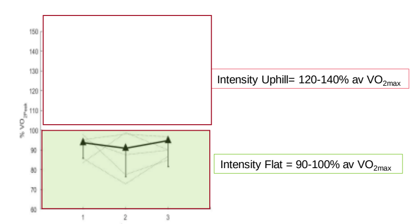


Karlsson et al., (2018)



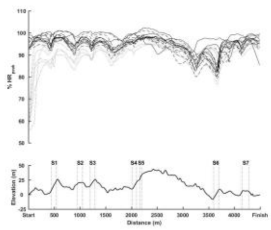
Karlsson et al., (2018)

Variabel pacing (intensity) – Uphill versus Flat



Karlsson et al., (2018)

Heartrate



Karlsson et al., (2018)

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Energy turnover during 15 km XC skiing race

Part II

Gløersen et al unpublished

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Purpose

Investigate ***aerobic*** and ***anaerobic*** energyturnover during a distance XC skiing race

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Methods

- 8 elite/well-trained male skiers
  - Test 1; 13,5 km race - **outdoors**
  - Test 2: Submaximal and maximal tests - **indoors**
  - Test 3: Simulating ("copi") the 13,5 km race - **indoors**

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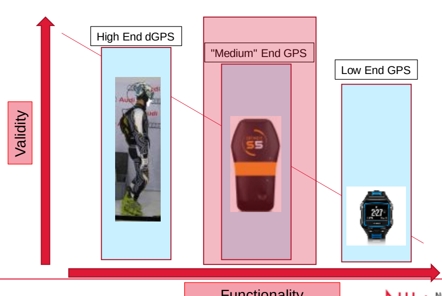

Modified from Myklebust 2016

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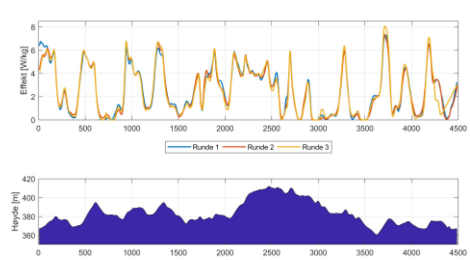
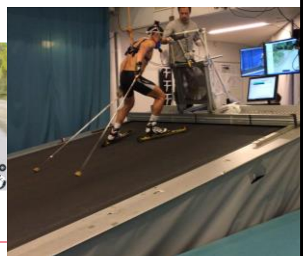
-Race 3 laps (4.6 km) in Holmenkollen.
-Estimate mechanical power thruout the race



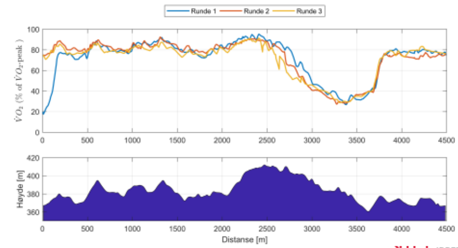
Gløersen et al (unpublished)

OLE



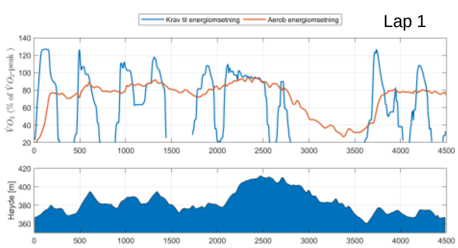
Gløersen et al (unpublished)

VO$_2$ during the race



Gløersen et al (unpublished)

Aerobic and anaerobic turnover



Gløersen et al (unpublished)

Conclusion

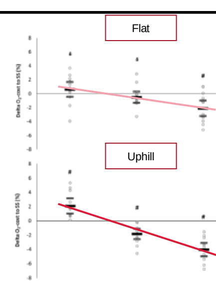
GPS - combined with treadmill testing, we have shown:

- XC skiers repeatedly applied exercise intensities exceeding VO$_{2max}$
- ΣO_2-deficit was considerably higher during uphill skiing compared to flat
- XC skiers applied a variable pacing pattern (higher intensity in uphill vs flat)
- HR is not a valid method to quantify exercise intensity in XC skiing

Thank you for your attention!

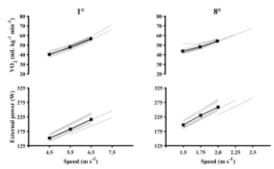
Thomas.losnegard@nih.no

Questions?



Carlsen et al 2018

Submaximal tests



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