Occupational Cancer Research Centre (OCRC)
and the Institute for Work and Health (IWH)

Interventions mitigating health risks among shift workers: Current knowledge and workplace practices

Controlled exposure to light and darkness

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Circadian adaptation to shift work

- ❑ Complete circadian entrainment despite a series of shifts in a minority of shift workers (Sack et al 1992; Rodent et al 1993; Koller et al 1994; Costa et al 1997; Henning et al 1998; Folkard 2008)

- ❑ Circadian physiology substantially affects an individual tolerance to working shifts
  - ❑ Chronotype (Breithaupt, H. *et al* 1978; Hilliker, N. A. Et al 1992; Natale et al 2003)
  - ❑ Gene-environment interaction (Viola, A. U. *et al.* 2007, 2008 ; Gamble et al 2011)
  - ❑ Daily pattern of light and darkness (Czeisler et al 1990; Koller et al 1994; Dawson et al 1995; Barnes et al 1998; Horowitz et al 2001; Dumont et al 2001; Boivin et al 2002; Yoon et al 2002; Burguess et al 2002; James et al 2004; Lowden et al 2004; Bjornvatn et al 2006; Smith et al 2008; Thorne et al 2008; Sasseville et al 2010; Zamanian et al 2010; Boivin DB et al 2012)
  - ❑ Phase angle of entrainment (Benhaberou-Brun et al 1999; Gibbs et al 2007)

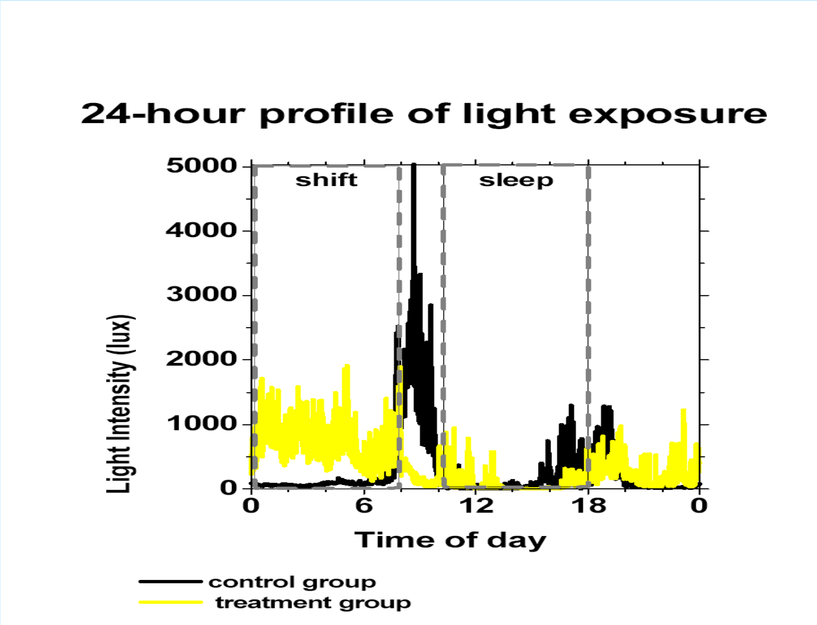
Aims

- ❑ Review a series of interventions based on controlled exposure to light and darkness for shift workers

- ❑ Discuss the pros and cons of circadian adjustment to night shift work

Phototherapy trial in nurses

- Control nurses: 3 men, 6 women, 42.0 ± 7.2 y.o
- Treatment nurses: 4 men, 6 women, 41.7 ± 8.8 y.o
- ≥ 8 night shifts/15 days



Boivin et al. J Biol Rhythms (2002)

Circadian adaptation to permanent night shifts

Light/Darkness Intervention

Regular sleep/darkness schedule, darkened bedrooms

Bright light exposure at night (3,243± 928 lux)

Sunglasses (15% visual light transmission) during commute

Phase shifts

Control group:

CBT: –4.09 ± 1.94 h

S. melatonin: –5.08 ± 2.32 h

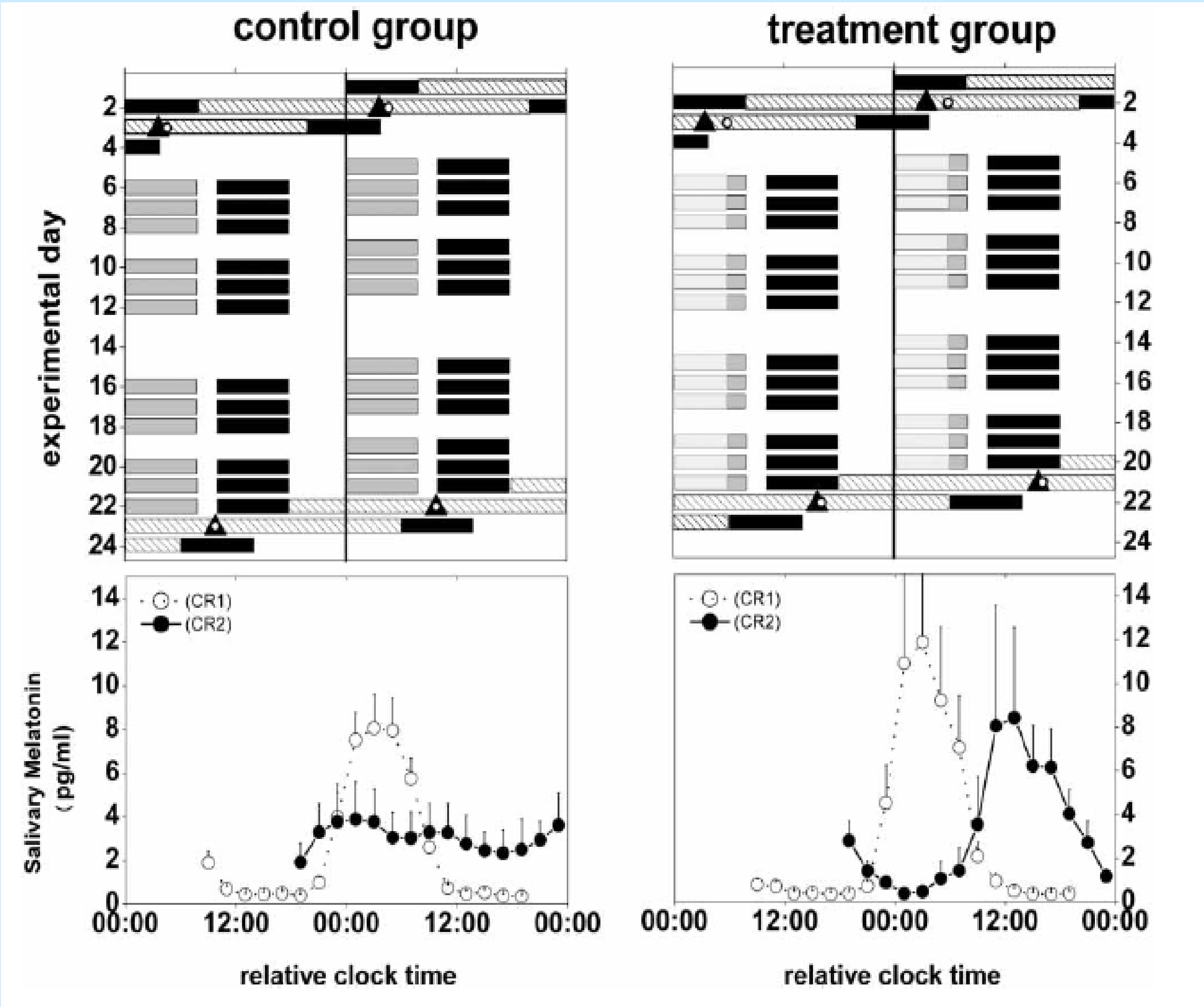
S. cortisol: –3.05 ± 2.12 h

Intervention group:

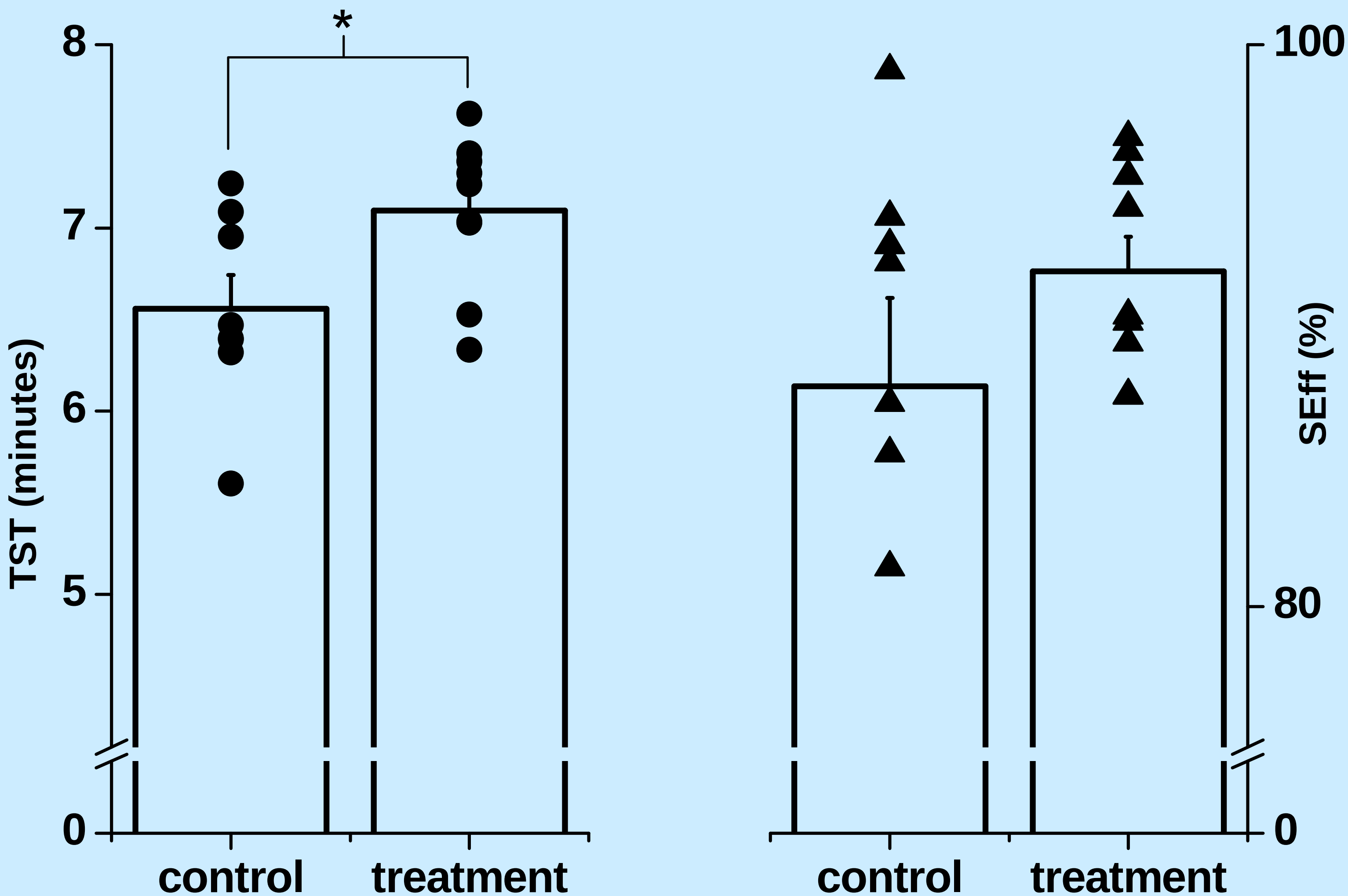
CBT: –9.32± 1.06 h

S. melatonin: –11.31 ± 1.13 h

S. cortisol: –11.07 ± 1.27 h

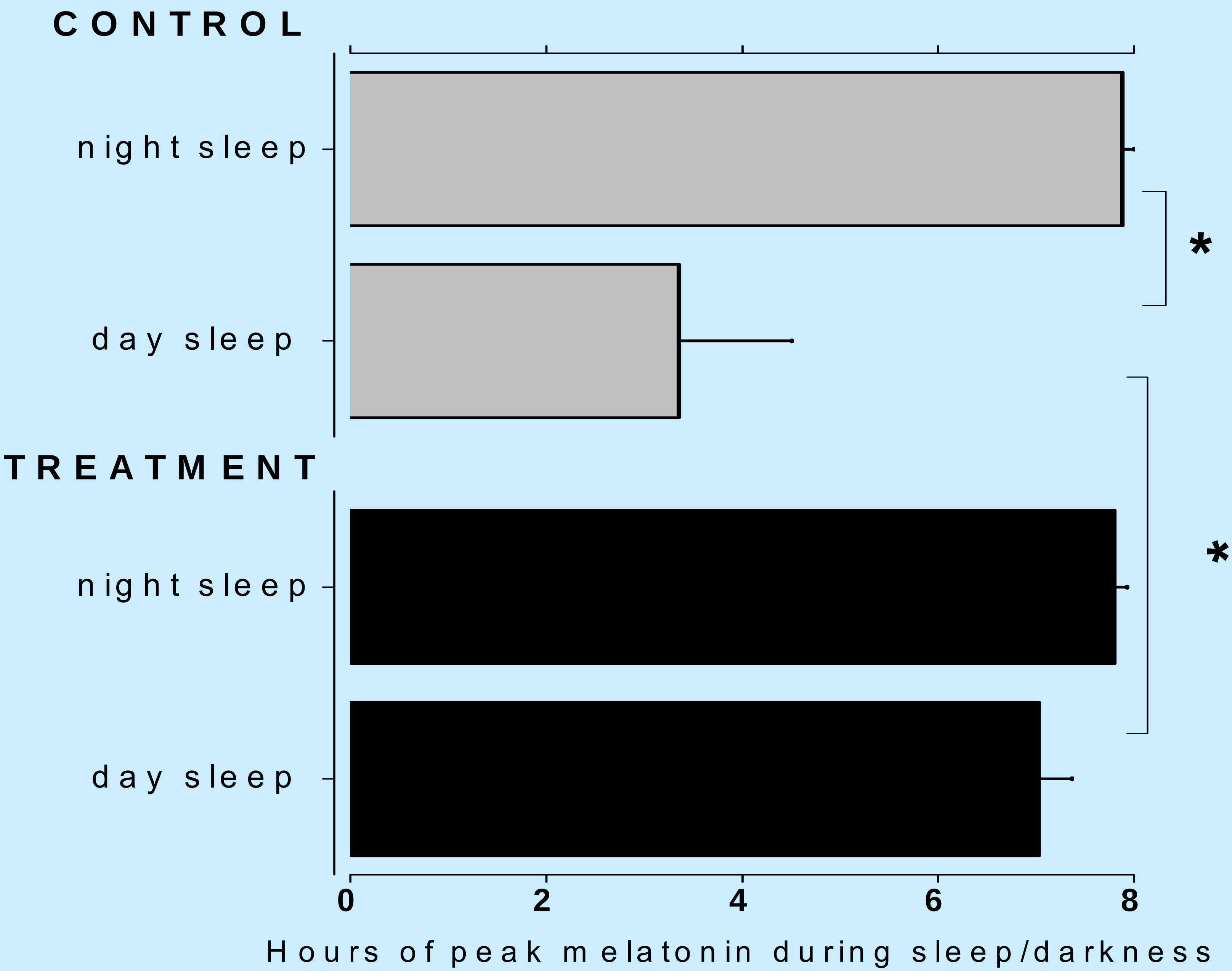


Boivin et al. J Biol Rhythms (2002)
Boivin et al. Chronobiol International (2012)



TST (±SEM): 7:06 ± 0:08 vs 6:36 ± 0:11 h, treatment and control, respectively

Boivin et al. Chronobiol International (2012)



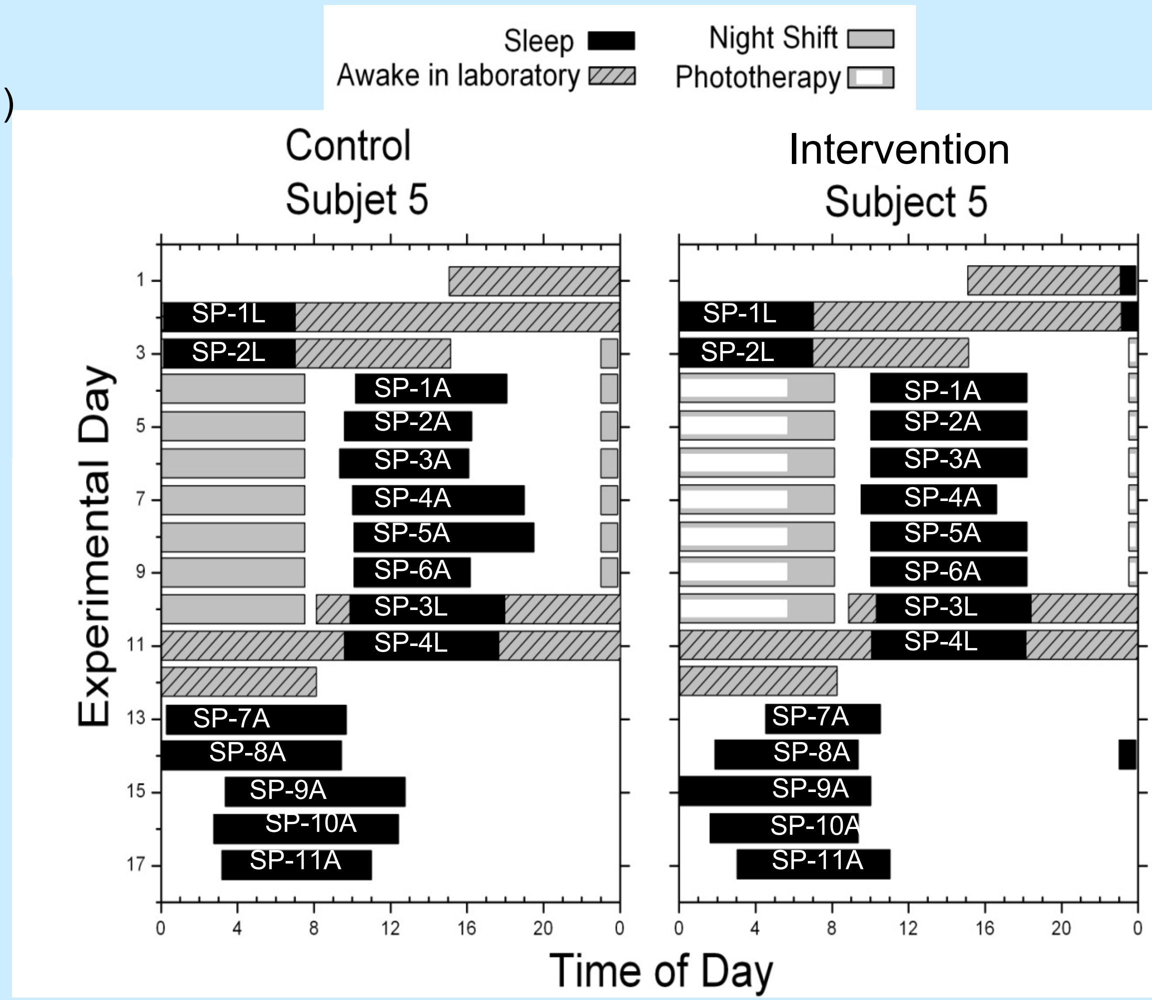
Boivin et al. Chronobiol International (2012)

Experimental Protocol

- 15 police officers on patrol
  - control n=9; intervention n=8
  - 2 police officers participated in both conditions (1 year interval)
- Age: 30.1 ± 5.2 years old

D--Day shift
E--Evening shift
N--Night shift
O--Off

Dim	Lun	Mar	Mer	Jeu	Ven	Sam
1 **O**	2 **E**	3 **E**	4 **E**	5 **O**	6 **O**	7 **D**
8 **D**	9 **D**	10 **D**	11 **O**	12 **O**	13 **N**	14 **N**
15 **N**	16 **N**	17 **N**	18 **N**	19 **N**	20 **O**	21 **O**
22 **O**	23 **O**	24 **O**	25 **O**	26 **E**	27 **E**	28 **E**
29 **E**	30 **O**	31 **O**	32 **D**	33 **D**	34 **D**	35 **O**

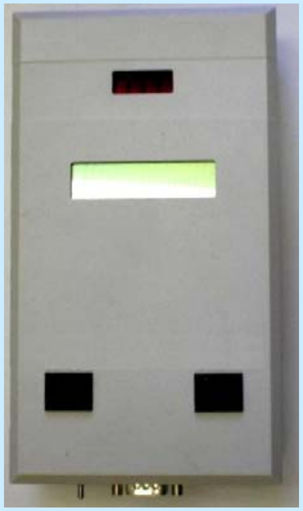


Boivin et al. Chronobiol International (2012)

Experimental Measures

Laboratory

- Urinary aMT6s
  - Wake period: 1x / 3h
- Salivary melatonin
  - Wake period: 1x / 30 minutes
  - 1st sleep period: 1x / 2 hours

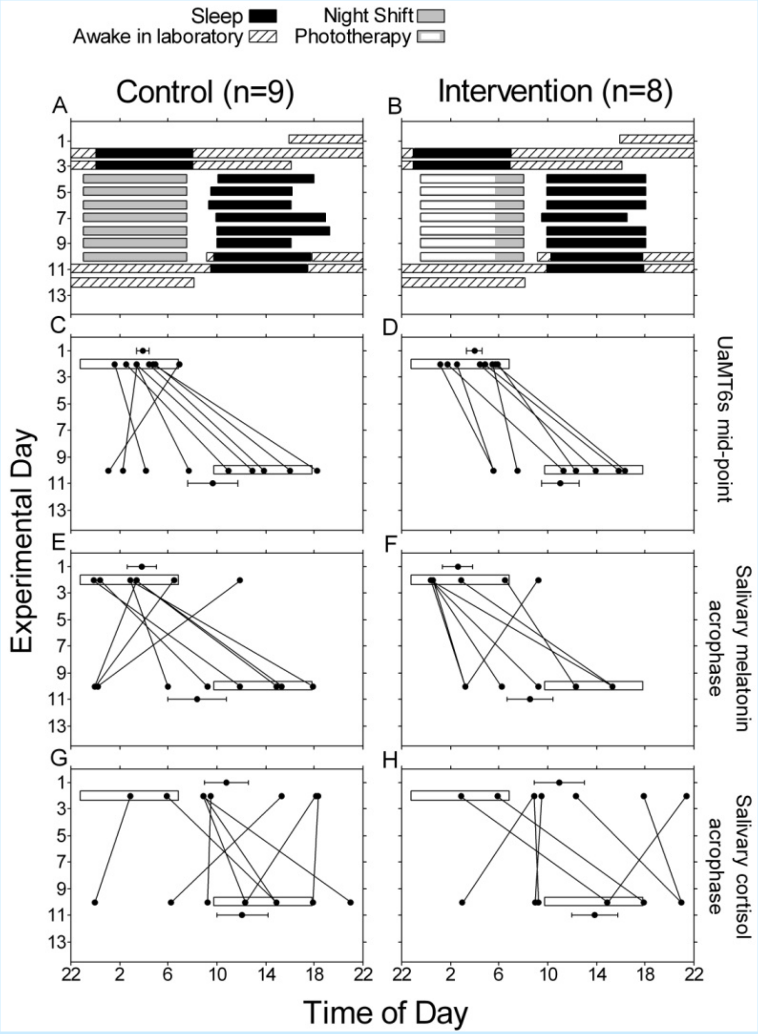


Ambulatory

- Urinary aMT6s
  - 10 minutes before and after main sleep period
- Psychomotor Vigilance Task (PVT)
  - Before and after work shift

Boivin et al. Chronobiol International (2012)

Results: Phase Shift of Circadian Markers

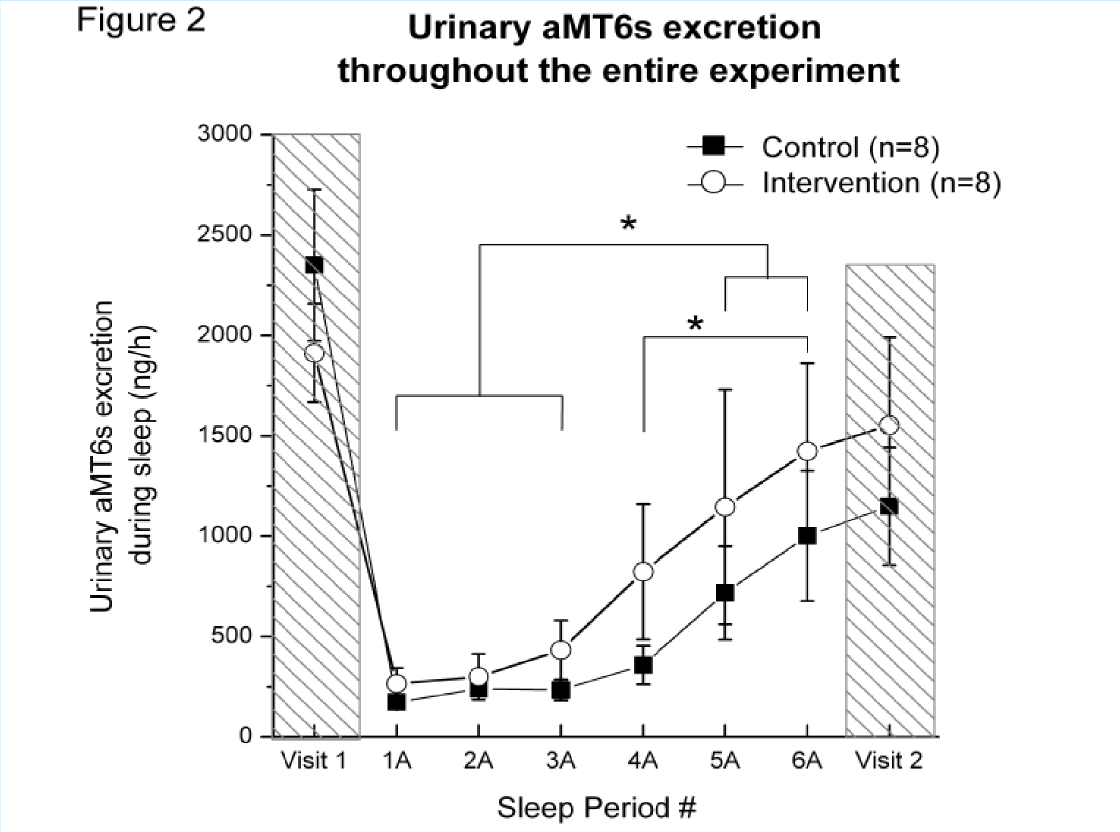


	UaMT6s	Salivary Melatonin
Control group		
(n=9) **Average**	**-5.75**	**-4.52**
SE	**2.10**	**3.21**
Intervention group		
(n=8) **Average**	**-7.07**	**-5.93**
SE	**1.26**	**2.3**
p value Bilateral t test	***0.62***	***0.73***

- Significant phase delays in both groups (p=0.009)
- Greater, but not significant, phase delays in the intervention group compared to controls.

Boivin et al. Chronobiol International (2012)

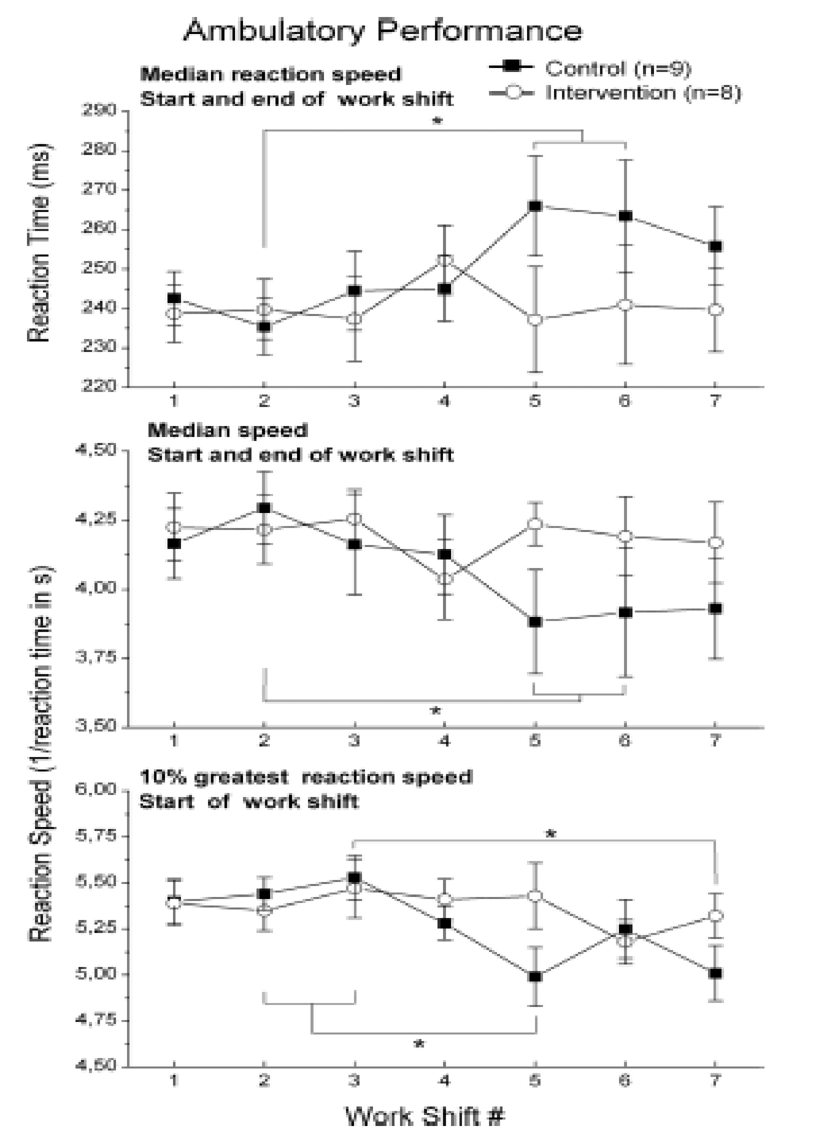
Results: Urinary aMT6s Excretion Rate



- Significant increase of Urinary aMT6s excretion during daytime sleep across consecutive night shifts in both groups (p≤0.0001)
- Significant greater rate of increase in the intervention group (p=0.032)

Boivin et al. Chronobiol International (2012)

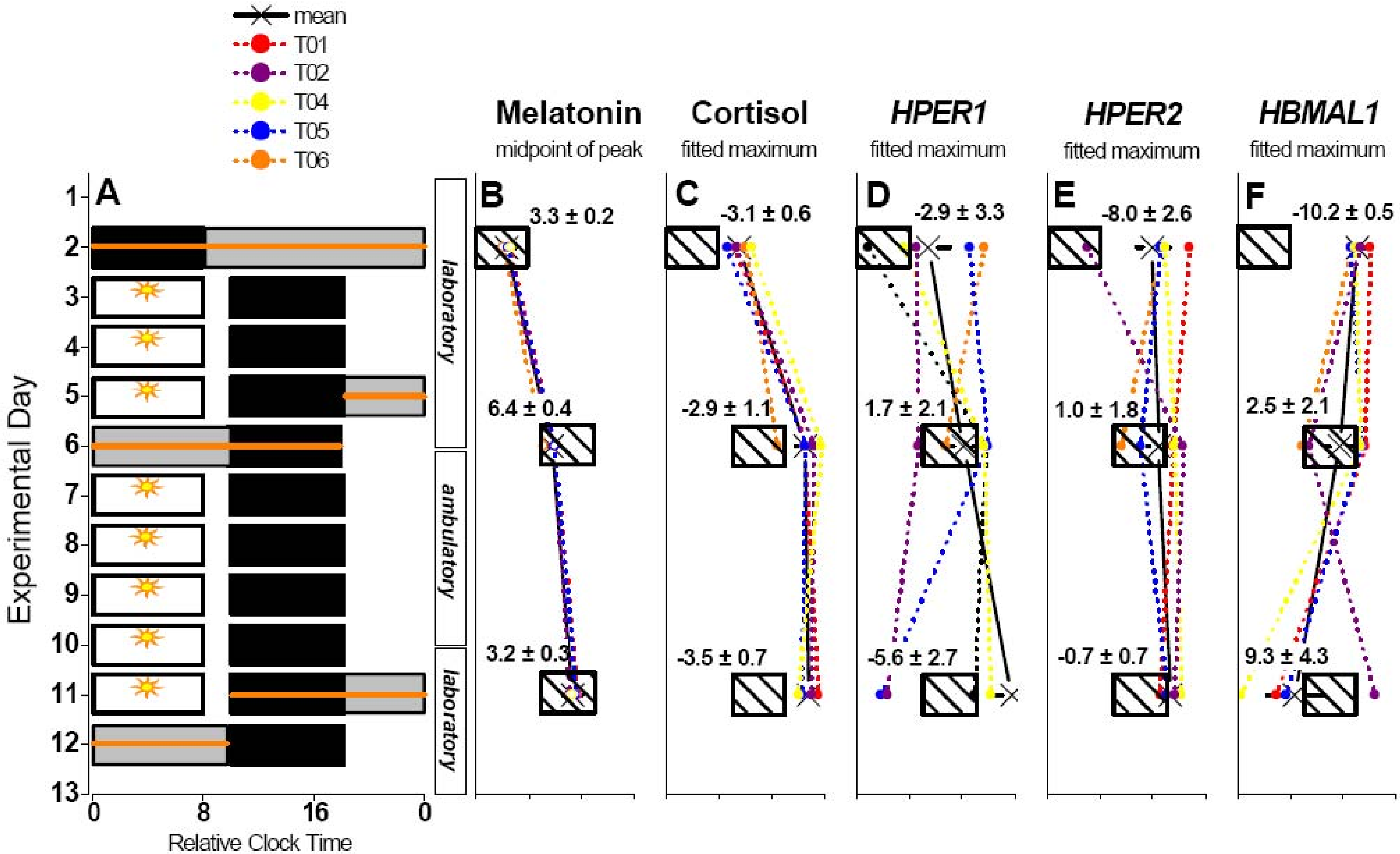
Results: Ambulatory Performance



- Significant decrease of reaction speed across consecutive night shifts in the control group ($p \leq 0.04$) but not in intervention group ($p \geq 0.35$).

Boivin et al. Chronobiol International (2012)

Peripheral clocks and simulated night shift work



James et al., Sleep (2007)

Summary of findings

- ❑ Circadian misalignment in shift workers
  - ❑ Major determinant of sleep duration, quality
  - ❑ Impact the temporal relationship between circadian rhythms and the shifted sleep schedule
  - ❑ individual differences in tolerance to living at abnormal circadian phases
  - ❑ “Molecular” circadian desynchronisation (peripheral and non-SCN brain oscillators)
  - ❑ Sensitive to light-induced phase shift of the central circadian pacemaker
  - ❑ Possible greater role in increased medical risks associated with shift work than reduced melatonin

- ❑ Control of light-darkness in shift workers
  - ❑ Can improve the phase angle between circadian rhythms and the atypical sleep schedule
  - ❑ Possible direct stimulating effect of bright light exposure
  - ❑Pros and cons

Promoting circadian resetting?

PROs: intermittent timed bright light exposure is an effective countermeasure:

1. Robust phase shifts (Baehr et al 1999; Rimmer et al 2000; Boivin et al 2002; James et al 2004; Gronfier et al 2004; Lee et al 2006; Revell et al 2006)

2. Circadian adaptation in 78-100% of participants (appropriate phase angle between ECP and the sleep-wake cycle)

3. Improves daytime sleep duration, efficiency, quality (Yoon et al 2002; Burch et al 2005; Bjortvatn et al 2006; Garde et al 2009; Sasseville et al 2009)

4. Improves alertness, performance at night (Campbell et al 1990; Czeisler et al 1990; Dawson et al 1991; Daurat et al 2000; Yoo et al 2002; Lavoie et al 2003; Lowden et al 2004; Sasseville et al 2010; Boivin et al 2011)

Interventions targeting circadian resetting

CONs:

1. Partial adaptation in 52-56% of controls (Midwinter and Arendt 1991; Baehr et al 1999; Boivin et al 2002) might be sufficient to stabilize psychomotor performances (Crowley et al 2004)
2. Maintenance of stable daytime sleep might be sufficient for appropriate phase angle and increased TST (Santhi et al 2008; Dumont et al 2009)
3. Melatonin reduction at night (Hansen et al 2006; Stevens et al 2006; Davis et al 2006; Schernhammer et al 2010)
4. Bright light levels could be aversive
5. The repetitive shifting back can be a health hazard
6. Blocking low wavelength light at night (Kayumov et al 2005)

Sources

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