UNIVERSITY OF JYVÄSKYLÄ

Finnish Institute of Occupational Health

Metrics for Identifying Fatigued Driving

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Rationale for developing metrics of driver fatigue

Valid metrics of driver fatigue

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Sufficient knowledge of driver fatigue

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Measures to alleviate the problem

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Reduction in road traffic casualties

Physiologic metrics

Method	Metric	Reference standard
EEG	- alpha, theta & beta power density[1,2,3, 4,5,6,7] -alpha spindle parameters[3]	- response to fatigue-inducing factors while driving -self-rated sleepiness - lane drifting
EOG	- slow eye movements[1,5,7] -blink duration, amplitude, density[2,5,7,8] - lid closing and opening velocity[5,8] - saccadic & fixation parameters[8]	- response to fatigue-provoking factors while driving - self-rated sleepiness

[1]**Mitler et al.** N J Engl Med 1997, 337, 755-61. [2]**Sandberg et al.** 2011, 34, 1317-25.
[3]**Simon et al**. Clin Neurophysiol 2011, 122, 1168-78. [4]**Kecklund & Åkerstedt**. Ergonomics 1993, 1007-17.
[5]**Åkerstedt et al**. J Sleep Res 2010, 19, 298-309. [6]**Wei et al.** Neurosci Letters 2012, 506, 235-39.
[7]**Anund et al**. Acc Anal Prev 2008, 40, 1970-76. [8]**Schleicher at al**. Ergonomics, 2008, 982-1010.

Behavioral metrics

Method	Metric	Reference standard
Task-based methods	- ***PVT:*** lapses, response speed[1] -***Posturography*:** balance scores[2]	- response to fatigue-inducing factors
Video–based methods	- ***Perclos***: the proportion of time eyes are 80–100% closed[3,4,5] -***ORD:*** eye closures, facial tone, behavior, mannerisms[3,4]	- "near crashes" - self-rated sleepiness - lane drifting
Vehicle & steering wheel –based methods	- lane variability[6,7,8,9,10,11] - steering variablity[6,7,8]	- self-rated sleepiness - vigilance performance - response to fatigue-inducing factors while driving

[1]**Baulk et al.** Accid Anal Prev 2008, 40, 396-402. [2]**Forsman et al**.J Sleep Res 2007, 16, 259–61. [3]**Hanowski et al.** Accid Anal Prev 2003, 35, 153–60. [4]**Dingus et al.** Accid Anal Prev 2006, 38, 1127-36. [5] **Sommer & Golz** Conf Proc IEEE Eng Med Biol Soc 2010, 4456-9. [6]**Friedricsh & Young** EUSIPCO-2010, 2010, 209-13. [7]**Berglund** Master's Thesis, 2007. [8] **Mattson** Master's Thesis 2007. [9]**Sandberg et al.** IEEE Trasaction on Intelligent Transportation 2011, 12, 97-108. [10] **Forsman et al.** Accid Anal Prev (in press). [11]**Soccolich et al.** Accid Anal Prev (in press).

Vehicle/steering wheel-based metrics

Study	Driving conditions	N of metrics tested	Ref. standard	Most sensitive metric
Friedrics[1] (2010)	Real roads	31	Subj. fatigue (KSS)	Average *steering* angular velocity
Berglund[2] (2007) & Mattson[3] (2007)	Simulator	17	Subj. fatigue (KSS)	Combination of *steering wheel* direction reversals, *vehicle* path deviations, and sd of lateral position
Forsman[4] (in press)	Simulator	87	Beh. & subj. fatigue (PVT, KSS)	Combination of *lane variability* metrics (e.g., sd of lateral lane position)

[1]**Friedricsh & Young** EUSIPCO-2010, 2010, 209-13.
[2]**Berglund** Master's Thesis, 2007.
[3]**Mattson** Master's Thesis 2007.
[4]**Forsman et al.** Accid Anal Prev (in press).

Subjective sleepiness and driving

Subjective sleepiness (KSS)	Driving errors
1 extremely alert	
2 very alert	
3 alert	
4 rather alert	
5 neither alert nor sleepy	
6 some signs of sleepiness	minor lane drifting markedly increases[1,2]
7 sleepy, no effort to stay awake	
8 sleepy, some effort to stay awake	major lane drifting (lane departures)
9 very sleepy, great effort to keep awake, fighting sleep	markedly increases [1,3,4]

1 Reyner & Horne, Int J Legal Med, 1998, 111, 120–23

2 Sagaspe et al., PloS ONE, 2008, 3, e3493.

3 Anund et al., Acid Anal Prev, 2008, 15, 1970-6

4 Ingre et al. J Sleep Res, 2006, 15, 142-8

How can you choose the right metric(s)?

1) For the moment, there is *no "silver bullet"* to measure driver fatigue. Therefore, it is recommended using *multiple methods/metrics.*

2) The easiest way is to rely on *introspection (subjective metrics)*. It is a quite valid/reliable and inexpensive method but sensitive to manipulation.

3) *Vehicle/steering wheel and eye closure metrics* are also among the first choices. They are unobtrusive and objective by nature.

4) *Physiologic metrics* are objective by nature but often obtrusive (electrodes) and expensive (analyses). However, they will become more feasible to use in the future along with the development of technology .

Truck driver sleepiness – an ongoing project at FIOH

1. How sleepy are long-haul truck drivers at the wheel?
2. Is it possible to improve their alertness through training?

Pre-intervention measurement

- 2 week measurement period including 3 days of intensive measurements

52 long-haul truck drivers — 11/2010 – 04/2011

Intervention group (N=32)

Control group (N=20)

Intervention

- half-day fatigue management training
- self-made plan for fatigue management + feedback from the plan

Fatigue management training (N=29) — 05 – 09/2011

Post-intervention measurement

- 2-week measurement period including 3 days of intensive measurements

49 long-haul truck drivers — 11/2011 – 03/2012

Proportion of "sleepy" shifts

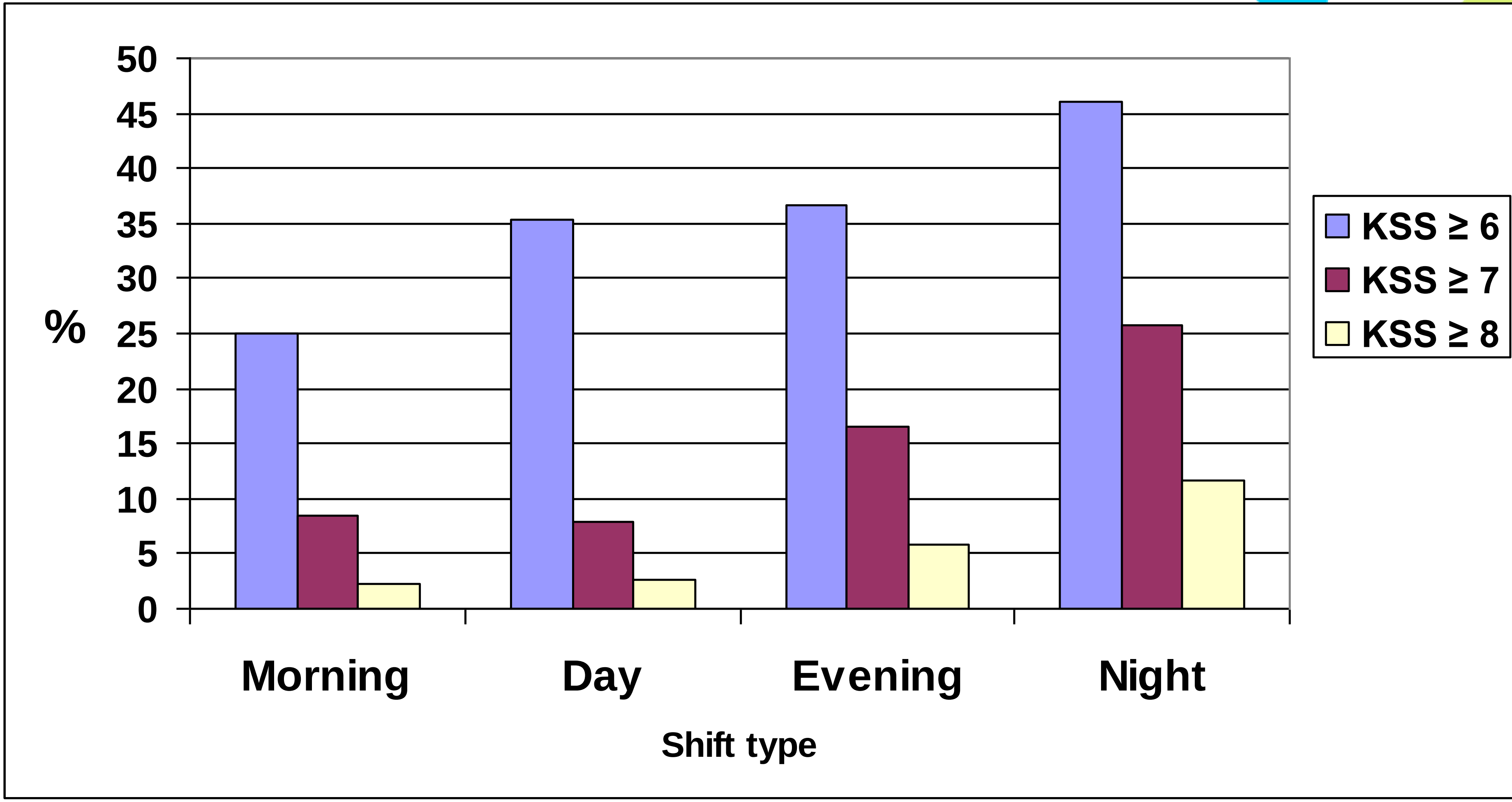

Fig. 1. The proportion of shifts during which the drivers rated their sleepiness ≥ 6, ≥ 7 or ≥ 8 on the Karoliska Sleepiness Scale at least once.
A total of 130 morning shifts, 38 day shifts, 85 evening shifts, and 222 night shifts have been included in the analysis.

Does fatigue management training reduce fatigue?

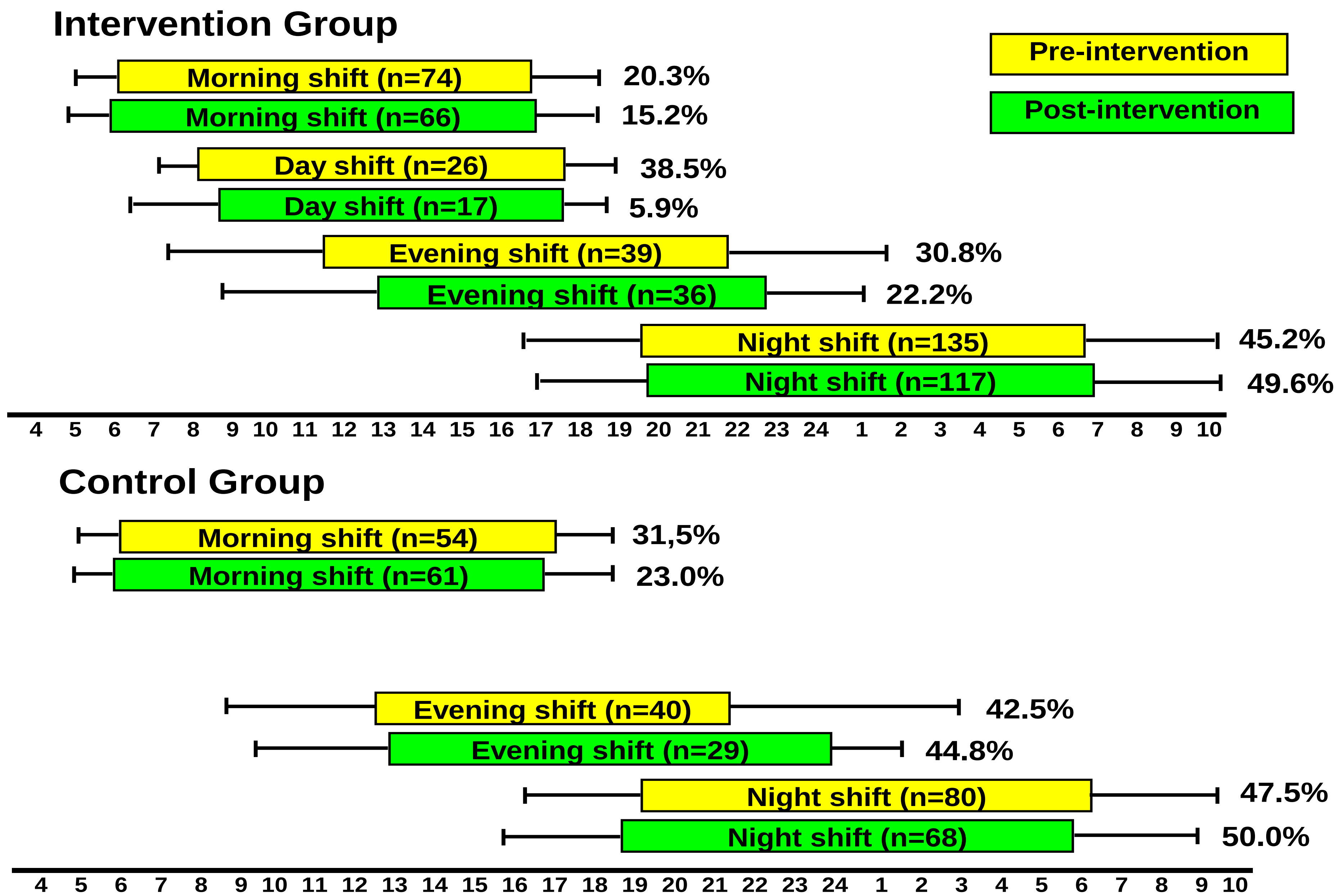

Fig. 2. % of "sleepy" shifts (KSS≥6 at least once) in the intervention and control groups.

Thank you!