FFI Forsvarets forskningsinstitutt

Monitoring Physiological Parameters during a Military Ski March in North Norway. Pulk contra Backpack.

Principal Scientist
Svein Martini

FFI's field trail under the ski march at Garrison in Sør-Varanger (GSV) in March - Participants

The Team from left:

Mr. Lasse Sundem Eriksen	(FFI)
Mr. Svein Martini	(FFI)
Mr. Bjarte Hestvik	(GSV)
Dr. Pierre Valk	(TNO)

The ski march started at Grenseberget and ended at Grense Jakobselv - 174 km.

Grenseberget

Transport of the team and equiment with snowmobiles with hagers

”Mobile lab” – A tent with a stove (15 kW) and power supplies (to light and PC) which is very quick to put up.

It is possible to stand and work inside the tent

The team slept in the ”Mobile lab” (sleeping bag with mattress) and had the opportunity to work sitting at a table with the PC (folding chairs and table).

The ”Mobile lab” was establish close to the soldiers camp.

Usually the soldiers were taken into the tent in the evening to check the monitoring equipment and then the short distance was practical

Weighing of the soldiers and his equipment along the ski-track. Electrical power to the balance and the computers from a power supply based on gasoline.

(Photo CHRISTIAN NØRSTEBØ, Forsvarets Forum)

Pulk versus backpack

8 days ski march

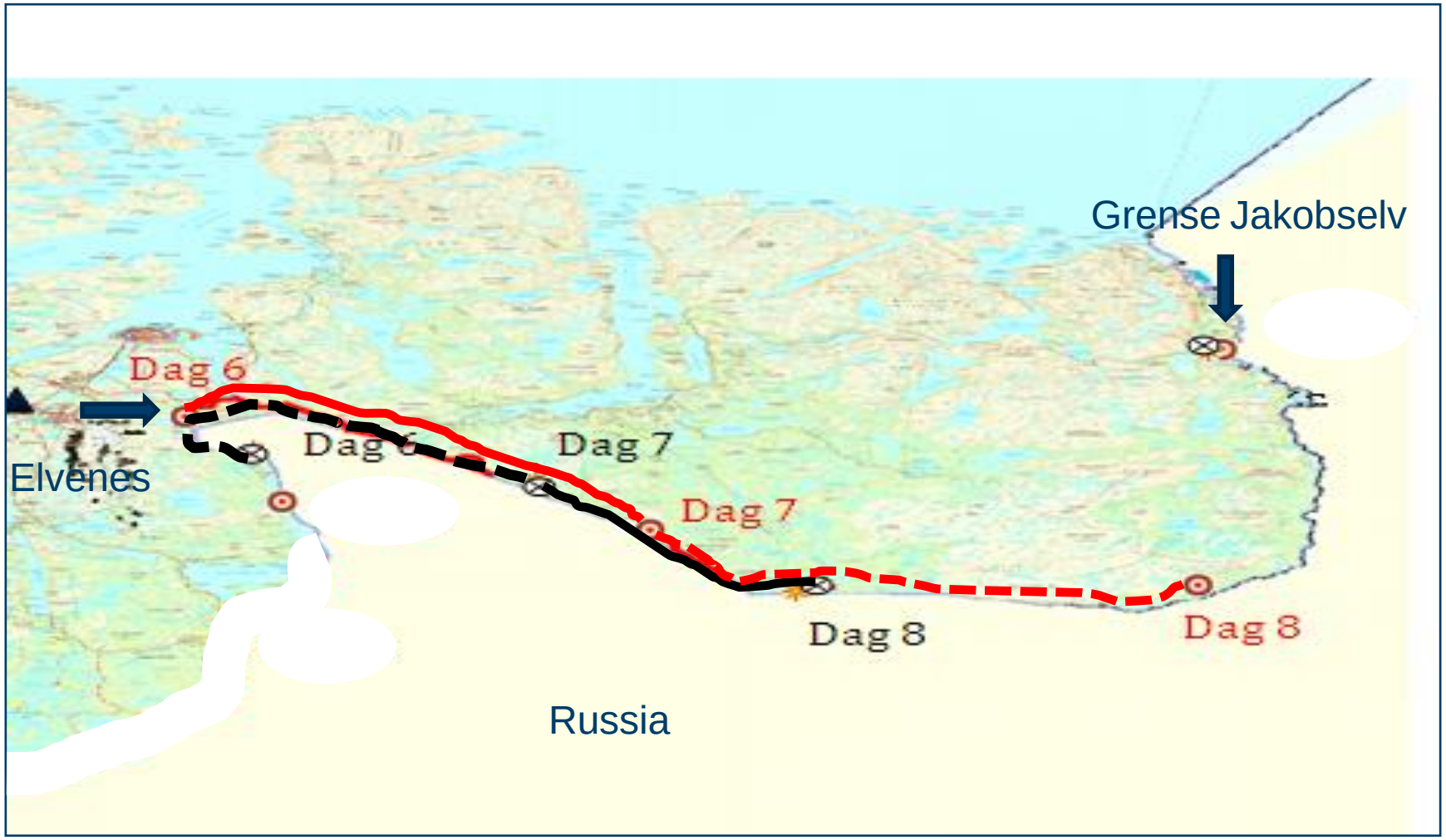
Two teams (squads) were followed

1. Carried most on the back
   (backpack 25 - 30 kg)

2. Almost everything in pulks
   (pulk 45 – 55 kg)

   Clothing/personally
   equipments (ski) :
   (18 – 20 kg)

Squad 1 (red) pulk (solid) day 7 and backpack day 8
Squad 2 (black) backpack (dotted) day 7 and pulk day 8



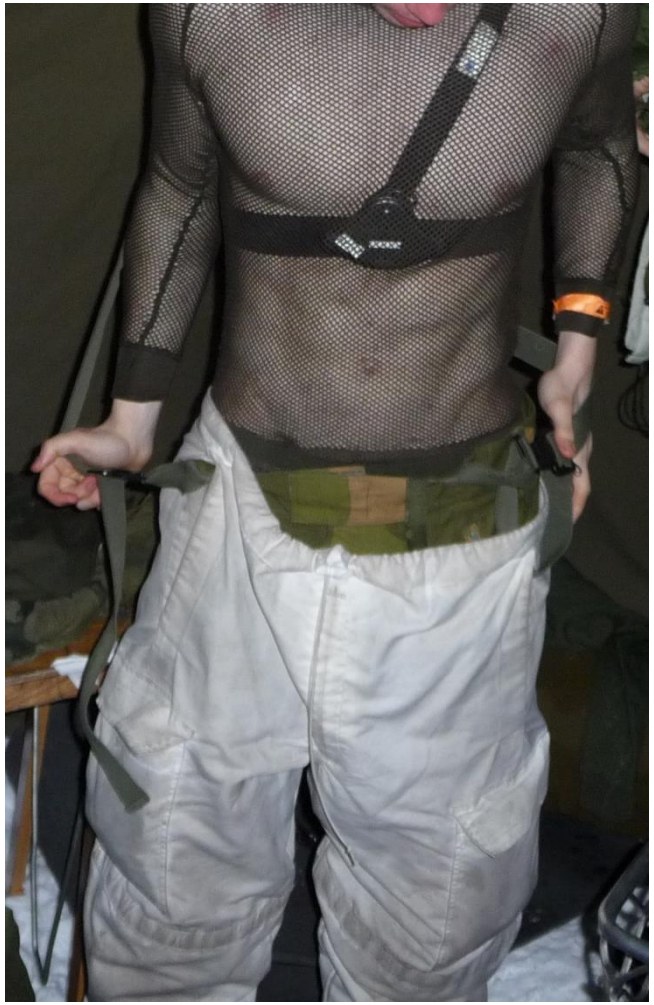
The distance walked, mean speed and vertical movement during the day in meter (ascend or descend)

Pack	Day [no]	Squad [no]	Time (hours)	Distance [km]	Speed [km/t]	Ascend (meter)	Descend (meter)
Pulk	7	1	07:30-19:00 (11,5)	19	1,7	**510**	**390**
	8	2	06:30-19:00 (12,5)	13	1,0	**310**	**290**
	Mean for both days for the two squads with pulk:					**410**	**340**
Back-pack	7	2	00:30-10:30 12:30-17:30 (15)	21	1,4	**540**	**400**
	8	1	08:00-18:00 (10)	23	2,3	**330**	**350**
	Mean for both days for the two squads with backpack:					**435**	**375**

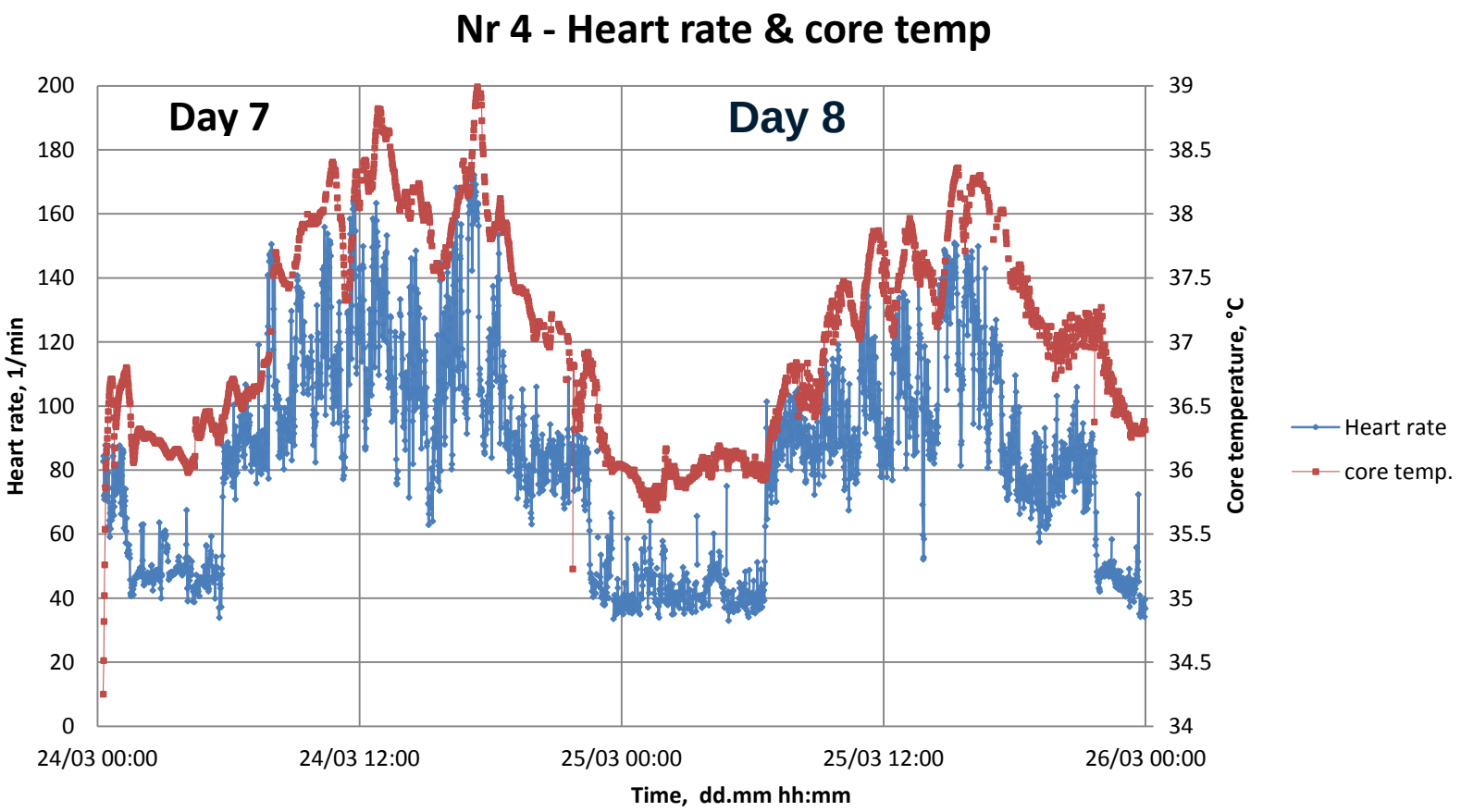
Weather conditions day 7 and day 8

	Day 7	Day 8
Date	24/3	25/3
Temp, °C	- 6	- 8
RH, %	78	65
Wind, m/s	4,7	4,8
Precipitation , mm	no	no

Equipment to measured heart rate and core temperature - Equivital Hidalgo (EH) , Ltd



Heart rate and core temperature for soldier nr. 4 in squad 1 during two 24-hours period – Day 7 with pulk – Day 8 with backpack



Comparison of heart rate and core temperature when using pulk and backpack

Pack	Day [no]	Squad [no]	Time (hours)	Distance [km]	Speed [km/t]	Weight [kg] Mean ± SD (n)	Heart rate [1/min] Mean ± SD (n)	Core temperature [°C] Mean ± SD (n)
Pulk	7	1	07:30-19:00 (11,5)	19	1,7	45,7 ± 8,8 (4)	113 ± 20 (4)	37,9 ± 0,4 (2)
	8	2	06:30-19:00 (12,5)	13	1,0	33,9 ± 4,8 (4)	120 ± 27 (4)	37,5 ± 0,4 (4)
	Mean for both days with pulk:					**39,8 ± 9,1 (8)**	**117 ± 9 (8)**	**37,7 ± 0,2 (6)**
Back-pack	7	2	00:30-10:30 12:30-17:30 (15)	21	1,4	21,2 ± 1,8 (5)	104 ± 21 (4)	37,6 ± 0,4 (3)
	8	1	08:00-18:00 (10)	23	2,3	27,5 ± 2,7 (4)	109 ± 20 (4)	37,7 ± 0,5 (4)
	Mean for both days with backpack:					**24,0 ± 3,9 (9)**	**107 ± 5 (8)**	**37,6 ± 0,2 (7)**

Conclusions: pulk contra backpack

When the squads in this relative hilly country, have a pulk each, compare to the solution with backpacks and one common pulk.

Based on the monitoring in the field

- they could take about 50 weight% more with them.
- however the speed decrease with about 25-30 %
- the load based on heart rate increase with 10 %.
- skin temperature decreased with about 3 °C (due to increased ventilation in the clothing)

Based on questionnaire

- 67 % of the soldiers wanted the solution with the pulk
- 33 % want a combination of pulk and backpack.
- Nobody wanted a solution only based on backpack

In a flat landscape it is obvious an advantage to have pulk

Equipment to measured heart rate and core temperature - Equivital Hidalgo (EH), Ltd.

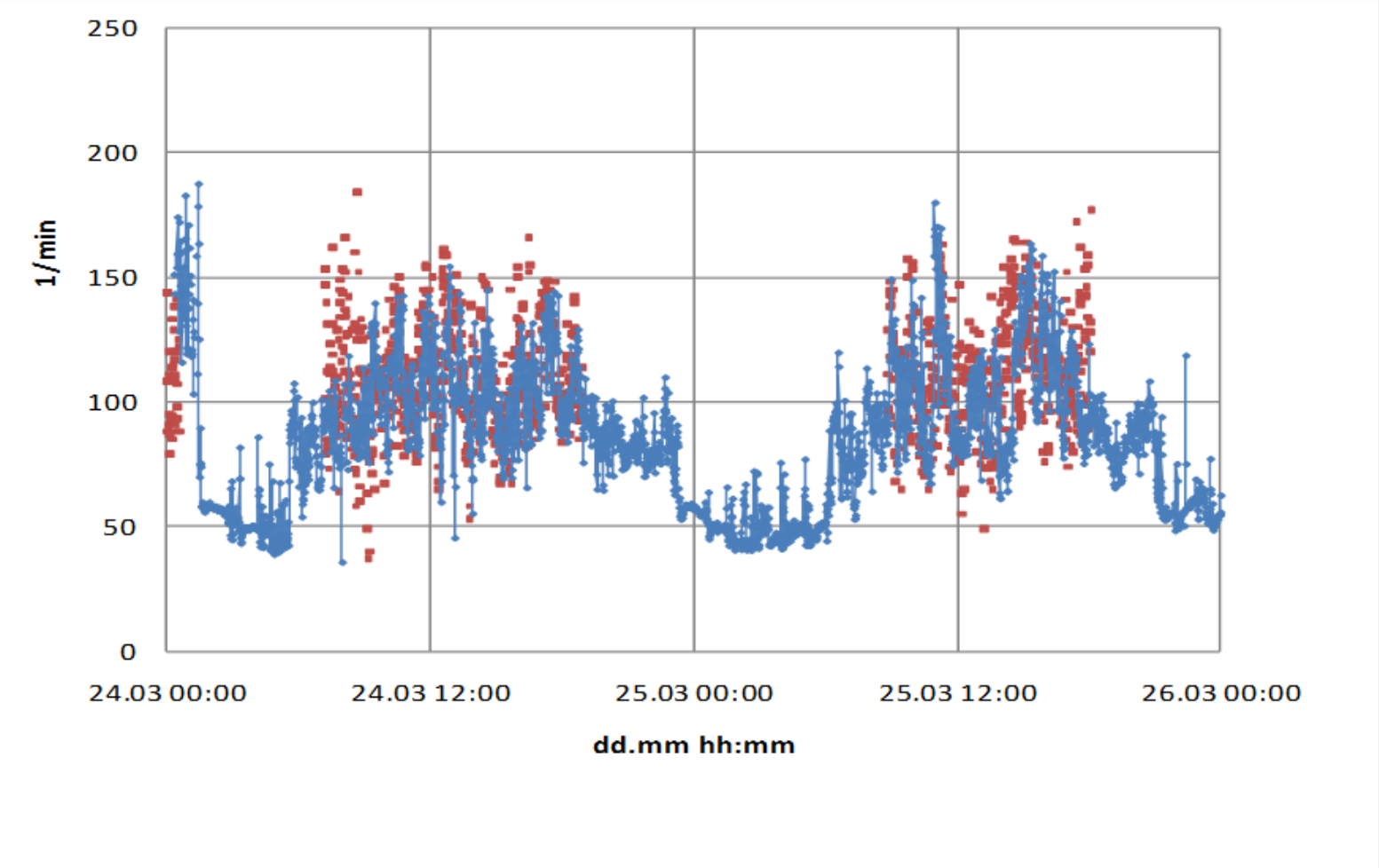
Sometimes another monitoring system was used:

1) Grant's monitoring system with cables was used for skin temperatures

2) The Polar system for heart rate and GPS.

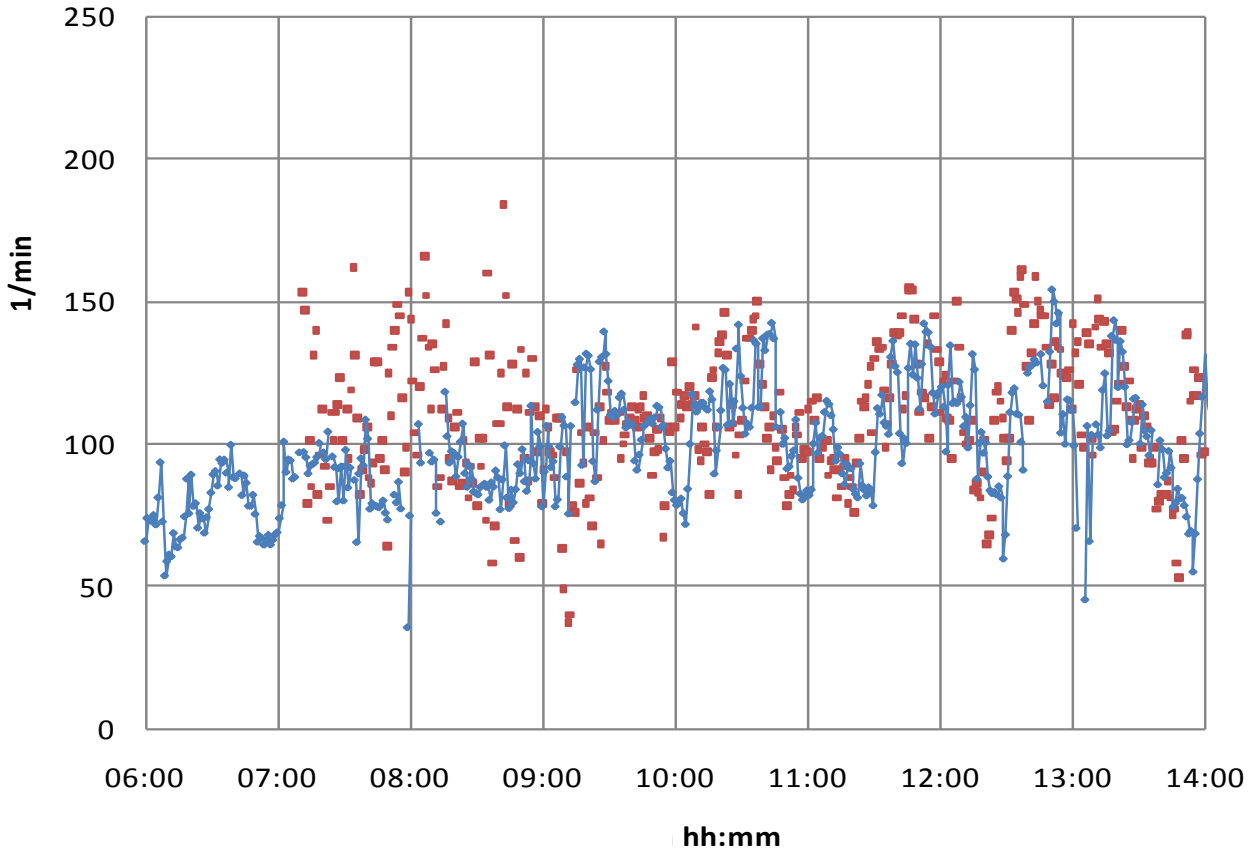
Heart rate for monitored by Equivital Hidalgo (blue) and by Polar system (read) during two 24-hours period

(soldier nr. 1 in squad 1)

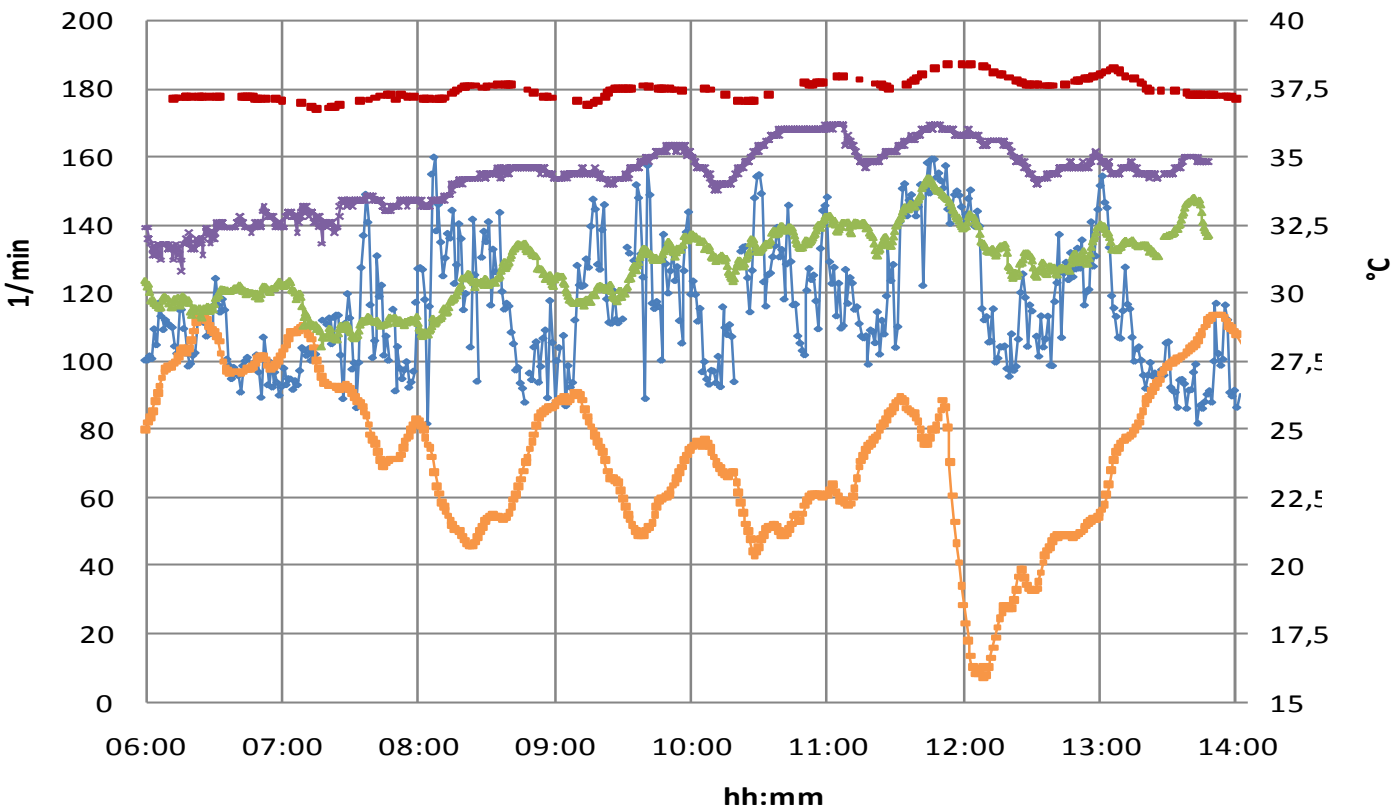


Heart rate for monitored by Equivital Hidalgo (blue) and by Polar system (red) during eight hours

soldier nr. 1 in squad 1 at day 7

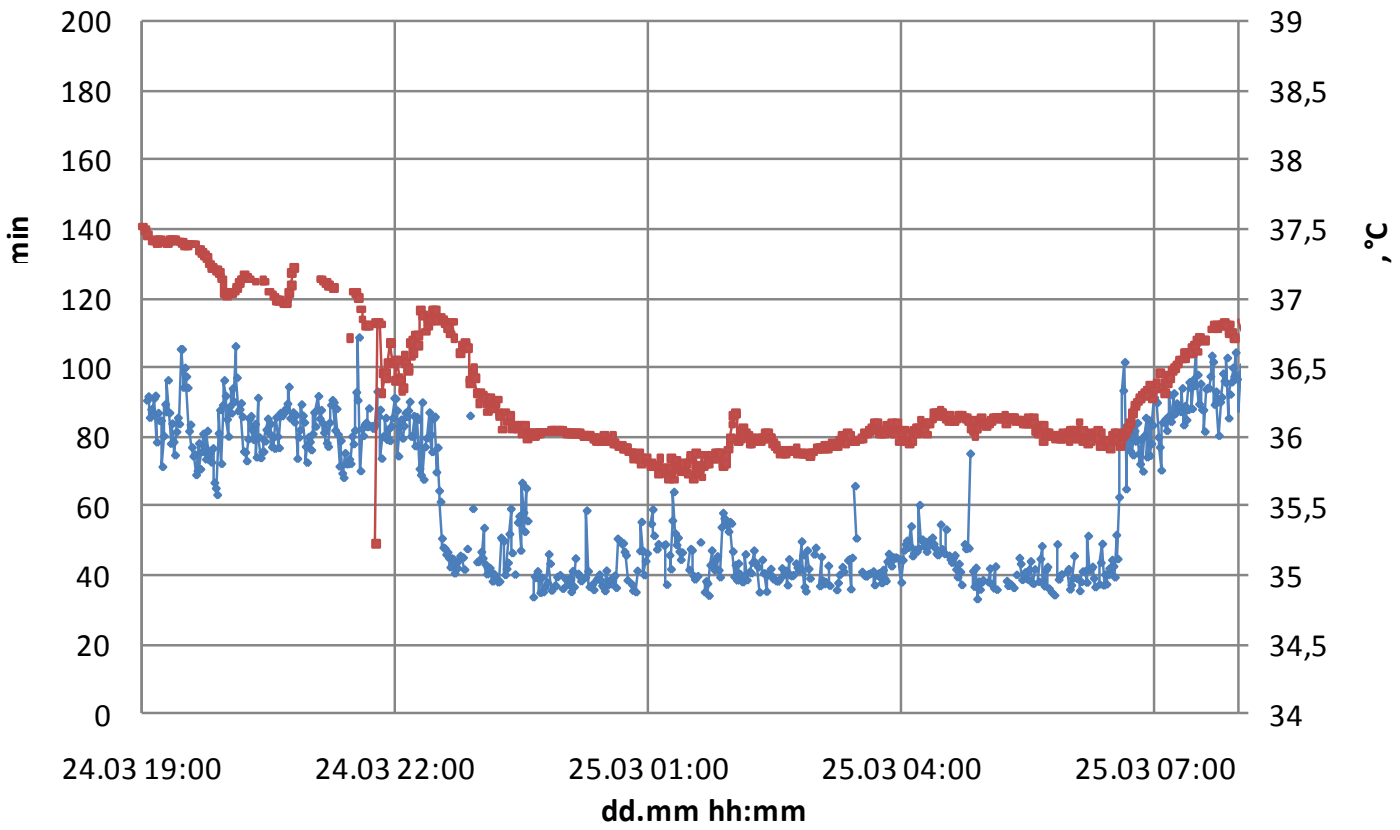


Skin temperature (breast) monitored by Equivital Hidalgo (orange) and by Grant system (lilac) during eight hours green- MST & blue - heart rate soldier nr. 10 in squad 2 at day 8



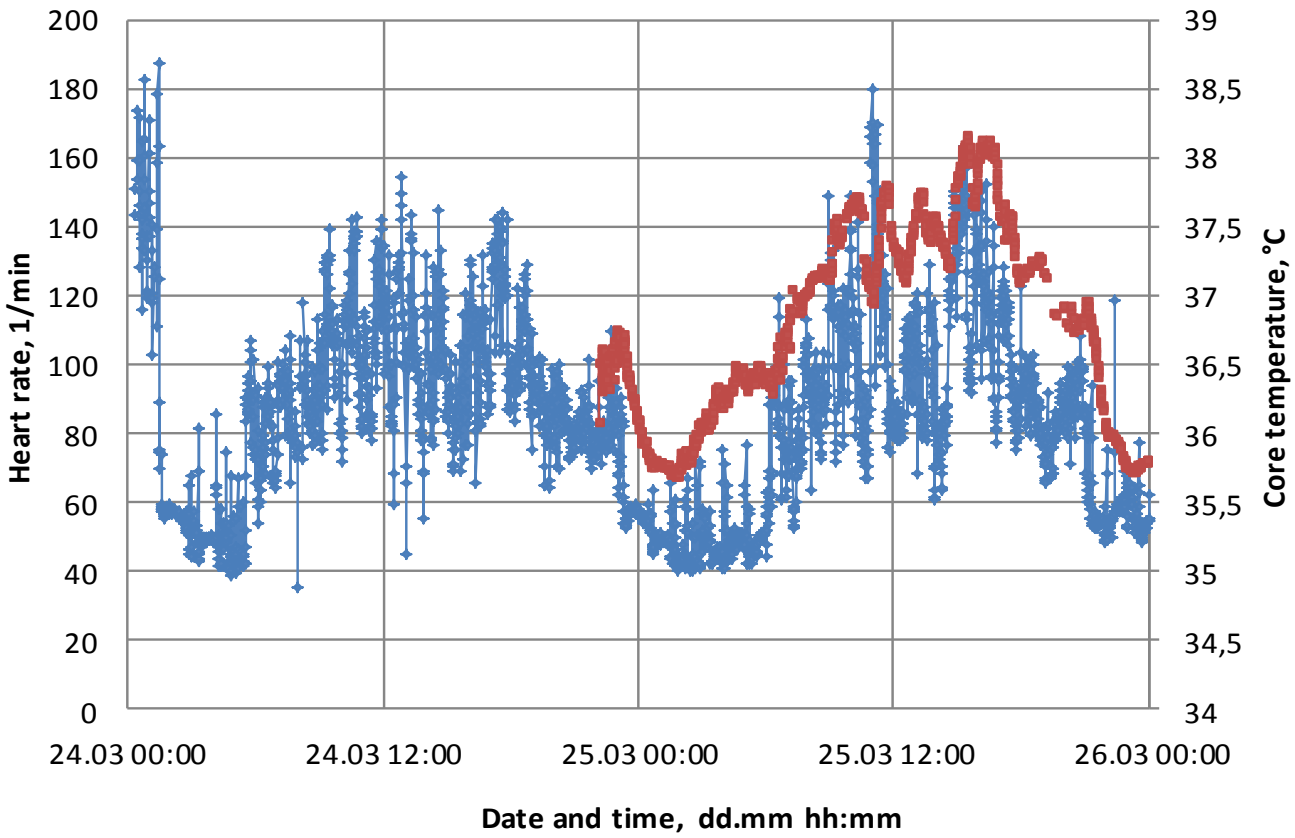
Heart rate (blue) and core temperature (red) during evening, night and morning (12 hours)

soldier nr. 4 in squad 1 at day 7 and 8



Heart rate (blue) and core temperature (red) during two 24-hours period

soldier nr. 1 in squad 1 at day 7 and 8



Conclusions: Monitoring heart rate and core temperature continuously for 8 soldiers over 2 days with Equivital Hidalgo during a Ski March

- The soldiers did not complain about the Equivital Hidalgo belt
  (much more convenient that Grant's monitoring system with cables)
- The monitoring equipment function good during the Ski March regarding the low temperature and great changes in relative humidity and several fall during skiing with heavy backpack and pulk
- Some data from Equivital Hidalgo the was lost, especially core temperature data.
- The hear rate from Equivital Hidalgo was better than polar system
- The core temperature was decreased during drinking cold water in about the first two hours after the pill was swallowed.

Physiological Monitoring Applications
Svein Martini

Category	Description
Purpose(s)	Predict soldier performance in the field (includes thermal work strain)
Location (lab / field)	Field
Actionable information	Physiological strain index
System(s)	Hidalgo EQ-02 (also Grant's monitoring system)
Sensors used	Heart rate, core & skin temperature, accelerometer
Algorithm	Have not used T_core estimation yet
Real-time or Post Hoc	Real-time Hidalgo display, Android display. I have this system now, but the study at GSV it was Post Hoc
Readiness	Commercial system, validating algorithm

Thank you for your attention.

Questions?

Health and Performance Monitoring in Stressful Field Environments
Agenda

Start	Presenter	Topic
0900	B. Telfer, P. Valk	Welcome
0910	M. Buller	Performance and Thermal-Work Strain Safety Optimization
0940	A. Hunt	Monitoring Thermal and Work Strain in the Australian Defence Force
1020	K-Y. Seng	Statistical Modelling and Analysis Approaches for Individualized Heat Strain in Soldiers
1100	Break	
1110	H-C. Gunga	TBD
1150	C. Ledderhos	Objective Determination of the Efficiency of Anti-G Suits Under High GZ Loads using Different Pulse Wave Components
1230	Lunch	
1400	E. Kaniusas	Assessment of Fatigue and Fitness via Heart Rate Variability and Induced Apnea
1440	P. Valk, B. Veenstra	Development and Implementation of a Workload Monitoring System in the Royal Netherlands Army
1520	S. Martini	Monitoring Physiological Parameters during a Military Ski March in North Norway
1600	Break	
1610	T. Wyss	Ambulatory Assessment of Physical Activities and Demands in Swiss Soldiers
1650	K. Friedl	Roadmapping Personal Physiological Monitoring – What Do We Need and What Will Be SAMI (Soldier Acceptable, Minimally Invasive)?
1730	Adjourn	

Dinner at Zeughauskeller, 1830

The squad with backpack and one old pulk.

The squad with new one-man pulks (Acapulka)

Day 7 and 8 were quite hilly for both squad 1 and 2