



1



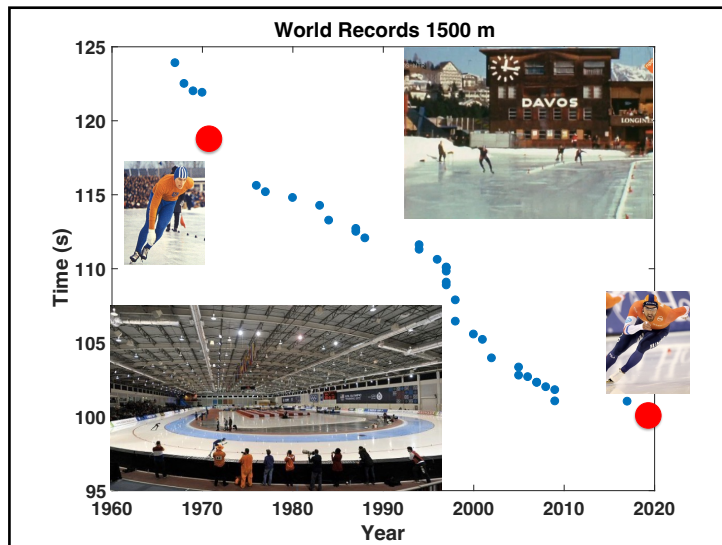
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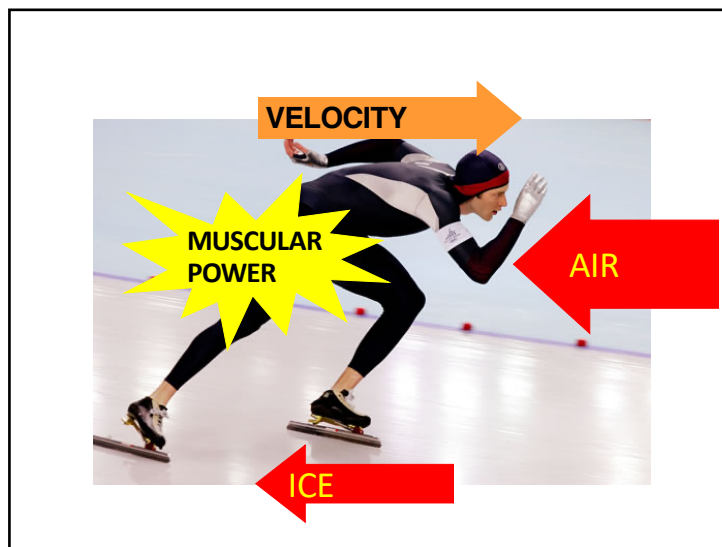


5

Waar komt de progressie
vandaan?

Van training of van innovaties?

6



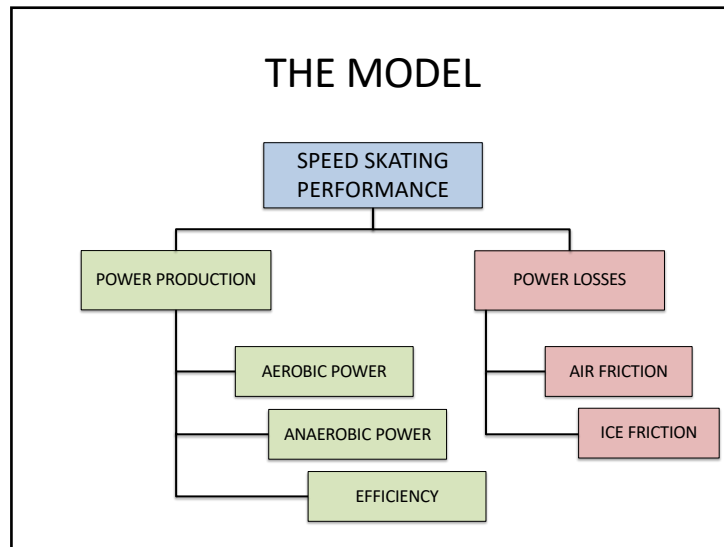
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Belangrijke begrippen:

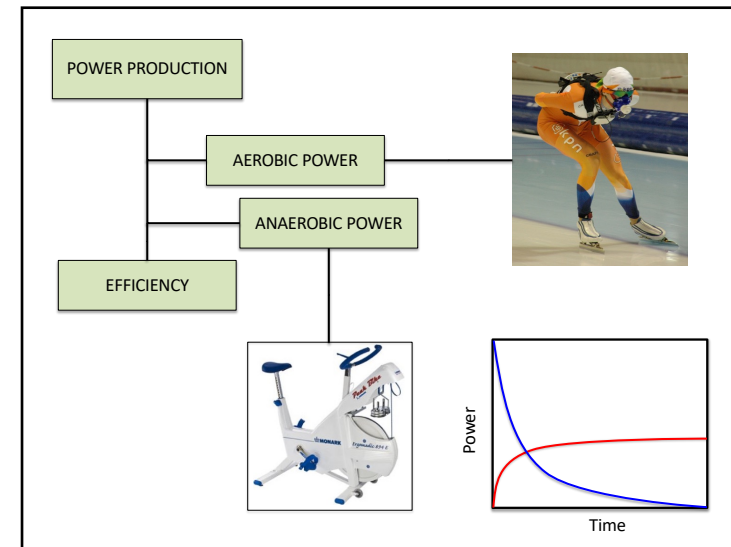
kracht
arbeid
vermogen

snelheid
versnelling

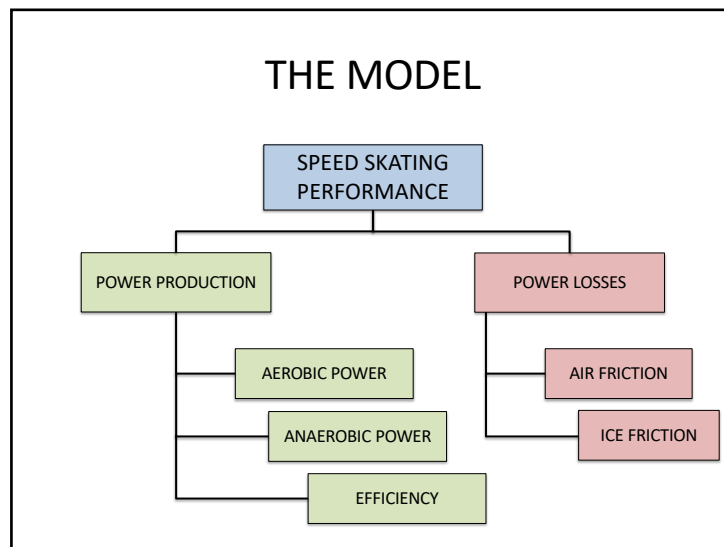
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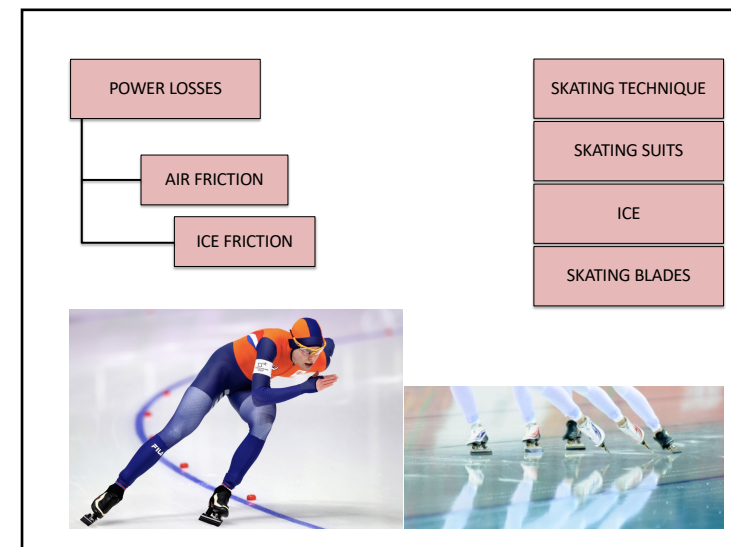
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12

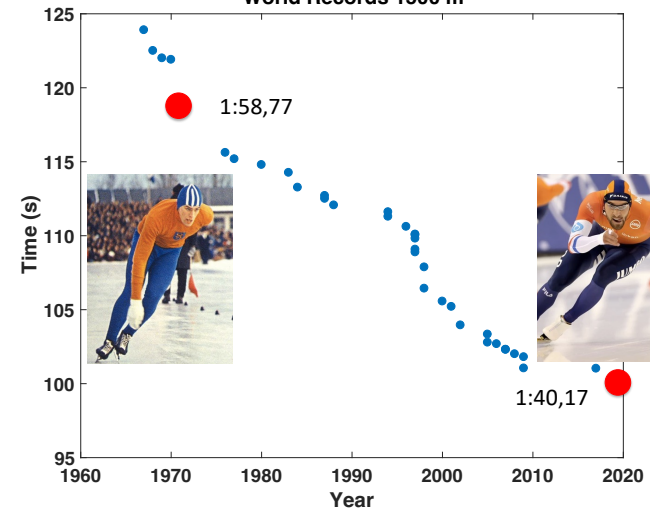
Parameters influencing WR

- Altitude
- Ice condition
- Skating suits
- Skates

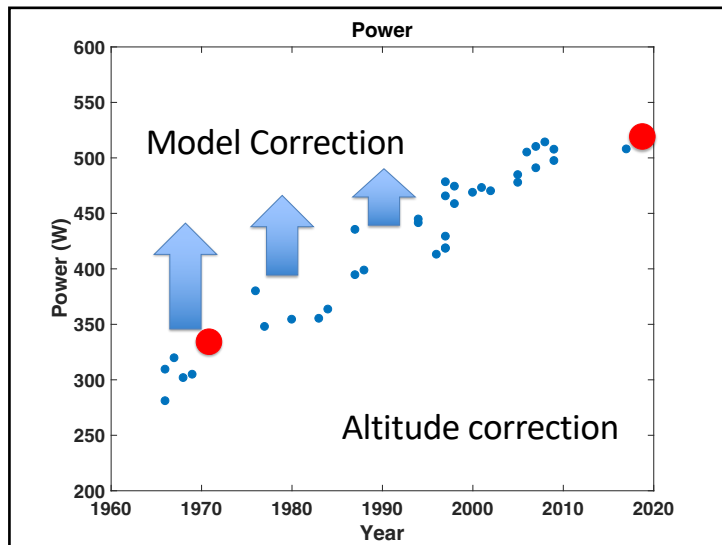


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World Records 1500 m

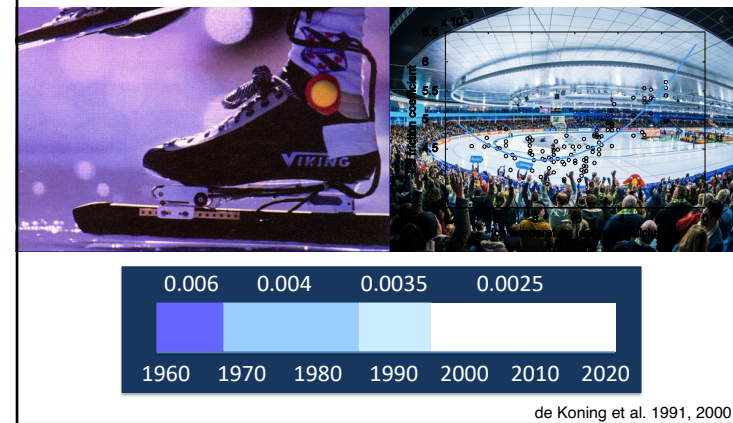


14



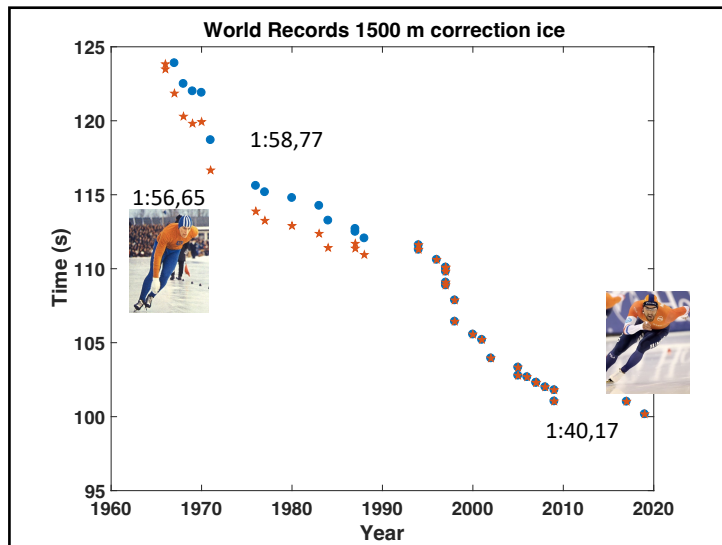
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Correction for Ice

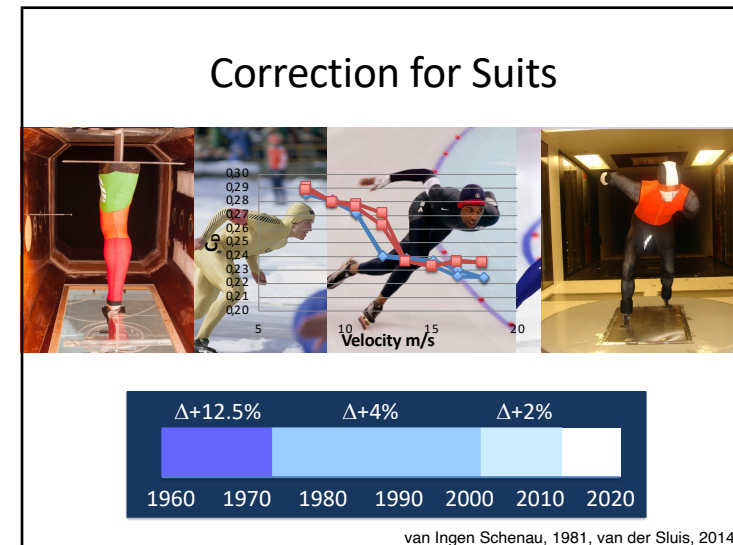


de Koning et al. 1991, 2000

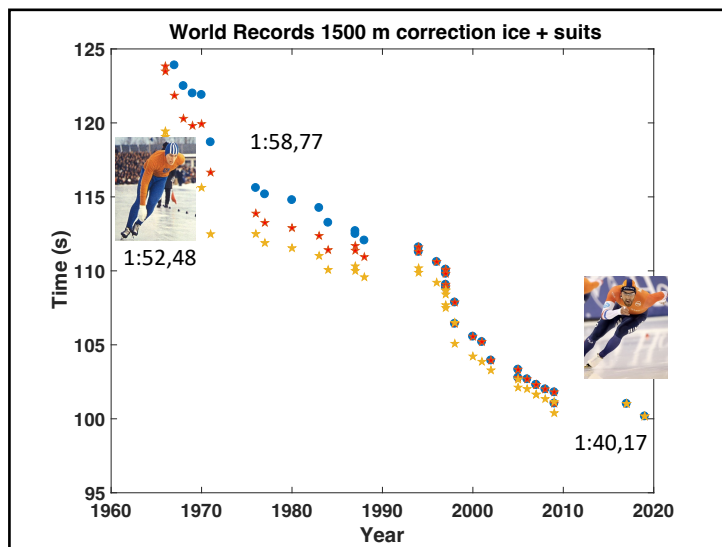
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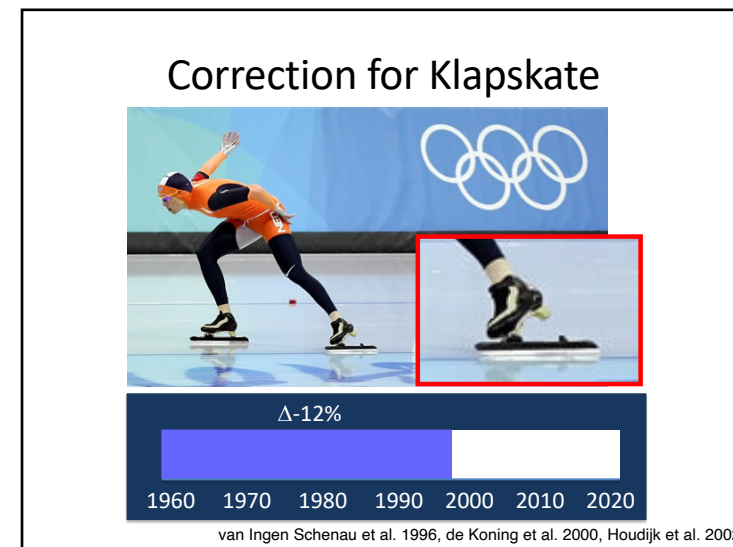
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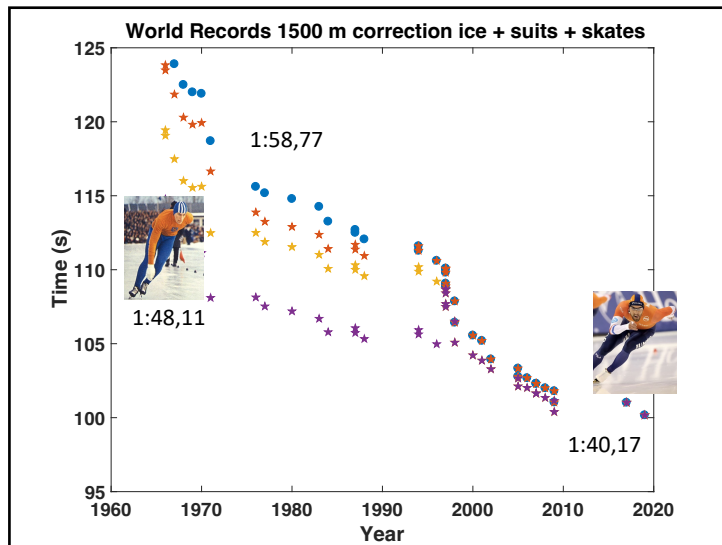
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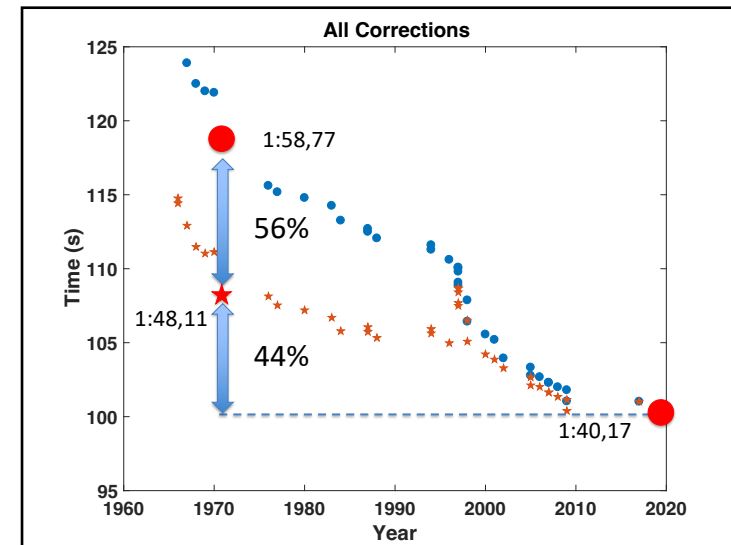
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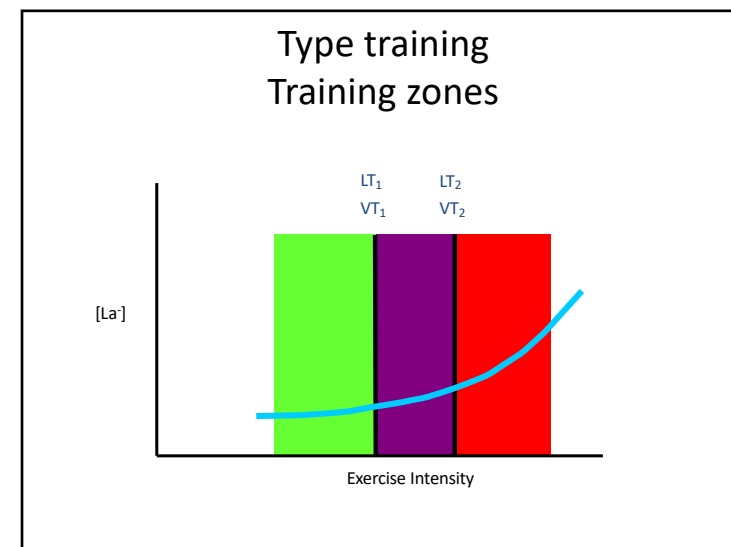
Waar komt die 44% vandaan?

Hoeveelheid training?

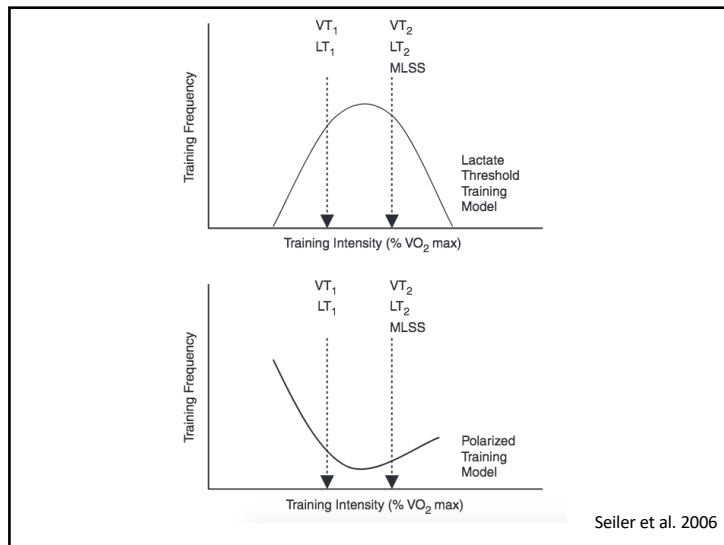
Type training?

Pacing strategie?

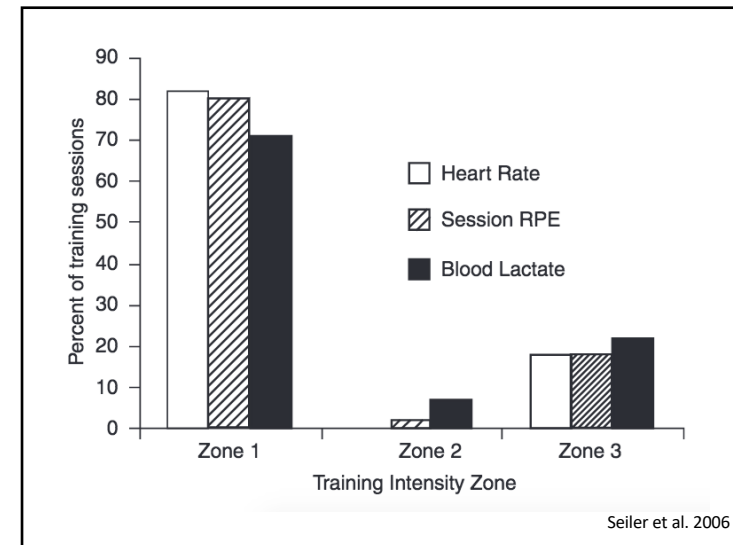
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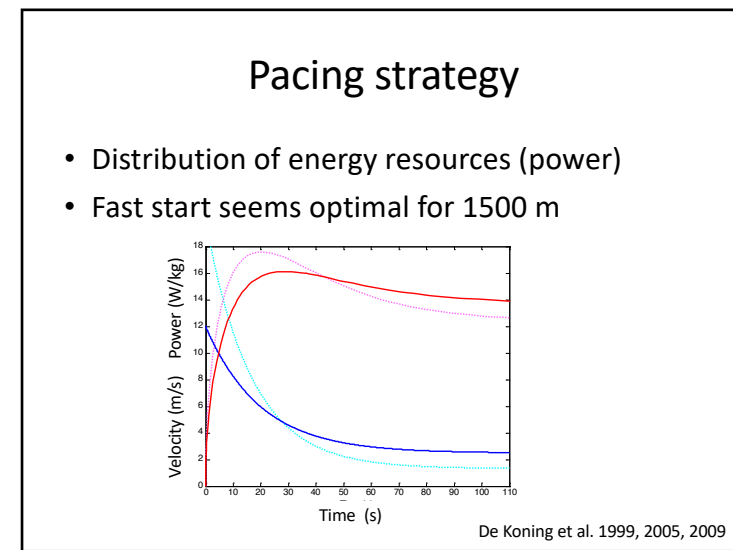
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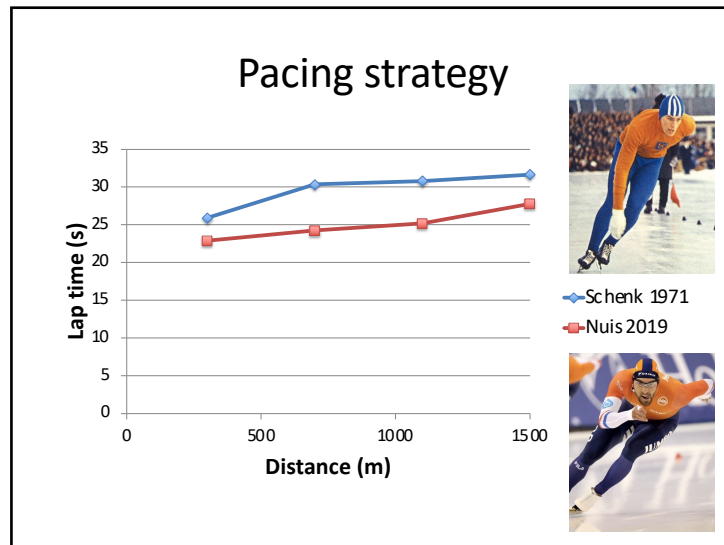
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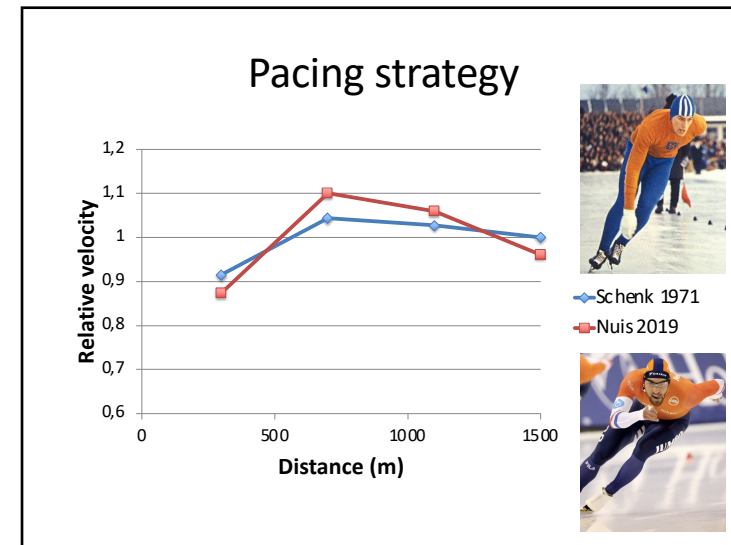
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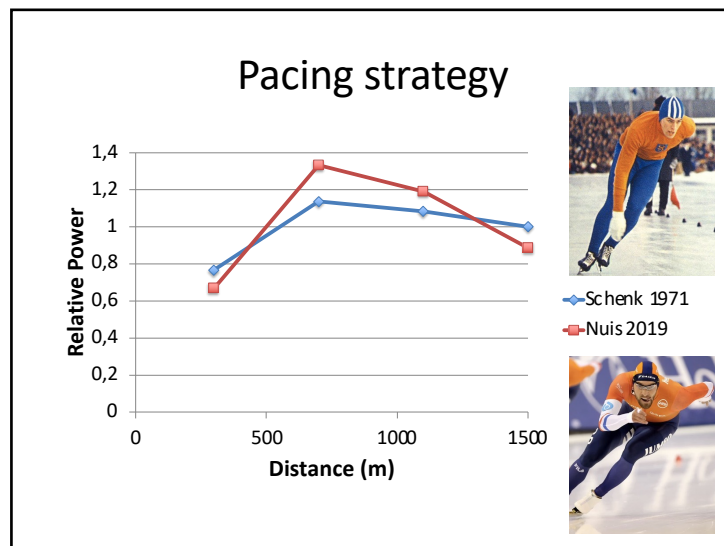
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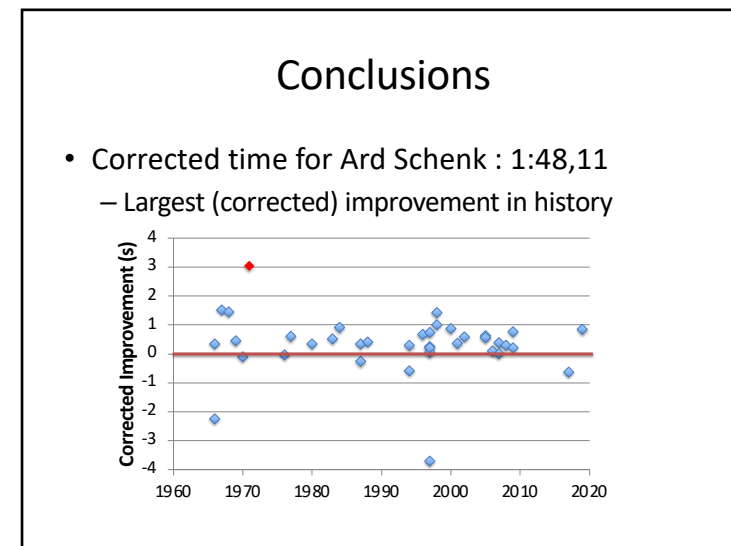
29



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Conclusions

- Corrected time for Ard Schenk : 1:48,11
- Improvement in the last 50 years for 56% due to technological innovations.
- The remaining 44% due to:
 - Type of training
 - Pacing strategy

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Hoeveel tijdwinst met armen op de rug?

05:58.52

New World record
Sander Eitrem
Inzell (GER)
23rd January 2026

➔ Both arms on back while cornering



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Nordic Winter Sport Conference 2026
Trondheim, 22.04.2026

The Aerodynamic Influence of Arms while Cornering During a 5000 m Speed Skating Race

Ola Elfmak^{1,2} and Jos de Koning³

¹ Department of Neuromedicine and Movement Science, Centre for Elite Sport Research, NTNU

² Norwegian Olympic and Paralympic Committee (Olympiatoppen)

³ Department of Human Movement Sciences, Amsterdam Movement Sciences, Vrije Universiteit Amsterdam

NTNU
Centre for Elite
Sports Research

NORGE
OLYMPIATOPPEN

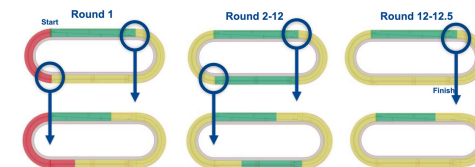
VU
UNIVERSITY
AMSTERDAM

Department of Human
Movement
Sciences



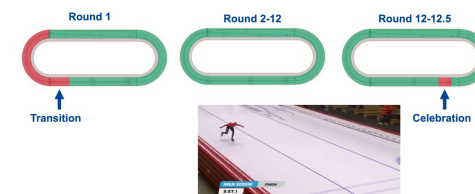
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“Old” technique: 2% 2 arms – 52% 1 arm – 46% 0 arms



With 30m transition: 2.5% 2 arms – 65.5% 1 arm – 32.0% 0 arms

“New” technique: 3% 2 arms – 0% 1 arm – 97% 0 arms



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Hoogte ijsbaan

Competitions of interest



Utah Olympic Oval
Salt Lake City (USA)
Altitude: 1429 m
Date: 14.11.25



Air: 18°
Humidity: 28%
Ice: -8°
Air density (ρ): $\sim 1.02 \text{ kg/m}^3$

Max Aicher Arena
Inzell (GER)
Altitude: 690 m
Date: 23.01.26



Air: 14°
Humidity: 37%
Ice: -9.8°
Air density (ρ): $\sim 1.13 \text{ kg/m}^3$
(+11%)

Thialf Ice Arena
Heerenveen (NED)
Altitude: 4 m
Date: 07.03.26



Air: 15.9°
Humidity: 53.1
Ice: -9°
Air density (ρ): $\sim 1.22 \text{ kg/m}^3$
(+20%)

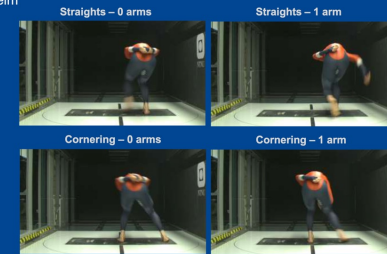
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Windtunnel data

Experimental Setup

- Wind tunnel measurement at NTNU Trondheim
- Dimensions (H: 1.8 m, W: 2.7 m)
- Blockage ratio: 10-15%
 - No blockage correction was applied
- Speed: 14 m/s ($Re \sim 5 \cdot 10^5$)
- Schenk six-component force balance
- Side and downstream camera
- Dynamic measurement
 - Sampling time: 30s
 - Sampling hertz: 1000
 - Number of measurements: 3
- Test subject: Sander Eitrem
 - Competition suit

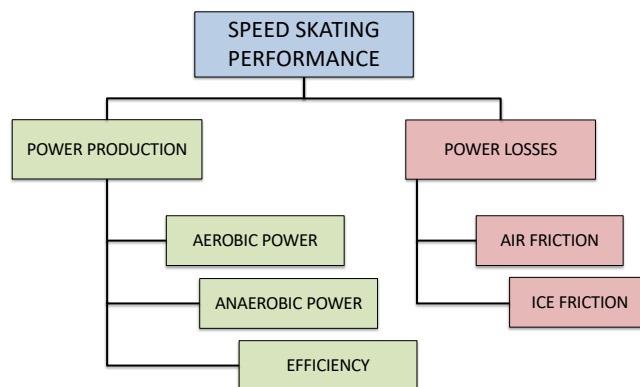


No available pictures for 2 arms loose

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Het model



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tijdwinst

05:58.52

- One arm loose while cornering
 - 06:04.63 (+5.82 s)
- ... without 30 m transition
 - 06:03.49 (+4.95 s)

(+0.87 s)

Place	Altitude [m]	ρ [kg/m ³]	Power pr. [W/kg]	Time [m:s]
Heerenveen	1429	1.22	7.63	06:06.4
Inzell (Ref)	690	1.13	7.54	05:58.5
Salt Lake City	4	1.02	7.41	05:48.6

Maximum power Tour de France cyclist: 6.5-7.5 W/kg

Santalla, A., Earnest, C. P., Mermoz, J. A., & Lucia, A. (2012). The Tour de France: an updated physiological review. *International Journal of Sports Physiology and Performance*, 7(3), 290-299.



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Kan het sneller?



Place	Altitude [m]	ρ [kg/m ³]	23.01.26		07.03.26	
			Power pr. [W/kg]	Time [m:s]	Power pr. [W/kg]	Time [m:s]
Heerenveen	1429	1.22	7.63	06:06.4	7.91	06:01.6
Inzell	690	1.13	7.54	05:58.5	7.82	05:53.7
Salt Lake City	4	1.02	7.41	05:48.6	7.68	05:44.0

World Allround Speed Skating Championships
Heerenveen, 07.03.26 – 5000 m: 06:01.6

Improvement of 4.8 s!

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Samenwerken is leuk!

Acknowledgment



Contact



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NTNU
Centre for Elite
Sports Research

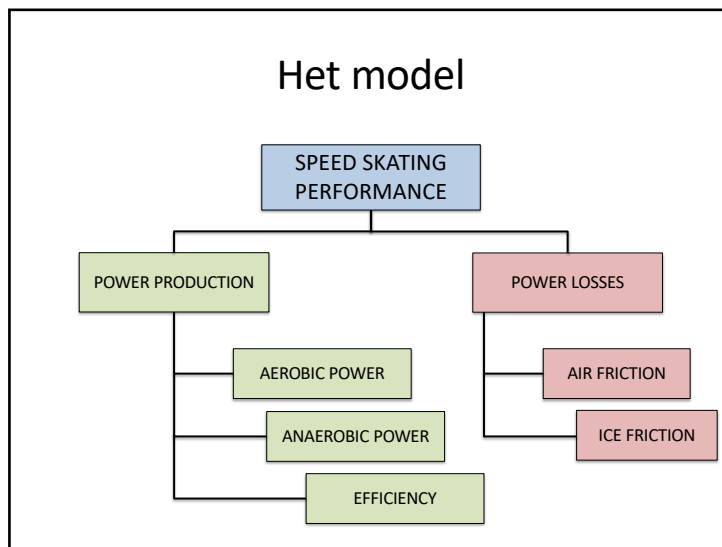


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Het model



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Thank You



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