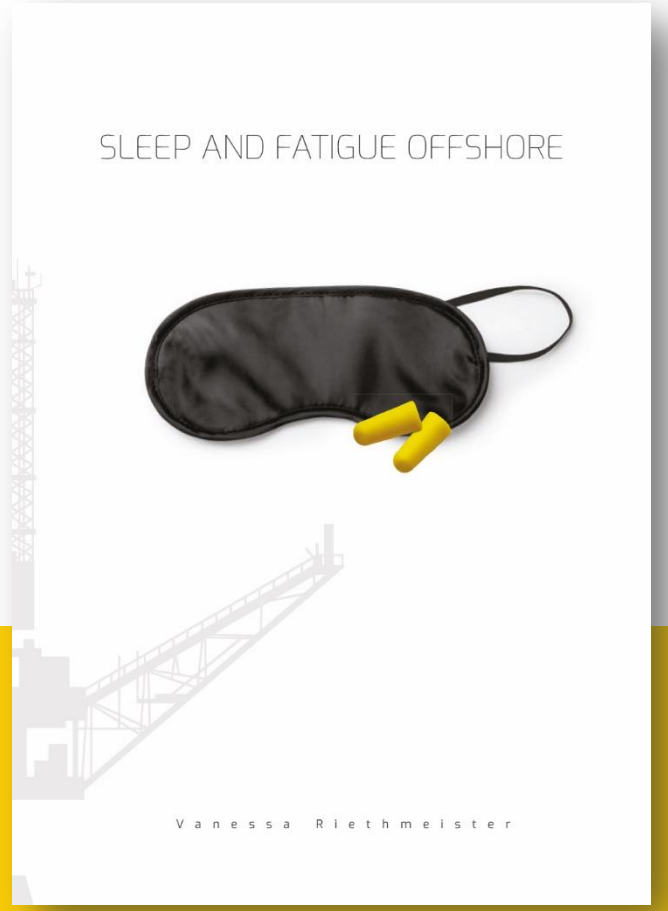
SLEEP AND FATIGUE OFFSHORE

IMPLICATIONS FOR FATIGUE RISK MANAGEMENT



NOGEPA Meeting

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DISCLOSURE OF SPEAKER'S INTERESTS

(Potential) Conflict of Interest	See below
Potentially relevant company relationships in connection with event	None
• Sponsorship or research funding	• Nederlandse Aardolie Maatschappij B.V. / Royal Dutch Shell
• Fee or other (financial) payment	• Nederlandse Aardolie Maatschappij B.V. / Royal Dutch Shell
• Shareholder	• /
• Other relationship, i.e. …	• /

AGENDA

1.  BACKGROUND
2.  STUDY METHODOLOGY
3.  MAIN FINDINGS
4.  IMPLICATIONS
5.  CONCLUSIONS
6.  Q&A

FRM – Fatigue Risk Management
FRMP – Fatigue Risk Management Plan
FRMS – Fatigue Risk Management System

FATIGUED

TIRED

DROWSY

SLEEPY

NOT ALERT

WHY IS FATIGUE A PROBLEM OFFSHORE?

- The offshore environment is a high risk environment in which consequences can be severe
- Fatigue is one of the major health & safety risk factors offshore (→ e.g. due to shift work & consecutive long work days)
- Fatigue offshore is not well understood

  (e.g. causes, courses & etiology)

Piper Alpha Disaster, 1988

Deep Water Horizon Disaster, 2010

* U.S. Chemical Safety and Hazard Investigation Board. Investigation report volume 3 drilling rig explosion and fire at the Macondo well. 2016; Report No.: 2010-10-I-OS.

SNAPSHOT OF CURRENT FRM PRACTICES OFFSHORE

- Significant variations of FRMPs based on country legislations and operating companies
- Existing work rostering (partially) based on FRMS (e.g. FAID®)
- In general, more attention is paid to night- and swing-shift workers than day-shift workers
- FRM protocol for HSSE-critical positions
- Fatigue awareness training for workers and supervisors
- Inconsistent use of Journey Management Plans
- Voluntary fatigue/fit-for-duty checks (e.g. the prior sleep/wake calculator)

There is still a lot to be learned and improved!

OFFSHORE SLEEP AND FATIGUE STUDY

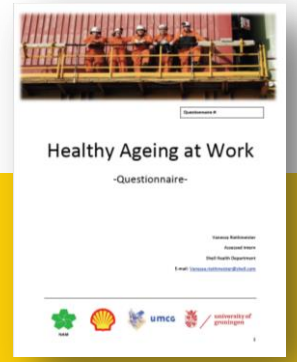
OBJECTIVE

To better understand sleep & fatigue parameters during offshore shift rotations, to improve existing FRMPs

→ Prevalences, time courses and predictors of sleep and fatigue parameters were investigated.

METHODS

1. Cross-sectional mixed methods baseline study



- Interviews (N=19), Focus Groups (N=47) & Questionnaires (N=260)
- N= 5 platforms (Dutch Central North Sea)

* *Work Eat and Sleep: Towards a Healthy Ageing at Work Program Offshore. BMC Public Health. 2016; 16:134.*

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METHODS

1. Cross-sectional mixed methods baseline study
2. Intensive longitudinal repeated measures study (28-days)

- N= 60 offshore day-shift workers (contractors & permanent staff)
- N= 4 platforms (Dutch Central North Sea)
- Bi-daily objective & subjective sleep and fatigue measures (pre-/post-shift, i.e. morning/evening measures)
- Statistical analyses: (Generalized) linear mixed model analyses

SUBJECTIVE & OBJECTIVE MEASURES

- Sleepiness/Sleep quality (Karolinska Sleepiness Scale (KSS), Range [1-9])
  Bi-Daily

- Reaction Times/Alertness
  Bi-Daily Offshore

  No significant changes over time

- Sleep parameters/Activity during the day
  Continuous

- Circadian Rhythms (Melatonin & Cortisol)
  Offshore Days: 2, 7, 13

  No Circadian shift detected

* Investigating daily fatigue scores during two-week offshore day shifts. *Appl Ergon*. 2018;71:87-94.

RESULTS

→ PREVALENCES, TIME COURSES & PREDICTORS

PREVALENCES

- Cross-sectional data:
  - 73% reported prolonged fatigue
  - 41% experienced a 'Dip', which 60% experienced on day 10/11

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- Cross-sectional data:
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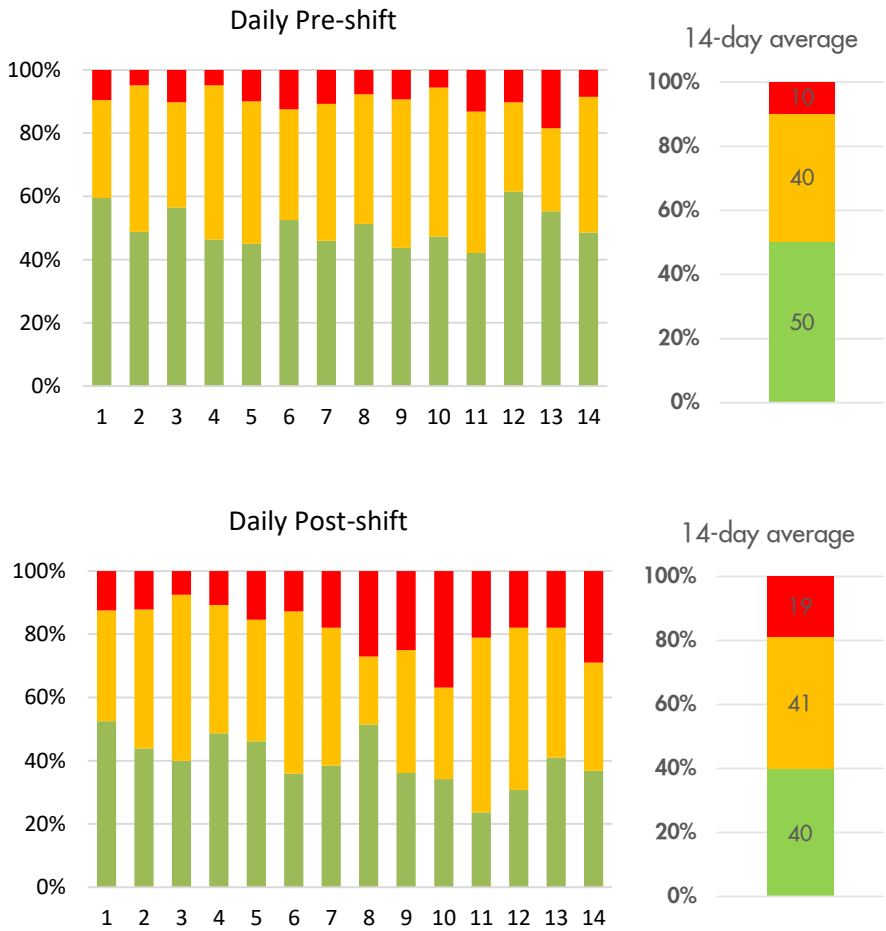
- 1 in 7 offshore workers reported severe sleepiness (KSS>6) each offshore day

- The average daily prevalence of severe sleepiness was 10% in pre-shift and 19% in post-shift measures

- In the second week, 25% of offshore workers reported severe sleepiness

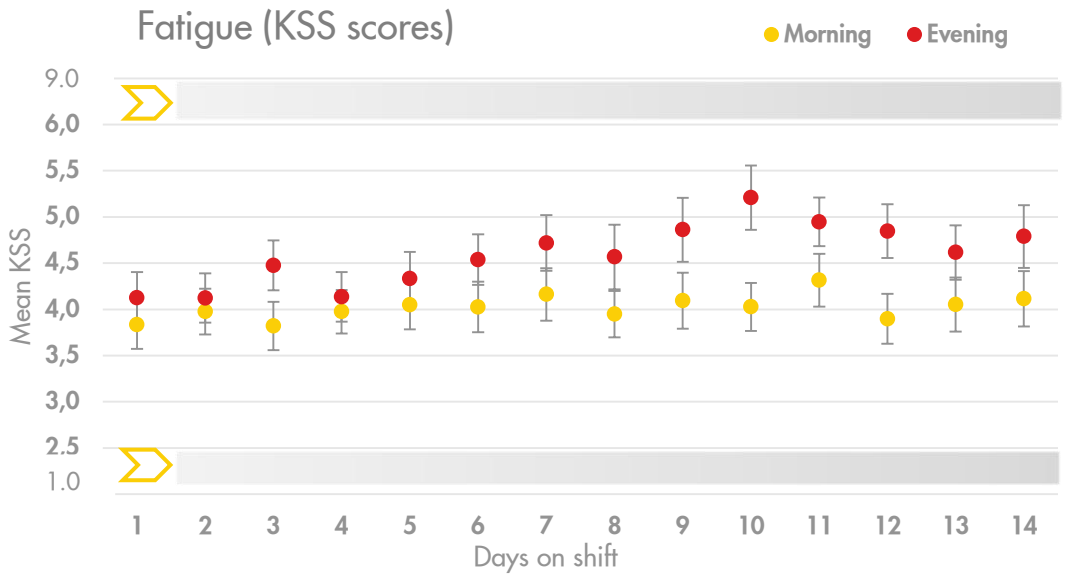


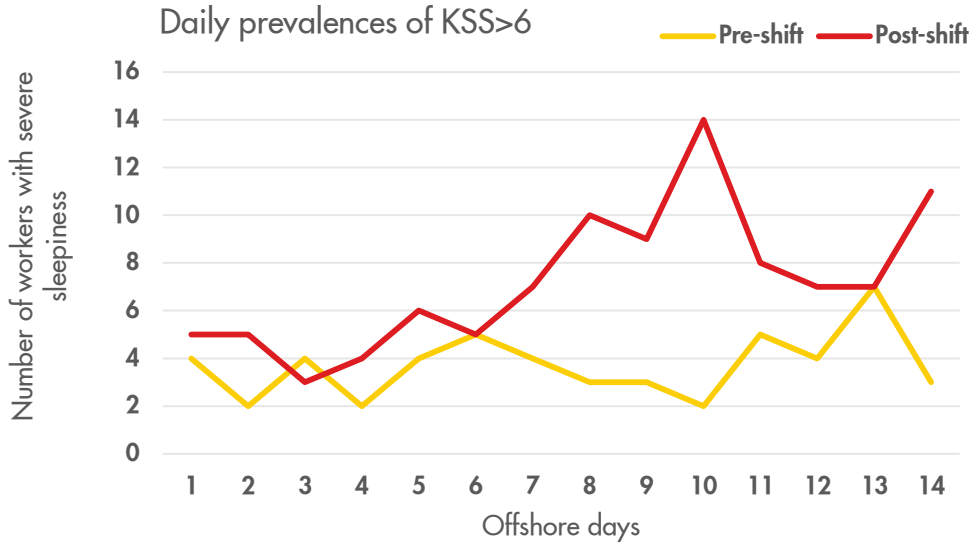
Traffic light graphs. Percentages of employees in low (KSS≤3), medium (KSS=4-6) and severe (KSS>6) sleepiness categories over the course of a fourteen-day offshore shift period. Green columns indicate low, orange medium and red high fatigue risk.

RESULTS

→ PREVALENCES, TIME COURSES & PREDICTORS

ACCUMULATION OF FATIGUE



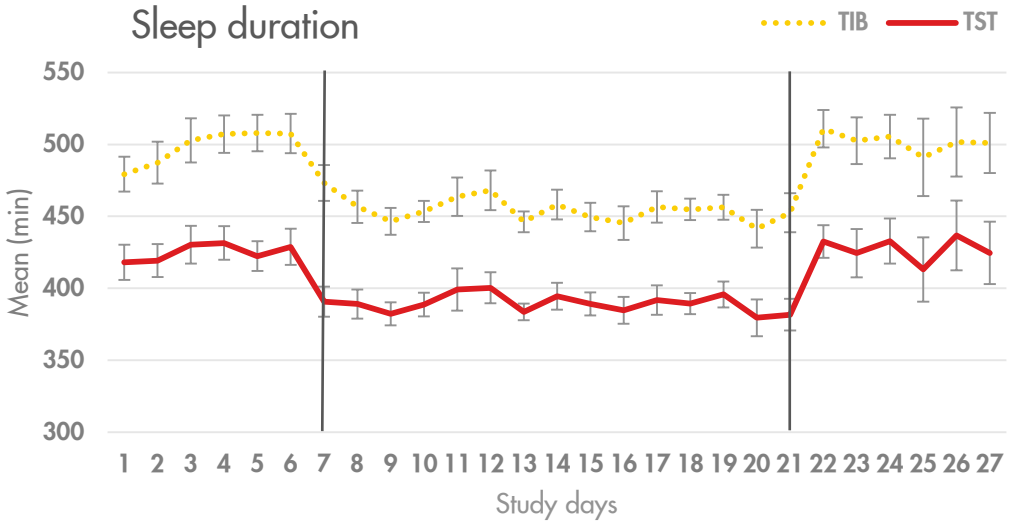


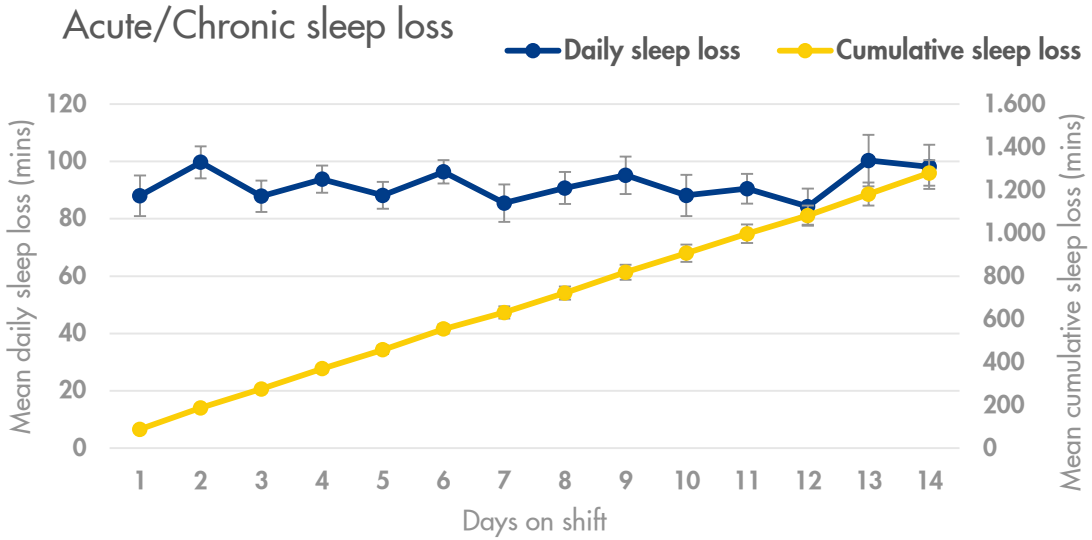
OFFHORE PERIOD

- Post-shift fatigue scores are higher & increase at a faster rate compared to pre-shift fatigue scores
- Peak of fatigue on day 10 (37%)

→ PREVALENCES, TIME COURSES & PREDICTORS

ACCUMULATION OF SLEEP DEBT





OFFHORE PERIOD

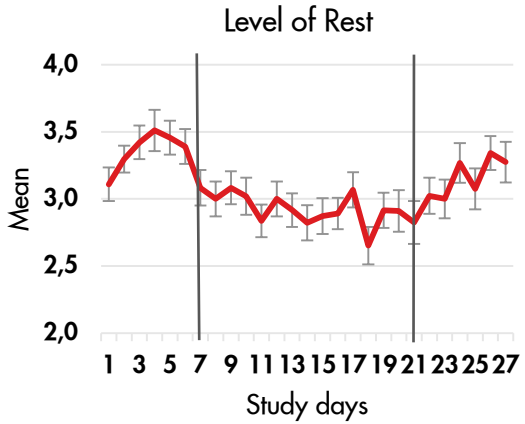
- Shorter sleep durations offshore
- Average daily acute sleep loss of 92 min
- Average chronic sleep loss of >2.5 consolidated sleep periods

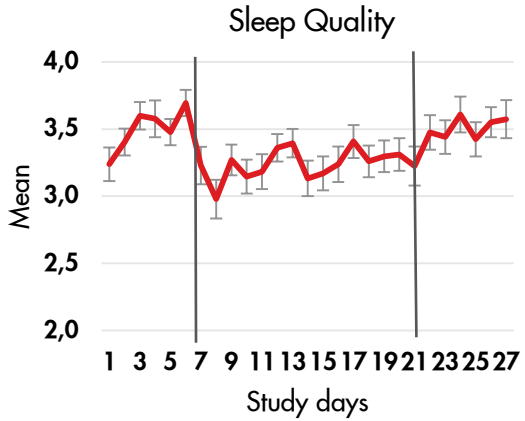
TIB – Time in Bed
TST – Total Sleep Time

RESULTS

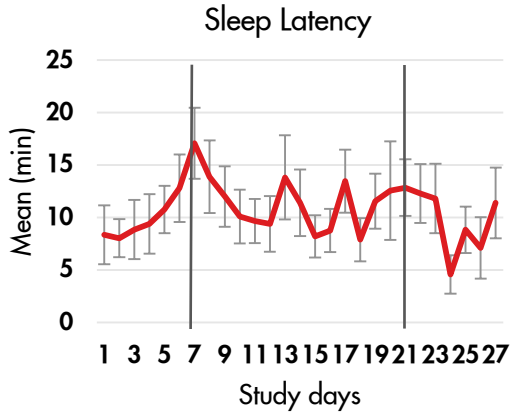
→ PREVALENCES, TIME COURSES & PREDICTORS

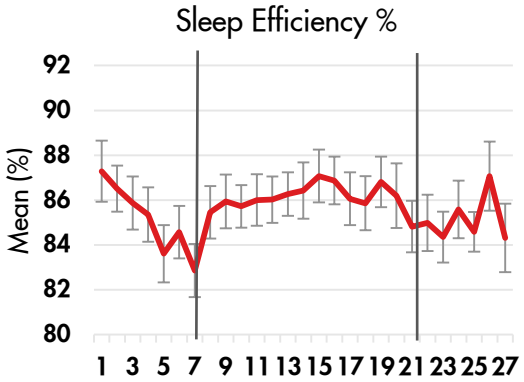
SUBJECTIVE





OBJECTIVE





SUMMARY

PRE-OFFHORE PERIOD → Preparation period

- SE% scores decreased, sleep latency, and duration increased

OFFSHORE PERIOD

- Sleep durations, perceived sleep quality and level of rest after awakening decreased
- Sleep loss and post-shift sleepiness scores accumulated over the 14-day offshore work periods
- Post-shift sleepiness accumulation was significantly related to successive days on shift and chronic sleep loss

POST-OFFSHORE PERIOD → Recovery period

- Evening sleepiness scores were high and declined rapidly

POTENTIAL FATIGUE RISK PRONE PERIODS

End-of-shift effect – high and increasing post-shift fatigue scores in a 14-day offshore work period

Third-quarter-phenomenon – peak in fatigue scores on day 10/11 of a 14-day offshore work period

Spill-over-effect – leave periods affecting work periods and vice versa

For example:

- High & rapidly declining fatigue scores and longer sleep durations in post-offshore work periods
- Sleep banking strategies in pre-offshore work periods

RESULTS

→ PREVALENCES, TIME COURSES & PREDICTORS

PREDICTORS (for individual sleepiness)

- Suggestive evidence for differential demographic (age, chronotype), lifestyle (smoking, baseline fatigue) and health (BMI, mental & physical health) predictors for pre- and post-shift sleepiness scores

Pre-shift — low baseline sleepiness scores, older age, earlier chronotypes, smoking and poor level of mental & physical health

Post-shift — low baseline sleepiness scores, younger age, good mental and poor physical health

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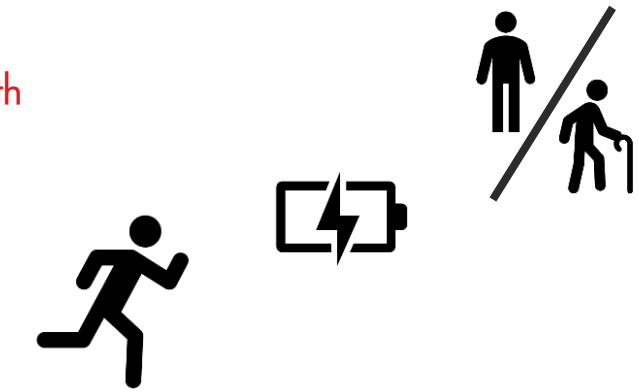


STRENGTHS & LIMITATIONS

STRENGTHS

- Mixed methods design & Intensive longitudinal repeated measures study design
- Subjective & objective sleep and fatigue measurements
- (Generalized) Linear mixed model analyses
- Large offshore sample: including contractors, from multiple platforms

LIMITATIONS

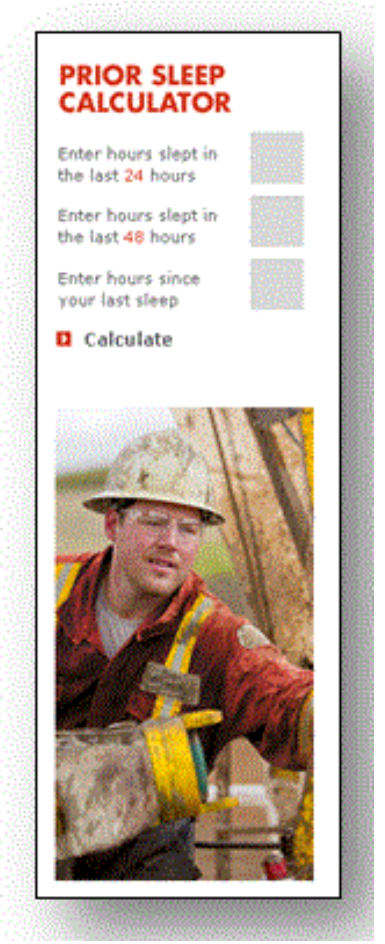
- Limited sample size in absolute terms
- Offshore logistics
- Bi-daily instead of hourly measures

CONCLUSIONS

- Study findings add new and unique knowledge to the existing sleep and fatigue literature
- FRMPs should focus on the whole offshore cycle, including pre- and post-offshore work periods
- All offshore workers (including day-shift workers and workers in non-HSSE critical positions) should be covered in FRMPs
- Prolonging offshore shifts beyond two-weeks will likely result in elevated fatigue/sleepiness risk
- Study findings provide important input for the advancement and optimization of existing FRMP and FRMS

RECOMMENDATIONS FOR (OFFSHORE) FRMPs

- Consider accumulating fatigue risk with consecutive (offshore) shift days
- Be mindful of potential fatigue risk prone periods (also applies to JMP & Road Safety)
- Develop→ Test (cost-effectiveness)→ Implement fatigue prevention strategies, e.g.:
  - Pre-/Post-offshore work period fatigue checks
  - Pre-HSSE critical tasks fatigue checks
  - Real-time fatigue monitoring
  - Sleep Hygiene education
  - Caffeine intake/Napping strategies/etc.



! Data Privacy | Fatigued… what now? | Stigma/ Prejudice | Intrinsically safe appliances

Take home message

- Take the risk of fatigue serious as fatigue affects us all!
- Spent sufficient time on fatigue/alertness management

- Evaluate your own work/work environment and try to identify the fatigue risks and potential mitigation strategies
- Create a culture of trust where people can speak up when they are not alert to prevent mistakes and harm.

Thank you for your attention

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NAM

APPENDIX

FUTURE RESEARCH

Future sleep and fatigue offshore studies should build on the presented findings to further advance bio-mathematical fatigue prediction models of FRMS to ultimately improve health and safety of offshore workers.

Specific future research examples

- Cost-benefit analyses of the accumulated fatigue risk in extended offshore periods vs the additional commuting risk in shorter offshore periods
- Effectiveness of fatigue proofing/prevention strategies offshore, including feasibility studies, impact assessments, cost-efficiency studies and offshore worker satisfaction surveys
- Intensive longitudinal prospective studies of the consequences of accumulated sleep loss and fatigue

PVT-B ANALYSES

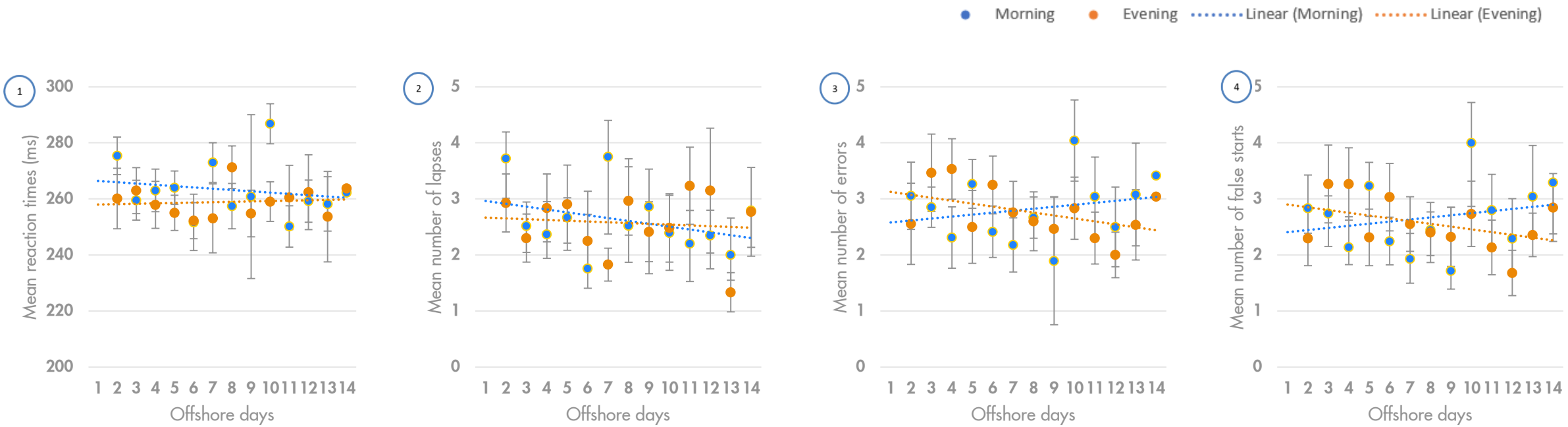


Figure. Outcomes of the pre- and post-shift objective fatigue metrics, obtained from the psychomotor vigilance task (PVT-B), over the course of the two-week offshore day-shift periods. Means, standard errors and linear prediction lines are plotted for (1) reaction times, (2) number of lapses, (3) number of errors, (4) and number of false starts.

CIRCADIAN RHYTHM ANALYSES

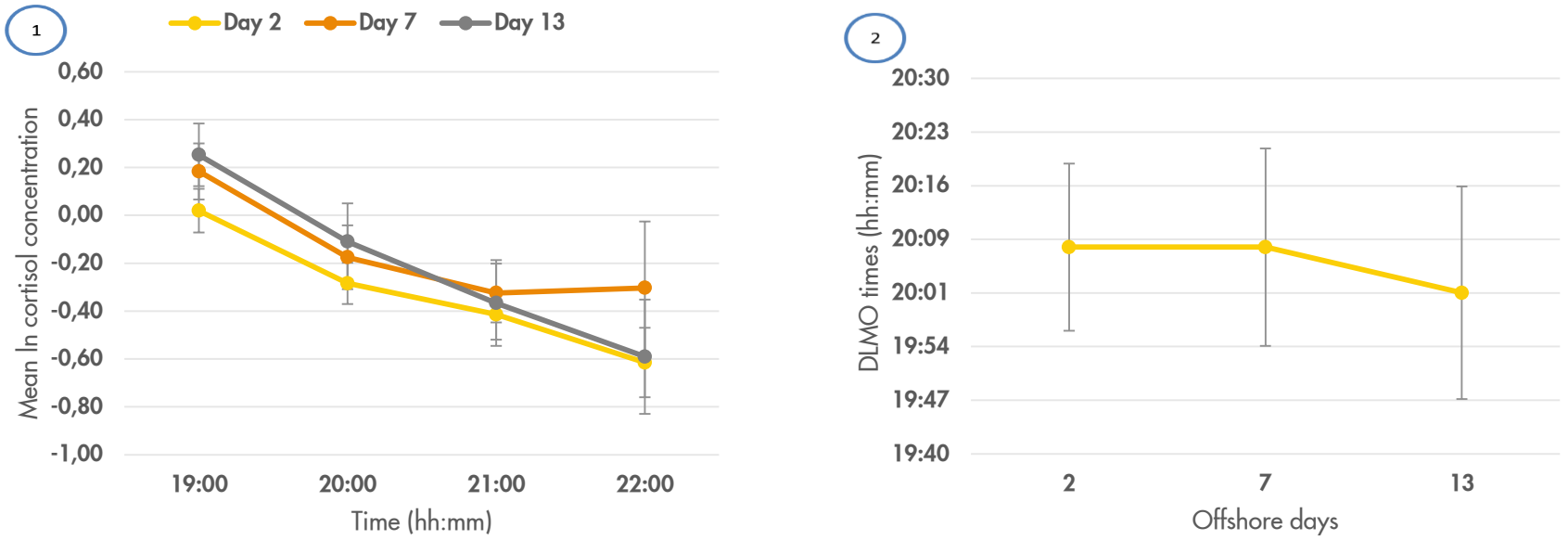
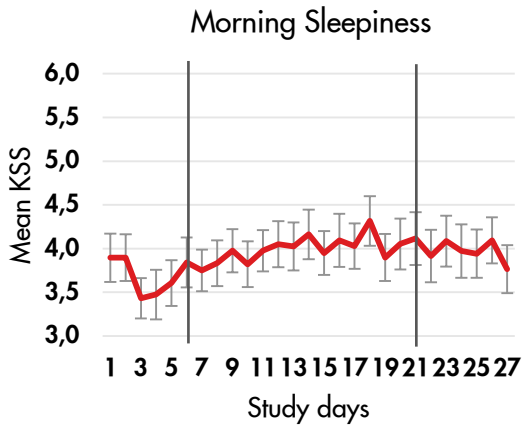
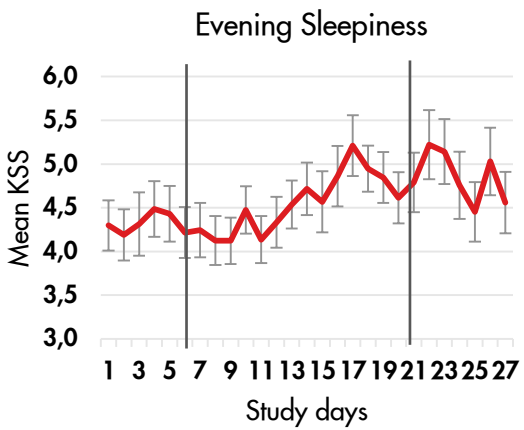
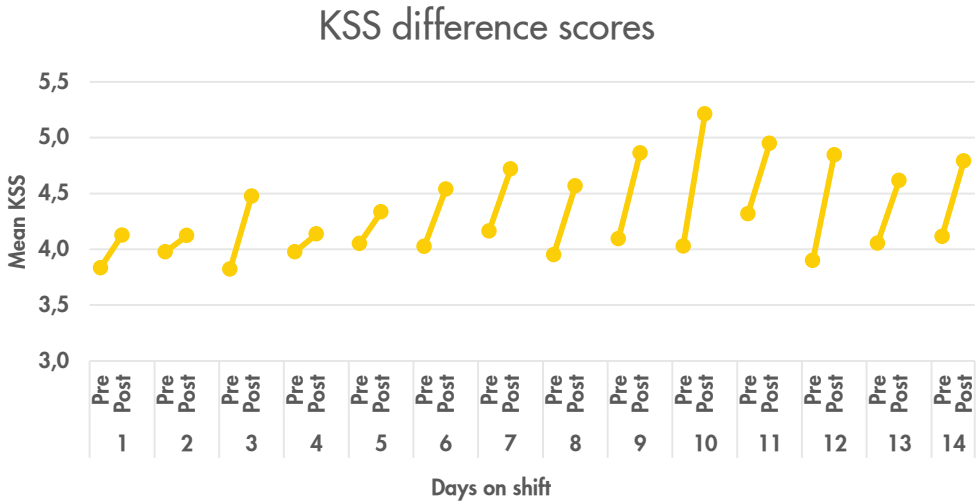


Figure. Outcomes of the circadian rhythm marker analyses. Graph (1) depicts mean salivary cortisol levels and standard errors during the three sampling days (offshore day 2, 7 and 13). Graph (2) depicts dim-light melatonin onset (DLMO) times and standard errors across the three sampling days (offshore days 2, 7 and 13).

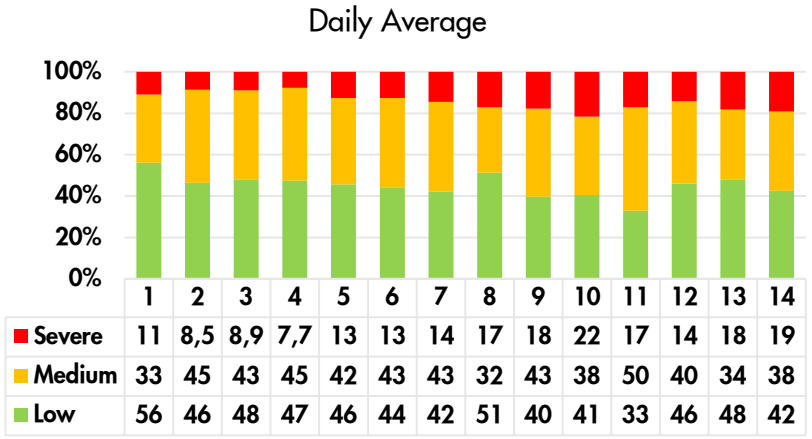
KSS ANALYSES



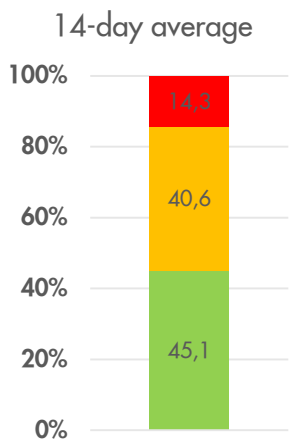




AVERAGE KSS PREVALENCES



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Severe	11	8,5	8,9	7,7	13	13	14	17	18	22	17	14	18	19
Medium	33	45	43	45	42	43	43	32	43	38	50	40	34	38
Low	56	46	48	47	46	44	42	51	40	41	33	46	48	42



PUBLICATIONS

- Riethmeister V, Brouwer S, van der Klink J, Bültmann U. Work, eat and sleep: Towards a healthy ageing at work program offshore. *BMC Public Health*. 2016;16:134.

- Riethmeister V, Bültmann U, Gordijn M, Brouwer S, de Boer MR. Investigating daily fatigue scores during two-week offshore day shifts. *Appl Ergon*. 2018;71:87-94.

- Riethmeister V, Bültmann U, de Boer MR, Gordijn M, Brouwer S. Examining courses of sleep quality and sleepiness in full 2 weeks on/2 weeks off offshore day shift rotations. *Chronobiol Int.* 2018; 35(6):759-72.

- Riethmeister V, Matthews R, Dawson D, de Boer MR, Brouwer S, Bültmann U. Time-of-Day and Days-on-Shift Predict Increased Fatigue Over Two-Week Offshore Day-Shifts. Applied Ergonomics, accepted for publication.

- Riethmeister, V.; Bültmann, U.; de Boer, M.; Brouwer, S. Predictors of sleepiness in two-week offshore day-shift workers. Submitted.